IRRIGATION DEPARTMENT
MINISTRY OF WATER RESOURCES AND IRRIGATION
ARAB REPUBLIC OF EGYPT

THE PREPARATORY SURVEY FOR THE IRRIGATION WATER RESOURCES MANAGEMENT IMPROVEMENT PROJECT IN THE ARAB REPUBLIC OF EGYPT

FINAL REPORT （ADVANCED VERSION）

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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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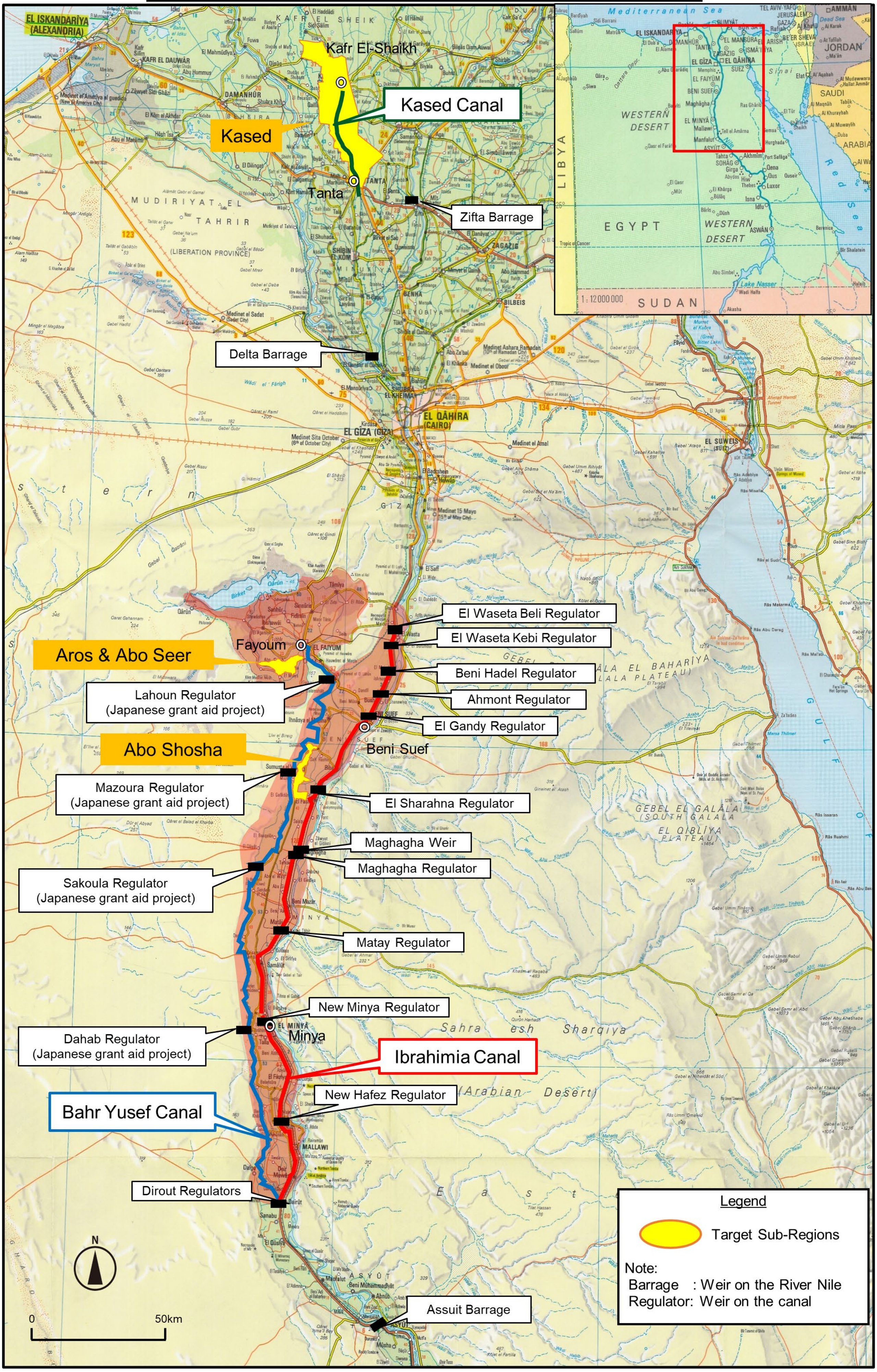
LOCATION MAP OF THE SURVEY AREA



EXECUTIVE SUMMARY

PREFACE

0.1 Submitted herewith is the Draft Final Report (DFR) prepared after all the field surveys completed for conducting 'the Preparatory Survey for the 'Irrigation Water Resources Management Improvement Project'. This report presents major findings obtained through a series of relevant data review and field surveys, and, based on those results, project components are presented by means of, e.g., construction of new hydraulic structures, rehabilitation of structures, improvement of big canals and lining of secondary canals, procurement of machineries, introduction of modern on-farm irrigations, etc. Further, cost estimation, project evaluation, and environmental and social conditions are also discussed.

1. RATIONALE, GOAL OF THE PROJECT, AND SETTING UP OF THE SURVEY

1.1 Egypt is a country with extremely little rainfall, which is only 51 mm of annual average rainfall. The River Nile water covers more than 90% of water resources in Egypt, yet it is regulated to 55.5 billion cum/year by an international agreement. The demand for water in Egypt has been increasing due to a rapid population growth in recent years showing an annual average of 2.04% from 2008 to 2017, and the expansion of farmlands. Consequently, the annual water resource per capita in the country has become 720 cum (2017), that is far below the 1,000 cum, a common standard threshold for water shortage.

1.2 The agricultural sector occupies about 95% of consumptive use of water in Egypt (National Water Resources Plan 2037), and therefore, the efficient use of water resources in the agricultural sector is an urgent issue. So far, the Government of Egypt (GOE) has been making efforts to realize appropriate water distribution through the construction and rehabilitation of regulators mainly on the principal canals. Japanese ODA has also been utilized to assist GOE in its efforts. However, the long irrigation canal network with aged irrigation facilities from the main to the terminal canals and sedimentation in the canals make it difficult to manage water distribution in the entire irrigation water system and to deliver required water properly to the farmlands.

1.3 With above as background, in August 2016, the GOE requested the Government of Japan (GOJ) to support 'the Irrigation Water Resources Management Improvement Project' in order to improve agricultural production and increase the income and living standards of the population in the target areas located in the Upper Egypt and also in the Central Delta. In response to this request, JICA agreed and signed the minutes of discussions (MD) on the framework of the Preparatory Survey for the 'Irrigation Water Resources Management Improvement Project' with the GOE on November 22, 2018, hence this Preparatory Survey was officially kick-offed in July 2021.

1.4 The objective of the Project, 'Irrigation Water Resources Management Improvement Project', is to achieve equivalent water distribution at the farmlands in the target areas, thereby contributing to the improvement of the living standard of residents through increasing of productivities of agricultural products. Towards realizing this project objective, the Preparatory Survey, as its purpose, is to conduct a study on the Project including its objectives, outline and project components, project cost, implementation schedule, implementation (procurement and construction) method, project implementation system, operation and maintenance management system, environmental and social considerations, etc., for the appraisal of the Project to be implemented as a Japan-funded ODA loan project.

1.5 The target areas of the Project as well as the Preparatory Survey are located in the following areas of Upper Egypt and also in the Central Nile Delta;

✓ Upper Egypt: irrigation areas covered by the Bahr Yusef (313 km) and Ibrahimia (256 km, measured from the Dirout Group Regulators) Principal Canals, and

✓ Central Nile Delta: irrigation area covered by the Kased Main Canal (34 km) extending in Gharbia and Kafr El Sheik Governorates.

1.6 In addition to above target areas, there are specific 3 priority sub-regions identified by the Ministry of Water Resources and Irrigation (MWRI). Sub-region here means that it is an irrigation area, having a certain extent, that is irrigated by an irrigation system consisting of principal-main-branch canals, as well as Meska[1], Marwa and its command area. There are 31 sub-region areas, 48 sub-region areas and 1 sub-region area in the Bahr Yusef Command Area, Ibrahimia Command Area, and under the Kased Main Canal area respectively, totaling to 80 sub-regions. Of them, the specific 3 priority sub-regions for the feasibility study purpose are as follows:

✓ Abo Shosha sub-region in Beni Suef Governorate, commanded by Ibrahimia Principal Canal,
✓ Aros & Abo Seer sub-region in Fayoum Governorate, commanded by Bahr Yusef Principal Canal, and
✓ Kased sub-region in Gharbia Governorate, Central Delta.

2. CHALLENGES AND OPPORTUNITIES IN EGYPT AGRICULTURE

2.1 The water resources in Egypt first consist of; 1) fresh water and 2) recycled water, and the former is further composed of Nile water being the major one, groundwater and rains & floods while the latter of agriculture drainage, sewage water and sea water desalination. In fact, the water of recycled ones shares as much as 17% of whole water resources in Egypt as of 2015/16. Of the fresh waters, as it is well known, the Nile water shares the most of it, say about 88%, which is 55.5 BCM per year. On the recycled waters, the major one comes from agriculture drainage water, sharing as much as 90% of all the recycled waters (Statistical Yearbook 2019).

2.2 Looking at the consumption side, agriculture sector uses far much water than other sectors, i.e. consuming more than 80% of all uses while drinking and health use shares 12 – 14%, industry sector does only 1.6% and loss shares about 3% only. In fact, total uses of water come to around 73 – 76 BCM per annum, while the fresh water total available per annum stands at around 63 BCM only. This implies that the water balance in Egypt is narrowly maintained on the use of recycled waters, whose share arrives at as much as 17% nowadays (as of 2015/16, National Water Resources Plan 2037).

2.3 There is a study, which forecasts water resources availability in connection with future water uses in Egypt, and this has been referred into the National Water Resources Plan (NWRP). The NWRP sets the year 2015 as the base year and forecasts water availability and uses, which together present water balance, up to 2037. According to the forecast, the base water requirement volume of 80.25 BCM will increase to 88.95 BCM in 2037. Apart from this NWRP estimation, the Statistical Yearbook (2018) estimates water availability in the same base year 2015 to be 76.25 BCM (4 BUM less from that of NWRP 37), and this will also increase proportionally towards 2037.

2.4 NWRP tried simple simulations for agriculture water availability in the future in Egypt under several conditions. On such condition that other uses than agriculture are given priority, namely, those water allocations than agriculture should be maintained first and then the remaining volume is allocated to agriculture sector, water available for agriculture sector will be 57.10 BCM in 2015 to 53.30 BCM only for the year 2037. In order to cultivate the same area and same crops with these reduced water volumes, there should be an increase of irrigation efficiency by as much as 14.24% for the year 2037 according to the numbers indicated in the NWRP 2037.

[1] Meska is the terminal canal that receives irrigation water from the upper branch canals, but while the branch canal is under government (MWRI) control, the Meska and beyond are under farmers' control and are their property. Marwa is an open channel established within the farmlands.

2.5 As of year 2022, there are 2 nationwide on-going projects related to irrigation and agriculture development in Egypt. One is the introduction of concrete linings to, in principle, secondary canals, and the second one is the introduction of modern on-farm irrigation to the Old Lands where there are clay and silty soils prevalent. The implementation of concrete lining was started in 2020, and the overall target is to introduce the lining to a total of 20,000 km secondary canals nationwide within 4 years till 2024. While, the modern on-farm irrigation is to be introduced over to a huge area of approximately 4 million feddans of Old Lands.

3. THE PROJECT AREA

3.1 SALIENT FEATURES

3.1 The Project area belongs to the Nile Valley and the Nile Delta. The irrigated areas by the Bahr Yusef and Ibrahimia Principal Canals are the areas where people live in the river valleys formed along the Nile River upstream before Cairo. The Nile Delta stretches 240 km from east to west, and the area between the Rosetta Branch in the west and the Damietta Branch in the east is called the Central Delta. The irrigated area by the Kased Canal running in the Gharbia and Kafr El Sheik Governorates is located in this Central Delta area.

3.2 Out of the 55.5 billion cum, it is estimated that 5 billion cum is allocated to the Bahr Yusef Canal, and 3.6 billion cum to the Ibrahimia Canal (source: NWRP 2017). Bahr Yusef Canal irrigates the farmlands in Fayum Governorate at the end of the canal, for which 2.6 billion cum including 0.2 billion cum for domestic use is allocated out of the 5 billion cum. On the other hand, Kased Canal is estimated to take an annual amount of 0.6 billion cum, though there are not regular discharge records.

3.3 In Egypt, villages are formed with mother villages and their hamlets. The number of the villages whose farmlands are irrigated mostly from the main canal and branch canals of the priority sub-regions, i.e., Abo Shosha, Aros & Abo Seer and Kased areas, are 14, 10 and 34 respectively. Number of the landowners in Abo Shosha, Aros & Abo Seer and Kased are 17,032, 11,324 and 39,056 households respectively, and the average land holding per household counts as small as 1.08 fed/HH, 1.30 fed/HH and 0.82 fed/HH respectively.

3.4 The number of beneficiary households is estimated from the irrigated area in each priority sub-region and the average farmland per household in each sub-region above-mentioned. Thus, the number of beneficiary households in Abo Shosha, Aros & Abo Seer, and Kased sub-regions are 16,600, 10,300, and 117,000 households, respectively, for a total of 143,900 households in the three priority sub-regions. Using the average number of household members in each sub-region from the Farm Household Economic Survey conducted by the JICA Survey Team, the number of beneficiaries in Abo Shosha, Aros & Abo Seer and Kased sub-regions is estimated at 101,260, 58,710 and 538,200, respectively. The total number of beneficiaries in the 3 sub-regions comes to 698,170.

Table 3.1 Estimated Number of Beneficiaries in the Priority Sub-regions

Sub-region	Service Area (fed) (a)	Ave. Landholding (fed/HH) (b)	No. of Households (c)=a/b	Ave. No. per Household (d)	Estimated Beneficiaries (e)=cxd
Abo Shosha	17,881	1.08	16,600	6.1	101,260
Aros & Abo Seer	13,330	1.30	10,300	5.7	58,710
Kased	95,976	0.82	117,000	4.6	538,200
Total	**127,187**	**0.88**	**143,900**	**4.9**	**698,170**

Sources: MALR and JICA Survey Team

3.2 IRRIGATION SYSTEMS

3.5 The Dirout Group Regulators (DGRs), which are the beginning of the Project area in the Upper

Egypt, are fed by the Ibrahimia Intake at the Assuit barrage on the Nile river. The Ibrahimia Intake at the Assuit barrage was rehabilitated in 2018 with KfW fund while the DGRs is rehabilitated by a Yen Loan Project to be completed in around 2025. All the four regulators located on the Bahr Yusef Canal have already been rehabilitated by Japanese Grant Aid Scheme while the eight regulators located on the Ibrahimia Canal have not been rehabilitated in large-scale till now.

3.6 Since the Bahr Yusef Principal Canal is originally a natural river, the canal is largely meandering. Total length of the canal is about 313 km irrigating about 582,000 feddan (245,000 ha) of farmlands in total (area detected by satellite analysis). Principal and main canals convey irrigation water continuously while branches are operated by a rotational system. The end of the Bahr Yusef Principal Canal is located in Fayoum, and the irrigation water conveyed by the Bahr Yusef finally effluents to the Lake Qarun and Lake Rayan through drainages. Most of the irrigation areas covered by Bahr Yusef in Fayoum are irrigated by gravity without pumping from the canals.

3.7 The Ibrahimia Principal Canal is an artificial man-made canal completed in 1873, and it is one of the longest canals in the world with total length of 350 km, of which it is 256km after the DGRs. The canal irrigates an extended area of about 479,000 feddans (202,000 ha) in the 2 governorates of Minya and Beni Suef (area detected by satellite analysis). The regulators located on the Ibrahimia Principal Canal is eight, which have not been rehabilitated in large-scale for the last 20 years. The number of regulators and intake facilities are about double of the Bahr Yusef Principal Canal, implying that the beneficial areas are irrigated by dividing them into smaller areas.

3.8 Aside from the target area in the Upper Egypt, there is one project area in the Central delta, that is Kased Main Canal Command Area. The Kased Main Canal is fed by the Tanta navigation canal diverted from El Rayah Monofy Canal. Kased Main Canal's length is about 42 km and has about 263 km of branch canals altogether with the service area of about 96,000 feddan (about 40,000 ha). There is no intake structure at the intake point of the Kased irrigation system as at now, and therefore the water is naturally diverted from the Tanta navigation canal.

3.9 In this Survey, there are three priority sub-regions selected for the purpose of conducting feasibility study. In the first Steering Committee (Kick-off meeting) held on July 13, 2021, the Aros & Abo Seer sub-region in Fayoum and the Abo Shosha sub-region in Beni Suef were selected from the Upper Egypt region, and the Kased was also selected from the Central Delta area. The net command areas are about 18,000 feddans, 13,000 feddans, and 96,000 feddans respectively for those sub-regions.

3.3 CURRENT IRRIGATION EFFICIENCIES

3.10 Along the Bahr Yusef Principal Canal and Ibrahimia Principal Canal, there are regulators where discharge data have been recorded based on the water levels measured. On the other hand, if there are cropping patterns and also actually cropped/ harvested area available, consumed water volume by those crops can be estimated. By making a comparison between the discharge data and the probable consumed water by crop, irrigation efficiency can be estimated, which can be probably the most accurate current efficiency.

3.11 To know the cropping patterns, i.e. crop types and those planed seasons, MALR data is referred, e.g. Bulletin of Important Indicators of the Agricultural Statistics Winter Crops, Summer and Nile Crops published every year. Actual cropped areas are estimated by satellite image analysis covering the recent years of 2017/18 to 2019/20 using the Sentinel-2 data. With the standard water consumption table utilized within the MWRI, a unit water consumption is obtained according to the crop type and its season represented by month.

3.12 Following the procedure above, irrigation efficiencies against fresh water, not considering drainage re-use, came to 0.560, 0.577, and 0.567 for Bahr Yusef, Ibrahimia and whole Bahr Yusef and

Ibrahimia as annual average (average from February to December). If we refer to the irrigation efficiencies during summer season, say from June to August where the highest efficiency takes place, the efficiencies are 0.692, 0.721, and 0.705 for Bahr Yusef, Ibrahimia and whole Bahr Yusef and Ibrahimia respectively.

3.13 If the re-use of drainage water is considered, the irrigation efficiencies come to 0.505, 0.522, and 0.510 for Bahr Yusef, Ibrahimia and for the both areas as annual average. If we refer to the irrigation efficiencies during summer season only, say from June to August, the efficiencies arrive at 0.515, 0.547, and 0.548 for Bahr Yusef, Ibrahimia and whole Bahr Yusef and Ibrahimia respectively. Note that considering the drainage re-use means an increase of available water for crops whereby efficiency becomes lower than the one estimated against only the fresh water.

3.4 AGRICULTURE

3.14 The cropping intensities of the Old Lands in the Bahr Yousef and Ibrahimia Canal areas and Kased Canal area have reached already as high as 196% and 200% respectively. According to the "Legend of the Soil Map of the World" (UNESCO, 1974), the soils in the Nile valley and the Delta are classified as Calcaric Fluvisols (Jc), which is a calcareous soil, showing up at least between 20 and 50 cm from the surface of the land, good for agriculture purpose. Salinization has been an issue especially in the northern part of the Nile delta regions, where rice has always been cultivated in order to leach out the salt.

3.15 In Upper Egypt, where Bahr Yousef and Ibrahimia Canals are located, the major crop in summer season is maize while rice is hardly cultivated. The major crops in winter season in Upper Egypt are wheat and berseem (Egyptian clover). In the Central Nile Delta, where the Kased Canal area is located, the major summer crop has been rice. Especially, Kafr El sheikh Governorate located in the downstream reaches of the Kased Main Canal is the most rice producing governorate in Egypt. However, the rice cultivation is now regulated to only 10% within the Kased Command Area as of year 2022, due to water shortage nationwide.

3.16 Nowadays, farmers ship their products through traders or by themselves to the village branch of the ABE, which is well equipped with storehouse and storage yard. There are some processing facilities and companies in the governorates, such as cold storage facilities, garlic and onion slicing company, etc. As for the export, the traders first select and purchase products from the farmers and sell them to agro-processing companies and/or exporters. This distribution includes grapes (raw), pomegranates (raw), garlic (raw), and onion (dried powder).

3.17 Aging agricultural extension workers are the major challenge in the agricultural extension services. Although the agricultural extension workers have accumulated their knowledge and skills through the work experiences and obtained trainings, these assets are diminishing in the rural areas. Nevertheless, the role of agricultural extension workers is indispensable to promote modern on-farm irrigation. The Water Resources Law was approved by the parliament in May 2021, which says that the agricultural cooperative is given the role of supervising Meska improvement and modern irrigation with the technical assistance from MWRI.

3.5 SATELLITE IMAGES ANALYSIS TO KNOW ACTUAL CROPPED AREA

3.18 The Team conducted a satellite image analysis to know the actually cropped (irrigated) area over time. The target period of the analysis covers 21 years, namely from year of 2000 to 2020. The analysis targeted the whole irrigated area under Assuit Barrage and Nile delta area, and evaluated the cropped (irrigated) area of each irrigation section, which is defined according to the regulators where discharge data are available. In the analysis, an agriculture year was divided into 2 seasons, namely winter cropping season and summer/Nile cropping season.

3.19 It was observed under Bahr Yusef Principal Canal that i) the total cropped area in winter and summer/Nile season has been increased in the 21 years in the section between Dirout and Sakoula Regulator, the section between Sakoula and Lahoun Regulator, and the section of Hassan Wasef, and ii) the total area of the section of Lahoun Regulator has declined in winter season and remained almost unchanged in summer/Nile season. For Ibrahimia Principal Canal Command Area, the cropped area in 2 sections, i.e., section between Dirout and Maghagha Regulator and section between Maghagha and El Wasta Regulator, has declined in winter and summer/Nile seasons. It was also shown that the cropped area of Kased area of both seasons has been decreased during the 21 years.

3.20 The comparison between the agriculture statistics of MALR and the analysis revealed that: i) in some years, drops of area in statistics was not observed by the analysis in Kahr El Shaikh and Gharbia; ii) in Beni Suef, there is approximately 50,000 to 200,000- feddan gap of summer/Nile crop area between the analysis and the statistics; iii) in Fayoum area, there are broad gaps in areas of winter crop; and iv) the statistical data of winter and summer/Nile crop area of Minia fluctuated during the years, yet, it was not observed in the analysis.

3.6 FARMERS' OPINION ON THE MODERN ON-FARM IRRIGATION

3.21 The farmers' perception of modern on-farm irrigation facilities and their opinions on the introduction of modern on-farm irrigation facilities were obtained through a questionnaire survey as well as from stakeholder meetings conducted as a part of the environmental and social considerations. According to the questionnaire survey, on average of the three priority areas, 64% of the sample households know about drip irrigation system. As for sprinkler irrigation system, 43% of households as average know it, less than the drip system. Most of them know the modern irrigation system from the actual practice in the New Lands in desert, thus it is indicated that the drip irrigation is more practiced in the New Lands.

3.22 The respondents were also asked that "if drip irrigation system costs 42,900 – 57,000 LE/ha (around18,000 - 24,000LE/fed)[2], do you want to introduce it?". As a result, approximately 90% of the farmers answered "No". The most common reason for this answer "No" is the high cost of the drip irrigation system accounting for 73% out of these 90% respondents. The same question was also asked for sprinkler irrigation system "If sprinkler irrigation system costs 42,900 – 57,000 LE/ha, do you want to introduce it?". The result was almost the same as drip irrigation: 96% of the farmers answered "No" and most common reason for this answer is "high cost" accounting for 64% out of these 96% farmers.

3.23 According to the results of stakeholder meetings, motivation for the introduction of modern on-farm irrigation varied among the priority areas. The most positive stance for introduction of modern on-farm irrigation was found in Kased (Gharbia) in Delta, followed by Abo Shosha (Beni Suef), and the most conservative stance was found in Aros & Abo Seer (Fayoum). As one of the most common requests raised at meetings, setting up of demonstration farms by the Project are necessary to show the success cases by applying modern on-farm irrigation techniques. This is because that most of farmers had seen and heard successful examples in New Lands, however, they had rarely experienced successful examples in Old Lands.

4. PROJECT PLANNING AND DESIGNING

4.1 THE TARGET AREA AND THE TARGET IRRIGATION EFFICIENCIES

4.1 The target areas in Upper Egypt are the two principal canals - Bahr Yusef and Ibrahimia - and two prioritized irrigation sub-regions, Abo Shosha located in Beni Suef Governorate and Aros & Abo Seer

[2] This questionnaire was carried out based on the orally collected information from MWRI as of September 2021 before the JICA Survey Team surveyed and estimated the cost with year 2022 price.

located in Fayoum Governorate. The target area in the Central Delta is Kased sub-region located in Gharbia and Kafr El Sheik Governorates. Following tables summarizes the characteristics of the project areas:

Table 4.1 Summary of the Project Target Area (Bahr Yusef and Ibrahimia Principal Canals)

<table>
<tr><th>General</th><th>Bahr Yusef</th><th>Ibrahimia</th><th>Remarks</th></tr>
<tr><td rowspan="2">Service Area (by MWRI) *</td><td>778,102 feddan (326,803 ha)</td><td>669,072 feddan (281,010 ha)</td><td rowspan="4">Only Minya, Beni Suef, and Fayoum, excluding Giza</td></tr>
<tr><td colspan="2">1,447,174 feddan (607,813 ha)</td></tr>
<tr><td rowspan="2">Service Area (Net, by satellite)</td><td>582,298 feddan (244,565 ha)</td><td>479,828 feddan (201,528 ha)</td></tr>
<tr><td colspan="2">1,062,126 feddan (446,093 ha)</td></tr>
<tr><td>Design Discharge</td><td>227 m³/s</td><td>186 m³/s</td><td>Provided by MWRI</td></tr>
<tr><td>Unit Design Discharge</td><td>0.3898 l/s/F (0.928 /ha)</td><td>0.3876 l/s/F (0.923 /ha)</td><td></td></tr>
<tr><td>Water Allocated (Annual Total)</td><td>5,000 MCM</td><td>3,600 MCM</td><td>From NWRP2017</td></tr>
<tr><td>Water Allocated (Annual, Irrigation)</td><td>approx. 4,600MCM</td><td>approx. 3,312 MCM</td><td>92%** of total assumed</td></tr>
<tr><td>Water Allocated (cm for Irrigation)</td><td>188 cm/ annual</td><td>164 cm/annual</td><td>Divided by Net SA</td></tr>
<tr><td>Drainage W. for Qarun & Rayan</td><td>500 MCM</td><td>—</td><td>Per annum</td></tr>
<tr><td>Facilities</td><td></td><td></td><td></td></tr>
<tr><td>Total Length of the Canal</td><td>313 km</td><td>256 km ***</td><td></td></tr>
<tr><td>Nos of Regulators on the Canal</td><td>4</td><td>8</td><td></td></tr>
<tr><td>Nos of Feeding Pump Stations</td><td>14</td><td>None</td><td></td></tr>
<tr><td>Farmers</td><td></td><td></td><td></td></tr>
<tr><td>Nos of Beneficiary Farmer Households</td><td colspan="2">892,543</td><td>Divided by A. farmland</td></tr>
<tr><td>Nos of Beneficiary Population</td><td colspan="2">5,265,750</td><td>HH members: 5.9****</td></tr>
<tr><td>Estimated Average Farmland****</td><td colspan="2">1.19 feddan (0.50 ha)</td><td>Ave of B. Suef&Fayoum</td></tr>
</table>

Source: MWRI, General Directorates of Beni Suef, Fayum, Gharbia and satellite image analysis data

Remarks: * Domestic and industrial water are provided by Bahr Yusef and Ibrahimia Canals for the 3 governorates of Minya, Beni Suef and Fayoum, and the ratio is reported at around 8% by relevant irrigation directorate office.

Remarks: ** Ibrahimia Principal Canal extends upstream of the Dirout Regulator, while this table shows only the part of canal after Dirout Regulator.

Table 4.2 Summary of the Project Target Area (3 Prioritized Irrigational Sub-regions)

Abo Shosa, Beni Suef Governorate	Indicators		Remarks
Service Area (by MWRI) *	19,870 feddan (8,345 ha)		
Service Area (Net, by satellite)	17,881 feddan (7,510 ha)		
Total Length of Main Canal (Nos)	34.4 km (1)		
Total Length & Nos of Branch Canals (Nos)	53.27 km (20)		Excl. Sub-branches
Nos of Farmer Households	16,600		Divided by A. farmland
Nos of Population	101,260		HH members: 6.1**
Estimated Average Farmland	1.08 feddan		Cooperative data
Aros & Abo Seer, Faiyum Governorate	Aros	Abo Sheer	Remarks
Service Area (by MWRI)	13,565 feddan (5,697 ha)		
Service Area (Net, by satellite)	13,330 feddan (5,599 ha)		
Total Length of Main Canal (Nos)	9.8 km (1)	3.5 km (1)	
Total Length of Branches (Nos)	40.4 km (4)	6.4 km (3)	Incl. sub-branches
Nos of Beneficiary Farmer Households	10,300		Divided by A. farmland
Nos of Beneficiary Population	58,710		HH members: 5.7**
Estimated Average Farmland	1.3 feddan		Cooperative data
Kased, Gharbia & Kafr El Sheik Governorates	Indicators		Remarks
Service Area (by MWRI)	95,461 feddan (40,094 ha)		
Service Area (Net, by satellite)	95,976 feddan (40,310 ha)		
Total Length of Main Canal (Nos)	42.2 km (1)		
Total Length of Branch Canals (Nos)	262.9 km (46)		Excl. Sub-branches
Nos of Beneficiary Farmer Households	117,000		Divided by A. farmland
Nos of Beneficiary Population	538,200		HH members: 4.6**
Estimated Average Farmland	0.82 feddan (based on Koror data)		Cooperative data
Total of 3 Sub-regions			
Service Area (by MWRI) *	128,896 feddan (54,136 ha)		
Service Area (Net, by satellite)	127,187 feddan (53,419 ha)		
Total Length of Main Canal (Nos)	89.9 km		
Total Length of Branch Canals (Nos)	362.97 km		Excl. Sub-branches

Nos of Beneficiary Farmer Households	143,900	Divided by A. farmland
Nos of Beneficiary Population	698,170	HH members: 4.9**
Estimated Average Farmland***	0.88 feddan	Cooperative data

Source: MWRI, General Directorates of Beni Suef, Fayum, Gharbia and satellite image analysis data
Note: * the area provided by MWRI is mostly big from the area detected by satellite image analysis, so the MWRI Service Area is not taken for the planning purpose. ** household members came from Farm Household Survey conducted by JICA Survey Team. *** Average farmland area provided from Agriculture Directorate (Cooperative).

4.2 In planning and designing the Project, what comes first is the level of irrigation efficiencies to be achieved with rehabilitation/re-construction and also the introduction of modern on-farm irrigation. In general, irrigation efficiency is determined considering three aspects, 1) conveyance efficiency, 2) distribution efficiency, and then 3) field application efficiency. Thus, the overall irrigation efficiency is calculated by multiplying those three efficiencies.

4.3 The estimated overall irrigation efficiency and the increment from the current irrigation efficiency under various conditions are examined in the table below. Cases A - D shown in the table refer to the examination cases of conveyance and distribution efficiencies. On the other hand, a total of six cases (Case 1 to 6) are examined for field efficiency improvement including current condition. Following are the findings identified as the results of calculating overall irrigation efficiency:

1) In case that the distribution efficiency is increased by 5%, reaching 93% distribution efficiency achievable by around 60% branch canal lining, the target of 14% increase in irrigation efficiency can be achieved with the introduction of modern on-farm irrigation to 40% of the area (Case B-3). The JICA Survey Team recommends this scenario (Case B-3) as the Government intends to implement the concrete lining on parts of the branch canals, except large ones.

2) If the distribution efficiency is increased to the maximum 95% (increase by 8%) and also the modern on-farm irrigation is introduced to allover the area except the lower Delta (Case C-6), which is also an intension of the Government, the irrigation efficiency could be increased by as much as 32%. This scenario could be an ideal future in the long run in Egypt.

3) On top of the Case C, conveyance efficiency is increased by 5% under Case D, meaning that principal and main canals are also to be concrete lined. In this case, the increment of irrigation efficiency is not so big from the ones of Case C, e.g., from 32.2% to 38.8%, increase only by 6.6%. To introduce concrete lining to principal and main canals, which are operated under continuous flow, would be a very hard work, also raising the cost. Therefore, JICA Survey Team does not in principle recommend to introduce lining to such continuous flow canals.

Table 4.3 Setting of Target Irrigation Efficiency

	Category	Efficiency Current	Increment	Efficiency Improved	On-farm & Overall	On-farm Efficiency	Cases and Shares by On-farm Irrigation Method					
							Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Case A	Conveyance	0.90	0%	0.90	Surface	0.70	100%	80%	60%	40%	20%	0%
	Distribution	0.88	0%	0.88	Sprinkler	0.80	0%	10%	20%	30%	40%	50%
					Drip	0.90	0%	10%	20%	30%	40%	50%
					On-farm E.	-	0.70	0.73	0.76	0.79	0.82	0.85
	Effi. before On-farm	0.79		0.79	Overall E.	-	0.55	0.58	0.60	0.63	0.65	0.67
	Increment					-	0.0%	5.1%	9.4%	13.8%	18.1%	22.4%
Case B	Conveyance	0.90	0%	0.90	Surface	0.70	100%	80%	60%	40%	20%	0%
	Distribution	0.88	5%	0.92	Sprinkler	0.80	0%	10%	20%	30%	40%	50%
					Drip	0.90	0%	10%	20%	30%	40%	50%
					On-farm E.	-	0.70	0.73	0.76	0.79	0.82	0.85
	Effi. before On-farm	0.79		0.83	Overall E.	-	0.58	0.61	0.63	0.66	0.68	0.71
	Increment					-	5.8%	10.4%	14.9%	-	24.0%	28.5%
Case C	Conveyance	0.90	0%	0.90	Surface	0.70	100%	80%	60%	40%	20%	0%
	Distribution	0.88	8%	0.95	Sprinkler	0.80	0%	10%	20%	30%	40%	50%
					Drip	0.90	0%	10%	20%	30%	40%	50%
					On-farm E.	-	0.70	0.73	0.76	0.79	0.82	0.85
	Effi. before On-farm	0.79		0.86	Overall E.	-	0.60	0.62	0.65	0.68	0.70	0.73
	Increment					-	8.9%	13.5%	18.2%	-	27.5%	32.2%
Case D	Conveyance	0.90	5%	0.95	Surface	0.70	100%	80%	60%	40%	20%	0%
	Distribution	0.88	8%	0.95	Sprinkler	0.80	0%	10%	20%	30%	40%	50%
					Drip	0.90	0%	10%	20%	30%	40%	50%

	Category	Efficiency Current	Increment	Efficiency Improved	On-farm & Overall	On-farm Efficiency	Cases and Shares by On-farm Irrigation Method					
							Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
					On-farm E.	-	0.70	0.73	0.76	0.79	0.82	**0.85**
	Effi. before On-farm	**0.79**		**0.90**	Overall E.	-	0.63	0.66	0.68	0.71	0.74	**0.76**
	Increment					-	14.3%	19.2%	24.1%	-	33.9%	**38.8%**

Source: JICA Survey Team

4.2 LARGE HYDRAULIC STRUCTURE CONSTRUCTION (COMP. 1)

4.4 A series of field surveys were conducted on the existing hydraulic structures, through which it was found that structures rated S1 need to be reconstructed, while those rated S2 need rehabilitation or repair. Of the structures rated S1, the Mahlet Menouf Regulator (19.33 KM) and the Sorad Regulator (30.36 KM) located on the Kased Main Canal are large in size. In addition, the lack of structure at the Kased Canal Intake seems to present difficulties for adequate water intake for the Kased Main Canal.

4.5 Therefore, existing Mahlet Menouf regulator and Sorad regulator have been studied from the viewpoint of hydraulic condition, and also structural conditions. These results showed that the current structures are not durable enough to continue using because of porous space condition within the piers, not good concrete/brick quality, etc. Thus, the 2 structures were decided to replace by new ones. In addition, the hydraulic simulation on the Kased intake point verified that the current condition, where no intake structure exists, can hardly divert design discharge into the Kased canal, and therefore Kased Intake should be constructed. The dimensions for the new 3 structures are as follows:

Table 4.4 Pier Top Elevation and Height for Each Structure

Regulator's name		Regulator basement	Design water level	Pier clearance	Extra height for F.H. gate	Pier head level U/S (Height)	Pier head level D/S (Height)	Gate Vents width (numbers)	Entire width of regulator (Between abutments)
Kased Intake	Kased C.	EL 5.70m	EL 9.70m	0.50m	0.50m	EL 10.70m (5.00m)	EL 10.20m (4.50m)	3.0m (4vents)	15.0m
	Tanata N. C	EL 5.70m	EL 9.70m			EL 10.70m (5.00m)	EL 10.20m (4.50m)	3.0m (4vents) +11.0m (one Nav. Lock)	7.0m
New Mahlet Menouf		EL 4.00m	EL 7.10m			EL 8.10m (4.10m)	EL 7.60m (3.60m)	3.0m (4vents)	15.0m
New Sorad		EL 3.10m	EL 5.60m			EL 6.60m (3.50m)	EL 6.10m (3.10m)	3.0m (4vents)	15.0m

Source: JICA Survey Team

4.3 SMALL STRUCTURE CONSTRUCTION AND REHABILITATION (COMP. 1& 2)

4.6 In order to clarify reconstruction and/or rehabilitation for the hydraulic structures in the target areas, the JICA Survey Team has surveyed structures which were constructed or installed on the Bahr Yusef and Ibrahimia Principal Canals and in the three priority sub-regions. The structure survey was conducted by 2 stages, of which 1st stage survey focused mainly on the functionality of the whole structures with scores from S1 (worst) to S5 (nil-malfunction); and 2nd stage survey focused on the physical status together with the level of required rehabilitation and/or reconstruction, i.e., S1 and S2, on those structures which are severely damaged.

4.7 As a result of 1st stage survey, S1 rated facilities should be given the highest priority for reconstruction in order to restore the hydraulic function, which accounts for 7% of the irrigation facilities, that is 39 facilities out of 560 irrigation structures surveyed. S2 rated facilities should be given the second highest priority in most cases by rehabilitation, which accounts for 41% of the irrigation facilities, that is 232 facilities out of 560. During the 2nd stage survey, where only S1 and S2 structures were surveyed at the field again, a reassessment was done including the ID's final decision. The final assessment ranks were decided as shown below (for the detail of S1 ranked structures, see Table 4.6):

Table 4.5 Number of S1 and S2 Structures identified in the Field and Final Quantities by ID

Category	From Field		ID HQs Finalization		Difference		Remarks
Evaluation (S1/S2)	S1	S2	S1	S2	S1	S2	
Aros	4	3	4	3	0	0	
Abo Seer	6	0	7	0	1	0	
Abo Shosha	1	24	1	24	0	0	
Kased	15	22	3 (0)*	1	-12	-21	
Bahr Yusef	0	9	0	5	0	-4	
Ibrahimia	15	86	7	80	-8	-6	
Total	41	144	22 (19)*	113	-19	-31	

*/ Shows Kased Intake works (new), Mahlet Menouf Regulator (renewal) and Sorad Regulator (renewal), which are new large hydraulic structures. The numbers in parentheses are the quantities excluding the three large structures.
Source: JICA Survey Team through site observation with the relevant irrigation directorate/district officers, and ID headquarters

Table 4.6 Structures Ranked at S1 by Canal Command Area Base

No.	Ref. No.	Structure Type	Location	Structure Name	Survey Score			Measures
					Body	Gate	Total	
Abo Seer (Fayoum)								
1	S1-AA-1	Intake	km 0.00	Abo Seer intake	50	35	85	All replacement (including the road)
2	S1-AA-2	Intake	km 1.754	Omar Bek intake	35	35	70	All replacement.
3	S1-AA-3	Intake	km 1.755	Bahr El Kashef intake	35	-	70	All replacement.
4	S1-AA-4	Weir	km.1756	Bahr El Kashef Weir	35	35	70	All replacement.
Aros (Fayoum)								
1	S1-AA-5	Intake	km 5.666	El Maasra intake	35	-	70	All replacement.
2	S1-AA-6	Weir	km 5.674	Defno Weir	35	-	70	All replacement.
3	S1-AA-7	Intake	km 5.671	El Swafna intake	35	-	70	All replacement.
4	S1-AA-8	Weir	km 5.674	El Barq Weir	35	-	70	All replacement.
5	S1-AA-9	Intake	km 1.277	Khamas sawaki (5 wheels)	50	50	100	All replacement (reinstall water wheels)
6	S1-AA-10	Intake	km 1.745	Talat Sawaki (2 wheels)	50	50	100	All replacement (reinstall water wheels)
7	S1-AA-11	Screen		Bahr Yusef trash screen	Added by ID			New construction with electrical system, at the upstream of Lahoun Regulator.
Abo Shosha (Beni Suef)								
1	S1-AS-1	Intake	km 215.00 IB canal LHS	Abo Shosha intake	45	40	85	Replace the upstream part.
Kased (Gharbia)								
1*	S1-KA-1	Regulator	km 22.000	Sorad cross Regulator *	47	25	72	All replacement (to be studied with structural test)
2*	S1-KA-2	Regulator	km 12.000	Mahlet Menouf Regulator *	44	50	94	All replacement (with electric system).
3*	S1-KA-3	Intake	-	Kased intake *				New construction at the intake point
Ibrahimia (Beni Suef)								
1	S1-IB-1	Intake	229.700 RHS	Intake of Ahmed Pashe El Bahria	30	50	80	Replace the body & gate (incl. edge & upper layers of the conduit).
2	S1-IB-2	Tail Escape	249.175	Tail escape of El Saida	38.5	33	71.5	Replace the upstream part (with electrical system).
3	S1-IB-3	Weir	273.237	Bani Hader Weir	38.5	50	88.5	All replacement.
4	S1-IB-4	Tail Escape	279.16	El Zawia Tail Escape	35	35	70	Replace the upstream part.
5	S1-IB-5	Tail escape	-	El Fent canal tail escape	added by ID			New construction.
Ibrahimia (Minya)								
1	S1-IB-6	Intake	113.35	Intake of Kom El Zoheir (Right)	40	46	86	Replace the upstream part.
2	S1-IB-7	Intake	114.325 LHS	Intake of Kom El Zoheir (Left)	40	46	86	Replace the upstream part.

*/ Since these are new large hydraulic structures, a basic design was conducted as Component 1.
Source: JICA Survey Team through site observation with the relevant irrigation directorate/district officers, and ID headquarters

4.4 LARGE CANAL REHABILITATION (COMP. 4)

4.8 According to the non-uniform analysis conducted for Ibrahimia & Bahr Yusef principal canals, it was found that the both canals have a possibility of overflows due to inadequate flow capacity at the design discharge. In a canal with insufficient cross-sectional area, it is possible to compensate for the lack of cross-sectional area by raising the embankment, in addition to measures by dredging. Based on the scale of the overflow depths simulated, it is assumed that an increase of approximately 1 m would be sufficient, and concrete retaining walls can be considered for this smaller overflow depths (for the sections, see tables below).

Table 4.7 Raised Sections of Bahr Yousef Principal Canal

Bahr Yousef canal			
Left bank		Right bank	
Distance from DGR	Length(km) *	Distance from DGR	Length(km) *
61.202 - 70.772km	9.570 (1.431)	66.746 - 68.983km	2.237 (1.059)
79.241 - 80.249km	1.008 (0.754)	77.929 - 79.895km	1.966 (1.449)
216.623 - 219.626km	3.003 (0.932)	94.638 - 97.705km	3.067 (2.093)
Sub total	13.581km (3.117km)	Sub total	7.270km (5.411km)
		Grand total	20.851km (8.528km)

Note: The total distance (Length) is from the Dirout Regulator Group (DGR), to the target area scattered within the section.
* ( ) shows the section where the concrete retaining wall shall be installed.
Source: JICA Survey Team

Table 4.8 Raised Sections of Ibrahimia Principal Canal

Ibrahimia Canal			
Left bank			
Distance from DGR	Length(km) *	Distance from DGR	Length(km) *
1.459 - 10.957km	9.498 (2.903)	117.068 - 120.442km	3.374 (0.000)
11.935 - 17.977km	6.042 (2.272)	121.929 - 131.434km	9.505 (1.165)
24.476 - 31.016km	6.540 (3.657)	131.434 - 138.429km	6.995 (0.277)
31.016 - 36.966km	5.950 (1.703)	141.453 - 149.93km	8.477 (4.420)
45.455 - 49.961km	4.506 (0.999)	155.398 - 159.927km	4.529 (2.937)
52.963 - 59.957km	6.994 (1.493)	163.418 - 170.418km	7.000(3.258)
60.780 - 61.456km	0.676 (0.246)	171.418 - 179.42km	8.002 (4.507)
83.949 - 89.948km	5.999 (0.496)	182.421 - 188.732km	6.311 (2.622)
93.448 - 100.443km	6.995 (1.264)	191.006 - 206.236km	15.230 (0.891)
101.445 - 103.814km	2.369 (0.000)		
Sub total	55.569km (15.033km)	Sub total	69.423km (20.077km)
		Grand total	124.992km (35.110km)

Note: The total distance (Length) is from the Dirout Regulator Group (DGR), to the target area scattered within the section.
* ( ) shows the section where the concrete retaining wall shall be installed.
Source: JICA Survey Team

4.9 As the Bahr Yusef Principal Canal is used to be a natural river, it has numerous curves where scouring and sedimentation can easily occur at the outer and inner sides of the curves respectively. These curved sections can be one of the main factors to decrease the flow capacity, so it is necessary to take measures to mitigate the further sedimentation and erosion to the existing farmlands and houses sometimes found just behind the curved sections. According to field surveys, total 45 curves have been found, and the sections to be covered by the gabions are to be a total of 8.61 km, by selecting only big curve sections.

Table 4.9 List of Locations where There are Curved Sections along Bahr Yusef

No.	Jurisdiction GD	From the Dairy Route Distance (km)	Curve length (m) *	No.	Jurisdiction of directorate	Distance from DGRs (km)	Curve length (m) *
1	East Minya	6.10	350 (350)	26	West Minya	105.00	300 (0)
2		6.80	400 (0)	27		108.00	350 (350)
3		7.30	400 (400)	28		136.70	200 (200)
4		8.90	400 (400)	29		163.70	250 (0)
5		10.10	300 (300)	30		164.50	250 (0)
6		12.20	350 (0)	31	Beni Suef	210.00	100 (100)
7		14.10	400 (400)	32		211.50	200 (200)
8		14.85	250 (0)	33		213.00	200 (200)
9		16.50	350 (350)	34		214.50	400 (0)
10		18.10	250 (250)	35		215.50	160 (160)
11		22.80	400 (400)	36		216.50	200 (0)
12		23.50	350 (350)	37		217.00	400 (0)
13		48.90	300 (0)	38		218.20	300 (300)
14		50.70	300 (0)	39		219.00	200 (0)
15		60.80	400 (400)	40		219.50	300 (0)
16	West Minya	61.60	500 (0)	41		221.00	300 (0)
17		64.50	250 (0)	42		222.00	50 (0)
18		71.05	500 (500)	43		224.00	200 (200)
19		72.75	300 (0)	44		225.00	400 (400)

No.	Jurisdiction GD	From the Dairy Route Distance (km)	Curve length (m) *	No.	Jurisdiction of directorate	Distance from DGRs (km)	Curve length (m) *
20		75.40	300 (300)	45		231.00	250 (250)
21		76.10	400 (400)				
22		79.05	300 (300)				
23		85.50	450 (450)				
24		87.40	350 (350)				
25		89.79	350 (350)	Total			13,910 (8,610)

* ( ) shows the section where the gabions shall be installed.
Source: Cooperation Planning Survey on the Irrigation Sector (upper Egypt and Middle Delta) in Egypt (JICA, 2018)

4.10 Based on the hydraulic analysis for the Kased Main Canal, no overflow from the channel is currently occurring. However, it is known that Black Cotton Soil, which expands under wet-condition, is present along the Kased Canal, resulting in a partial expansion of the canal slope towards canal inside. Based on interviews with the officers in Gharbia irrigation directorate, it was revealed that the following 2 sections (No.1 and 6), which have particularly high priority for rehabilitation, need to be addressed, and a measure should be included in the project plan. Therefore, a sheet pile method is adopted with priority, which does not require channel excavation/embankment during construction.

Table 4.10 Typical Protection Section of Kased Main Canal

No.	Distance from Kased .C B.P.	Length (km)	Remarks
1	**11.56 - 14.46km**	**2.90**	To be protected
2	15.16 - 17.60km	2.50	No protection, monitoring only
3	19.56 - 21.26km	1.70	ditto
4	28.00 - 29.30km	1.30	ditto
5	29.30 - 31.00km	1.70	ditto
6	**33.00 - 33.12km**	**0.12**	To be protected
	Total length	10.22	
	Target section length	**3.02**	Sheet pile introduced

Source: JICA Survey Team based on reports from Gharbia Irrigation Directorate

4.5 BRANCH CANAL REHABILITATION AND LINING (COMP. 5)

4.11 In Egypt, concrete lining works are underway starting in 2020 for existing branch canals that are operated ON and OFF basis (rotational operation). Therefore, the Project is also to incorporate such concrete lining to the branch canals in the 3 priority areas as one of the project components. According to the future target irrigation efficiency, if the distribution efficiency of the branch canal is increased from the current 0.88 to 0.92, the necessary overall irrigation efficiency can be attained. In other words, the required water savings can be achieved by lining approximately 60% of the total length of the branch canals.

4.12 With above, basically, 60% of the total branch canal length has been selected with a canal bottom width of less than 6 m, assuming that lining is to be done from the upstream section. In the Abo Shosha and Aros and Abo Seer priority areas, concrete lining by MWRI has not been implemented any to date (as of March 2023), while in the Kased area, lining has already been implemented by MWRI to some extent. The target under this branch canal lining is to achieve 60% coverage, including this previously lined canal length. Thus, a total of 53 km, 32 km, and 90 km of branch canals will be concrete-lined for Abo Shosha, Aros & Abo Seer and Kased priority areas respectively.

4.13 The current concrete lining method (10 cm thick) by MWRI is a reasonable lining method from the view of preventing water leakage from the canals and the required construction speed. However, the current base thickness of 30 cm (to a maximum of 50 cm) should be less effective in preventing the reduction of the water level in the canals, which usually takes place with the introduction of smooth surface concrete lining. In addition, due to the significantly high permeability of the coarse stone piled base, small-scale collapse may occur on the back of the slope due to seepage water through the joints of the lining or in the event of cracks on the concrete.

4.14 Based on above considerations, the JICA Survey Team proposes some alternative construction methods for the concrete lining. The most desirable is to form the base with a good quality mixed materials that have been adjusted for particle size, including clay and silt without organic content. However, since clay and silt without organic content may be difficult to obtain in Egypt, in such a case, a mixture of sand and cobbles should be placed at 20-30 cm, depending on the foundation conditions. Further, in locations where the groundwater table is high or there is a spring water, a sand bed (5 to 8 cm) should be placed first, then a geotextile could be placed, and precast concrete panels be placed on top of the sand bed and geotextile. In this case, joint sealing should not be made allowing the groundwater coming out.

4.6 WATER MANAGEMENT IMPROVEMENT (COMP. 6)

4.15 Water management by MWRI has been practiced for many years and is a method that has been developed through experience in water management at the ground level. On the other hand, however, flexible and equitable water management is required to meet recent social needs, such as responding to changes in water demand due to crop diversification, real-time water distribution based on water supply, demand for effective use of water resources, and water-saving agriculture with the introduction of modern on-farm irrigation systems.

4.16 Through interviews with each GDs (Gharbia, Beni Suef, and Fayoum) and the Lower Egypt (Tanta) Water Distribution Division, each organization requested that the monitoring targets should include regulators, intakes, weirs, and facilities located on the borders of the governorates. The monitoring facilities for the Kased Main Canal will cover the regulators along the canal as well as the major branch canal intakes in Gharbia GD and Kafr El-Sheikh GD, and the midstream and upstream locations along the branch canal that diverts irrigation water upstream of the Tanta 1 Regulator. In the Abo Shosha and Aros & Abo Seer canals, the facilities that are already monitored by the Project for Construction of the New Dirout Group of Regulators will be excluded from this Preparation Survey.

Table 4.11 Water Management Monitoring Equipment in the Kased Command Area

GD	Canal	Name	Facility	Proposed Facility	Remarks
Gharbia	Kased	Kased Intake	Regulator	WL, CCTV, Gate Status, Discharge	
		Tanta 1	Regulator	WL, CCTV, Gate Status	
		Tanta 2	Regulator	WL, CCTV, Gate Status	
		Mahlet Menouf	Regulator	WL, CCTV, Gate Status	
		Site-1	Intake	WL, CCTV, Gate Status, Discharge	Ganabyet Shabsher
		Site-2	Intake	WL, CCTV, Gate Status	Semella
		Site-3	Intake	WL, CCTV, Gate Status	Damat
		Site-4	Intake	WL, CCTV, Gate Status	Sorad Mostagada
		Site-5	Intake	WL, CCTV, Gate Status	Samhat
		Site-6	Intake	WL, CCTV, Gate Status, Discharge	Rwena
		Site-7	Cana	WL	Mid of G. Shabsher
		Site-8	Canal	WL	Tail of G. Shabsher
		Sorad	Regulator	WL, CCTV, Gate Status, Discharge	
		-	Monitoring Room	Monitoring System	

Source: JICA Survey Team

4.17 As an advanced water management method, the Team would like to propose the introduction of satellite image analysis to follow the cropped area. This method allows MWRI to obtain information on the planting status and the area where harvesting has taken place, which can then be reflected in the water management system. By referring to the satellite data, we can know how much the plant growths are, and according to that, MWRI should release the irrigation water which is exactly required by the plants.

4.7 PROCUREMENT OF MAINTENANCE MACHINERIES (COMP. 7)

4.18 The current maintenance machinery owned by the Canal Maintenance Directorates in Gharbia and Minya is aging, and therefore maintenance and repairs may result in time-consuming. In addition, there are several pieces of equipment that have broken down and cannot be repaired, or are no longer repairable due to unavailability of spare parts and consumables. The equipment in the workshop is also very old, having been provided by USAID in 1984 and procured by MWRI around in 1980s and 1990s.

4.19 The following should be considered as a guide in selecting the necessary machineries and equipment; 1) as almost all of the machineries/equipment are obsolete, in many cases beyond its depreciation periods, replacement/renewal of those which are needed for required canal maintenance works should be considered; 2) for the canal maintenance work, new models that contribute to the improvement of work efficiency should be introduced; 3) new machineries and equipment should be introduced to maintain the concrete lined canals; and 4) equipment that can rush to the site to perform maintenance and repair of the equipment should be introduced. With these, the following machineries and equipment should be included as one of the project components.

Table 4.12 Proposed List of Maintenance Machineries and Equipment

No.	Name of Machinery	Specification	Required Number	
			Gharbia Office	Minya Office
1	Long Armed Hydraulic Excavator	14ton class, Bucket capacity: 0.28m^3	1	1
2		30ton class, Bucket capacity: 0.69m^3	1	1
3	Hydraulic Excavator (Standard Type)	7ton class, Bucket capacity: 0.30 - 0.37m^3	1	1
4		20ton class, Bucket capacity: 0.50 - 1.20m^3	1	1
5	Floating (Amphibious) Hydraulic Excavator	20 - 25ton class, Bucket capacity: about 1m^3	1	1
6	Wheel Loader	16ton class, Bucket capacity: 2.7 - 4.0m^3	1	1
7		22ton class, Bucket capacity: 3.6 - 5.2m^3	1	1
8	Backhoe Loader	6 - 7ton class, Loader bucket capacity: 0.8m^3	1	1
9		7 - 8ton class, Loader bucket capacity: 1.0m^3	1	1
10	Dump Truck	Loading capacity: 12ton (7m^3)	1	1
11		Loading capacity: 25ton (14 - 16m^3)	1	1
12	Truck Loader Crane	Maximum loading capacity: 12ton	1	1
13	Rough Terrain Crane	Maximum loading capacity: 30ton	1	1
14	Low Bed Semi-Trailer	Width of platform: more than 3.0m	1	1
15	Tractor (Crawler Type)	3ton class with rubber crawler	1	1
16	Small Mowing Boat	less than 2ton class, weed harvester	1	1
17	Mowing Machine for Submerged grasses	2 - 3ton class, weed harvester	1	1
18	Work Truck (Mobile Workshop)	Air compressor, welding machine, generator, and mechanic tool set etc.	1	1
19	Forklift Truck	Diesel engine type, Loading capacity: 7 - 8ton	1	1
		Total	**19**	**19**
		Grand Total	**38**	

Source: JICA Survey Team based on a series of discussions with the Regiona/ Central Directorate of Canal Maintenance

Table 4.13 Proposed List of Workshop Equipment

No.	Name of Workshop Equipment	Required Number		Reasons for Procurement
		Gharbia Office	Minya Office	
1	Hydraulic Press Machine	1	1	Renewal due to low performance
2	Welding Machine, Diesel Engine	1	1	Renewal due to dysfunction
3	Welding Machine, Electric	1	1	Renewal due to outdated
4	Electric Cutter (for steel cutting)	1	1	Renewal due to outdated
5	Portable Crane	1	1	Renewal due to dysfunction, low performance
6	Hydraulic Hose Fitting Press Machine	1	1	New procurement - repair of hydraulic system

Source: JICA Survey Team

4.8 MODERN ON-FARM IRRIGATION DEVELOPMENT (COMP. 8)

4.20 Sprinkler and drip irrigation, i.e., a modern on-farm irrigation, can already be seen in almost all of the New Lands and in small parts of Old Lands in Egypt. Modern on-farm irrigation is a method of irrigating only around the roots of crops with smaller amounts of water than traditional irrigation methods. When considering modern on-farm irrigation, irrigation interval days should be established based on soil property and crop type. The irrigation interval days are calculated using TRAM, and the number of days between irrigation intervals is set at 5 days, and the daily irrigation time is set to be 12 hours during the peak irrigation period of the daytime for the purpose of designing a typical modern irrigation system manageable by farmer groups.

4.21 For an on-farm irrigation system which will be a pressure pumping system to the end of the field, it is necessary to set a proper size of the area for ensuring proper collective pump operation. In this Project, 30 feddan is used as a guideline for the maximum covered area where a collective pump is installed for modern on-farm irrigation development. The modern irrigation facilities consist of a covered Meska in cases, a collective pump to withdraw water from the Meska to the field, a sand filter, liquid fertilizer mixer, pipelines, drip tubes or sprinklers, and an outlet valve for leaching.

4.22 In the standard layout for sprinkler and drip irrigation, the existing Meska may be buried underground and replaced by concrete pipes as per the farmers' need, from which irrigation water will be pumped to the main pipeline. The main pipeline will be buried along the existing Marwa. From the main pipeline, a sub-pipeline will be placed in the fields. Based on the standard layout of approximately 30 feddan, the overall estimated construction cost will be 58,000 LE/feddan for sprinkler irrigation systems and 60,000 LE/feddan for drip irrigation systems respectively, excluding Meska improvement.

4.23 The installation of a collective pump and the introduction of modern on-farm irrigation system must be accompanied by organizing farmers and providing trainings. As the institutional development and capacity building, a 3-layered training program is proposed. As Stage 1, TOT training is provided for MWRI staffs, especially CDIAS by external experts and experts within MWRI. Trainees at Stage 1 would play the role of trainers at Stage 2 and the targets are GDIAS as well as newly recruited contracted IAS staffs. Then, at Stage 3, GDIAS and contracted IAS staffs train farmers for their capacity building in each target area.

4.24 The modern on-farm irrigation requires sophisticated skills in the Operation and Maintenance, and therefore WUA should be organized and structured in order to well respond to this system. In this sense, the modern on-farm irrigation system should be established with limited areas of 30 feddans as a standard. In one WUA, there should be three decentralized dimensions, namely planning, decision making, and implementation, in which the sub planning groups, the General Assembly, the Management Board would play the role respectively. Similar organizational structure might be established as Branch Canal WUA with representative of Meska WUAs.

4.25 To support farmers in introducing modern on-farm irrigation system into their farmlands, the JICA Survey Team firstly examined the possibility of two-step loans (TSL), in which ABE and NBE are granted small loans to a large number of farmer end-users as PFIs. However, due mainly to the constraints and operational risk on those PFIs, the JICA Survey Team would recommend a disbursement mechanism under Advance Procedure for the purpose of supporting the introduction of modern on-farm irrigation systems under this Project.

4.9 NO INTERVENTION OF MODERN ON-FARM IRRIGATION IN FAYOUM

4.26 The water source for the Fayoum area is the Bahr Yusef Principal Canal only with two major supply canals of; 1) Hassan Wassef and 2) Bahr Yusef itself. From these 2 canals, an annual allocated amount of water, 2.6 billion CUM, is delivered to the whole Fayoum area. The biggest consumer for water use is irrigation. When the water has been applied to the farmlands, percolation takes place by nature, and the percolation comes first in the sub-surface drainage pipes, and then, shows up in tertiary drain, secondary drain, main drain, and finally to the 2 lakes of Qarun and Rayan. No water goes out anywhere from the Fayoum.

4.27 There are specified drainage discharge amount to these lakes that the MWRI has decided in order to maintain the lake water level not much changed. The specified annual amounts are 100 MCM/year and 400 MCM/year for Rayan and Qarun respectively. The specified total 500 MCM is corresponding to as much as 19.2 % of 2.600 MCM, which is allocated to Fayoum whole area. On the other hand, annual evaporations from Lake Rayan and Lake Qarun come to around 160 MCM and 400 MCM every year. Specified amount for Rayan may have to be increased to 160 MCM, or the lake starts becoming smaller, while the specified amount for Qarun, 400 MCM, should be kept as the actual annual evaporation is almost the same as the MWRI's specified amount.

4.28 Among the irrigation water provided for Fayoum area, 61% is consumed for crop consumptive water, 27% for drains to the 2 lakes of Qarun and Rayan, and the remaining 12% for losses such as deep percolation and evaporation based on an estimation by JICA Survey Team. From this estimation of the overall water balance in 2019, the current irrigation efficiency against the total irrigation water supplied by Bahr Yusef Principal Canal in Fayoum area is calculated at 61%, and with the addition of drainage re-use amount as a part of irrigation water, the efficiency comes down to 57%.

4.29 At present, the farmers in the Fayoum area practice flood irrigation except for new lands, which have been developed in the peripheral areas from the Old Lands of Fayoum. With the introduction of modern on-farm irrigation to Fayoum area, percolation from the on-farm irrigation and then seepage out to the drainages will be changed, and accordingly drainage into the Qarun and Rayan would be very much changed. Future change of water regime with the introduction of modern on-farm irrigation to Fayoum area was examined by adapting the irrigation efficiencies of modern on-farm irrigation; as 0.95 for drip irrigation, 0.8 for sprinkler irrigation and 0.70 for the current flood irrigation.

4.30 As a result of the analysis above, drainage amounts decrease from on-farm with the introduction of water saving on-farm irrigation methods, for example, a 3% reduction in drainage water with sprinklers installed on 10% of the area, and a 7% reduction if drip irrigation is used on the 10% of the area. Further, on condition that the current water levels of the lakes be kept, an additional water should be released ranging from 218 MCM per annum in case of sprinkler introduced fully to as much as 451 MCM per annum in case of drip irrigation fully introduced. The additional water should be from fresh water, and thus salinity level of the lakes would dramatically change.

4.31 Therefore, from the environmental point of view, the water levels and also the water quality of the 2 lakes of Quran and Rayan should be maintained, or otherwise many stakeholders engaged in, e.g., tourism, salt production, and fisheries sectors, will be affected. Thus, the JICA Survey Team does not recommend the introduction of modern on-farm irrigation to the Fayoum area. Instead, as one of the modernizations of irrigation modality without reducing drainage volume to the lakes, it is recommended to promote Meska rehabilitations together with the rehabilitation of main and branch canals for the efficient and equal water use of farmers.

4.10 AGRICULTURE DEVELOPMENT PLAN

4.32 Equitable water distribution with the improvement of irrigation system and introduction of modern irrigation would encourage farmers to change their cropping patterns towards more profitable ones. Also, considering a conservative strategy of farmers, the cropping pattern with Project proposes such two cases: Case 1: no change from the current cropping patter and Case 2: change to profitable horticulture crops for some extent. The cropping intensity as a whole in large extent areas is already very high in Egypt. Therefore, the cropping intensity with Project shall be proposed unchanged from the present ones. Cropping patters are shown in the following tables:

Table 4.14 Proposed Cropping Pattern and Intensity with Project in Upper Egypt

Season	Without Project			With Project: Case1			With Project: Case 2		
	C.I. (%)	Crop	C.I. (%)	C.I. (%)	Crop	C.I. (%)	C.I. (%)	Crop	C.I. (%)
Winter	88	Wheat	51	88	Wheat	51	88	Wheat	51
		Long berseem	23		Long berseem	23		Long berseem	21
		Sugar beet	7		Sugar beet	7		Sugar beet	7
		Vegetables & other	19		Vegetables & other	19		**Vegetables**	**21**
Summer	77	Maize	63	77	Maize	63	77	Maize	60
		Sorghum	13		Sorghum	13		Sorghum	12
		Oil crop	5		Oil crop	5		Oil crop	5
		Vegetables & other	19		Vegetables & other	19		**Vegetables & Other**	**23**
Nile	15	Maize	49	15	Maize	49	15	Maize	41
		Vegetables & other	51		Vegetables	51		**Vegetables & other**	**59**
Permanent	16	Sugar cane	20	16	Sugar cane	20	16	Sugar cane	20
		Cotton	27		Cotton	27		Cotton	27
		Fruit trees	53		Fruit trees	53		Fruit trees	53
Total	196			196			196		

Source: JICA Survey Team

Table 4.15 Proposed Cropping Pattern and Intensity with Project in the Delta

Season	Without Project			With Project: Case1			With Project: Case 2		
	C.I. (%)	Crop	C.I. (%)	C.I. (%)	Crop	C.I. (%)	C.I. (%)	Crop	C.I. (%)
Winter	95	Wheat	46	95	Wheat	46	95	Wheat	46
		Long berseem	23		Long berseem	23		Long berseem	20
		Sugar beet	17		Sugar beet	17		Sugar beet	17
		Vegetables & other	14		Vegetables & other	14		**Vegetables & other**	**17**
Summer	86	Rice	10	86	Rice	10	86	Rice	10
		Maize	34		Maize	34		Maize	28
		Vegetables & other	56		Vegetables & other	56		**Vegetables & other**	**62**
Nile	5	Maize	59	5	Maize	59	5	Maize	29
		Vegetables & other	41		Vegetables & other	41		**Vegetables & other**	**71**
Permanent	15	Sugar cane	1	15	Sugar cane	1	15	Sugar cane	1
		Cotton	70		Cotton	70		Cotton	70
		Fruit trees	29		Fruit trees	29		Fruit trees	29
Total	200			200			200		

Source: JICA Survey Team

4.33 Unit yield increase with Project is expected from two dimensions; namely, 1) effect of increased water availability and equitable water distribution with the irrigation improvement, and 2) the effect of better crop husbandry with modern on-farm irrigation system. Farmers located downstream reaches can more benefit from the irrigation improvement. The degree of unit yield increase by this effect is assumed to level the unit yields between the farms located upstream and downstream. As for the effect of modern on-farm irrigation, it enables rational water utilization and ideal fertilization for crop cultivation. Such elaborated crop cultivation method will bring about the increase of yield.

4.34 The degree of the yield increase is based on the result of the farm economy survey conducted by the JICA Survey Team and the results of past studies available. In summary, it is expected that the yield increase with irrigation improvement would be from 5% to 15% from the present yields. With regard to the modern on-farm irrigation system, since the conditions of the studies referred vary so much, a conservative increase is applied, namely 11% to 40% with drip or sprinkler introduced.

5. LOAN PLANNING: DISBURSEMENT, COST, SCHEDULE, INSTITUTIONAL

5.1 PROJECT COMPONENTS AND IMPLEMENTATION MODALITY

5.1 Following table summarizes the components and those work contents together with the relevant responsible sectors/ directorates under the ID to implement; namely, there are 8 components in total under the Project. It is noted that the component No.8 'Modern On-farm Irrigation' is divided into 2 sub-components, namely, 1) procurement of the equipment and installment, and construction of the modern on-farm irrigation system, and 2) necessary trainings that the Irrigation Advisory Services under IIS should administer to those farmers who are to introduce the modern on-farm irrigation.

Table 5.1 Project Components by Prospective Implementing Sector

No.	Component	Contents	Responsible
1	Large Hydraulic Structure Construction (LHSC)	Construction of; 1) Kased Intake, 2) Mahlet Menouf Regulator, and 3) Sorad Regulator.	RGBS
2	Small Hydraulic Structure Construction (SHSC)	Construction of; 1) Beni Hedear Weir of Ibrahimia, 2) intakes of, e.g. Abo Seer, Omar Bek, Bahr El Kasheir, etc., 3) tail escapes, 4) culvert and aqueduct, etc.	IS
3	Hydraulic Structure Rehabilitation (HSR)	Rehabilitation of Hydraulic Structures assessed as S2 including replacement of gates, gate appurtenant.	IS
4	Large Canal Rehabilitation (LCR)	Rehabilitation including canal sectioning and slope protection, and/or partial lining for large canals, e.g. Bahr Yusef and Ibrahimia Principal Canals and Kased Main Canal.	IS
5	Branch Canal Rehabilitation and Lining (BCRL)	Rehabilitation including canal sectioning and concrete lining for the canals other than above, e.g. branch canals, small main canals. Note that concrete lining work is on-going covering around 20,000 km nationwide, so this component will be added to the loan.	IS
6	Water Management Improvement (WMI)	Procurement and installation of water management equipment, and development of visual on-time monitoring system. Note that the system concerning Bahr Yusef and Ibrahimia Command Areas are included in the Project for Construction of the New Dirout Group of Regulators, and therefore, the system here to be introduced in Kased Command Area.	IS
7	Procurement of Maintenance Machineries (PMM)	Procurement of maintenance machineries specifically for the purpose of concrete lined canals, and also machineries required for urgent repairment. Note that periodic and ordinally maintenance works are out-soured to private companies.	General Directorate of Canal Maintenance
8	Modern On-farm Irrigation (MOI) 8.1 Construction 8.2 Organizing & Trainings	8.1 Installment of modern on-farm irrigation system composed of sprinkler and drip facilities, including one-lifting pump stations and pipelines, together with the improvement of Meska by means of lining or installation of pipes. 8.2 Organizing of the farmers into WUAs, and trainings to the farmers who introduce modern on-farm irrigation	Irrigation Improvement Sector (IIS)
9	Project Management (PM)	Procurement of vehicles and office equipment, trainings, monitoring of project progress and evaluation of the project, and dispute board	IS

Source: JICA Survey Team

5.2 To implement the Project components, the best implementation modality should be applied, e.g. by direct force account (DFA), by contractor/ supplier procured through local competitive bidding (LCB), by the contractor/ supplier procured through international competitive bidding (ICB), by direct shopping, etc. Following table indicates the implementation modality for each of the components, e.g., by LCB, ICB, and DFA. The table below also proposes the suitable modality of fund flow from the financing body to MWRI:

Table 5.2 Project Components and Implementation Modality

No.	Component	Implementation Modality	Fund Flow Modality
1	Large Hydraulic Structure Construction (LHSC)	**ICB**	**Transfer**
2	Small Hydraulic Structure Construction (SHSC)	LCB	Advanced
3	Hydraulic Structure Rehabilitation (HSR)	LCB	Advanced
4	Large Canal Rehabilitation (LCR)	LCB	Advanced
5	Branch Canal Rehabilitation and Lining (BCRL)	LCB	Advanced
6	Water Management Improvement (WMI)	LCB	Advanced
7	Procurement of Maintenance Machineries (PMM)	LIB / ICB	**Transfer**
8.1	Modern On-farm Irrigation (MOI-C), Construction	LCB	Advanced
8.2	Modern On-farm Irrigation (MOI-T), Trainings	**DFA (by IAS of IIS)**	Advanced
9	Project Management (PM), including dispute board	**DFA**	Advanced

No.	Component	Implementation Modality	Fund Flow Modality
10	Consulting Services (CS)	**ICB**	Transfer

Note: ICB stands for International Competitive Bidding, LCB stands for Local (national) Competitive Bidding, LIB stands for Limited International Bidding (basically equivalent to ICB procedure but only pre-selected contractors are invited to the bidding), and DFA means Direct Force Account works to be undertaken by the MWRI's capacity.
Source: JICA Survey Team, 2022

5.3 Fund flow modality should be designed with reference to the implementation modality by component and also from a viewpoint of effective fund disbursement from and accounting to the financier. A Transfer Procedure should be applied for the disbursement on the international procurements (ICB, e.g., large scale construction works and consultant services). On the other hand, an Advance Procedure is recommended for the disbursement of local procurements (LCB) including the direct force account works.

5.2 PROJECT COST, AND IMPLEMENTATION SET-UP

5.4 In estimating the project cost, the following considerations should be made for No. 2 (SHSC) Construction of Small Hydraulic Structures and Mo. 3 (HSR) Hydraulic Structures Rehabilitation (HSR), and No. 8 (MOI) Modern Field Irrigation component.

1) Two components, No. 2 (SHSC) Construction of Small Hydraulic Structures and Mo. 3 (HSR) Hydraulic Structures Rehabilitation (HSR), will renew or rehabilitate small to medium-sized hydraulic structures within the priority areas. As the two priority areas in Upper Egypt (Abo Shasha and Aros & Abo Seer areas) are very small as compared to the overall Bahr Yusef and Ibrahimia Command Areas, and if similar priority areas exist, these two components should be expanded in order to improve overall hydraulic conditions of the principal canals' command area. With this in mind, the JICA Survey Team would propose these 2 components should be extended over to another 12 first priority areas identified in a previous JICA survey, thus an area wise multiplication factor of 1.52 shall be applied in terms of cost estimation purpose for the 2 components, and

2) Concerning No.8 (MOI) Introduction of Modern On-farm Irrigation, the Egyptian government is planning to introduce modern on-farm irrigation basically to the entire area of the Old Lands except for the Lower Delta (target of about 4 million feddans). Even excluding the Aros & Abo Seer area, which is located in the Fayoum area due to environmental concerns, the Abo Shosha area is about 18,000 feddan, while the Kased area is very large (about 96,000 feddan). In addition, the introduction of modern on-farm irrigation is likely to take time, as it requires agreement from the farmers or farmer groups. Therefore, although the Project area would cover all of Kased and Abo Shosha areas, the area to be covered by the loan could be set reasonable in terms of scale. With this, the JICA Survey Team would, as a base case, propose to introduce the No.8 component only to 10% of the 2 priority areas as the first phase, i.e., 1,800 feddans and 9,600 feddans for Abo Shosha and Kased respectively. In addition, A reference case is also proposed, for which only some typical Meskas are selected and the No.8 component be tried as pilot, covering only 1,080 feddans.

Undisclosed Information

Undisclosed Information

5.6 As the Project involves several components related to different sectors and sections under MWRI, there should be a Steering Committee (SC) at the MWRI central level, which should be in charge of directing the Project towards the achievement of the project purpose. Under the SC, there should be the Project Management Unit (PMU) which has the responsibility of leading all the project components to the successful completion working together with the management units established at the regional level, e.g., at Tanta for the implementation of Kased related components and at Beni Suef for Bahr Yusef and Ibrahimia Command Area related components including Fayoum area.

6. PROJECT EVALUATION

6.1 ECONOMIC EVALUATION

6.1 Due to the COVID-19 and also the war in Ukraine, the international market prices of major agricultural produces except rice from 2020 to 2022 rose around 1.5 to 2 times and the prices of fertilizers rose 2.5 to 3 times in the same period. Although the domestic market prices have been drastically risen since 2020, the hike of the international markets in the same period seems exceeding them. Considering such special occasion, the average prices from 2020 to 2022 are applied to estimate the economic prices of these produces and products.

6.2 The benefits of the project are defined as; 1) increase of crop unit yield, 2) reduction of crop production cost, 3) change of cropping pattern, i.e., increase of profitable horticulture crop and, 4) increase of cropping intensity. Based on the Agricultural Development Plan afore-mentioned, these factors of benefits with Project are numerically defined and estimated.

6.3 Incremental benefits of the project are calculated with the combination of Cases 1 (only the increase of unit yield and no change in cropping pattern) and Case 2 (the increase of unit yield and increase of horticulture crops) and other categories such as Cases A, B and C. Case A is only to implement the rehabilitation / construction of the irrigation facilities (Irrigation Improvement), while Case B is to implement Modern On-farm Irrigation (MOI), and then Case C is to implement both irrigation improvement and MOI (full-scale). The incremental benefits from Case 1-A to Case 2-C for the three target sub-regions are shown below:

Table 6.1 Incremental Benefits of the Project at Economic Price

Category	Sub-region	Service Area (fed)	Incremental Benefit (000 LE)					
			Case 1-A	Case 2-A	Case 1-B	Case 2-B	Case 1-C	Case 2-C
Upper Egypt	Abo Shosha	17,881	73,784	87,361	20,668	22,954	96,088	110,734
	Aro & Abo Seer	13,330	55,005	65,126	-	-	55,005	65,126
Delta	Kased	95,976	392,049	506,013	130,340	149,463	530,921	653,803
Total		127,187	520,838	658,500	151,008	172,417	693,014	829,663

Source: JICA Survey Team
Note: MOI (related to Case B and Case C) is planned to install 10% of the service areas of Abo Shosha and Kased.

6.4 With all the models set above and cost-benefit flows for the economic evaluation, the EIRR of the project is calculated as shown in the table below. EIRR in the set cases are calculated from 11.2% to 20.3%. EIRR of all the cases exceed the opportunity cost of capital, 10% and the NPV calculated with the discount rate of 10% are positive in all the cases. Therefore, the Project is judged feasible from the economic point of view.

Table 6.2 EIRR and NPV with the Project

Case	Description	EIRR	NPV (000 LE)
Case 1-A	No change of cropping pattern, Irrigation Improvement	15.9%	1,083,357
Case 2-A	Increase of horticulture crop, Irrigation Improvement	20.3%	1,994,718
Case 1-B	No change of cropping pattern, Modern On-farm Irrigation (MOI)	11.2%	65,639
Case 2-B	Increase of horticulture crop, Modern On-farm Irrigation (MOI)	13.5%	207,368
Case 1-C	No change of cropping pattern, Irrigation Improvement + MOI	15.0%	1,217,393
Case 2-C	Increase of horticulture crop, Irrigation Improvement + MOI	18.7%	2,194,872

Source: JICA Survey Team

6.2 FARM BUDGET ANALYSIS

6.5 A farm income model is established with the same ones applied for the above economic analysis but the financial prices are used for the items. In this farm income analysis, one model for Upper Egypt (Abo Shosha and Aros & Abo Seer) and another for the Delta (Kased) are prepared. The model is made as per feddan and the net farm income is calculated excluding the value of family labor from the production cost, since here discussed is the financial term or cash income to be left for the farmer beneficiaries.

6.6 In this farm income analysis, the affordability of farmers for the repayment of the modern on-farm irrigation (MOI) system is focused and therefore, the farm income analysis is carried out for the Cases with MOI only (Case 1-B and Case 2-B) and full-scale project (Case 1-C and Case 2-C) as defined above. The incremental farm income per feddan is estimated from 11,011 LE/feddan (Case 1-B in Upper Egypt) to 19,672 LE/feddan (Case 2-C in Delta). Apart from the production cost, the maintenance cost of the modern on-farm irrigation system is assumed at 1% of the initial investment cost, which is estimated at 590 LE. After deducting this cost, the net incremental farm income per feddan arrives at 10,421 LE/feddan to 19,082 LE/feddan.

Table 6.3 Farm Budget Analysis: Incremental Farm Income per Feddan

Region		Upper Egypt				Delta			
Case		Case 1-B	Case 1-C	Case 2-B	Case 2-C	Case 1-B	Case 1-C	Case 2-B	Case 2-C
Without Project (LE/fed)	Gross Income	41,908				49,221			
	Production Cost	15,245				18,478			
	Net Farm Income	**26,663**				**30,743**			
With Project (LE/fed)	Gross Income	51,598	56,452	53,673	58,612	60,441	65,226	63,615	68,519
	Production Cost	13,924	14,164	14,530	14,769	16,939	17,147	17,895	18,104
	Net Farm Income	**37,674**	**42,288**	**39,143**	**43,843**	**43,502**	**48,079**	**45,720**	**50,415**
1) Incremental Farm Income (LE/fed)		**11,011**	**15,625**	**12,480**	**17,180**	**12,759**	**17,336**	**14,977**	**19,672**
Maintenance cost of Modern Irrigation		590	590	590	590	590	590	590	590
2) Incremental Farm Income (LE/fed)		**10,421**	**15,035**	**11,890**	**16,590**	**12,169**	**16,746**	**14,387**	**19,082**

Source: JICA Survey Team

6.7 The cash flow analysis was carried out for Case 1-B, Case 2-B, Case 1-C and Case 2-C. In the ten year-cash flow for the repayment period, the total net incremental farm income in each case in each region exceeds the total cost repaid and incurred by the farmer beneficiaries. However, the share of cost to be paid against the incremental farm income reaches 86% and 74% for the Case 1-B (no change in cropping pattern with MOI component only) in Upper Egypt and Delta respectively, which is still affordable but if this share were lower, the farmers would be more encouraged to pay for it.

6.8 In the Case 2-B (increase of horticulture crop with MOI only), the share of the cost against the incremental farm income goes down to 76% and 63% in Upper Egypt and Delta respectively. Shifting to profitable horticulture crop in their cropping pattern will leave more benefit to the farmers, otherwise, a measure as extending repayment period would help encourage the beneficiary farmers to introduce to the modern on-farm irrigation system.

6.9 Further, for the Cases 1-C and 2-C (with combination of irrigation improvement and MOI) for Upper Egypt, the share of cost against the net incremental income goes down to 61% and 55% respectively. As for the Cases 1-C and 2-C for Delta, it goes down to as low as 55% and 48% respectively. This means that the irrigation improvement, namely rehabilitation/ construction of hydraulic structures and canal lining, will greatly contribute to augmenting farm income and encouraging the farmer beneficiaries to introduce the modern on-farm irrigation system.

7. ENVIRONMENT AND SOCIAL CONSIDERATION, LAND ACQUISITION

7.1 ENVIRONMENT AND SOCIAL CONSIDERATION

7.1 The Ministry of Environment (MOE) and the Egyptian Environmental Affairs Agency (EEAA) are the environmental administrative bodies in Egypt. The EEAA is responsible for the review and issuance of environmental approval for the EIA (Environmental Impact Assessment) application of the new project. The EIA guideline provided by EEAA regulates the application and review procedure for the EIA process by environmental category given by the EEAA at the submission of the new application. MWRI, the implementation ministry of the Project, should properly complete EIA process before the commencement of the Project.

7.2 A GAP analysis between the Egyptian EIA guideline and JICA environmental and social consideration guideline was made, with the results of that, there are basically no GAPs between both since most of the requirements by JICA guideline are covered by Egyptian EIA guideline. The Project is classified as Category B by the JICA environmental and social consideration category system with the perspectives of the Project, which do not likely give significant impacts to the environmental and social condition.

7.3 The proposed project components for the environmental review are mainly classified into two project categories from the nature of the components, 1) Civil works at various levels of the canals including hydraulic structure construction/ rehabilitation, and 2) Introduction of modern on-farm irrigation with Meska improvement when needed, respectively. Some negative environmental impacts related to the construction works are expected for the former project category while some negative environmental and social impacts may be expected especially at the operation stage for the latter project category.

7.4 As the features of the current natural environment of the Project area, it should be mentioned that Qarun and Rayan lakes are located in Fayoum, which are designated as nationally protected and the Ramsar Wetlands and so on. Both lakes are the sanctuary of birds and other species. Locations of the Project area in Fayoum for the civil works are around 20 km far from the both lakes, so that the civil works will not directory affect the lakes. On the other hand, it should be carefully considered the impact of the implementation of modern on-farm irrigation since its concept is water-saving agriculture with less drainage water to be occurring. In fact, the drainage water is only the water source of Qarun and Rayan lakes (See the “Irrigation Development in Fayoum with the Introduction of Modern On-farm Irrigation).

7.5 Alternative examinations were done mostly for the project components of modern on-farm irrigation, including Zero option application. The current project proposal for implementing the modern on-farm irrigation in Aros & Abo Seer area was rejected since the plan was evaluated to produce negative impacts on the Qarun and Rayan lakes very high. Instead, a possible alternative, which undertakes the implementation of Meska improvement and hydraulic structure improvement, should be selected under this examination considering the balance of benefits of the Project and the affected environmental aspects (avoiding significant negative impacts of Qarun and Rayan lakes).

7.6 The environmental and social impact evaluation of the Project was examined based on the scoping results and the environmental and social consideration survey results. For the project components of civil works on canals/ structures, some negative impacts on pollution such as air quality, water quality, waste and garbage, noise and vibration, are anticipated during the construction period. On the other hand, for the project components of modern on-farm irrigation, major negative impacts are not anticipated much during the construction period, while some negative impacts are anticipated on the social environment such as farming, water management, economic conditions of farmers during the operation phase of the Project.

7.7 Mitigation measures and their cost against the anticipated adverse impacts during the construction and operation periods should be planned. During the construction period, some negative impacts are anticipated by the construction works. To mitigate these negative impacts, necessary mitigation measures will have to be taken during construction works (e.g. proper maintenance of construction machinery and vehicles, use of vehicles with soundproofing equipment, taking necessary measures for construction drainages, consideration of the construction time, prevention measures for the accidents, securing safety for residential people, etc.).

7.8 During the operation stage of modern on-farm irrigation, there are concerns that the Project may affect the social aspects of the beneficiary farmers such as water management and farming techniques to be changed, joint water management by the group to be needed, and installation costs to be covered by the farmers. The WUAs support program, which will be implemented in parallel with the survey/designing/construction, could be the migration measures of such anticipated social impacts of the farmers. The WUAs support program will be implemented by IIS (Irrigation Improvement Sector) of MWRI and should start activities before the construction commencement.

7.9 Monitoring plans for the implementation of necessary mitigation measures are also planned. Necessary monitoring such as drainage water quality conditions, construction waste disposal conditions, safety measures conditions, and so on, will be conducted during the construction period. Some monitoring items such as water quality monitoring of irrigation canals and allocated irrigation volume of Fayoum area are continued during the operation phase, as well. Monitoring for the WUAs support program by IIS should be conducted through the confirmation of IIS activity report with the supervision of project implementation units (PMU and RCU) of MWRI.

7.10 Series of stakeholder meetings were held in November and December 2022. The meetings were scheduled to be in 9 villages in total, with selecting 3 villages, each from priority sub-regions. Received comments from the farmers in the meetings, are concerned mainly for modern on-farm irrigation. Many of the participants are aware of the irrigation system and benefits of modern on-farm irrigation as they had seen examples in New lands. However, they seldom know the examples applied in Old Lands. Therefore, they requested the setting up of demonstration farms as pilot and the provision of technical assistance by the Project. This will be reflected in the design of WUAs support program.

7.2 LAND ACQUISITION

7.11 All the civil works for canals (each principal, main and branch level) and hydraulic structures planned in the Project are located within existing irrigation canals. These irrigation canals are, as a matter of fact, located within the management area of MWRI and houses are not located in the area of the planned construction sites. Therefore, resettlement is not expected, and new land acquisition is also not expected either. It is noted the lands for the storage of construction materials will be secured within the management area of MWRI extended alongside the irrigation canals.

7.12 One set of modern on-farm irrigation facility consists of one lifting pump and pipeline system, and watering equipment (sprinkler, drip, etc.). Lands for the pump facility will be used for the area of Sakia (water wheel), which is the public space of the farmers concerned. Pipelines will be installed on the land of the existing Marwa (on-farm small canal). Therefore, the facilities will be arranged within the existing land use and thus new land acquisition will be not necessary. Further, there are no houses on these lands, and therefore, resettlement will be not necessary.

8. CONCLUSION AND RECOMMENDATION

8.1 CONCLUSION

Undisclosed Information

1) The Project, from the viewpoint of national development, gives an EIRR 11.2 - 20.3% for all the 6 cases examined. In detail, the cases where only irrigation improvement is implemented give the EIRR of 15.9% (no change of cropping pattern) and 20.4% (increase of horticulture crops); the cases where only modern on-farm irrigation is implemented provides 11.2% (no change of cropping pattern) and 13.5% (increase of horticulture crops); and cases where both irrigation improvement and modern on-farm irrigation are implemented together generates 15.0% (no change of cropping pattern) and 18.7%(increase of horticulture crops). All cases show higher returns than the opportunity cost of capital, 10%, applied in most of the development projects.

2) Current agricultural income per feddan is calculated to be 26,663 LE/feddan in Upper Egypt and 30,743 LE/feddan in the Delta under the standard model, and 21,164 LE/feddan under the relatively poor farm household model. Then, the increase in farm income from the Project results in 43,843 LE/feddan, 50,415 LE/feddan, and 32,425 LE/feddan respectively. Thus, the Project will contribute significantly to improving the income and livelihood of the beneficiary farmers, which is the objective of the Project. It is also noted that for an average family of 5 members in the Project area, the poverty line for a household is calculated to be 51,420 LE (2019/2020 price), which means that the Project will contribute to poverty reduction by bringing the beneficiary households to the poverty line closer, yet the agricultural income per feddan alone is still below the poverty line.

8.2 Recommendations

1) The Project has eight components. The implementation varies from international competitive bidding (ICB) for the construction of the three regulators on the Kased main canal and equipment procurement for maintenance to local competitive bidding (LCB) for small-scale works, and further to direct force account works (organizing and training of farmers for the introduction of modern on-farm irrigation). In particular, the number of packages for lining of branch canals (BCRL) and introduction of modern on-farm irrigation (MOI), which are intended for local competitive bidding, is large. Therefore, it is planned to establish a Project Management Unit at the central office and Regional Coordination Units in Beni Suef City in Upper Egypt and Tanta City in the Delta, and fulltime MWRI staff with extensive experiences in project management and procurement should be ensured and assigned.

2) Construction planning is important for structures located within principal and main canals, as they must be constructed within a narrow canal cross-section while passing through the water. It is desirable to select a contractor with experiences working in similar size waterways in Egypt. In addition, since some of the facilities will be located beside trunk roads or adjacent to residential areas, it is necessary to select a contractor that can propose sound plans for safety measures for surrounding facilities and fully coordinate with relevant organizations as necessary. In particular,

the three new regulators to be constructed on the Kased Main Channel (Kased Intake, Mahlet Menouf Regulator, and Sorad Regulator) will be constructed under relatively high water volume conditions and at the side of a main road or near residential areas, so it is necessary to select an experienced construction company by ICB. For the construction of structures that can be constructed under dry conditions or under branch canals, it is considered that domestic contractors in Egypt are capable of performing the work, and therefore, bidding by LCB is appropriate.

3) Although the Kased Intake is planned to be equipped with a lock for vessel passing at the request of Navigation Authority, it may not be necessary to install the lock because there is no actual boat traffic in the area. If the lock is not required, it is expected to reduce costs by reducing the amount of concrete used for the structure, and by reducing the scope of temporary closure and foundation piles for construction on the left side of the canal. For the three regulators' foundations of the Kased Main Channel, foundation piles were selected for the Kased Intake, and foundation improvement was selected for the Mahlet Menouf and Sorad Regulators. If good foundation conditions are confirmed by additional in-canal borings during the detail design, it is expected that the scope will be reduced or direct foundation (without foundation improvement) may be adopted to reduce the cost.

4) A series of hydraulic simulation results showed that even if modern on-farm irrigation system is introduced in the future and water saving is achieved, it is possible to raise the water level in the canals by operating regulators located within the canals as needed, and water distribution to the lower branch canals can be so possible. In this case, since the longitudinal slope of the canals in Egypt is very gentle, ranging from 1/10,000 to 1/15,000, a regulator that functions as designed is required approximately every 10 km to 15 km. In other words, it is necessary to ensure that there should be always one regulator that functions adequately approximately every 10 to 15 km to control the water level in the canals and distribute water to the lower canals, even when irrigation water amount is reduced due to future water saving with the modern on-farm irrigation introduced (new regulators to be constructed on the Kased main canal will be in every 10 km or so, including the existing Tanta 1 Regulator).

5) Regarding the financial assistance scheme for the introduction of modern on-farm irrigation system, the Team initially had the Two Step Loan (TSL) in mind, but in order to hedge the following three risks associated with the implementation of the TSL, a project loan with the advance disbursement method should be used; first, farmers may hesitate to introduce modern on-farm irrigation due to the complexity of bank loan application procedure; second, ABE (the most promising candidate for PFI), which accounts for about 70% of the share of lending to agriculture sector in Egypt, abolished the Foreign Currency Borrowing Bureau in 2016, so there may be a risk that the PFI could not participate in TSL scheme; and third is the uncertainty of the NPL problem, the lack of a timely information disclosure system, and the lack of experience in TSL (since 2016).

6) Although the economic feasibility of the project implementation has been confirmed, especially for the introduction of modern on-farm irrigation system such as drip and sprinkler irrigation, it is essential to increase yield and reduce chemical fertilizer input through appropriate facility operation by the farmers to ensure that the benefits of the investment are realized. Increasing the planting of profitable horticultural crops is also an important issue. Therefore, it is essential to ensure that farmers be trained in cultivation techniques using modern on-farm irrigation system and that farmers be well organized to operate the facilities. In addition, farmers should be motivated to introduce the facilities by extending the repayment period for their initial investment from 10 to 20 years, and by providing farmers with explicit information in advance to exempt or defer repayment in the event of crop failure or a collapse in grain prices in market.

7) Modern on-farm irrigation using drip and sprinkler systems contributes not only to water and fertilizer savings, but also to crop profitability through increased yields. However, farmers who are new to modern on-farm irrigation systems on Old Lands will need time to become familiar with the equipment and to achieve full-scale yield increase. Although the number is small for the farmers implementing modern on-farm irrigation on the Old Lands, some farmers are already conducting the modern on-farm irrigation, e.g., in the lower reaches of canals where water shortages are occurring. These farmers have learned how to operate modern on-farm irrigation system from earlier adapted farmers in the New Lands, as well as from drip and other equipment suppliers and agricultural extension workers. Therefore, it is necessary to provide a series of technical trainings along with demonstration plots to the farmers who are introducing modern irrigation systems for the first time. The training for the farmers should be led by regional officials of the Irrigation Advisory Services (IAS).

8) For the Fayoum area, the introduction of modern on-farm irrigation facilities such as sprinkler and drip irrigation is not recommended, as there are two lakes at the end of the Fayoum area, Quarn Lake and Rayan Lake, and the introduction of modern on-farm irrigation will significantly reduce the drainage to the both lakes (e.g., a 3% reduction in drainage water with sprinklers installed on 10% of the area, and a 7% reduction if drip irrigation is used on the 10% of the area). Both lakes have many stakeholders involved in tourism, salt production, fish culture, etc., thus both the water quality and water level should be maintained as saline lakes. In other words, it is recommended to improve irrigation facilities in the Fayoum area only in conjunction with canal rehabilitation at the main and branch levels, including the improvement of Meska to achieve efficient water management, under conditions that do not reduce the volume of drainage.

9) As an advanced water management method, the Team has proposed to introduce satellite image analysis to follow up the planted area. This will enable MWRI to obtain information on the planted area and the area that has been harvested, and to allocate water based on appropriate water requirements. Satellite imagery can also be used to identify areas that require more water supply due to poor growth. In addition, while the Project is expected to improve the efficiency of water use, it is also desirable to improve the operational management of the water distribution. Currently, the Directorate Engineers belonging to the 26 General Directorates for Irrigation nationwide operate the facilities, while the engineers of the Maintenance Section perform daily management and simple maintenances. However, this information is rarely shared except for the main barrages on the Nile River. It is therefore necessary to introduce a system, e.g., using cloud system, to update and share the status of these facilities among the parties concerned, e.g. among the MWRI central office, regional offices.

MAIN
REPORT

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ACRONYMS AND ABBREVIATIONS

ABE	Agricultural Bank of Egypt
AfDB	African Development Bank
AES	Agricultural Extension Sector
AMS	Agricultural Mechanization Sector
ARC	Agricultural Research Center
ASFS	Agricultural Services and Follow-up Sector
BCWUA	Branch Canal Water Users' Association
BOD	Biochemical Oxygen Demand
BOQ	Bill of Quantities
CDIAS	Central Department for Irrigation Advisory Service
CDIIP	Central Department of Irrigation Improvement Project
CDWD	Central Directorate of Water Distribution
CDCM	Central Directorate for Canal Maintenance
COD	Chemical Oxygen Demand
CAPMAS	Central Agency for Public Mobilization and Statistics
DD	Detailed Design
DFA	Direct Force Account
DGRs	Dirout Group of Regulators
DWB	District Water Board
DO	Dissolved Oxygen
EC	Electric Conductivity
EEAA	Egyptian Environmental Affairs Agency
EGP	Egyptian Pound
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMMP	Environment Management and Monitoring Plan
EPADP	Egyptian Public Authority for Drainage Project
ESA	Egyptian General Authority for Land Survey
EU	European Union
EVI	Enhanced Vegetation Index
FAO	Food and Agriculture Organization of the United Nations
FIMP	Farm-level Irrigation Modernization Project
FIRR	Financial Internal Rate of Return
GD	General Directorate
GDI	Gender Development Index
GDIAS	General Directorate of Irrigation Advisory Service
GDIIP	General Department of Irrigation Improvement Project
GDP	Gross Domestic Product
GII	Gender Inequality Index
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GNSS	Global Navigation Satellite System
GNP	Gross National Product
GOE	Government of Egypt
GOJ	Government of Japan
HDI	Human Development Index
HEPS	Horizontal Expansion Project Sector
IAS	Irrigation Advisory Service
IBRD	International Bank for Reconstruction and Development

ICB	International Competitive Bidding
ICT	Information and Communication Technology
ID	Irrigation Department
IFAD	Implementation Fund of Agriculture Development
IIIMP	Integrated Irrigation Improvement and Management Project
IIP	Irrigation Improvement Project
IIS	Irrigation Improvement Sector
IMT	Irrigation Management Transfer
IS	Irrigation (Affairs) Sector
IWMD	Integrated Water Management District
IWRM	Integrated Water Resource Management
JICA	Japan International Cooperation Agency
JSSS	JICA Standard Safety Specification
KfW	Kreditanstalt für Wiederaufbau
LA	Loan Agreement
LCB	Local Competitive Bidding
LE	livre égyptienne (French for Egyptian pound)
MALR	Ministry of Agriculture and Land Reclamation
MD	Minutes of Discussions
MED	Mechanical and Electric Department
MOA	Memorandum of Agreement
MODIS	Moderate Resolution Imaging Spectroradiometer
MOE	Ministry of Environment
MOF	Ministry of Finance
MOH	Ministry of Housing, Utilities and Urban Development
MOIC	Ministry of International Cooperation
MWRI	Ministry of Water Resources and Irrigation
NBE	National Bank of Egypt
NCW	National Council for Women
NH_3	Ammonia
NPL	Nonperforming Loan
NPV	Net Present Value
NWRC	National Water Research Center
NWRP	National Water Resources Plan
OFIDO	On-farm Irrigation Development in the Old Lands
OPEC	Organization of the Petroleum Exporting Countries
O&M	Operation and Maintenance
PFI	Participating Financial Institution
PS	Planning Sector
RD	Record of Discussions
RGBS	Reservoirs and Grand Barrages Sector
SADS2030	Sustainable Agricultural Development Strategy towards 2030
SCF	Standard Conversion Factor
SDS	Sustainable Development Strategy
SS	Suspended Solid
STAR	Sustainable Transformation for Agricultural Resilience in Upper Egypt Project
SWMT	Strengthening for Water Management Transfer
TCP	Technical Cooperation Project (of JICA)
TDS	Total Dissolved Solid
T-N	Total Nitrogen

TOR	Terms of Reference
T-P	Total Phosphorus
TSL	Two Step Loan (of JICA)
TSS	Total Suspended Solid
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WARUS	Project for Drainage Water Quality Control for Irrigation in Middle Delta
WB	World Bank
WMIP	Water Management Improvement Project
WTO	World Trade Organization
WUA	Water Users' Association
WUO	Water Users Organization

UNIT CONVERSION

1 pound (lb)	0.454 kg
1 kilogram	2.205 pounds
1 long ton	2,240 pounds
1 metric ton	1,000 kilograms, 2205 pounds
1 Gallon	4.546 litre (based on Imperial gallon)
1 Litre	0.220 Gallon (based on Imperial gallon)
1 inch (in.)	2.540 cm
1 feet (ft.)	30.480 cm
1 meter	3.281 feet
1 kilometer	0.621 mile
1 mile	1.609 kilometers
1 feddan	0.420 ha (60m x 70m), 1.037 acres
1 hectare (ha)	2.381 feddans
1 acre (ac)	0.405 ha
1 hectare (ha)	2.471 acre
1 Milliard	One thousand millions; equivalent to U.S. billion

CURRENCY EQUIVALENTS（AS AT NOVEMBER 2022）

1 US$	=	147.5 Japanese Yen
1 EGP	=	6.38 Yen
1 US$	=	23.12 EGP

EGYPT FINANCIAL YEAR

July 1 to June 30 of the following year

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REFERENCES:

Chapter	References	Publisher	Language	URL (Mar. 2023)
2	National Water Resources Plan 2017/2037	MWRI	English	https://faolex.fao.org/docs/pdf/egy147082.pdf
2, 6	Statistical Yearbook (annual)	CAPMAS	Arabic/English	https://www.capmas.gov.eg/Pages/Publications.aspx?page_id=5104&Year=23577-
2	National Climate Change Strategy 2050	Government of Egypt	English	National Strategy for Climate Change 2050 (sis.gov.eg)
3	The World Factbook 2006	CIA	English	https://www.cia.gov/the-world-factbook/countries/egypt/
3	Health Sector Cooperation Planning Survey in Arab Republic of Egypt Final Report, JICA (2017)	JICA	Japanese/ English	https://libopac.jica.go.jp/search/detail?rowIndex=9&method=detail&bibId=1000030569
3	Demographic Health Survey (2014)	Ministry of Health and Population (funded by USAID, UNICEF and UNEFPA)	English	https://www.unicef.org/egypt/media/1351/file/Egypt%20Demographic%20and%20Health%20Survey%202014.pdf
3	Progress on Drinking Water, Sanitation and Hygiene, Joint Monitoring Program (JMP), 2017	UNICEF, WHO	English	https://www.unwater.org/sites/default/files/app/uploads/2020/04/WHOUNICEF-Joint-Monitoring-Program-for-Water-Supply-Sanitation-and-Hygiene-JMP-%e2%80%93-2017_ENG.pdf
3	PMU COMPLETION REPORT IBRD Loan no 7291-EGTIIS, Integrated Irrigation Improvement and Management Project, August 2016	Ministry of Water Resources and Irrigation	English	-
3	Irrigation Modernization in the Nile Delta and Valley, December 2020	EU Water STARS	English	-
3	Bulletin of Agricultural Boundaries and Properties 2017	CAPMAS	Arabic / English	-
3	Fertilizer use by crop in Egypt	FAO	English	-
3	Soil fertility management in Egypt Regional Workshop on Soil Fertility Management Through Farmer Field Schools in the Near East	-	English	-
3	Bulletin of Important Indicators of the Agricultural Statistics Winter Crops, Summer and Nile Crops	MALR	Arabic / English	-
3	Bulletin of the Agriculture Statistics	MALR	Arabic / English	-
3	Central Agency for Public Mobilization and Statistics	CAPMAS	Arabic	https://www.capmas.gov.eg/HomePage.aspx
3	Income & Expenditure Search 2019-2020	CAPMAS	Arabic	https://www.capmas.gov.eg/Pages/Publications.aspx?page_id=5109&YearID=23629
3	Egypt Human Development Report 2021	UNDP and Ministry of Planning and Economic Development	English	https://egypt.un.org/en/146158-egypt-human-development-report-2021
3	Country Gender Assessment of the	FAO	English	https://www.fao.org/documents/card/fr/

Chapter	References	Publisher	Language	URL (Mar. 2023)
	Agricultural and Rural Sector – Egypt(2021)			c/CB8060EN
3	Global Gender Gap Report 2022	World Economic Forum	English	https://www.weforum.org/reports/global-gender-gap-report-2022/in-full
3	National Strategy for the Empowerment of Egyptian Women 2030 (2017)	National Council for Women	English	http://ncw.gov.eg/wp-content/uploads/2018/02/final-version-national-strategy-for-the-empowerment-of-egyptian-women-2030.pdf
3	Country Gender Profile (2019)	Islamic Development Bank	English	https://www.isdb.org/sites/default/files/media/documents/2020-10/Egypt%20Gender.pdf
8	MWRI (2016) *PMU Completion Report (IBRD Loan no 7291-EGT) Integrated Irrigation Improvement and Management Project (IIIMP)*	MWRI	English	-
4	HEC-RAS Hydraulic Reference Manual Version 5.0 (February 2016)	Hydrologic Engineering Center	English	https://www.hec.usace.army.mil/software/hec-ras/documentation/HEC-RAS%205.0%20Reference%20Manual.pdf
4	Open-Channel Hydraulics	Chow, Ven Te	English	-
4	Irrigation Modernization in the Nile Delta and Valley (December 2020)	EU Water STARS	English	-
4	Implementation Completion and Results Report for Egypt Farm-Level Irrigation Modernization (June 2018)	World Bank	English	-
4	Financing Options for A Blended Financing Instrument to Support Irrigation Modernization at the Farm Level (Mar. 2021)	EU Water STARS	English	-
4	Assessment of Modern Irrigation Systems in the Old Lands of the North Delta, Technical Report for Joint Experiment Research between MWRI and JICA (January 2021),	Water Management Research Institute, Kafr El-Sheikh Research Station MWRI	English	-
4	The Project for Drainage Water Quality Control for Irrigation in Middle Nile Delta in the Arab Republic of Egypt (Mar. 2016)	JICA	Japanese / English	https://libopac.jica.go.jp/search/detail?rowIndex=30&method=detail&bibId=1000025882
4	Overhead and Drip irrigation system effects on tomato growth and yield in California's Central Valley (December 2014)	Horltechnology	English	https://journals.ashs.org/horttech/view/journals/horttech/24/6/article-p637.xml
4	Efficient management of water and nutrients in drip irrigation and fertigation.	The Fluid Journal, Winter 2017 Vol. 25, No.1. Issue #95	English	https://fluidfertilizer.org/wp-content/uploads/2017/03/W17-A2.pdf
4	Effect of drip irrigation on yield of cabbage under mulch and non-mulch conditions.	Agricultural Water Management,	English	https://www.sciencedirect.com/science/article/abs/pii/S0378377402000847#:~:text=The%20use%20of%20drip%20irri

Chapter	References	Publisher	Language	URL (Mar. 2023)
		Vol 58, Issue 1, January 2003		gation%20either%20alone%20or,irrigation%20treatment%20%28VF%29%20followed%20by%206.99%20for%200.6VD.
4	Implications of Adopting Drip Irrigation System on crop yield and gender-sensitive issues: the case of Haramaya District, Ethiopia (September 2020)	Journal of Open Innovation	English	https://www.mdpi.com/2199-8531/6/4/96
4	Water Saving with the use of different irrigation systems under Egyptian conditions (July 2012)	Irrigation and Drainage, Misr J. Ag. Eng.	English	https://www.researchgate.net/publication/342852538_WATER_SAVING_WITH_THE_USE_OF_DIFFERENT_IRRIGATION_SYSTEMS_UNDER_EGYPTIAN_CONDITIONS
4	Sprinkler irrigation – an asset in water scarce and undulating areas (June 2018)	ICAR Research Complex for NEH Region Umiam, Meghalaya, India	English	https://www.researchgate.net/publication/325870811_Sprinkler_irrigation_-_An_asset_in_water_scarce_and_undulating_areas
4	Yield performance of red onion under different irrigation management in Jaffna Peninsul (2008)	JSc-EUSL Vol.5. No.1. 2008, Sri Lanka	English	https://www.digital.lib.esn.ac.lk/server/api/core/bitstreams/75a1daa5-e02d-4594-a190-046aa55d3daa/content
5	MWRI Structure	MWRI	Arabic	https://www.mwri.gov.eg/
6	OECD (Details of Public Revenues – Egypt)	OECD	English	https://stats.oecd.org/Index.aspx?DataSetCode=REVEGY
6	Commodity price Forecasts (October 2022)	World Bank	English	https://thedocs.worldbank.org/en/doc/d8730a829c869c7aeaba547eb72d6b3f-0350012022/related/CMO-October-2022-forecasts.pdf
7	Guidelines of Principles and Procedures for Environmental Impact Assessment 2nd edition (2009)	EEAA	English	https://www.eeaa.gov.eg/Service/67/sub/171/index
7	Law No. 10/1990 on expropriation of real estate for public benefit and improvement	Egyptian government	Arabic	-
7	Law No. 4/1994 Environmental Protection Law	Egyptian government	Arabic	https://www.eeaa.gov.eg/Laws/55/index
7	Law No.48/1982 Regarding the Protection of the Nile River and Waterways against Pollution	Egyptian government	Arabic	-
7	Egyptian Biodiversity Strategy and Action Plan (2015 - 2030), Ministry of Environment, Egypt (January 2016)	Ministry of Environment	English	https://faolex.fao.org/docs/pdf/egy156958.pdf
7	Information Sheet on Ramsar Wetland (RIS)	Ramsar Convention Wetland Secretariat	English	https://rsis.ramsar.org/RISapp/files/RISrep/EG2040RIS.pdf https://rsis.ramsar.org/RISapp/files/RISrep/EG2041RIS.pdf
7	State of Environment 2022	Ministry of Environment	Arabic	https://www.eeaa.gov.eg/Reports/Index
7	National Solid Waste Management Program (NSWMP) Egypt	EEAA	English	https://www.eeaa.gov.eg/Uploads/Project/Files/20221119135000850.pdf

Chapter	References	Publisher	Language	URL (Mar. 2023)
7	Water Quality for Agriculture (1994)	FAO	English	https://www.fao.org/3/T0234E/T0234E00.htm
8	PMU Completion Report (IBRD Loan no 7291-EGT) Integrated Irrigation Improvement and Management Project (IIIMP) (2016)	MWRI	English	-
8	Project Performance Assessment Report - Arab Republic of Egypt – Integrated Irrigation Improvement and Management Project and Farm-Level Irrigation Modernization Project (Report No. 173462)	WB	English	https://openknowledge.worldbank.org/server/api/core/bitstreams/04394c94-f6ab-5b26-a2e7-19e29d304597/content
8	UN Women (2018) Profile of women in rural Egypt	UN Women	English	https://egypt.unwomen.org/sites/default/files/Field%20Office%20Egypt/Attachments/Publications/2018/05/Profile%20of%20rural%20women%20%20final%20version.pdf
8	Women, irrigation and social norms in Egypt: ‘The more things change, the more they stay the same?’, Water Policy 21(4) (2019)	Najjar Dina, Baruahb Bipasha and Garhic Aman El	English	https://www.researchgate.net/publication/331461637_Women_irrigation_and_social_norms_in_Egypt_'The_more_things_change_the_more_they_stay_the_same'

CHAPTER 1 RATIONALE AND SETTING-UP OF THE SURVEY

1.1 Rationale of the Project

Egypt is a country with extremely little rainfall, which is only 51 mm of annual average rainfall (annual average rainfall is 880 mm in the world). The Nile River water covers more than 90% of water resources in Egypt, yet it is regulated to 55.5 billion cum/year by an international agreement. The demand for water in Egypt is increasing due to the rapid population growth in recent years showing an annual average of 2.04% from 2008 to 2017, and the expansion of farmlands. Consequently, the annual water resource per capita in the country has become 720 cum (2017), that is far below the 1,000 cum[1], a common standard threshold for water shortage.

The agricultural sector occupies about 95% of consumptive use of water in Egypt (National Water Resources Plan 2017), and therefore, the efficient use of water resources in the agricultural sector is an urgent issue. So far, the Government of Egypt (GOE) has been making efforts to realize appropriate water distribution through the construction and rehabilitation of regulators mainly on the principal canals. Japanese ODA has also been utilized to assist GOE in its efforts. However, the long irrigation canal network with aged irrigation facilities from the main to the terminal canals and sedimentation in the canals makes it difficult to manage water distribution in the entire irrigation system and to deliver required water properly to the farmlands.

With regards to above issues, the GOE has identified the agriculture sector as one of the pillars required for economic development in the long-term development strategy of “Egypt Vision 2030” formulated in 2015, and thus aims at an efficient and sustainable use of water resources. Besides, one of the pillars in the National Water Resources Plan (1997-2017) is the efficient use of water resources in irrigation, and also the Sustainable Agriculture Development Strategy 2030 addresses that the goal is to increase agricultural productivity as per unit amount of water. Further, in the National Water Resources Plan (2017-2037) updated, the introduction of modern irrigation such as drip irrigation and sprinklers in the terminal farmlands is addressed as an important measure for the efficient water use.

With above as background, in August 2016, the GOE requested the Government of Japan (GOJ) to support ‘the Irrigation Water Resources Management Improvement Project’ in order to improve agricultural production and increase the income and living standards of the population in the target areas located in Upper Egypt and also in the Central Delta. In response to this request, JICA agreed and signed the minutes of discussions on the framework of the Preparatory Survey for the ‘Irrigation Water Resources Management Improvement Project’ with the GOE on November 22, 2018, hence this Preparatory Survey was commenced.

1.2 Objective of the Project

The objective of this Project is to improve and rehabilitate irrigation facilities in the Upper Egypt and Central Delta of the Nile River Basin in order to achieve sound water distribution throughout the entire basin from the principal, main to the terminal canals, thereby contributing to improving the agricultural productivity of the target area and the income and living standards of the beneficiary population.

1.3 Purpose of the Survey

Towards realizing above project objective, the Preparatory Survey, as its purpose, is to conduct a series of studies on the Project including its objectives, outline and project components, project cost, implementation schedule, implementation (procurement and construction) method, project implementation system, operation and maintenance management system, environmental and social considerations, etc., for the appraisal of the Project to be implemented as a Japan-funded ODA loan

[1] UN: World Water Development Report (2015), P12, Figure 1.1 https://unesdoc.unesco.org/ark:/48223/pf0000231823

project.

1.4 Project Target and Survey Areas

The target areas of the Project as well as the Preparatory Survey are located in the following areas of Upper Egypt and also in the Central Nile Delta. Note that these are called Project Area, or Target Area, while irrigation blocks located within the area are called region or sub-region as per the scale of the command area.

The target areas were so selected because, in Upper Egypt, the two principal canals branching from the new Dirout regulator group, which is under implementation as of 2022, need to be improved, and the need for areal improvements from the branch canals to the terminal level was also identified. The survey area in the Delta was selected since the project area should also be selected from the Delta, which has different agricultural conditions and severer water scarcity problems than Upper Egypt.

- ✓ Upper Egypt: irrigation areas covered by the Bahr Yusef (313 km) and Ibrahimia (256 km[2]) principal canals, located in Miniya, Beni Suef, and Fayoum Governorates, and
- ✓ Central Nile Delta: irrigation area covered by the Kased Main Canal (42 km), located in Gharbia and Kafr El Sheik Governorates.

  Note: Principal canals are the main watercourses that take water from the Nile River or from larger watercourses called Carriers that have been constructed to convey water from the Nile River. Within the survey area, two canals, Bahr Yusef and Ibrahimia, are the principal canals. In most cases, major canals branching off from the principal canals, and are operated under continuous flow, are called main canal. Following the main canal is a secondary canal, after which rotational irrigation is practiced in most cases.

In addition to above target areas, there are specific 3 priority sub-regions identified by the Ministry of Water Resources and Irrigation (MWRI). Sub-region here means that it is an irrigation area, having a certain extent, that is irrigated by an irrigation system consisting of principal-main-branch canals, as well as Meska[3], Marwa and its command area. There are 31 sub-region areas, 48 sub-region areas and 1 sub-region area in the Bahr Yusef Command Area, Ibrahimia Command Area, and under the Kased Main Canal area respectively[4], totaling to 80 sub-regions. Of them, the specific 3 priority sub-regions for the feasibility study purpose are as follows:

- ✓ Abo Shosha sub-region in Beni Suef Governorate, commanded by Ibrahimia Principal Canal,
- ✓ Aros & Abo Seer sub-region in Fayoum Governorate, commanded by Bahr Yusef Principal Canal, and
- ✓ Kased sub-region in Gharbia Governorate, Central Delta.

1.5 Project Executing and Related Organizations

The Ministry of Water Resources and Irrigation (MWRI) is the implementation agency of the Project, hence the ministry is the line counterpart agency of the Survey and the Irrigation Department (ID) under the MWRI is the contact counterpart organization. While, the Ministry of Agriculture and Land Reclamation (MALR) is a relevant organization in agricultural aspects.

[2] This length is after the Dirout regulator, and not from the Nile River (the length of Ibrahimia principal canal from the Nile reaches 350km).

[3] Meska is the terminal canal that receives irrigation water from the upper branch canals, but while the branch canal is under government (MWRI) control, the Meska and beyond are under farmers' control and are their property. Marwa is an open channel established within the farmlands.

[4] Based on a JICA Survey titled ‘COOPERATION PLANNING SURVEY ON THE IRRIGATION SECTOR (UPPER EGYPT AND MIDDLE DELTA) IN THE ARAB REPUBLIC OF EGYPT, FINAL REPORT, FEBRUARY 2018’

CHAPTER 2 CHALLENGES AND OPPORTUNITIES IN EGYPT AGRICULTURE

This chapter discusses challenges and opportunities in Egypt agriculture, which fully needs irrigation. It starts with the review of water resources development and irrigation development in a historical context, utilization of water as identified by sector, and also drainage reuse to cope with water shortage. Then, policies and plans related to agriculture as well as irrigation sectors are reviewed in order to know the direction of MWRI.

2.1 Water, as the Essence of Agriculture, in Egypt

2.1.1 Irrigation Development in Historical Context

From ancient times to the second half of the 19th century, the basin irrigation system had remained as the prevalent form of irrigation in Egypt. In the flood cycle, the water level of the Nile River used to rise from late June and reach its 'High' water mark in September. Such flood water on the land was somehow controlled by the system of basins, dykes, canals and inlets/outlets to retain water within the basins for 40 to 50 days. When the land was still wet after the flood had receded, farmers planted crops. Following the natural flood cycle, one-time harvest per annum used to be practiced as a fresh layer of Nile silt containing nutrients was delivered annually while noxious salts were washed out of the soils.

Transition from the traditional seasonal basin irrigation to year-round irrigation had commenced with the construction of Delta Barrage in the 1860s. Since then, a modern irrigation system has been built with the completion of the Aswan Dam in 1902 and the High Aswan Dam in 1970 (see Figure 2.1.1). The construction of the High Aswan Dam has completely shifted the traditional seasonal basin irrigation system, which had depended on flood, to year-round irrigation, and an extensive irrigation & drainage network have been built in the Nile Valley as well as over the Nile Delta to date.

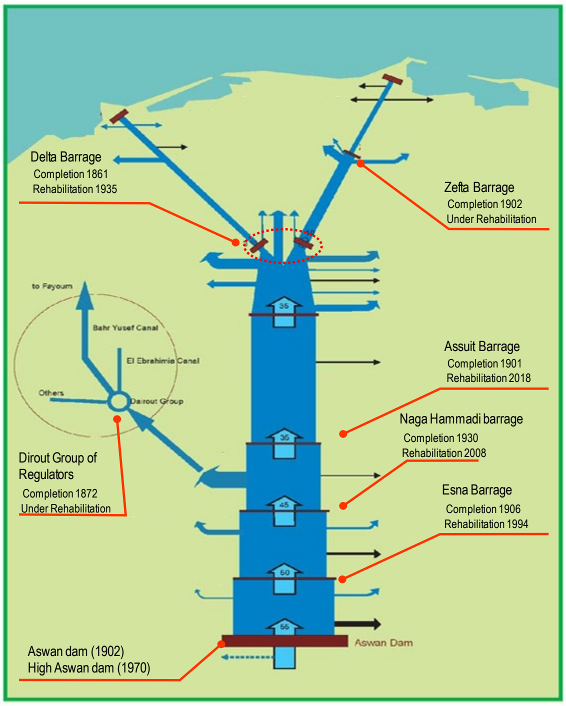


Figure 2.1.1 Major Irrigation Facilities in Egypt
Source: modified from NWRP 2017

Above the history of irrigation, modernization could be comparable to the process of irrigation laboring from community basis towards individual basis. Community level participation of the farmers used to be a must to maintain the dykes and canals under the basin irrigation system, while after the 19th century, the farmer-level irrigation form had moved to a small group base operating a common *Sakiya* (animal driven water-lifting device), and further to individual basis engine pump. Yet, in 1990s and afterwards, for the purpose of improving water use efficiency, the GOE has been organizing farmers into a group assigned to Meska to be equipped with a common pump installed at the beginning point of the Meska.

2.1.2 Water Resources by Category and Consumption by Sector in Egypt

Table 2.1.1 summarizes water resources available by category and also the consumption by sector in Egypt (source: Statistical Yearbook, 2016, 2018). The water resources first consist of; 1) fresh water and 2) recycled water, and the former is further composed of Nile River water (see No.1.1 of the table) being the major one, groundwater (No.1.2) and rains (No.1.3) while the latter is composed of agriculture drainage (No.2.1), treated sewage water (No.2.2) and seawater desalination (No.2.3). In fact, the water of recycled ones shares as much as 17% of whole water resources (see Table 2.1.2, and No.4).

Of the fresh waters, as it is well known, the Nile River water shares the most of it, say about 88%, which is 55.5 BCM per year according to an agreement made between Egypt and Sudan signed on 8th November 1959, called 'United Arab Republic and Sudan Agreement (With Annexes) For The Full Utilization of the Nile Waters'[1]. On the recycled water, the major one comes from agriculture drainage reuse water, sharing as much as 90% of all the recycled water (see No.2.1).

Looking at the consumption side (see No.7 and below), the agriculture sector uses far much water than other sectors, i.e., consuming more than 80% of all uses while drinking and health use shares 12 - 14%, industry sector does only 1.6% and loss by evaporation shares about 3% only (see Figure 2.1.3). In fact, total uses of water come to around 73 - 76 BCM per annum (No.7), while the freshwater total available per annum stands at around 63 BCM only (No.1). This implies that the water balance in Egypt is narrowly maintained on the use of recycled waters, whose share arrives at as much as 17% (see No. 4 of the table and the top part of the bars in Figure 2.1.2).

Table 2.1.1 Trend of Water Resources Available by Category and Consumption by Sector in Egypt

No.	Particulars	Year	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
1	Fresh Water Resources	BCM/year	63.00	62.85	63.10	63.10	63.63	63.94	63.10	63.30	63.05
1.1	Nile Water	BCM/year	55.50	55.50	55.50	55.50	55.50	55.50	55.50	55.50	55.50
1.2	Groundwater	BCM/year	6.20	6.25	6.30	6.30	7.50	7.70	6.70	6.90	6.90
1.3	Rains	BCM/year	1.30	1.10	1.30	1.30	0.63	0.74	0.90	0.90	0.65
2	Recycled Water Total	BCM/year	NA	NA	NA	10.65	10.53	11.46	12.90	13.10	13.20
2.1	Agricultural Drainage Water	BCM/year	NA	NA	NA	9.30	9.17	10.10	11.50	11.70	11.90
%2.1	*No.2.1 / No.2*	*%*	*NA*	*NA*	*NA*	*87.3%*	*87.1%*	*88.1%*	*89.1%*	*89.3%*	*90.2%*
%2.1	*No.2.1 / No.1*	*%*	*NA*	*NA*	*NA*	*14.7%*	*14.4%*	*15.8%*	*18.2%*	*18.5%*	*18.9%*
%2.1	*No.2.1 / No.7.1*	*%*	*NA*	*NA*	*NA*	*15.3%*	*14.9%*	*16.3%*	*18.4%*	*18.8%*	*19.1%*
2.2	Treated Sewage Water	BCM/year	NA	NA	NA	1.30	1.30	1.30	1.30	1.30	1.20
2.3	Sea Water Desalination	BCM/year	NA	NA	NA	0.05	0.06	0.06	0.10	0.10	0.10
3	**No.1 + No.2**	**BCM/year**	**NA**	**NA**	**NA**	**73.75**	**74.16**	**75.40**	**76.00**	**76.40**	**76.25**
4	No.2 / (No.1 + No.2)	%	NA	NA	NA	14.4%	14.2%	15.2%	17.0%	17.1%	17.3%
5	Population	'000 pop.	72,940	74,439	76,099	77,840	79,618	81,567	83,667	85,783	87,963
6	Water volume (excl. Recy)	CUM/P/year	864	844	829	811	799	784	754	738	717
7	**Uses of Water Total**	**BCM/year**	**70.23**	**73.60**	**73.85**	**73.75**	**74.50**	**75.50**	**76.00**	**76.40**	**76.25**
7.1	**Agriculture Use**	BCM/year	**60.00**	**61.30**	**61.30**	**60.90**	**61.50**	**62.10**	**62.35**	**62.35**	**62.15**
7.2	Drinking and Health Uses	BCM/year	6.60	9.00	9.35	9.55	9.60	9.70	9.95	10.35	10.40
7.3	Industry Uses	BCM/year	1.33	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
7.4	Loss by Evaporation	BCM/year	2.30	2.10	2.00	2.10	2.20	2.50	2.50	2.50	2.50
%7.1	**% of Agriculture Use**	**%**	**85.4%**	**83.3%**	**83.0%**	**82.6%**	**82.6%**	**82.3%**	**82.0%**	**81.6%**	**81.5%**
%7.2	% of Drinking & Health	%	9.4%	12.2%	12.7%	12.9%	12.9%	12.8%	13.1%	13.5%	13.6%
%7.3	% of Industry Uses	%	1.9%	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%
%7.4	% of Loss by Evaporation	%	3.3%	2.9%	2.7%	2.8%	3.0%	3.3%	3.3%	3.3%	3.3%
8	No.7 / No.1	%	111%	117%	117%	117%	117%	118%	120%	121%	121%
9	No.7 / (No.1 + No.2)	%	NA	NA	NA	NA	100%	100%	100%	100%	100%

Source: Statistical Yearbook 2016 for the data from 2007/08 to 2014/15, and Statistical Yearbook 2018 for 2015/16.

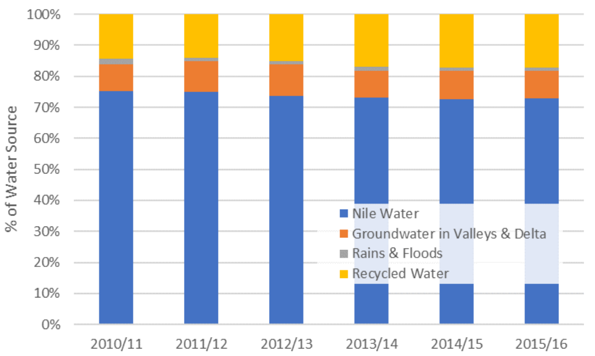


Figure 2.1.2 Share of Water Source by Category

Source: Statistical Yearbook 2016, 2018

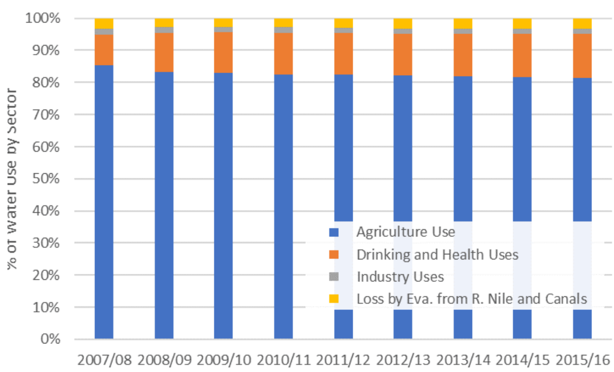


Figure 2.1.3 Share of Water Use by Sector

Source: Statistical Yearbook 2016, 2018

[1] This is the latest Nile Basin agreement. Prior to this agreement, there were the 1891 agreement, 1902 agreement, 1925 agreements, and 1929 agreement.

2.1.3 Future Water Uses, and Implications to Improving Irrigation Efficiency

National Water Resources Plan (NWRP, July 2017) incorporates a study result of 'SNWRP[2] Water Balance[3] Studies' in its Annex 1, which is the base of forecasting water sources availability in relation to the future water uses in Egypt under the NWRP. The NWRP sets the year 2015 as the base year and forecasts water availability and uses, which together presents water balance, up to 2037. The base year's water balance is summarized in Table 2.1.2 in comparison with those indicated in Statistical Yearbook (refer to Table 2.1.1).

Table 2.1.2 Water Balance in 2015 (2015/16) by NWRP and Statistical Yearbook (2018)

Water Supply	NWRP 2015 Base	Statistics 2015/16	Allocation/ Consumption	NWRP Allocation	Statistics Consumption
Conventional Water Sources	(BCM/Year)	(BCM/Year)		(BCM/Year)	(BCM/Year)
Nile	55.50	55.50	Drinking (Fresh W only)	10.75	10.40
Deep Groundwater	2.10	1.51	Industry	5.40	1.20
Rainfall & Flash Floods	1.30	0.65	Agriculture	61.10	62.15
Desalination	0.35	0.10	Drainage to Sea	Nil	Nil
Sub-total	**59.25**	**57.76**	Loss by Evaporation	2.50	2.50
Unconventional Sources	(BCM/Year)	(BCM/Year)	Environmental Balance	0.50	0.00
Shallow Groundwater (Delta)	7.50	5.39			
Re-use of Ag. Drainage Water	9.31	11.90			
Treated Wasted Water Re-used	4.19	1.20			
Sub-total	**21.00**	**18.49**			
Total Water Available	**80.25**	**76.25**	**Total W. Allocation/Uses**	**80.25**	**76.25**
Ratio	(A)	(B)	-	(B) / (A)	95%

Source: National Water Resources Plan (July 2017) see Page 86, Statistical Yearbook (2018)

The NWRP presents total available water in Egypt in 2015 as 80.25 BCM per annum composed of 59.25 BCM conventional waters and 21.00 BCM unconventional waters while the Statistical Yearbooks show smaller volumes such as 76.25 BCM for the total, 57.76 BCM for conventional waters, and 18.49 BCM for unconventional waters. Then, the allocated waters or consumed waters are automatically balanced to those of available water volumes (see right columns of Table 2.1.2). The difference between the NWRP and Statistical Yearbooks comes mainly from the fact that the former stands for available and allocation basis while the latter does actual usable and consumed volume basis.

By looking at both cases of NWRP and Statistical Yearbooks, one may know that we could utilize as much as 80.25 BCM per annum and realize the somewhat target-like allocated water volume, that is also 80.25 MCM per annum. Yet, when looking into the actual uses from a practical point of view, we may have to recognize the available consumable water volume in Egypt as of 2015 may be limited to 76.25 BCM per annum, that includes unconventional waters such as treated sewerage and drainage reuse water, groundwater, desalination water.

NWRP also presents future water balance towards 2037, and excerpts are summarized in the upper rows of Table 2.1.3 (see No.1 – No.7 of the table). According to the forecast, the base water requirement volume of 80.25 BCM will increase to 88.95 BCM in 2037 (see No.7), and such volume could be balanced by those increased water availabilities as indicated in Table 2.1.4. According to Table 2.1.4, the increment (8.7 BCM) could be managed by increasing each component of water resources, except for shallow groundwater sources, including an increment of Nile water (3 BCM).

Table 2.1.3 Future Water Uses and Availability for Agriculture Sector

No.	Particulars	Unit	2015 (Base)	2020	2030	2037	Remarks
1	Population	M. Capita	88	102	129	145	
2	Domestic Water	BCM/Year	10.75	11.50	13.30	14.00	
3	Industries	BCM/Year	5.40	5.50	5.70	5.75	

[2] Support for the National Water Resources Plan – Phase II, an EU funded project
[3] Balance here means the balance between water demand and water supply available.

No.	Particulars	Unit	2015 (Base)	2020	2030	2037	Remarks
4	Agriculture	BCM/Year	61.10	61.80	64.20	66.00	
5	Evaporation Loss	BCM/Year	2.50	2.55	2.55	2.60	
6	Environmental Balance	BCM/Year	0.50	0.55	0.55	0.60	
7	**Total Required Water**	**BCM/Year**	**80.25**	**81.90**	**86.30**	**88.95**	
8	Water Available	BCM/Year	76.25 (usable & consumption basis)				Including recycled waters
9	Water Available for Agr.	BCM/Year	57.10	56.15	54.15	53.30	No.8-(No.2+No.3+No.5+No.6)
	Irri. Efficiency to Improve	**%**	**8.13**	**9.65**	**12.87**	**14.24**	(No.13(2015) - No.9) / No.13(2015)
	Water Use Forecast based on 2015 Statistics						
10	Domestic Water	BCM/Year	10.40	11.13	12.87	13.54	
11	Industries	BCM/Year	1.20	1.22	1.27	1.28	
12	Evaporation Loss	BCM/Year	2.50	2.50	2.50	2.50	
13	Water for Agriculture	BCM/Year	62.15	61.40	59.62	58.93	No.8-(No.10:No.12)
	Irr. Efficiency to Improve	**%**	Balanced	**1.20**	**4.08**	**5.18**	(No.13(2015) - No.13) / No.13(2015)

Source: National Water Resources Plan (July 2017), and JICA Survey Team's Estimation

Aforementioned Table 2.1.3 tries simple simulations for agriculture water availability in the future in Egypt on condition that;

Table 2.1.4 Comparison between 2015 and 2037 by NWRP

Water Supply	NWRP 2015 Base	NWRP 2037 M.Probable
Conventional Water Sources	(BCM/Year)	(BCM/Year)
Nile	55.50	58.50
Deep Groundwater	2.10	3.85
Rainfall & Flash Floods	1.30	1.40
Desalination	0.35	1.00
Sub-total	**59.25**	**64.75**
Unconventional Sources	(BCM/Year)	(BCM/Year)
Shallow Groundwater (Delta)	7.50	7.20
Re-use of Ag. Drainage Water	9.31	11.04
Treated Wasted Water Re-used	4.19	5.96
Sub-total	**21.00**	**24.20**
Total Water Available	**80.25**	**88.95**
Difference, BCM/Year		**8.7**

Source: National Water Resources Plan (July 2017)

1) Future water availability is fixed as that base of Statistical Yearbook (76.25 BCM per annum for the base year 2015) as this volume was estimated based on the actual consumption and use (not the available and allocation basis), and
2) Other uses than agriculture, e.g., domestic, industries, evaporation and environmental balances, are given priority, namely, those water allocations indicated in NWRP and also Statistical Yearbook than agriculture use should be maintained first, and then the remaining volume is allocated to the agriculture sector (see No.9 of Table 2.1.3 in case of NWRP and see No.13 in case of Statistical Yearbook), and
3) Prioritizing non-agricultural water use is the same as condition 2) above, but the future use of water for drinking water, industrial water, etc. is estimated based on the volumes from the 2015 Statistical Yearbook, taking into account the rate of increase indicated in the NWRP to estimate the future increase in water use. The remaining amount of water available for the agricultural sector is then set as 76.25 BCM minus these non-agricultural water requirements.

Based on the above conditions, water available for agriculture sector will be 57.10 BCM in 2015 to 53.30 BCM only for the year 2037. Then, if we should cultivate the same area and same crops with these reduced water volumes available, there should be increase of irrigation efficiencies. The increment of the irrigation efficiencies is calculated at 14.24% for the year 2037. Another case, in which other uses than agriculture are assumed based on those of 2015 bases of Statistical Yearbooks, shows that incremental irrigation efficiencies should be 5.18% at the year 2037.

Given above implications, the JICA Survey Team thinks that only 5% increment could be risky in terms of planning purpose and therefore the Team recommends that the irrigation efficiency increment with project interventions should target 14% towards the year 2037. Irrigation efficiency increase of as much as 14% can hardly be achieved only by facility improvement, but should include change of crops and also change of on-farm irrigation, e.g., from the conventional surface irrigation to sprinkler and/or drip irrigation, together with water management improvement.

2.2 Policies and Plans in Agriculture/ Irrigation Sector

2.2.1 Egypt Vision 2030 (Sustainable Development Strategy: SDS)

In years of 2014 and 2015, the government of Egypt prepared the Sustainable Development Strategy (SDS), the so-called Egypt Vision 2030, through participatory processes. The SDS has followed a principle of sustainable development as a general framework for improving the quality of lives and welfare, taking into consideration the rights of new generations in a prosperous life. Under the principle, the SDS deals with three main dimensions; namely, economic, social, and environmental dimensions with major focusing intervention areas, key performance indicators, and programs/ projects which need to be implemented by the year 2030.

The Vision has ambitious targets especially in the area of economic dimension. To achieve the targets under the three dimensions, the SDS proposes a number of programs and projects. The water sector including the irrigation and agriculture sector is relevant to the economic dimension as well as the environmental dimension. In the two dimensions, water and agriculture related programs/ projects are proposed as follows (Note that the numbers below are the ones listed in the SDS):

1) Water related programs/ projects under Economic Dimension:
   - ✓ Rationalization of water usage (No.46), and
   - ✓ Water resources development (No.49).
2) Agriculture related programs/ projects under Economic Dimension:
   - ✓ Four million acres development project (No.4),
   - ✓ Developing agricultural areas and supporting agro-industry (No.40),
   - ✓ Establishing collection points and storage facilities for strategic commodities (No.41), and
   - ✓ Establishing "Agriculture Modernizing Center" (No.43).
3) Water quality improvement related programs/ projects under Environmental Dimension:
   - ✓ Expanding infrastructure for supporting a sustainable water system (No.2).

The SDS presents only the titles of programs/ projects and provides no details about them. Yet, it can be noted that the SDS puts emphasis on agriculture development in the framework of economic development. In line with it, the rationalization of water use is pursued as one of the important water-related programs/ projects. The Project should be in connection with the agriculture and water programs/ projects.

2.2.2 National Strategy for Climate Change 2050

Egypt has launched on May 19, 2022, the National Strategy for Climate Change 2050, prior to the country hosting of the UN Climate Change Conference 2022 (COP27). The strategy is established based on 5 main pillars, which are 1) achieving sustainable economic growth and low-emission development in various sectors, 2) enhancing adaptive capacity and resilience to climate change, and alleviating the associated negative impacts, 3) enhancing climate change action governance, 4) enhancing climate financing infrastructure, and 5) enhancing scientific research, technology transfer, knowledge management and awareness to combat climate change.

Under the second pillar, there are policy level objectives as Objective (2.c): Preserving the country's resources from the impacts of climate change, under which there are policy directions of 'Develop policies to reduce waste and raise the efficiency of water resource use', and 'Preserving agricultural land and water resources by maintaining the fertility of agricultural soil continuously'. These are in conformity with the objective of the Project. The Strategy also indicates adaptation programs cost, and as the largest part, 59,108 million US$ (52%) is indicated for implementing irrigation and water resources related programs, out of total 113 billion US$.

2.2.3 National Water Resources Plan of Egypt (2017 and 2037)

The first National Water Resources Plan (NWRP) was formulated in 2005 with the target year of 2017. Upon having reached the target year, the plan was evaluated and renewed with the new target year of 2037 (NWRP 2037).

1) NWRP 2017

NWRP 2017 was developed by MWRI as the water program leading authority with the support of the Government of the Netherlands in May 2005, which was formed based on an understanding that, in case of lack of proper management of water, water will become a constraining factor in the socio-economic development of the country. The main issue presented in the plan is how Egypt safeguards its water resources in the future under the conditions of high population growth and limited water availability. The following strategies were employed for the water resources management policy:

Table 2.2.1 Strategies of NWRP 2017

Strategy	Contents
New water resource development	・ Nile water development: Coordination with Nile riparian countries to research possibilities to increase Nile water availability ・ Groundwater development: Development of deep groundwater in the Western Desert with close monitoring of groundwater levels, detailed studies on the potential of developing deep groundwater in the Sinai and the Eastern Desert, investigation of the validity of using brackish groundwater for agriculture and aquaculture, and strengthening of the management of shallow groundwater of the Nile aquifer. ・ Rainfall and flash flood harvesting: To stimulate small-scale rainfall harvesting along the Mediterranean coast, to study flash flood harvesting in Sinai in combination with flood protection ・ Desalination in Coastal area: To increase brackish / saltwater desalination in line with demands
Making better use of existing resources (Irrigation Management Improvement, Reuse of drainage water, Reuse of treated wastewater, etc.)	・ Demand management of Municipal and Industrial water: To install/rehabilitate metering system and apply a progressive tariff structure ・ Reduction of loss by leakage: repair/installation of metering system ・ Reuse of drainage water / treated wastewater ・ Aquaculture and Navigation: To review restrictions, dredging in the navigation ・ Improvement of irrigation efficiency

Source: JICA Survey Team summarized tables on Water for Future, National Water Resources Plan 2017 National_Water_Resources_Plan_2017_en.pdf (unescwa.org), MWRI (Jan 2005)

2) NWRP 2037

The NWRP 2037 was formulated in 2017, which was the target year of NWRP 2017. Since the coordination mechanism to guide implementers to decision-making was poor in the NWRP 2017, NWRP 2037 intends to have stronger guidance for stakeholders. Based on the experience of water shortage by draught in the Nile Basin in 2016[1], NWRP 2037 is also positioned as an important plan of the country to deal with water balance issue urgently.

NWRP 2037 sets the purpose to achieve "Water security for all" and defines following target indicators; i) water stress index will remain above 450 cum/capita/year until year of 2037 (658 cum/capita/year in 2015) and ii) water security of Egypt is rated as score 4 (effective) by year 2037 (score 2 (engaged) in 2015), which is evaluated by Asian Water Security Index[2] of ADB.

It is considered in NWRP 2037 that i) population growth increases water demand, ii) climate change destabilizes water flow into Lake Nasser, and iii) the economic growth of riparian countries is high toward future. Given the factors, in addition to "Supply-driven Strategy" and "Demand-oriented

[1] In year of 2016, the government of Egypt strongly restricted the rice cultivation, which had consumed a lot of water, and burnt out illegally planted paddy in the farms.

[2] Asian Development Bank (ADB) has presented Asian Water Security Index as the National Water Security Stage. The Index consists of five stages from Level 1: Hazardous to Level 5: Model. The government of Egypt targets to step up to level 4 (effective) from the present level 2 (engaged).

Strategy", which were included in NWRP 2017, a strategy called "Adaptive Strategy" to adapt the situation of water shortage has been integrated in the NWRP 2037 to improve water allocation and water use efficiency.

The NWRP 2037 focuses on the adaption to water shortage as an urgent issue. Since tension is to build between water suppliers and users, innovations including participatory water management are required. MWRI recognizes this tension and intends to motivate water users to collectively explore solutions by adaptive water management, thereby creating an enabling environment for innovation to happen. It can be said that the innovation in agriculture sector is very much focused in the NWRP 2037.

It is presumed that water shortage affects the agriculture sector seriously. Water shortages in various scenarios indicate 6% to 11% decrease of water supply per land area. In order to maintain the agricultural production under such circumstances of water shortage, such adaptive measures will be required as; i) to apply technical innovations in less water cultivation of crops, ii) to shift from conventional crops to crops requiring less water, and iii) to organize Water Users' Association at branch canal level, etc.

It is necessary for MWRI to supply irrigation water by rehabilitating the irrigation facilities, improving water distribution, and establishing accurate measuring system of water distribution and consumption, etc. It is of crucial importance that MWRI establishes trust on securing water to encourage farmers to invest in new innovative agricultural technologies. It is considered as an essential condition to apply the adaptive strategy that MWRI secures accurate and reliable water supply to the farmlands even under the circumstance of water shortage.

To achieve the goals, NWRP 2037 sets the following objectives:

1) To improve enabling environment for Integrated Water Resources Management (IWRM) planning and implementation,
2) To enhance availability of freshwater resources,
3) To improve water quality, and
4) To enhance the management of water use.

Various approaches were planned under the above four objectives. Of them, under the objective 4) To Enhance the management of water use, MWRI is to improve the performance of national water resources system infrastructure, to improve the performance of private (tertiary and quaternary) irrigation and drainage system, and to increase the efficiency of water management in the agriculture sector, etc. The Project formulated in this Survey shall contribute to the accomplishment of the approaches.

2.2.4 EGYPT 2030 Updated Sustainable Agricultural Development Strategy Towards 2030

The MALR established a strategy, "Sustainable Agricultural Development Strategy towards 2030 (SADS 2030)", which was initially developed in 2009. In December 2020, SADS 2030 was updated as titled "EGYPT 2030 Updated Sustainable Agriculture Development Strategy" (Updated SADS 2030), assisted by FAO.

This updated version elaborates action plans including national realistic agriculture projects and programs needed to be accomplished in the framework of the period 2020 - 2025 and 2025 - 2030. The updated strategy has set the following vision, mission statement, and strategic objectives. Among the objectives below, "2) Enhance sustainable agriculture (focus: sustainable management of natural resources)" is related to water resources management.

Vision: Inclusive economic and social development based on fast, sustainable and inclusive growth of agricultural sector within the framework of integrated rural development to help, in particular, marginalized groups and alleviate rural poverty.

Mission Statement: Modernize the agricultural sector to achieve food security for all citizens and improve nutrition and standards of living of rural population, through improving the efficiency of resources use and capitalizing on the geographic comparative advantages of different agricultural regions.

Strategic Objectives:
1) Achieve food security and improved nutrition (to address undernourishment, food insecurity, achieve sustainable agriculture productivity growth, sustainable agriculture growth), focusing on decreasing the imports of agriculture products.
2) Enhance sustainable agriculture (focus: sustainable management of natural resources).
3) Eradicate poverty in rural areas, improve income and standards of living (focus: Upper Egypt).
4) Adapt to climate change and mitigate its impacts.
5) Increase the competitiveness of agricultural products in local and international markets (functioning and inclusive value chains – increase exports).
6) Create job opportunities for employment, especially for youth and women.

Updated SADS 2030 features "Provide absolute priority to the management of the limited and scarce water resources and their rational use in agriculture" as one of the key aspects of the action plan. This requires the expansion of modern irrigation technology to reduce the amount of water used in irrigation. Further, the SADS 2030 adopts this direction as one of the strategies for expanding the cultivated area and addressing the potential shortage in the Nile River water reaching Egypt. Accordingly, the SADS 2030 gives critical priority to the sustainable use of irrigation water through improving the management systems of water and irrigation networks, and also upscaling of the use of modern irrigation technologies.

The action plan provides 9 main programs and a number of national projects under each program. Among them, the national project of "1-1. The National Project on Land Reclamation" and "1-2. The National Project for the development of on-farm irrigation and rationalization of irrigation water use in agriculture" are proposed under the main program of "1. The National Sustainable Use of Agriculture Resource Program" (see Table 2.2.2)

Among the main expected results of those national projects, issues of the "on-farm irrigation development in Old Lands" of 1-1.(1), "Improvement and modernization of irrigation system" of 1-2.(3) and the "Equality in the distribution of irrigation water among farmers" of 1-2. (4) are very much correspondent to the purpose of the Project.

Table 2.2.2 National Projects Planned by MALR (1-1 and 1-2 only)

Name of National Program	1. The National Sustainable Use of Agriculture Resource Program
Name of National Project	**Main Expected Results**
1-1. The National Project on Land Reclamation	***(1)*** Expand the area of New Lands in desert areas, which is mostly depend on groundwater resources and ***the water expected to be saved from the on-farm irrigation development project in the Old Lands.*** (2) Increase per-capita share of land. (3) Update data for the newly reclaimed land in promising areas for horizontal expansion, and include them in an information system for reclaimed lands. (4) Maximize the return from other agricultural inputs and rationalize its use and environmental impact. (5) Reclamation and farming of 1.5 million feddan in various areas where the requirements of agriculture production are available (land, water, climate and human resources). (6) Development of Center and North Sinai (around 500,000 feddan), among which 128,000 feddan is already implemented, and the rest (372,000 feddan) is under study in Center and North Sinai to determine the arable lands and estimate the costof their reclamation and operation. (7) Generate about 2 million new job opportunities. (8) Identify the best land use in terms of cropping mix which is suitable for the soil characteristics and water quality.
1-2. The National Project for the development of on-	(1) Increase the cultivated area in the Nile Valley and Delta regions by around 160-200 thousand feddan, which is currently used in ditches, Marwas and Masqas (ditches).

farm irrigation and rationalization of irrigation water use in agriculture	(2) Improve land fertility and contribute to increase its productivity by 20-30%. ***(3) Improve the irrigation system in the old and New Lands to the improved and modernized irrigation system.*** ***(4) Achieve equity in the distribution of irrigation water among farmers.*** (5) Increase the productivity of land unit from 15 to 20% in the developed areas. (6) Raise the average income of small farmers by 15-20%. (7) Add financial capital (capitalization) to the agriculture land value as a result of the improvements. (8) Maintain and improve farmers' health by reducing the impacts of endemic diseases. (9) Contribute to the improvement and modernization of irrigation management (estimation of irrigation water requirements) at the national level. (10) Provide energy needed for irrigation. (11) Double agricultural mechanization rates and increase agricultural intensification rates from around 177% to 195% by 2030. (12) Increase investment opportunities for manufacturing equipment and advanced on-farm irrigation raw materials, and increase farmers' income. (13) Create enabling environment to stimulate commercial business and investment market.

Source: EGYPT 2030 Updated Sustainable Agriculture Development Strategy

According to the performance indicators of the Action Plan, the Plan targets the increase of the proportion of lands irrigated with modern irrigation methods, e.g., modernized surface, sprinkler, and drip irrigation, to around 31.7% by 2030 (see 1-1 in Table 2.2.3). In addition to this increase, on-farm irrigation efficiency, which is estimated at 50% at present, is targeted to increase to as high as 100% in 2030 (the targeted area is 2.2 million feddan) as indicated in 1-2 of the same table:

Table 2.2.3 Performance Indicators of National Projects Planned by MALR (1-1 and 1-2 only)

Project	Performance Indicators		
	Current Status	2025	2030
1-1. The National Project on Land Reclamation	- Reclamation of New Lands	1.5 million feddan	-
	- The ratio of agriculture exports to total good exports: 20 %	26%	30%
	- Creation of new job opportunities (the ratio of labor in the agriculture sector) 25 %	28%	30%
	- ***The ratio of lands irrigated using the advanced and modern irrigation methods (modernized surface irrigation, sprinkler, drip): 16.5 %***	***28.5%***	***31.7%***
1-2. The National Project for the development of on-farm irrigation and rationalization of irrigation water use in agriculture	- Increase the productivity by laser leveling	10-15%	-
	- Increase the productivity by sub-soiling deep tillage	10-15%	-
	- ***On-farm irrigation efficiency: 50 %***	***75%***	***100% (2.2 million feddan)***
	- Increase the land productivity by	20%	30%
	- Irrigation water savings	0.6 billion m^3	1 billion m^3
	- Increase the mean income for small farmers by	15%	20%
	- Agriculture intensification rates: 177 %	185%	195%

Source: EGYPT 2030 Updated Sustainable Agriculture Development Strategy

The updated SADS 2030 of MALR, hence, shares the goal of NWRP 2017, which is the efficient use of water resources. However, the emphasis in the updated SADS 2030 is put on the improvement of on-farm irrigation efficiency and improvement of crop varieties as the nature of MALR whose mandate does not include the operation and management of irrigation facilities. Accordingly, the role of improving irrigation efficiency at conveyance and distribution levels, namely improving irrigation structures and canals under the jurisdiction of MWRI, is left to MWRI.

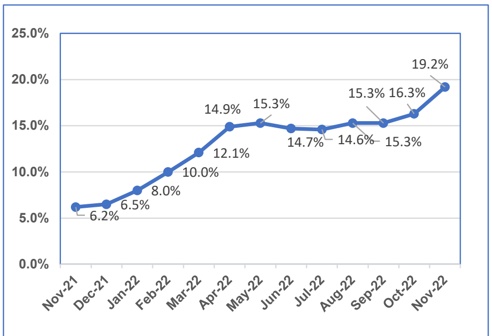


Figure 2.2.1 CPI in the Same Month of Previous Year in Egypt (Source: CAPMAS)

The war in Ukraine broke out in February 2022 and since March 2022, the consumer price index (CPI) of Egypt hiked from 12 to 19% compared to the same month of the previous year (Figure 2.2.1). Accordingly, the price of wheat flour, the main staple food of Egyptian people, has been risen. While 145kg per capita per year of wheat is consumed, Egypt is relying on around 60% of wheat from imports, out of which 85% would come from Russia and Ukraine[3]. The situation has threatened the food security of the country.

By the Black Sea Initiative, the grain export of Ukraine has been carried on albeit the amount of export declined by 30.8% of the previous year[4] and USA and EU carved out the grain and fertilizers from the sanction against Russia[5]. However, the international market prices of wheat, maize and chemical fertilizers have been risen and that may affect to the agricultural sector in Egypt.

The government of Egypt fixes the purchasing price of wheat from producers through state owned silos and raised the purchasing price from 5.5LE/kg in 2021 to 6.7EL/kg in 2022. Egypt is a fertilizer exporting country, but its domestic price would also be affected by the international market. Farmers can buy fertilizers with a subsidy from the government through the agricultural cooperative. However, as the amount of subsidized fertilizers is limited according to the size of farmland, farmers may have to buy additional fertilizers from the market, which may affect the decrease of fertilizer use by the farmers. The government's timely measures against the affect of international circumstances would be consistent with the achievement of the long-term vision of this strategy.

2.2.5 Nationwide On-going Project: Concrete Lining and Modern On-farm Irrigation

As of the year 2022, there are 2 nationwide on-going projects related to irrigation and agriculture development in Egypt. One is the introduction of concrete linings to, in principle, secondary canals, and the second one is the introduction of modern on-farm irrigation to Old Lands where there are clay and silty soils prevalent.

1) Introduction of Concrete Lining to Secondary Canals

It was decided in the year 2019 by the Government, and the implementation was started in 2020. The overall target is to introduce the concrete lining to a total of 20,000 km of secondary canals nationwide within 4 years till 2024. The lining is basically introduced to such secondary canals with the bed width of 6 m or less than that, which are operated under rotational irrigation. Lining work is conducted by taking advantage of the off-water period, usually 10-days off during the winter season and 5-days off during the summer season.

With the huge length of the lining work, there are 4 implementing organizations under MWRI, which are Irrigation Sector (IS), Irrigation Improvement Sector (IIS), Reservoirs and Grand Barrages Sector (RGBS) and Horizontal Expansion Project Sector (HEPS). The work allocation is 13,000 km by the IS, while the remaining 7,000 km by such 3 sectors of IIS, RGBS, and HEPS.

The target by year is 7,000 km for the first 2 years of 2020/21 (1st July 2020 - 30th June 2021) and 2021/22 (1st July 2021 - 30th June 2022) with a cost of 17.5 billion LE (910 million US$[6]), and 1,200 km for the year of 2022/23 (1st July 2022 - 30th June 2023) with a cost of 4 billion LE (208 million US$). On the other hand, the actual achievement from the commencement of the concrete lining till the end of July 2022 has arrived at 5,615 km, equivalent to around 80% of the first 2 years' target, and as of August 2022, a total of 4,210 km lining is under construction.

The unit cost per km comes to 2.5 million LE (130,000 US$) per km for the years of 2020/21 - 2021/22, and 3.3 million LE (173,333 US$) for the year of 2022/23 (1st July 2022 - 30th June 2023). With the latest unit price of 3.3 million LE (173,300 US$), total lining cost for the total target of 20,000 km could be around 66 billion LE (3.5 billion US$). As of year 2021, the Egyptian government intended to proceed

[3] Egypt: Impacts of the Ukraine and Global Crises on Poverty and Food Security, IFPRI Aug. 2022
[4] https://www.cnn.co.jp/world/35196253.html, (Access 18th Dec. 2022)
[5] How sanctions on Russia and Belarus are impacting exports of agricultural products and Fertilizer, IFPRI Nov. 9, 2022
[6] Exchange rate of 1 LE = 0.052 US$ was applied as of August 2022.

with this concrete lining works with the national budget. However, sine 2022, the government budget has become very tight due to the Ukraine crisis and also worldwide high inflation. As a result, it is becoming increasingly difficult to secure government budget for future implementation of the concrete lining.

2) Introduction of Modern On-farm Irrigation

This program was considered together with the above concrete lining. As the introduction of modern on-farm irrigation to farmland needs farmers' consent, which may take time, the concrete lining of secondary canals was first started and the modern on-farm irrigation was officially decided to start in August 2021[7]. The overall target is to introduce the modern on-farm irrigation, sprinkler and/or drip irrigation, over to as large area as 4 million feddans of Old Lands. The Government wishes to complete such huge coverage work within 4 years, and this program is implemented by 2 ministries of MWRI and MALR.

As of September 2022, the work demarcation by the ministry is that the modern on-farm irrigation is introduced to Beni Suef Governorate by MALR and Qalyubia Governorate by MWRI as the first batch of the work (other governorates not yet decided). The unit cost for the introduction of modern on-farm irrigation could be around 30,000 LE/feddan to 50,000 LE/feddans. With this unit cost, the total project cost could arrive at 120 billion LE to 200 billion LE, equivalent to 6.2 billion LE to 10.4 billion US$.

2.3 Executing and Related Organizations

2.3.1 The Ministry of Water Resources and Irrigation (MWRI)

The Ministry of Water Resource and Irrigation (MWRI) is the executive authority in Egypt for water resource development and the public works concerning irrigation and drainage, e.g., survey for water resources development, management of water resources, planning and designing of irrigation and drainage facilities, and construction supervision and the maintenance & management of those facilities. MWRI consists of 8 subordinate organizations, and these units of subordinate organization are designated as "Affairs", "Public Authority", "Department", and "Center" owing to the function of the organizations (refer to Figure 2.3.1).

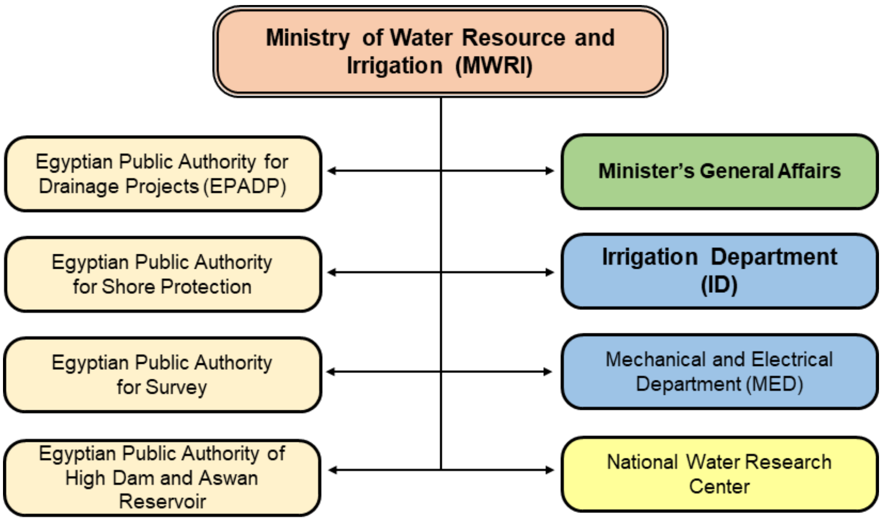


Figure 2.3.1 Organization of Ministry of Water Resource and Irrigation (MWRI)
Source; MWRI Home Page

Irrigation Department (ID), one of the core subordinate organizations of MWRI, is the implementing

[7] Since the introduction of modern on-farm irrigation facilities requires a large budget, a Joint Cooperation Protocol was signed on August 5, 2021 by the Ministry of Finance, NBE, ABE, and MWRI and MALR. The title of the document is "National Initiative for the Irrigation Improvement and the Transition to Modern Irrigation," and it provides that the Ministry of Finance will provide NBE and ABE with funds for the introduction of modern on-farm irrigation facilities, and that the farmers will receive loans from both banks. Subsequently, the Ministry of Water Resources and Irrigation decided to introduce modern on-farm irrigation facilities in the Ministerial Decree No. 143 (2022), dated May 9, 2022.

agency of this Project. In fact, the ID is in charge of survey, development, maintenance and management for the whole irrigation and drainage systems in Egypt. The ID has a total of 6 sectors, 1 central directorate, and 9 general directorates (refer to Figure 2.3.2). Among them, the Irrigation Affairs Sector, or usually called Irrigation Sector (IS), is directly related to the Project implementation together with the Irrigation Improvement Sector (IIS) and also Reservoir and Grand Barrages Sector (RGBS).

The Irrigation Affairs Sector has 2 central directorates and 3 general directorates at its head-office. Further, there are regional offices called the General Directorate of Water Resources and Irrigation directly under the Irrigation Affairs Sector. There are 29 regional offices of General Directorate of Water Resources and Irrigation nationwide, which are to be the responsible organization of the Project at the regional level.

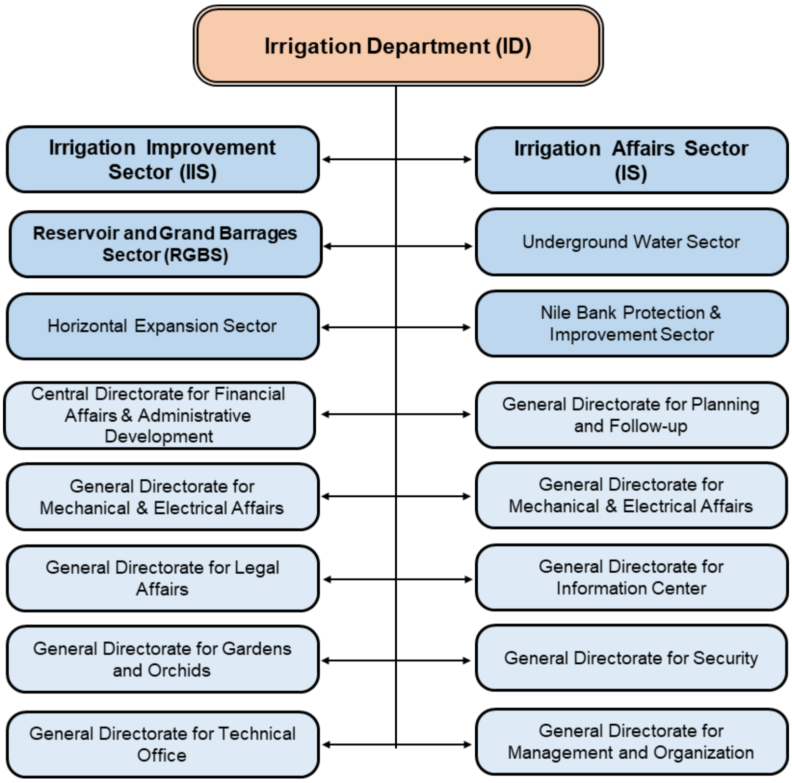


Figure 2.3.2 Organization of Irrigation Department (ID)
Source; MWRI Home Page

In addition to IS, IIS is also comparative to implement the Project in the field of dealing with beneficiary farmers, e.g., establishment of Water Users' Associations to be in charge of operating and managing modern on-farm irrigation systems. The IIS is composed of 2 main central directorates, each of which has regional offices, called General Directorate of either Irrigation Improvement or Irrigation Advisory Services respectively.

Reservoir and Grand Barrages Sector (RGBS) is in charge of only the large-scale regulators of Kased Intake, Mahlet Menouf and Sorad Regulators, all of which are within the Kased Command Area, Gharbia and Kafr El Sheikh Governorates. RGBS has accumulated many project experiences for large-scale regulator and barrage construction, including Dirout Group Regulators which is under construction with Yen loan assistance as of 2023. RGBS does not deploy regional offices but there are operation offices attached to large-scale barrages, e.g., Assuit Barrage, Delta Barrage, etc.

2.3.2 The Ministry of Agriculture and Land Reclamation (MALR)

The Ministry of Agriculture and Land Reform (MALR) consists of eight administrative sectors, namely Authorities Sector and Minister's Affairs, Economic Affairs Sector, Agricultural Extension Sector (AES), Agricultural Services and Follow-up Sector (ASFS), Land Reclamation Sector, Animal Production Development Sector, Agricultural Mechanization Sector (AMS) and Financial Affairs and Administrative Development Sector (refer to Figure 2.3.3).

AMS has received Japan's Grant Aid for the establishment of agricultural mechanization centers and 2KR for agricultural machines. Japan's technical cooperation project, "Improving Small-scale Farmers' Market-oriented Agriculture Project (ISMAP)" was implemented with ASFS as the counterpart agency.

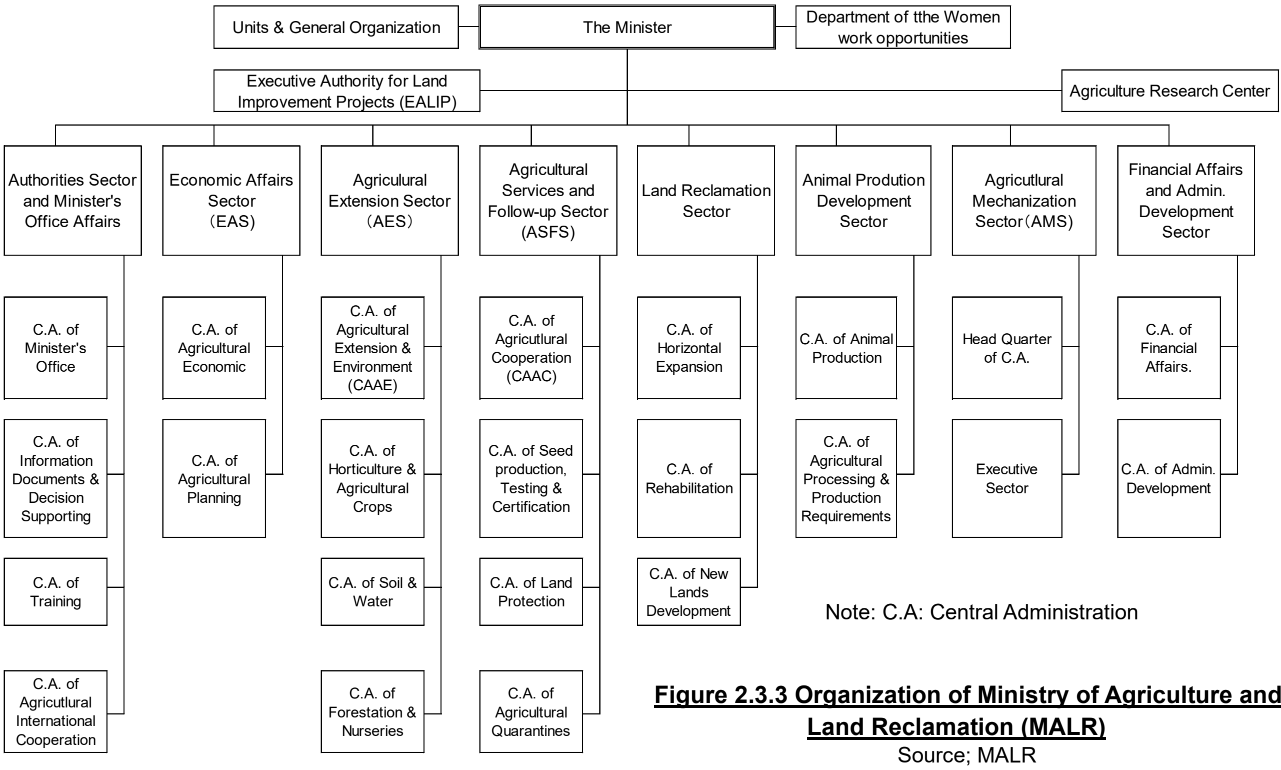


Figure 2.3.3 Organization of Ministry of Agriculture and Land Reclamation (MALR)

Source; MALR

In addition to the sectors, there are authorities and centers under the administration of MALR. As the major authority, the Agricultural Research Center (ARC) has been in place covering research from agricultural inputs to post-harvest. Executive Authority for Land Improvement Projects (EALIP) is in charge of land and on-farm irrigation improvement. EALIP has been implementing land reclamation, land consolidation, soil improvement, on-farm irrigation improvement, etc. Development partners such as IFAD and GIZ have implemented on-farm irrigation improvement with EALIP as the counterpart agency. Extension of agricultural techniques including irrigation methods are the responsibility of AES and it has carried out its activity in collaboration with ARC and EALIP.

Village agricultural cooperatives have been organized in all the villages of Egypt supervised by the Central Administration for Agricultural Cooperation under ASFS. By the 1970s, the socialistic policy had been adopted by the Egyptian government, and thus the village agricultural cooperative had functioned as the terminal administrative body to control the agriculture sector including the selection of crops and marketing, distribution of agricultural inputs and administration of farmlands.

Under such control by the 1970s, farmers had lost their incentive to increase the production and it resulted in stagnant agricultural production. Hence, the government turned the policy towards liberalization since the late 1970s. After the policy change, farmers became free to choose crops to cultivate, and the marketing of agricultural produce was also liberalized except for wheat[8].

Due to the policy change, the administrative role of the agricultural cooperative has been reduced to selling subsidized chemical fertilizers to the farmer members of the cooperative and farmland administration. Agricultural Cooperative Law (No.122) was enforced in 1980, based on which the agricultural cooperative was defined as an entity able to run agribusiness for the farmer members. However, there is still a limited number of cooperatives, which actually runs businesses. The data on annual cultivated areas and productions of the agricultural produce are collected by the village agricultural cooperative, then consolidated as the national annual agricultural statistics.

[8] Government owned companies have been purchasing wheat exclusively even as at now. Since the government sets the producer's price higher than the retail price, farmers can enjoy such subsidy to sell the produce to the government.

CHAPTER 3 THE PROJECT AREA

This chapter summarizes the Project area [1] from the viewpoints of, e.g., location, population, meteorology and hydrology, agriculture including farm economic survey result as well as rural society's situation, and irrigation and drainage systems. In addition to those issues, also summarized are the actual cropped area detected by satellite image analysis, and irrigation efficiencies estimated based on the satellite image analyzed cropped area and actual discharge data measured at the major regulators along the Bahr Yusef and Ibrahimia Principal Canals.

3.1 Salient Features of the Project Area

3.1.1 Selection of the Priority Sub-regions

The three priority sub-regions in this survey, namely Abo Shosha, Aros & Abo Seer and Kased have been selected from the 15 priority sites identified from the previous survey [2] and approved at the Steering Committee meeting on presenting the Inception Report of this survey on 13th July 2021 (for the location, see the Location Map at the beginning of this Report). The 15 sites in the previous survey were selected by the five criteria, water scarcity, command area size, structure distribution per area, ratio of the existence of Branch Canal Water Users' Association (BCWUA), and the policy of MWRI. As a result, 8 and 6 sites under Bahr Yusef and Ibrahimia Principal Canals respectively, and Kased Main Canal were selected.

Among the 15 sites, Kased has been selected as it is the only candidate from the delta region and all the branch canals under Kased Main Canal have BCWUA. From these points of view, Kased was considered as a model region for the irrigation improvement in the delta. As for the remaining two sub-regions, It was decided to select one each from Bahr Yusef and Ibrahimia Principal Canals, especially, the regions located in the lower reaches of the canals, namely Fayoum and Beni Suef Governorates.

These two regions were also taken into account to serve as a pilot, so that the regions can demonstrate the project effects as early as possible and therefore, the middle-size of the command area was considered. From Fayoum Governorate, Aros & Abo Seer has been selected as the region has more information than other regions. Abo Shosha has been selected as the worst situation of the structures and canals in the regions under Ibrahimia.

3.1.2 Spatial Settings

Egypt is divided into four major regions: i) the Nile Valley and Nile Delta, ii) the Western Desert, iii) the Eastern Desert, and iv) the Sinai Peninsula. The Project area belongs to i) the Nile Valley and the Nile Delta. The irrigated areas by the Bahr Yusef and Ibrahimia Principal Canals running through the Minya, Beni Suef and Fayoum Governorates in the Upper Egypt are the areas where people live in the river valleys formed along the Nile River upstream before Cairo.

The Nile River branches off into the Rosetta and Damietta Branches downstream after Cairo, forming the Nile Delta, and flows out to the Mediterranean Sea. The Nile Delta stretches 240 km from east to west, and the area between the Rosetta Branch in the west and the Damietta Branch in the east is called the Central Delta. The irrigated area by the Kased Main Canal running in the Gharbia and Kafr El Sheik Governorates is located in this Central Delta area. The irrigated areas in the Central Delta are formed with alluvial soils formed by the Nile River, thereby spreading over very flat terrain.

3.1.3 Area, Population and Beneficiaries

The information of farmland and beneficiaries for the Project area has been collected from the village

[1] The Project area in this report indicates the governorates in which the priority sub-regions and target canals are situated.

[2] Cooperation Planning Survey on The Irrigation Sector (Upper Egypt and Middle Delta) in The Arab Republic of Egypt, Final Report, Feb. 2018, JICA

agricultural cooperative located in such 3 priority sub-regions as Abo Shosha, Aros & Abo Seer and Kased, and farm economy survey carried out by the JICA Survey Team. In Egypt, villages are formed with mother villages and their hamlets. In each mother village, a village agricultural cooperative has been established by the Government and all the landowners in the village are registered at the cooperative as its member. As some landowners rent out their farmlands, the number of cultivators is different from that of the landowners. Yet, due to lack of the statistics on the land rent, the number of landowners is taken as the proxy of the number of beneficiaries.

Furthermore, farmlands covered by the village agricultural cooperatives do not always overlap with the service area of the main canals of the sub-regions, as the boundary of the village does not match with the service area of a canal. With such condition, the number of the villages whose farmlands are irrigated mostly from the main canal and branch canals of the priority sub-regions are 14, 10 and 34 in Abo Shosha, Aros & Abo Seer and Kased[3] respectively. Table 3.1.1 summarizes the land profile data provided from the village agricultural cooperatives in those villages:

Table 3.1.1 The Number of Landowners by Landholding Size in the Priority Sub-regions

Sub-region		Abo Shosha (Beni Suef)		Aros & Abo Seer (Fayoum)		Kased (Gharbia)	
No. of Village		14	-	10	-	34	-
Farmland by Village Cooperative (fed)		18,447	-	14,694	-	32,214	-
No. of Landowners by size (fed)	Total	17,032	-	11,324		39,056	-
	<1	9,795	57.50%	7,041	62.20%	25,782	66.00%
	1<2	3,596	21.10%	2,075	18.30%	7,079	18.10%
	2<3	2,009	11.80%	1,135	10.00%	2,977	7.60%
	3<4	592	3.50%	418	3.70%	1,841	4.70%
	4<5	418	2.50%	295	2.60%	865	2.20%
	5<	622	3.70%	360	3.20%	512	1.30%
Ave. Landholding (fed/HH)		**1.08**		**1.3**		**0.82**	

Source: Agricultural Directorates in Gharbia, Beni Suef and Fayoum, Ministry of Agriculture and Land Reclamation

Distribution of landowners by land holding size shows that the majority of the landholders are small-scale, as the shares of landholder with less than one feddan (0.42ha) are 57.5%, 62.2% and 66.0% in Abo Shosha, Aros & Abo Seer and Kased respectively, while landowners with more than 5 feddan (2.1 ha) are merely 3.7%, 3.2% and 1.3% of the total landholders. There is no data on the land rent, but there are significant number of farmers who are renting land, e.g., from family members/ relatives and consolidate them for cultivation. In such a way, farmers are trying to enlarge their cultivation areas.

The number of beneficiary households is estimated from the irrigated area in each priority sub-region (see Table 4.1.8), as in Section 4.1.2 of Chapter 4, and the average farmland per household in each sub-region is shown in the above Table 3.1.1. The irrigated area in each priority area is 17,881 feddan, 13,330 feddan, and 95,976 feddan in Abo Shosha, Aros & Abo Seer, and Kased sub-region, respectively, as shown in the 2nd left column of the table below. The average area of farmland per household is as small as 1.08 feddan (0.45 ha)/HH, 1.30 feddan (0.55 ha)/HH, and 0.82 feddan (0.34 ha)/HH in Abo Shosha, Aros & Abo Seer, and Kased Districts, respectively (see Table 3.1.1).

Thus, the number of beneficiary households in Abo Shosha, Aros & Abo Seer, and Kased sub-regions are 16,600, 10,300, and 117,000 households, respectively, for a total of 143,900 households in the three priority sub-regions. Using the average number of household members in each sub-region from the Farm Household Economic Survey (refer to Table 3.4.3 in Chapter 3), the number of beneficiaries in Abo Shosha, Aros & Abo Seer and Kased sub-regions is estimated at 101,260, 58,710 and 538,200, respectively. The total number of beneficiaries in the Aros & Abo Seer and Kased sub-regions is estimated at 698,170.

[3] For the Kased Main Canal, 34 villages do not cover the branch canals in the Kafr El Shake Governorate.

Table 3.1.2 Estimated Number of Beneficiaries in the Priority Sub-regions

Sub-region	Service Area (fed) (a)	Ave. Landholding (fed/HH) (b)	No. of Households (c)=a/b	Ave. No. per Household (d)	Estimated Beneficiaries (e)=cxd
Abo Shosha	17,881	1.08	16,600	6.1	101,260
Aros & Abo Seer	13,330	1.30	10,300	5.7	58,710
Kased	95,976	0.82	117,000	4.6	538,200
Total	**127,187**	**0.88**	**143,900**	**4.9**	**698,170**

Sources: (a): Table 4.1.8, (b): Table 3.1.1, (d): Table 3.9.3.

3.1.4 Meteorology: Temperature, Rainfall and Humidity

Climate of the Project Area is classified as the desert climate type. Climate seasons are divided into mainly two in a year: the mild winter season from November to April and the hot summer season from May to October. The average monthly maximum temperatures of the three governorates of Upper Egypt recorded in 2020 range from 19.5 ℃ in January to as high as 39.8 ℃ in July, while the average monthly maximum temperatures of Gharbia Governorate in Central Nile Delta range from 19.5 ℃ in January to 35.4 ℃ in June, all showing the same trend (see Table 3.1.3).

Table 3.1.3 Average Monthly Maximum Temperatures of the Project Area in 2020 (Unit: ℃)

Governorate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
Upper Egypt													
Fayoum	**21.3**	22.6	25.6	28.7	33.9	38.9	**39.8**	38.5	37.8	36.1	29.0	24.1	31.4
Beni Suef	**19.5**	23.7	24.9	26.4	34.7	**38.6**	38.3	37.1	33.7	32.4	28.3	23.2	30.1
Minya	**20.5**	23.4	23.2	27.3	35.0	37.6	**39.7**	38.3	36.4	33.6	28.6	21.7	30.4
Central Delta													
Gharbia	**19.5**	23.5	23.0	26.9	33.5	**35.4**	32.5	34.7	33.9	29.0	27.4	**19.5**	28.2

Note: Lowest and highest average monthly temperature are shown in bold in the table.
Source: Statistical Yearbook 2021

Rainfall of the Project Area is ultimately low throughout a year. Annual rainfalls of the governorates in the Project Area are 65.9 mm in Fayoum Governorate, 47.6 mm in Beni Suef Governorate, 12.6 mm in Minya Governorate and 85.7 mm in Gharbia Governorate, respectively. The rain falls mostly during the period from the winter to the beginning of summer, e.g., January to March in the Upper Egypt while from October to the early following year in the Central Delta (see Table 3.1.4).

Table 3.1.4 Average Monthly Rainfalls of the Project Area in 2020 (Unit: mm)

Governorate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Upper Egypt													
Fayoum	0	10.9	54.9	0	0	0	0	0	0	0	0.1	0	65.9
Beni Suef	1.1	2.3	44.2	0	0	0	0	0	0	0	0	0	47.6
Minya	0	0.8	11.8	0	0	0	0	0	0	0	0	0	12.6
Central Delta													
Gharbia	3.5	5.0	45.9	1.0	0	0	0	0	0	22.0	0	8.3	85.7

Source: Statistical Yearbook 2021

Humidity of the Project Area appears to be high in summer and low in winter. The period between April and June is the driest season in a year. There is around 6 % deference in the annual average monthly humidity between Upper Egypt (54 %) and Central Nile Delta (60%) as indicated in the 2020 year's monthly humidity records (see Table 3.1.5). Thus, the climate of Upper Egypt is drier than the that of Central Nile Delta.

Table 3.1.5 Average Monthly Humidity of the Project Area in 2020 (Unit: %)

Governorate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
Upper Egypt													
Fayoum	-	-	-	-	-	-	-	-	-	-	-	-	-
Beni Suef	58	54	54	54	**43**	53	52	53	58	56	55	**59**	54
Minya	**60**	59	57	53	**43**	45	53	49	53	55	56	**60**	54
Central Delta													
Gharbia	**52**	61	61	57	56	56	61	63	61	62	**66**	63	60

Note: Lowest and highest average monthly humidity are shown in bold in the table.
Source: Statistical Yearbook 2021

3.1.5 Hydrology and Water Available for Irrigation

The Nile is a gently flowing river with a gradient of about 1/12,000 in Upper Egypt and about 1/14,000 in the Nile Delta. The gradient of the main canals and branch canals in the Project area is also relatively small and therefore, its flow velocity is small. Small flow velocity leads, in general, to a sedimentation of silts and crays much in canals. However, the Aswan Dam constructed in 1902 and the Aswan High Dam commissioned in 1970 once store the flow of the Nile River, discharging less silts and clay contained flow to the downstream including canals. However, sedimentation in the canals can be found due to wind flown sands from the deserts especially in Upper Egypt.

Based on the water use agreement between Egypt and Sudan, annual water intake from the Nile River available for Egypt is designated at 55.5 billion CUM in a year. Out of the 55.5 billion CUM, it is estimated that 5 billion CUM is allocated to the Bahr Yusef Canal, and 3.6 billion CUM to the Ibrahimia Canal (source: NWRP 2017). Bahr Yusef Canal irrigates the farmlands in Fayoum Governorate at the end of the canal, for which 2.6 billion CUM including 0.2 billion CUM for domestic use is allocated out of the 5 billion CUM. On the other hand, Kased Canal is estimated to take an annual amount of 0.6 billion CUM, though there are not regular discharge records[4].

Discharge data recorded at major regulators of Bahr Yusef and Ibrahimia Principal Canals covering the period of the year 1999 to 2020 were availed to the JICA Survey Team. Figures 3.1.1 and 3.1.2 show the monthly discharge and annual discharge at the intake of the Bahr Yusef Principal Canal. As is indicated, the discharge comes to the lowest in January, which is basically canal closure period for maintenance, and starts increasing toward the summer season peaking in July and August. After that, the discharge starts descending. During the peak periods of July and August, the monthly discharge comes to around 470 - 570 MCM per month.

Annual discharge, as shown in Figure 3.1.2, had been increasing once in the late 2000s, and started decreasing after that. In the late 2000s, the annual discharge ranges from around 4,100 MCM to 4,500 MCM. The average discharge for the period of 1999 to 2020 comes to 4,774 MCM per annum, which is very close to the allocated amount of 5 billion CUM.

[4] Cooperation Planning Survey on the Irrigation Sector (Upper Egypt and Middle Delta) in the Arab Republic of Egypt, Final Report (JICA, 2018).

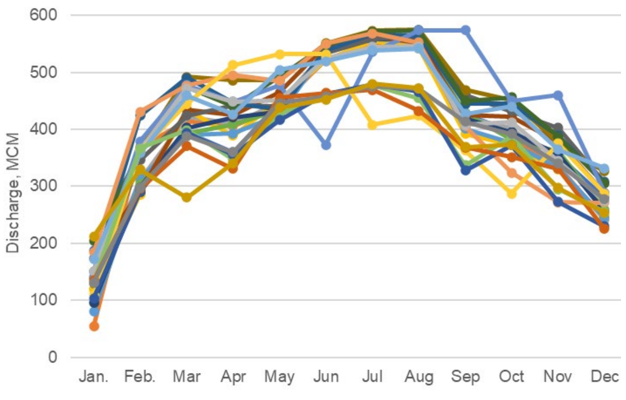


Figure 3.1.1 Monthly Basis Discharge for Bahr Yusef Canal

Source: Irrigation Sector, ID

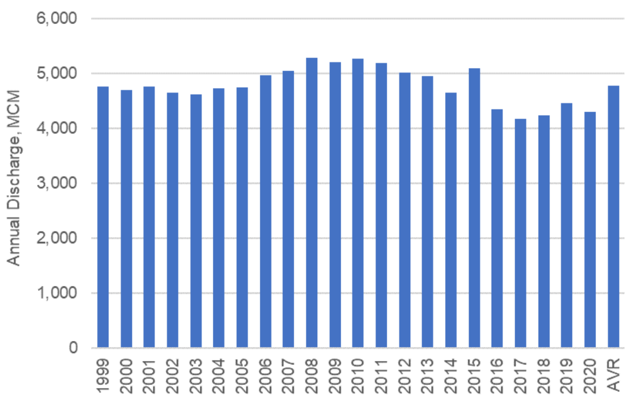


Figure 3.1.2 Annual Discharge for Bahr Yusef Canal

Source: Irrigation Sector, ID

Figures 3.1.3 and 3.1.4 show the monthly basis discharge and annual discharge at the intake of the Ibrahimia Principal Canal on the Dirout Group of Regulators. The overall trend of the discharge is almost the same as that of Bahr Yusef, peaking in July at around 400 - 500 MCM per month. Annual discharge, as shown in Figure 3.1.4, may have been on a decreasing trend with some exceptional years, i.e. years of 2007 and 2008. The average annual discharge is 3,851 MCM, which exceeds the allocated water volume of 3.6 billion CUM slightly.

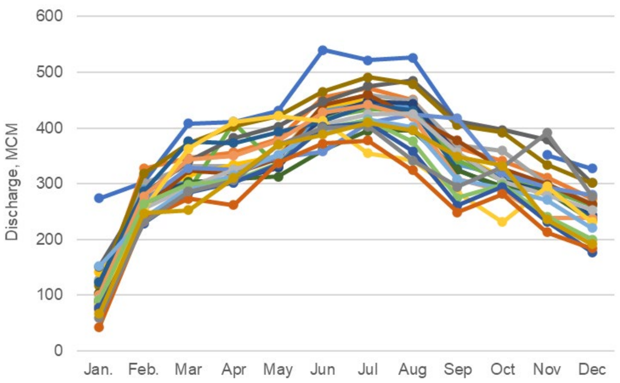


Figure 3.1.3 Monthly Basis Discharge for Ibrahimia Canal

Source: Irrigation Sector, ID

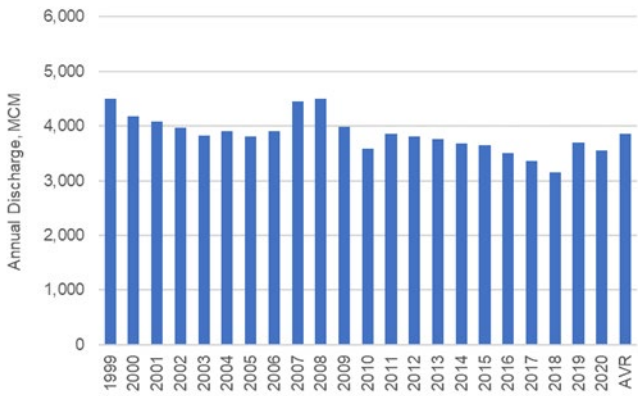


Figure 3.1.4 Annual Discharge for Ibrahimia Canal

Source: Irrigation Sector, ID

3.1.6 Social Situations

1) Form of Inhabitancy

Rural areas in Egypt lie on vast very flat farmlands. Nucleated settlements form villages on a relatively high land on such flatlands. The territory of the villages has been expanding due to population increase and especially they are extended along the canals to easily access to water. According to the Egypt Population Census 2017, the average family sizes in the governorates where the Project Area is located are 3.87, 4.32 and 4.41 in Gharbia, Beni Suef and Fayoum respectively, while several families of relatives opt to share a building with three stories or above, constructed with concrete pillars and brick walls. In general, the ground floor is used as cowshed and roof for poultry raising.

2) Health and Medical Care

Egypt has provided healthcare services free of charge, which has improved the access of the people to healthcare services. On the other hand, the quality of healthcare services declined due to a budget shortage, the lack of medicines at medical facilities, and the low salary of healthcare workers. From 1997, the health sector reform program has been promoted with e.g. the introduction of the Family Health Model (FHM), which is the registration system for the family unit, and it partially contributed to improving the equity, efficiency, and quality of healthcare services. Challenges are reported to establish a sustainable health insurance system and so on[5].

The following table summarizes health indicators available by the governorate from the most recently carried out national sample survey, the Demographic Health Survey (DHS) in 2014. The indicators show the tendency of worse status in Beni Suef and Minya for such as the under five years old mortality rate (to 1000 birth), and antenatal / postnatal care of pregnant women compared to the national average. On the question for ever-married women aged 15-49 reporting serious problem to access health care when they are sick, many of them addressed the concern on no availability of drugs and health providers and significant point is the high ratio of women raising the problem of getting permission to go for treatment in Beni Suef and Minya, where it is said conservative culture is still strong in the Upper Egypt. The ratio of infant to have taken immunization is higher than the national average except for Giza.

Table 3.1.6 Some Health Indicators in the Project Area

Region	Upper Egypt				Delta	National
Governorate	Giza	Beni Suef	Fayoum	Minya	Gharbia	
Under-five years old mortality (to 1,000 birth)	25	43	25	42	29	27
% of mothers who had regular antenatal care prior to the last birth	79.6	74.8	75.6	70.2	83.3	82.8
% receiving postnatal care from skilled provider within the days of delivery	90.3	71.7	63.2	62.8	89.5	81.5
% of ever-married women age 15-49 reporting serious problem to access health care when they are sick						
Get permission to go for treatment	1.7	15.4	5.1	23.9	3.3	7.3
Get money for treatment	12.2	14.9	6.9	21.1	8.4	10.5
Distance to health facility	21.9	20.9	16.0	25.9	14.9	18.2
Have to take transport	25.8	22.2	16.5	31.8	19.0	20.9
Not wanting to go alone	41.0	35.5	29.1	47.5	21.7	31.3
Concern no female provider available	37.2	28.2	32.1	52.7	30.4	28.9
Concern no health provider available	53.8	41.1	51.2	65.7	57.2	47.5
Concern no drugs available	63.0	45.7	58.5	65.5	58.8	54.0
% of children age 18-29 months fully immunized (BCG, measles, DPT and polio)	87.5	91.8	96.8	92.0	91.4	91.0
Anemia in ever-married women age 15-49	25.3	45.1	23.9	52.7	19.8	25.2

Source: Demographic Health Survey (2014) , Ministry of Health and Population (funded by USAID, UNICEF and UNEFPA) Egypt Demographic and Health Survey 2014 [FR302] (unicef.org)

3) Water and Sanitation Status

The access to safe drinking water has been significantly improving for the last few decades in Egypt. In 2014, around 91% of total population in Egypt have been able to have piped water supply in their homes. In 2017, the share of the population who can access to safe drinking water reached 98% (98% in rural areas and 99% in urban areas), Those who have hygiene latrine (with slab floor) reached 97% (95% in rural areas and 99% in urban areas), and the families who use both water and soap reached 88% (85% in rural areas and 92% in urban areas) [6].

Table 3.1.7 Coverage of Sewerage (2021)

Governorate	Coverage of Sewerage (%)
Giza	73.70
Beni Suef	38.73
Fayoum	49.63
Minya	25.88
Gharbia	73.03
National	61.30

Source: Egypt Holding Company for Water and Wastewater (HCWW)

On the other hand, the coverage of sewerage system has been almost done for urban areas, but the coverage in the rural areas is still so low that the national average coverage of sewerage system remains at 61.3% in 2021. Table 3.1.7 shows that the coverage of sewerage system in the Project Area ranges from 25 to 73%. The governorate with large governorate

[5] Health Sector Cooperation Planning Survey in Arab Republic of Egypt Final Report, JICA (2017) P3 https://libopac.jica.go.jp/search/detail?rowIndex=20&method=detail&bibId=1000030570

[6] Source: UNICEF/WHO, Joint Monitoring Program (JMP), 2017 WHOUNICEF-Joint-Monitoring-Program-for-Water-Supply-Sanitation-and-Hygiene-JMP-–-2017_ENG.pdf (unwater.org)

capital like Giza and Gharbia (Tanta city) shows higher coverage. Houses without connection to the sewerage are usually equipped with an individual septic tank and honey wagon to collect the sewage. There are houses discharging the sewage water directly to drains.

According to the DHS (2014), households, who were observed to have hand washing facility with water and soap, count 93.3%, 82.0%, 73.4% and 73.5% in Giza, Beni Suef, Fayoum and Minya respectively. It counts 95.5% in Gharbia, and the national average is 89.7%. In this case, also the governorates having big cities show higher rates and the rates of Beni Suef, Fayoum and Minya are lower than the national average. In the rural area, some people are still washing clothes and dishes in the canal water.

4) Education

According to the Population Census 2017, the illiterate rate of more than 10 years old counts 25.8% (21.1% for males and 30.8% for females). The illiterate rates of Beni Suef and Fayoum, in which the priority sub-regions are located, are 35.9% and 34.0% respectively, higher than the national average. On the other hand. The rate for the Gharbia Governorate in the Delta is 21.4%, better than the national average. As the result of the year 2006 Census showed a national average of the illiterate rate of 30.1% (22.8% for males and 37.6% for females), the nationwide literacy has improved between the two censuses for both sexes.

Dropout rates of 4 years old and above in 2017 count 7.28% (7.58% for male and 6.97% for female) at national average. The rates of Beni Suef and Fayoum are lower than the national average, while the one for Gharbia is higher than that except for female. In general, the dropout rate for female is lower than male, which may have contributed to improving the literacy of women. Public school enrollment is free of charge in Egypt by the way up to university.

Table 3.1.8 Illiterate Rate and Dropout Rate of Basic Education in the Project Area

Region	Governorate	Illiterate (%) (from 10 years old and above)			Dropout on basic education (%) (from 4 years old and above)		
		Male	Female	Total	Male	Female	Total
Upper Egypt	Giza	20.5	29.6	24.9	6.74	7.88	7.28
	Beni Suef	28.6	43.7	35.9	7.61	6.21	6.93
	Fayoum	28.5	40.0	34.0	6.92	6.73	6.83
	Minya	29.5	45.4	37.2	5.77	4.98	5.39
Delta	Gharbia	17.1	25.9	21.4	9.02	6.59	7.83
National		21.1	30.8	25.8	7.58	6.97	7.28

Source: Statistical Yearbook 2021 (Results of the Population Census 2017)

5) Other Infrastructure

Electrification in Egypt has been prevalent as almost 100% not only in urban areas but also rural areas. As for the road status, 94% of the roads have been paved in all over Egypt. Even in the Project area, the paved roads cover as high as 97 to 98%. The road density is around 2.3 to 2.9 km/km^2 except for Giza, many part of which are in urban areas. In the Project area, farmlands are widely spread and hence the road density is lower than the national average.

Table 3.1.9 Ratio of Paved Road in the Project Area

Region	Governorate	Road Length (km)			Arable Land (km^2)	Road Density (km/km^2)(*)
		Total	Paved	Unpaved		
Upper Egypt	Giza	7,228	7,094 (98%)	134 (2%)	1,406.3	5.1
	Beni Suef	3,729	3,670 (98%)	59 (2%)	1,357.8	2.7
	Fayoum	4,174	4,048 (97%)	126 (3%)	1,853.6	2.3
	Minya	6,649	6,477 (97%)	172 (3%)	2.449.9	2.7
Delta	Gharbia	5,339	5,260 (98%)	79 (2%)	1,872.5	2.9
National		193,841	182,949 (94%)	10,892 (6%)	42,800.1	4.5

Note (*): Roads are run in the desert land, as well. Therefore, the density calculated by the arable land becomes higher than actual density.
Source: Statistical Yearbook 2021 (as of 30th June 2019)

3.1.7 Poverty Situation

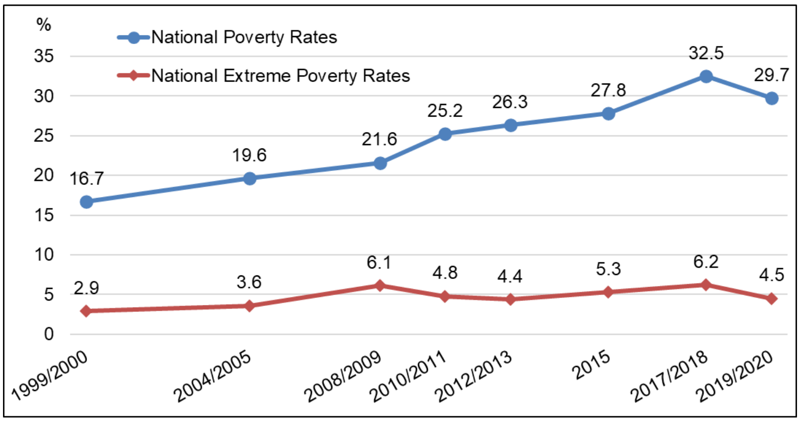


Figure 3.1.5 Trends of Poverty Rates and Extreme Poverty Rates in Egypt
Source: CAPMAS (2020) *Income & Expenditure Search 2019-2020*

Since there are no published statistical data on poverty specific to the project area, the following discussion of the poverty situation focuses on the entire country of Egypt and also rural and urban areas. Egypt's national poverty rate in 2019/2020 was 29.7%, according to the Income & Expenditure Search conducted by Central Agency for Public Mobilization and Statistics (CAPMAS) [7]. Figure 3.1.5 depicts trends of percentages of population below the national poverty line as well as national extreme poverty line from 1999 to 2020 [8]. Although certain improvements can be identified from 2017/2018 to 2019/2020 possibly because of structural reforms and social protection measures[9], overall trends for the last 20 years have been the expansion of poverty.

With the increasing population and remaining high population growth rates (see Figure 3.1.6), very large number of people have to live under severe economic conditions. It is estimated that as of 2019/2020, about 30 million Egyptian were under national poverty line.

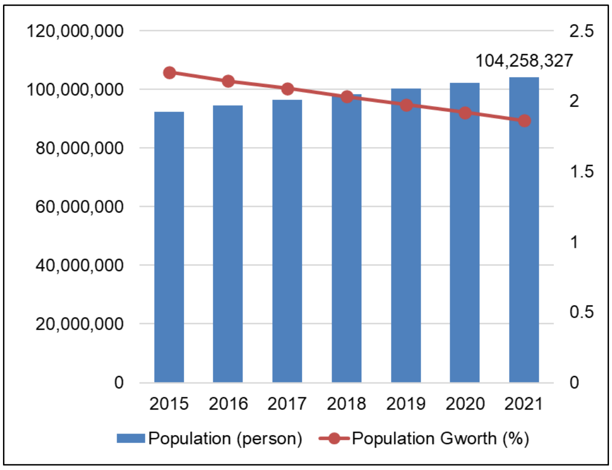


Figure 3.1.6 Population & its Growth in Egypt
Source: World Development Indicators

Egypt has faced disparities and imbalances in the level of development between different regions for a long time[10]. Figure 3.1.7 shows trends of poverty rates by different areas. Generally, economic situations in urban areas are better than rural areas, and people in Upper Egypt are poorer than those in Lower Egypt. It is obviously identified that Rural Upper Egypt is the most disadvantaged area, and roughly half of the population living there

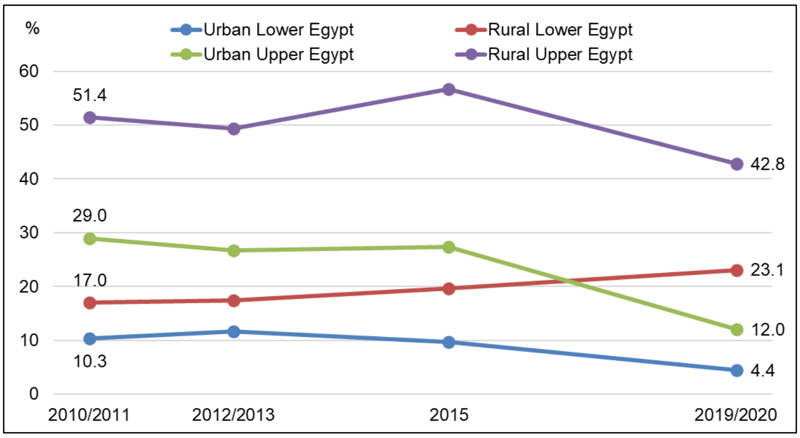


Figure 3.1.7 Trends of Poverty Rates by Areas
Source: CAPMAS (2020) *Income & Expenditure Search 2019-2020*

[7] https://www.capmas.gov.eg/HomePage.aspx
[8] In 2019/2020, the national poverty line and national extreme poverty line are set at EGP857 and EGP550 per month per capita respectively. CAPMAS (2020) *Income & Expenditure Search 2019-2020* https://www.capmas.gov.eg/Pages/Publications.aspx?page_id=5109&YearID=23629
[9] UNDP and Ministry of Planning and Economic Development, Egypt (2021) *Egypt Human Development Report 2021* https://egypt.un.org/en/146158-egypt-human-development-report-2021
[10] Ibid.

are in poverty.

Further in addition, it should be mentioned that the order of Rural Lower and Urban Upper Egypt were reversed recently. Although poverty rate of Rural Lower Egypt was lower than the Urban Upper Egypt in 2015, Rural Lower Egypt's rate increased and became much higher than that of Urban Upper Egypt in 2019/2020, indicating the increasing accumulation of poverty in rural areas.

There is a significant correlation between poverty and family size in Egypt[11]. As Figure 3.1.8 shows, the poverty rate of households with 10 or more family members is astonishingly high (around 80%), while it is less than 10 % for small households whose members are between 1 and 3.

Comparatively, number of persons in one household in rural area is bigger than that of urban area (Figure 3.1.9). While less than 15% urban households are living with 6 or more members, the share of the same household size in rural areas is about 20%. High fertility rates are reported as features of rural households[12]. These points explain difficult situation of rural people and the mechanism behind regional disparities.

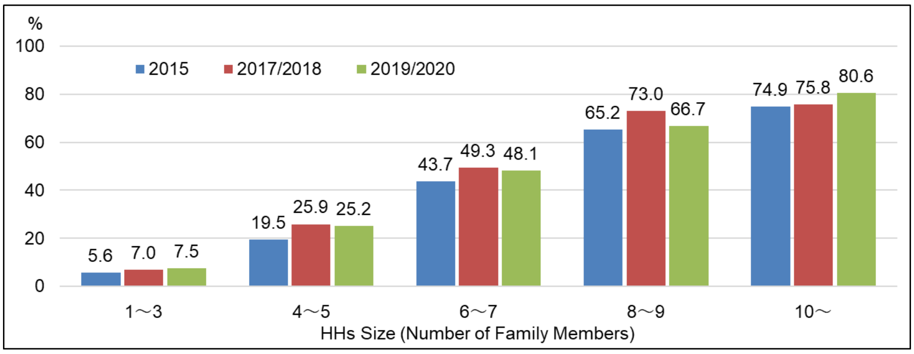


Figure 3.1.8 Poverty Rates by Number of Family Members

Source: CAPMAS (2020) *Income & Expenditure Search 2019-2020*

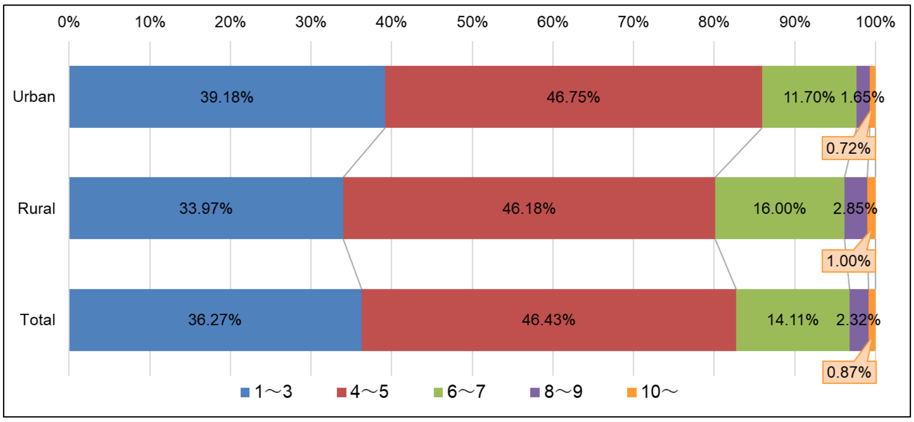


Figure 3.1.9 Distribution of Households by Number of Persons

Source: CAPMAS (2017) *Census - Population 2017*

Under the above poverty situation, the Ministry of Social Solidarity provides official support by offering 500 LE/month (per household) to the extremely poor families. In addition, the government also subsidizes the cost of medicines and operations for illnesses. Further, mutual assistance by relatives seems to remain relatively strong in rural areas of Egypt. For example, extremely poor households and single-mother households are provided with meals in turns by relatives, direct cash support, partial provision of harvested crops, and cooperative sharing of school-related expenses if there are school-going children in the household.

[11] Ibid.

[12] FAO (2021) *Country Gender Assessment of the Agricultural and Rural Sector – Egypt* https://www.fao.org/documents/card/fr/c/CB8060EN

The target beneficiaries of the Project live in rural areas which are identified as poor areas in Figure 3.1.7. Bearing in mind what Figures 3.1.8 and 3.1.9 show, farmers may earn less income from farming because of the land fragmentation stemming from inheritance by equal distribution. In this sense, the importance and necessity of the proposed project are very high, and it would contribute to the poverty reduction in the rural areas of Egypt.

3.1.8 Overview of Gender Situation

Since there are no published statistical data on gender specific to the project area, the following section discusses the situation throughout Egypt. To examine gender inequalities, Gender Development Index (GDI), defined as a ratio of the female Human Development Index (HDI) to that of male, is useful. The 2019 female HDI for Egypt is 0.652 with 0.739 for male, resulting in GDI value of 0.882 and placing it into Group 5 characterized by the lowest equality in HDI achievements between women and men[13]. Egypt's Gender Inequality Index (GII)[14] value for 2019 is 0.449, ranking it 108th out of 162 countries[15].

According to the Global Gender Gap Report 2022, Egypt is ranked at 129th out of 146 countries with Global Gender Gap Index score of 0.635 and stands in the middle among 13 countries in the Middle East and North Africa group[16]. While a steady improvement is observed in Political Empowerment subindex[17], other indexes such as Economic Participation and Opportunity and Education Attainment are pulling the score down.

Table 3.1.10 Gender Index Scores in Egypt

Indicators		Score	Rank	Year
Human Development Index (HDI)		0.707	116	2019
	Inequality-adjusted HDI (IHDI)	0.497	-	2019
	Gender Development Index (GDI)	0.882	Group 5	2019
	Gender Inequality Index (GII)	0.449	108	2019
Global Gender Gap Index (GGI)		0.635	129	2022
	Economic Participation and Opportunity	0.403	142	2022
	Education Attainment	0.971	103	2022
	Health and Survival	0.968	93	2022
	Political Empowerment	0.198	78	2022

Source1: UNDP (2020) Briefing note for countries on the 2020 Human Development Report - Egypt
Source2: World Economic Forum (2022) *Global Gender Gap Report 2022*

The constitution enacted in 2014 includes some articles to promote women's rights and gender equality; Article 9 declares equal opportunities for all citizens without discrimination and Article 11 acknowledges the State's obligation to ensure the achievement of equality between women and men in all spheres of life. The national authority for the promotion of gender mainstreaming in Egypt is the National Council for Women (NCW).

'The Sustainable Development Strategy: Egypt's Vision 2030' is designed to be gender sensitive and focuses on the importance of economic and social empowerment of women and youth in all strategic pillars[18]. 'The National Strategy for the Empowerment of Egyptian Women 2030', which was formulated in 2017, is based on four pillars: 1) political empowerment and leadership, 2) economic empowerment, 3) social empowerment, and 4) protection[19]. In addition, recently several other national

13 Ibid.
14 It reflects gender-based inequalities in three dimensions: reproductive health, empowerment, and economic activities.
15 Ibid.
16 World Economic Forum (2022) *Global Gender Gap Report 2022, Insight Report* https://www.weforum.org/reports/global-gender-gap-report-2022/in-full
17 Recently gender equality in the political spheres has been slightly improved in Egypt. Following the constitutional amendment in 2019 to reserve at least 25% of parliamentary seats for women and the critical election in 2020, women won 162 seats out of 596, making up about 27% of the Egyptian Parliament in the term from 2021 to 2026.
18 Ministry of Planning and Economic Development (2015) *Sustainable Development Strategy: Egypt Vision 2030*
19 National Council for Women (2017) *National Strategy for the Empowerment of Egyptian Women 2030*

strategies and legislations for ensuring women's rights and gender equality have been introduced or amended[20].

http://ncw.gov.eg/wp-content/uploads/2018/02/final-version-national-strategy-for-the-empowerment-of-egyptian-women-2030.pdf

[20] UNDP and Ministry of Planning and Economic Development, Egypt (2021) *Egypt Human Development Report 2021* and Islamic Development Bank (IsDB) (2019) *Country Gender Profile*
https://www.isdb.org/sites/default/files/media/documents/2020-10/Egypt%20Gender.pdf
For instances, 'the National Strategy for Combatting Violence against Women (2015-2020)' and 'the National Action Plan Against Female Genital Mutilation/Cutting (2016-2020)' are adopted. And some important laws were amended, such as the Investment Law (Law No. 72 of 2017), the Comprehensive Health Insurance Law (Law No. 2 of 2018) and the Inheritance Law (Law No. 219 of 2017).

3.2 Irrigation System in the Project Area: Upper Egypt

There are approximately 8,000 irrigation canals in Egypt, and the Principal Canal is a big canal that draws water from a large canal called the Carrier, which is constructed to withdraw water from the Nile River. Within the Project area, there are two principal canals which are the Bahr Yusef and Ibrahimia. Further, in most cases, the main canals branch off from the principal canals, and those principal and main canals are operated under continuous flow. Following the main canals are called secondary canals, which are operated intermittent (on and off basis) flow. There are 6 Carrier canals and 35 Principal canals in total in Egypt.

3.2.1 Irrigation System in Upper Egypt

This sub-chapter provides an overview of the irrigation system in the Upper Egypt, covering the area from the Dirout Group Regulators (DGRs) to Giza, including the target area of the Project. The DGRs is fed by the Ibrahimia Intake at the Assuit Barrage on the Nile River. The DGRs distribute irrigation water to the farmlands in the five downstream directorates of Assuit, Minya, Beni Suef, Fayoum and Giza through the seven major canals. About 90% of the total diversion flow is used for the irrigated areas by Bahr Yusef Principal Canal and Ibrahimia Principal Canal. The major regulators on the principal canals are shown in Figure 3.2.1.

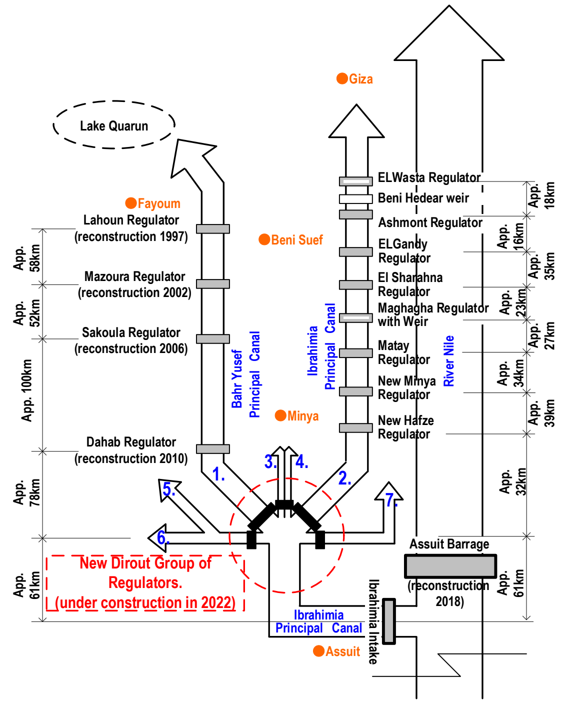


Figure 3.2.1 Major Irrigation Facilities in Project Area of Upper Egypt

Source: Edited by JICA Survey Team based on the Final Report of the preparatory survey for the rehabilitation and improvement of Dirout Group of Regulators, 2010

The Ibrahimia Intake at the Assuit Barrage had been reconstructed in 2018 with a fund from KfW. Likewise, the DGRs are now under reconstruction by a Yen Loan Project, commenced in 2022, and to be completed in around 2025 for the purpose of modernizing and restoring its functions. Furthermore, all of four regulators located on the Bahr Yusef Principal Canal have already been renewed by Japanese Grant Aid Scheme. On the other hand, the regulators located on the Ibrahimia Principal Canal have not been rehabilitated and/or renewed in large-scale until now.

The water distribution ratio among the two principal canals and others at the DGRs is shown in Table 3.2.1, which was determined by a water distribution agreement promulgated in 2001. The agreement was required by the concerned governorates benefited by the DGRs in order to make them sure their allocations. The max. flow rates of the new DGRs calculated based on the agreement are summarized in Table 3.2.2. While the water distribution ratio of new DGRs follows the rates of Table 3.2.2 basically, the diverted flow varies during actual operation. Same situation is found at the Ibrahimia Intake as well, as the operation is being carried out in consideration with the actual water situation at the time.

Table 3.2.1 Water Allocation Ratio based on the Water Distribution Agreement

Distributed area	Distribution ratio
Direct distribution (Assuit)	6.70%
Direct distribution (South Minya)	4.83%
Bahr-Yusef	51.63%
Ibrahimia	36.84%
Total	100%

Source: Water Distribution on the Ibrahimia canal in Assiut among governorates (2001)

Table 3.2.2 Maximum Flow Rate (Design Discharge) of New Dirout Group of Regulators (NDGRs)

Canal from Dirout Group of Regulators (DGRs)	Max. discharge based on distribution ratio (m^3/s)	Design Max. discharge of New DGR (m^3/s)
Ibrahimia	161.62	186※
Bahr-Yusef	226.50	227
Sahelyia	4.20	5
Diroutiah	11.70	12
Badraman	8.30	9
Abo Gabal	6.20	7
Irad Delgaw	8.60	9
Total	427.12	455

* Maximum design discharge new DGRs has been modified in the Detail Design stage, bigger than 161.62m^3/s of the original, in accordance with a request from MWRI.
Source: The preparatory survey for the rehabilitation and improvement of Dirout Group of Regulators in Oct. 2010 and the project for construction of new Dirout Group of Regulators Detailed design Study May, 2017

The schematic illustration and the canal diagram with beneficial area of the of Bahr Yusef and Ibrahimia Principal Canals are shown in Figures 3.2.2, 3.2.3 and 3.2.4 below, respectively. Note that the areas indicated in Figure 3.2.3 came from MWRI, and actual net irrigation areas may be different (as shown in Figure 3.2.4 and see 4.1.1).

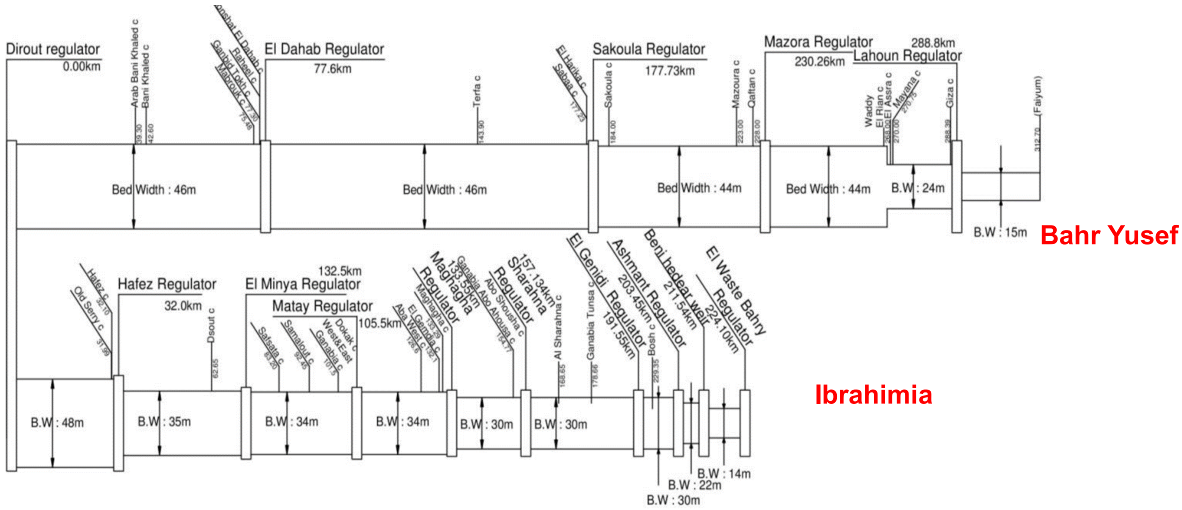
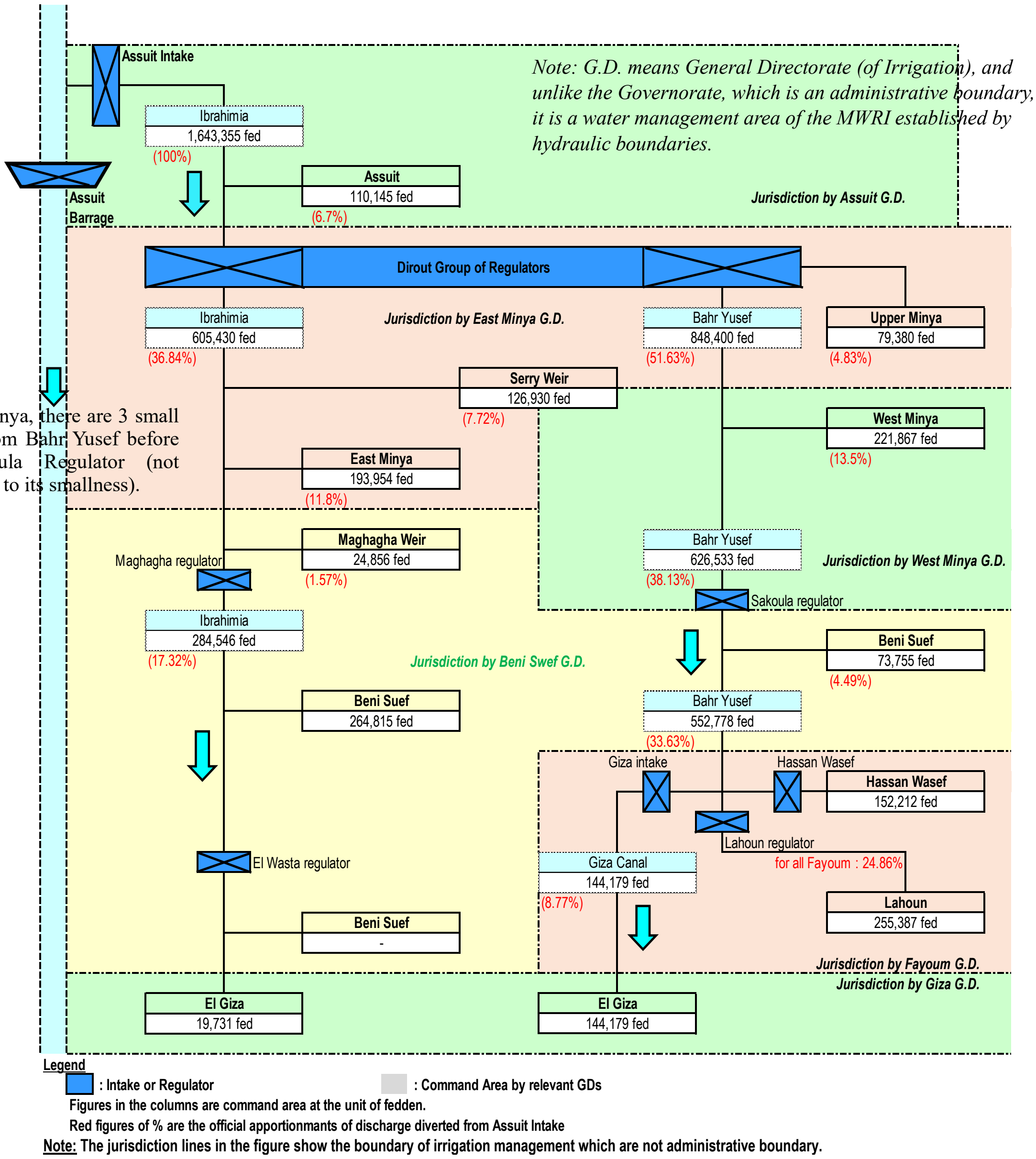


Figure 3.2.2 Schematic Illustration of Bahr Yusef and Ibrahimia Principal Canal
Source: Modification of Figure 4.12 of the JICA cooperation planning survey final report on the irrigation sector (upper Egypt and middle Delta) in Egypt (JICA, 2018)



In East Minya, there are 3 small feeders from Bahr Yusef before the Sakoula Regulator (not shown due to its smallness).

Figure 3.2.3 Canal Diagram with Beneficial area of Bahr Yusef and Ibrahimia Principal Canals

Source: Modification of Figure 4.14 of the JICA cooperation planning survey final report on the irrigation sector (upper Egypt and middle Delta) in Egypt (JICA, 2018)

Dirout Group of Regulators

Ibrahimia Canal

Canal	Fed	Ha
Ibrahimia	479,827	201,527

Bahr Yusef Canal

Canal	Fed	Ha
Ibrahimia	584,646	245,551

Old Hafez

Sub-Region	Fed	Ha
3. East Hafez	5,436	2,283
Total	5,436	2,283

Sub-Region	Fed	Ha
1. Seery	100,272	42,114
2. El Sahlyah	5,836	2,451
4. West Hafez	19,382	8,140
Total	125,490	52,706

New Hafez

Sub-Region	Fed	Ha
7. Damaris & Other	11,714	4,920
Total	11,714	4,920

Sub-Region	Fed	Ha
5. Kom El Zohir & Other	15,390	6,464
6. El Disout	5,094	2,139
Total	20,484	8,603

Dahab

Sub-Region	Fed	Ha
1. Bani Khalid & Other	10,519	4,418
2. Raheel	5,248	2,204
Total	15,767	6,622

New El Minia

Sub-Region	Fed	Ha
8. El Safsafa	4,294	1,803
10. Abo Essa	7,162	3,008
11. Adkak	4,586	1,926
12. Shoieb Darwish	5,940	2,495
14. Mataua & Other	11,426	4,799
Total	33,408	14,031

Sub-Region	Fed	Ha
9. Samalout	4,336	1,821
13. Abo Hasiba	7,712	3,239
Total	12,048	5,060

Matay

Sub-Region	Fed	Ha
18. Maghagha El Fashnia	10,318	4,334
Total	10,318	4,334

Sub-Region	Fed	Ha
15. Beni-Mazar & Other	6,195	2,602
16. Dahrout & Other	14,591	6,128
17. El Gendia	10,205	4,286
Total	30,991	13,016

Sakoula

Sub-Region	Fed	Ha
3. Dahab	53,532	22,483
4. Kamadir	9,513	3,995
5. Terfa	15,498	6,509
6. Bhnasa & Other	4,626	1,943
7. Saba	12,921	5,427
8. Harika	12,208	5,127
Total	108,298	45,485

Maghagha

Sub-Region	Fed	Ha
20. Saaedyat El fenshna	4,717	1,981
21. El Fashnya & Other	8,963	3,764
22. Abo Shosha	12,175	5,114
23. Abosoge & other	18,645	7,831
24. El Sultani	39,083	16,415
25. South Ahmed Pasha	5,650	2,373
Total	89,233	37,478

Sub-Region	Fed	Ha
19. El Fant	5,712	2,399
Total	5,712	2,399

El Sharahna

Sub-Region	Fed	Ha
10. Belhansa	11,335	4,761
Total	11,335	4,761

Mazoura

Sub-Region	Fed	Ha
9. Sakoula PS	6,791	2,852
11. Harika Delhans	15,676	6,584
12. Mazoura PS	14,431	6,061
13. Koftan	10,828	4,548
Total	47,726	20,045

Sub-Region	Fed	Ha
27. North Ahmed Pasha	4,080	1,714
29. Tansa Kela	20,254	8,507
30. Right Tansa Tezmet	5,141	2,159
31. Sheikh Haroun	2,367	994
32. Ahanasia Beni Haroud	15,138	6,358
34. Azhay	9,394	3,945
35. Saayda	2,644	1,110
Total	59,018	24,788

Sub-Region	Fed	Ha
26. Sharahna North	3,574	1,501
28. West Magrofa.	2,969	1,247
33. El Shahra	5,051	2,121
Total	11,594	4,869

El Gendi

Sub-Region	Fed	Ha
16. Waslat Bahbashin	3,192	1,341
17. El Sultani2	12,500	5,250
Total	15,692	6,591

Sub-Region	Fed	Ha
14. Monshaat El Hag	6,678	2,805
15. Wady El Ryan & Other	6,224	2,614
Total	12,902	5,419

Sub-Region	Fed	Ha
37. South Ashmont	3,770	1,583
Total	3,770	1,583

Ashmant

Sub-Region	Fed	Ha
36. Bosh & other	10,826	4,547
38. El Mansour	4,537	1,906
Total	15,363	6,452

Lahoun

Sub-Region	Fed	Ha
19. El Ghark	47,000	19,740
20. El Nazie	91,594	38,469
Total (Hassan Wasef)	138,594	58,209

Sub-Region	Fed	Ha
40. North Ashmont	6,912	2,903
Total	6,912	2,903

Beni Hedear

Sub-Region	Fed	Ha
39. South Qashisha	5,933	2,492
Total	5,933	2,492

Sub-Region	Fed	Ha
18. Giza Right	1,924	808
Total	1,924	808

Sub-Region	Fed	Ha
21. Bahr Wahby	39,194	16,461
22. Aros Abo Seer	13,523	5,680
23. El Elam & Dar Ramaday	18,991	7,976
24. Tanhala	22,047	9,260
25. Senours	31,515	13,236
26. El Zawia	15,524	6,520
27. Sanhor	16,408	6,891
28. Senrw	18,961	7,964
29. El Gharbia	25,956	10,902
30. Bahr Talat El Aly	9,226	3,875
31. Dwesia	21,063	8,846
Total	232,408	97,611

Sub-Region	Fed	Ha
41. Qashisha & other	2,513	1,055
43. Attwab Hooma	3,440	1,445
48. Attwab	12,475	5,240
Total	18,428	7,740

El Wasta

Sub-Region	Fed	Ha
42. El Zawya & other	2,069	869
44. Medoum	4,423	1,858
46. El Monsour	3,811	1,601
47. Ibrahimia & other	3,672	1,542
Total	13,975	5,870

To Giza

Canal	Fed	Ha
Giza (Bh)	90,629	38,064

To Giza

Canal	Fed	Ha
Giza (Ib)	11,991	5,036

Figure 3.2.4 Schematic Diagram of Bahr Yusef and Ibrahimia Principal Canal Command Area

Note: 1/ Above areas were estimated based the satellite image analysis, meaning all NET irrigation areas, different from MWRI's original numbers.

2/ Above areas are summarized by sub-region basis, that specifies an irrigation area, having a certain extent, that is irrigated by an irrigation system consisting of principal-main-branch canals, as well as Meska, Marwa and its command area. The definition of this Sub-region was referred to a previous study, "page 1-5 on JICA cooperation planning survey, final report, February 2018".

3.2.2 Irrigation System in Bahr Yusef Principal Canal (Upper Egypt)

Since the Bahr Yusef Principal Canal is originally a natural river which branches off from the Nile River, the canal is an earthen canal and largely meandering. The canal begins at the Dirout Regulator and flows through Minya, and Beni Suef Governorates, then diverts the Giza Branch Canal at the Lahoun Regulator and finally ends at Fayoum. Total length of the canal is about 313 km irrigating about 850,000 feddan (360,000 ha)[1]. Principal and main canals convey irrigation water continuously in 24 hours/day and related canals in branch and Meska levels are operated by a rotational system, e.g., 5 days on & 5 days off, or 5 days on & 10 days off.

The end of the Bahr Yusef Principal Canal is located in Fayoum and the irrigation water conveyed by the Bahr Yusef finally effluents to the Lake Qarun through drains. Since the difference of the elevation between the Lahoun regulator and the Lake Qarun is around 60 - 70m (1/500 - 1/600), most of the irrigation areas covered by Bahr Yusef in Fayoum are irrigated directory (by gravity) without pumping from the canals. Based on the hearing from the Irrigation Directorate, about 70% of the farmlands in this area are irrigated by gravity and continuously. Drop-weirs have been constructed on the canals at many places for controlling water level to distribute water into the branch level. Major irrigation structures located on the Bahr Yusef Principal Canal are summarized in Table 3.2.3.

Table 3.2.3 List of Major Irrigation Structures Located on the Bahr Yusef Principal Canal

Location	Regulator	Intake/ Others	Pump station	Re-use pump station	Total
Dirout regs. - Dahab reg.	1	9	2	3	15
Dahab reg. - Sakoula reg.	1	8	2	1	12
Sakoula reg. - Mazoura reg.	1	7	6	1	15
Mazoura reg. - Lahoun regs.	1	22	4	4	31
Total	**4**	**46**	**14**	**9**	**73**

Source: Modification of table 4.23 of the JICA cooperation planning survey final report on the irrigation sector (upper Egypt and middle Delta) in Egypt (JICA, 2018)

There are four regulators, Dahab, Sakoula, Mazoura and Lahoun, located at intervals of 50 to 100 km each other from the upstream of Bahr Yusef Principal Canal. In the renewal of the regulators, a type of “double-leaf overflow gates” was installed to enable accurate flow control with an efficient water level control. Gate operation of regulators follows the instructions from the Central Directorate of Water Distribution in MWRI with basic rule of keeping specified water level at downstream side of the gate. Since the H-Q (Water level – Flow rate) curve at downstream side is available among the major regulators located at the boundary of the governorates, actual flow rate can be calculated based on the observation data.

① Double-leaf overflow type gates (by grant aid project)	② Hoist gate type (single or double leaf)	③ F.H.(Fahmy Henen) gate type
		

Figure 3.2.5 Types of Gates Installed in the Irrigation Facilities in Egypt

Source: Edited by JICA Survey Team based on the Report for construction of new Dirout Group of Regulators DD, May 2017

[1] It is noted that according to the P4-15, JICA Cooperation Planning Survey Final report on the Irrigation Sector (Upper Egypt and Middle Delta) in Egypt (JICA, 2018), the area is reported as 850,000 feddan (about 360,000 ha), which may include urban areas. Based on a satellite image analysis we did, the net cropped area (irrigated area) was estimated to be 670,000 feddan (about 282,000 ha) within the 4 governorates of Minya, Beni Suef, Fayoum and Giza, much smaller than the 850 feddans, about 79%.

The types of gates are classified into mainly three (3) including the double-leaf overflow gate which was applied by the Japanese Grand Aid Scheme. Most of the gates installed in Egypt are either the ② Hoist gates (single or double leaf type) or the ③ F.H. (Fahmy Henen) gates (See Figure 3.2.5). Hoist gates are classified into manual type or electrical type. F.H. gates are often used for intakes or regulators since they do not require operating platform at the top of the gate and have a low-cost structure. However, in case the opening of a gate is large, the gate may easily lose balance, and in fact such unbalanced gates could be found sometimes.

Table 3.2.4 Gate Type of Irrigation Facilities Located on Bahr Yusef Principal Canal

Facility	Name of facility	Gate type		
		①	②	③
Regulator	Dahab Regulator	●		
	Sakoula Regulator	●		
	Mazoura Regulator	●		
	Lahoun Regulators	●		
Intake	Manshat EL-Dahab			●
	El-Hareka			●
	El-Sabaa			●
	Quftan			●
	Wesh El-Bab			●
	EL-Giza		●	
	Hassan Wasef		●	

Note) ①: Double-leaf with overflow type gates (by grant aid project), ② Hoisted gates type (single or double leaf),
③: F.H.(Fahmy Hansen) gate

Aside from regulators, there are intake facilities (with gate) for branch canals, irrigation pump stations and drainage reuse-pump stations on the canals. The large-scale reuse pumps are usually managed by MED (Mechanical and Electric Department). Previous survey[2] pointed out that the problems of irrigation pumps are the failure of the pump motors, blocking of the suction pipe by garbage, and the natural deterioration by being exposed at outside due to no building, and so on.

3.2.3 Irrigation System in Ibrahimia Principal Canal (Upper Egypt)

The Ibrahimia Principal Canal is an artificial man-made canal completed in 1873, and it is one of the longest canals in the world with total length of 350 km[3] from the Nile River till the end. The purpose of the canal at the time of its construction was to convert the sugarcane plantations of the then Governor of Egypt to year-round irrigation with 550,000 feddan (about 230,000 ha). At present, it is reported that the irrigated area is about 610,800 feddan[4]. This area may include urban areas because a satellite image analysis conducted by the JICA Survey Team identified smaller areas (see discussions in 4.1.1).

The regulators located on the Ibrahimia Principal Canal is eight, which is more than that on the Bahr Yusef Principal Canal. All such regulators have not been rehabilitated or updated in large-scale since decades ago. In other word, modernization of the regulators on Ibrahimia Principal Canal are delayed comparing with the regulators on the Bahr Yusef Principal Canal, such as the electrification of gates. List of major irrigation structures located on the Ibrahimia Principal Canal is given in Table 3.2.5 and the gate type of the irrigation facilities located on the Ibrahimia Principal Canal is shown in Table 3.2.6.

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2 JICA Cooperation Planning Survey on the Irrigation Sector (upper Egypt and middle Delta) in Egypt (JICA, 2018).

3 The length of Ibrahimia Principal Canal after the Dirout regulator is only 256 km.

4 Based on satellite image analysis conducted by JICA Survey Team, the net cropped area (irrigated area) was estimated to be 472,000 feddan (about 198,000 ha). It is noted that according to the JICA Cooperation Planning Survey Final report on the Irrigation Sector (Upper Egypt and Middle Delta) in Egypt (JICA, 2018), the area is reported as 610,800 feddan (about 256,000 ha), which may include urban areas as the satellite detected area in the 3 governates of Minya, Beni Suef and Giza is equal to only about 74% of the 610,800 feddan.

Table 3.2.5 List of Major Structures Located on Ibrahimia Principal Canal

Location	Regulator	Intake/ Others	Weir	Siphon	Spillway/ Culvert	Re-use pump st.	Total
Dirout regs. ~ New Minya reg.	2	6	0	0	1	0	9
New Minya reg. ~ Maghagha weir	2	32	1	0	1	0	36
Maghagha weir ~ El Wasta	4	40	1	3	2	3	53
Total	**8**	**78**	**2**	**3**	**4**	**3**	**98**

Source: Modification of the JICA cooperation planning survey final report on the irrigation sector (upper Egypt and middle Delta) in Egypt (JICA, 2018)

There are many irrigation facilities on the Ibrahimia Principal Canal more than the case of Bahr Yusef Principal Canal. In particular, the number of regulators and intake facilities are about double of the Bahr Yusef Principal Canal, implying beneficial areas are irrigated by dividing them into smaller areas. In this reason, the number of irrigation pumps and reuse-pumps can be reduced, and its number is much smaller than the Bahr Yusef Canal (about 1/7). Thus, the irrigation system in Ibrahimia area can be assumed low-cost system for the entire system. Meanwhile, the reuse-pump stations in Ibrahimia are managed by IS (Irrigation Sector) and around 4 - 5 pumps with the capacity of about 1m^3/s are installed in a station.

The Ibrahimia Principal Canal equips spillway running in parallel of the canal on the right side for discharging excess water to Nile River. However, it is almost not used nowadays since the High Aswan Dam completely controls the flooding.

Table 3.2.6 Gate Type of Irrigation Facilities Located on Ibrahimia Principal Canal

Facility	Name of facility	Gate type		
		①	②	③
Regulator	New Hafze Regulator		●	
	New Minia Regulator		●	
	Matay Regulator		●	
	Maghagha Regulator		●	
	El Sharahna Regulator			●
	El Gandy Regulator			●
	Ashmont Regulator			●
	EL Wasta Regulator			●
Intake	Irad El Maharak			●
	El Kosia			●
	East hafez			● (with crane)
	West hafez			● (with crane)
	Adkak			● (with crane)
	Gendia			● (with crane)
	EL Soultany			●
	Tansa			●
	EL Azhary			●
	Bosh			●
	El Mansour			●

Note: ①: Double-leaf with overflow type gates (by grant aid project), ② Hoisted gates type (single or double leaf),
③: F.H.(Fahmy Hansen) gate

3.2.4 Priority sub-regions in Upper Egypt

In this Survey, three irrigation sub-regions are selected as the priority area. In the first Steering Committee (Kick-off meeting) held on July 13, 2021, Abo Shosha sub-region in Beni Suef and Aros & Abo Seer sub-region in Fayoum were selected as the priority sub-region from the Upper Egypt. Basic information (number of canals, beneficial areas, etc.) of the Abo Shosha sub-region and Aros & Abo Seer sub-region in Upper Egypt are summarized in the Tables 3.2.7 and 3.2.8, and the location of two sub-regions is illustrated in Figure 3.2.6 (canals in the maps are indicated up to branch canal level).

Further, detail information on the canals is elaborated in Table 3.2.9 with canal schematic diagram in Figure 3.2.7 for Abo Shosha sub-region and in Table 3.2.10 with the schematic graph in Figure 3.2.8 for

Aros & Abo Seer sub-region respectively. Though most of the branch canals in Egypt are operated under rotational system, the canals in Aros & Abo Seer are operated with continuous flow as the water in the area is distributed by gravity. On the other hand, the branch canals under Abo Shosha are operated by rotation, yet, different from common 5-ON/5-OFF or 5-ON/10-OFF. With the feeding pumping from the Bahr Yusef Canal, the rotation is as per the illustration in Figure 3.2.7, i.e., 10-ON/5-OFF in the upstream reach while 10-OFF/5-ON for the downstream.

Table 3.2.7 Summary of the Abo Shosha Irrigational Sub-Region (Beni Suef Governorate)

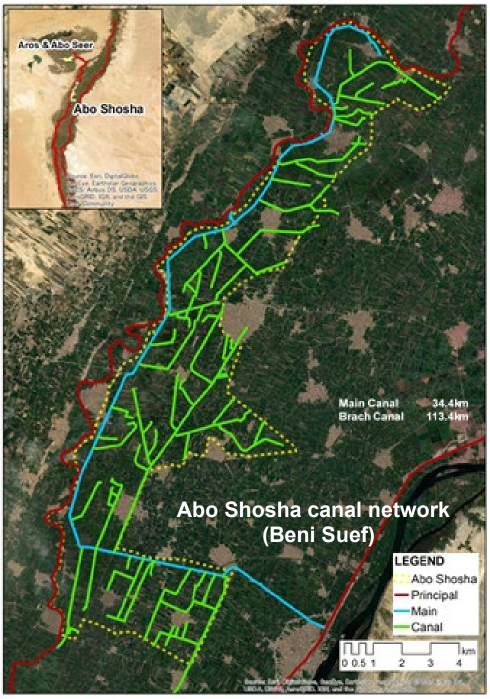
General (Abo Shosha)	Indicators	Remarks
Service Area (by MWRI)	19,870 feddan (8,345 ha)	
Service Area (Gross, by satellite)	19,489 feddan (8,186 ha)	Net/0.92
Service Area (Net, by satellite)	17,881 feddan (7,510 ha)	Av. of 3 yrs winter crop
Major Irrigation Method (To the Farm)	Pump up from Branches/Meska	
Major Irrigation Method (On-farm)	Furrow/ Basin	No modern irrigation
Rotational Irrigation	5-day ON 10-day OFF,	Many gates not operational
Facilities (Abo Shosha)		
Total Length of Main Canal (Nos)	34.4 km (1)	
Total Length & Nos of Branch Canals (Nos)	53.27 (20) 84.06 km (24+)	Excluding Sub-branches Including Sub-branches
Nos of Regulators on the Main Canal	5	
Nos of Feeding Pump Stations	1 (Fr. Bahr Yusef Canal)	4 working 0.5 m^3/s, 10-17 hrs
Nos of Re-use Pump Stations	2	Talt PS, Mazora PS
Nos of Feeder Canal	1	Fr. BY to Abo Shosa

Source: General Directorate of Irrigation, Beni Suef

Table 3.2.8 Summary of the Aros & Abo Seer Irrigational Sub-Region (Fayoum Governorate)

General (Aros & Abo Seer)	Aros	Abo Sheer	Remarks
Service Area (by MWRI)	13,565 feddan (5,599 ha)		
Service Area (Gross, by satellite)	14,571 feddan (6,120 ha)		Net/0.91
Service Area (Net, by satellite)	13,330 feddan (6,120 ha)		Av. of 3 yrs winter crop
Major Irrigation Method (To the Farm)	Gravity		+Pump up w/ low head
Major Irrigation Method (On-farm)	Furrow/ Basin		No modern irrigation
Rotational Irrigation	Not Applied (Continuous irrigation)		
Facilities (Aros & Abo Seer)			
Total Length of Main Canal (Nos)	9.8 km (1)	3.5 km (1)	
Total Length of Branches (Nos)	40.4 km (4)	6.4 km (3)	Incl. sub-branches
Nos of Regulators on the Main Canal	0	0	
Nos of Feeding Pump Stations	0	0	
Nos of Re-use Pump Stations	0	0	
Nos of Drop Weirs	4	2	

Source: General Directorate of Irrigation, Gharbia, Kafr El Sheik



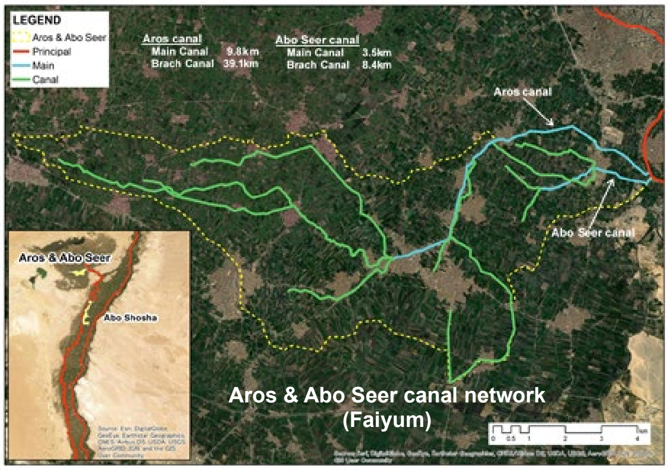


Figure 3.2.6 Prioritized Irrigational Sub-Regions in Upper Egypt
(Left: Aros & Abo Seer, Right: Abo Shosha)
Source: Prepared by JICA Survey Team by editing Google Earth

Table 3.2.9 Detail Information for Canals in Abo Shosha Sub-Region (Beni Suef Governorate)

No.	Canal name	Length, km, 1/	Area (Satellite), feddan	Area, ha	Remarks
Abo Shosha Main Canal		34.4			
①	Abo Shosha Branch 1	4.56	519	218.0	
②	Mesqa Aref	2.10	432	181.4	
③	Abo Shosha Branch 2	2.84	459	192.8	
④	Abo Shosha Branch 3	2.00	610	256.2	
⑤	Talt Canal	8.60	4,807	2,018.9	
⑥	Talt Branch	2.30	513	215.5	
⑦	Shawky	2.05	225	94.5	
⑧	Henna	2.74	405	170.1	
⑨	Tawfik	1.65	903	379.3	
⑩	Branch 1 Abo Shosha	1.76	967	406.1	
⑪	Kamoun	0.56	445	186.9	
⑫	Mazoura	2.63	560	235.2	
⑬	Nousir	0.77	334	140.3	
⑭	Belani	1.76	340	142.8	
⑮	El Sheikh Abid	2.68	2,159	906.8	
⑯	Walida	2.75	622	261.2	
⑰	Al Kassaba	1.33	351	147.4	
⑱	Branch (1) Abo Shosha	4.69	535	224.7	
⑲	Branch (2) Abo Shosha	1.00	409	171.8	
⑳	Dashtout	2.60	1,044	438.5	
	End of Abo Shosha Main Canal	1.91	1,242	521.6	
	Total	53.27	17,881	7,510.00	

Note: 1/ the length of sub-branch canals is not included but the area served includes all. There are sub-branch canals under such 4 branch canals of ⑤ Talt Canal, ⑮ El Sheikh Abid, ⑱ Branch (1) Abo Shoush, and ⑳ Dashtout. The total length of the sub-branch canals comes to 30.79km, summing up to 84.06 km under the Abo Shosha Main Canal (53.27 + 30.79km).
Source: Irrigation Directorate (Beni Suef), and the area by satellite image analysis conducted by JICA Survey Team

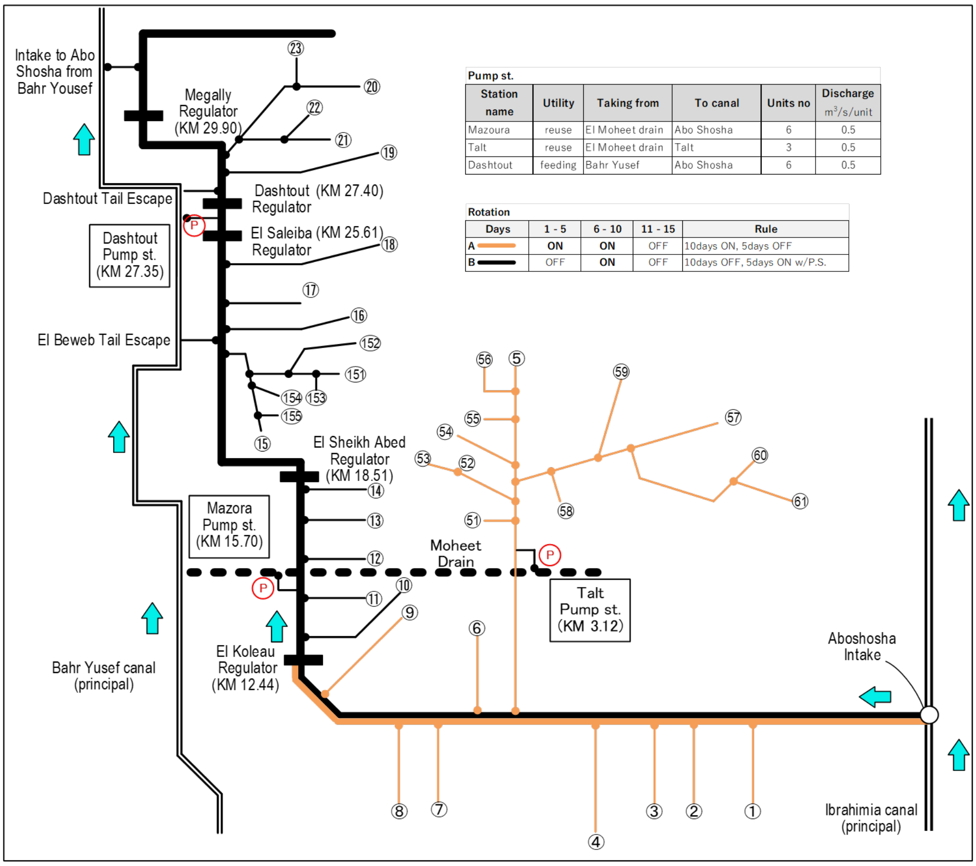


Figure 3.2.7 Schematic Diagram of Abo Shosha Irrigation Network
Source: JICA Survey Team, prepared based on the information by General Directorate of Irrigation (Beni Suef)

Table 3.2.10 Detail Information for Canals in Aros & Abo Seer Sub-Region (Fayoum Governorate)

No.	Canal name	Length km	Area (Satellite), feddan	Area, ha	Remarks
	Abo Seer Main Canal	3.50			
①	Bahr Abo Sir (main), /1	3.77	957	402.0	
②	Bahr Omar Bek	0.91	338	142.0	
③	Al Kashif	0.99	630	264.6	
④	Extension Bahr Abo Seer	0.74	621	260.8	
	Sub-total Abo Seer	6.41	2,546	1,069.4	
	Aros Main Canal	9.80			
⑤	Bahr Aros (main), 1/	9.61	1,563	656.6	
⑥	Bahr Defno Al oumomy, 2/	9.55	2,236	938.9	
⑦	Bahr Abo Al meir	7.59	2,574	1,080.9	
⑧	Bahr AL Ghaba	9.92	2,040	856.8	
⑨	Bahr Itsa al kebly, 2/	3.70	2,371	995.9	
	Sub-total Aros	40.38	10,784	4,529.1	
	Total	46.79	13,330	5,598.5	

Note: 1/ Direct irrigation areas from the main canal. 2/ Canal length/ command area include sub-branches.
Source: Irrigation Directorate (Fayoum), and the area by satellite image analysis conducted by JICA Survey Team

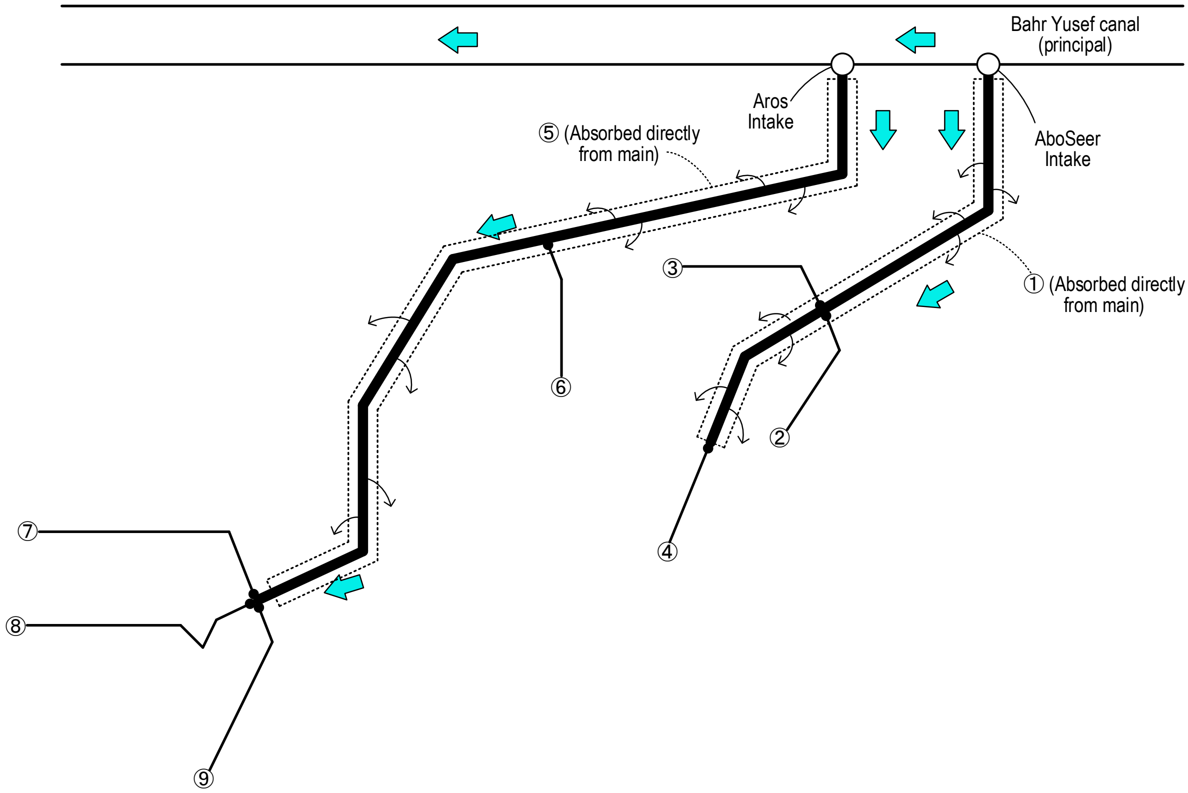


Figure 3.2.8 Schematic Diagram of Aros & Abo Seer Irrigation Network
Source: JICA Survey Team, prepared based on the information by General Directorate of Irrigation (Fayoum)

3.3 Irrigation System in the Project Area: Kased Area

3.3.1 Irrigation System in the Nile Delta

The Nile River is divided by the Delta Barrage in Cairo into the Rosetta Branch on the west side of the Delta and the Damietta Branch on the east side of the Delta. At the Delta Barrage, other artificial canals such as, Menufa, Behera, Nasser, Ismailia and Tawfiki are branched off to irrigate the Delta. Among them, big 3 canals taking water from the Delta Barrage are called Carrier[1] by MWRI (see Figure 3.3.1). Total irrigated area of the Delta is quite huge, about 7.2 million feddan (about 3 million ha).

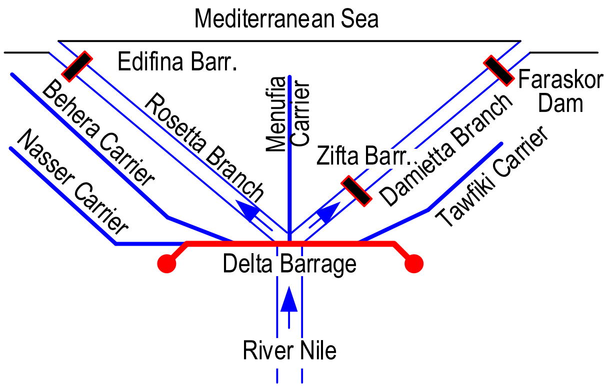


Figure 3.3.1 Schematic Diagram of Barrage and Major Canals in Delta
Source: Modification of Figure 4.14 of the JICA cooperation planning survey final report on the irrigation sector (upper Egypt and middle Delta) in Egypt (JICA, 2018)

The irrigation method to deliver water onto the farm lands from the Meska is basically to use pumps, which lift up the water in the lower level from the farm lands. This irrigation method is almost same as that of the Project area in Upper Egypt except for Fayoum where gravity irrigation is the majority. In the on-farm level, basin irrigation and/or furrow irrigation are mostly practiced.

3.3.2 Irrigation System in the Kased Area

The Kased sub-region area is located within the Gharbia and Kafr El Sheikh Governorates in the Central Delta. The Kased Main Canal is fed by the Tanta navigation canal diverted from El Rayah Monofy Canal, which is further branched from the Menufa Canal from the Delta Barrage constructed on the Nile River. Map of the Kased sub-region is shown in Figure 3.3.2 as on the right side. As shown in the map, the Kased sub-region has 42 km of main canal and about 205 km of branch canals altogether with the service area of about 96,000 feddan (about 40,000 ha).

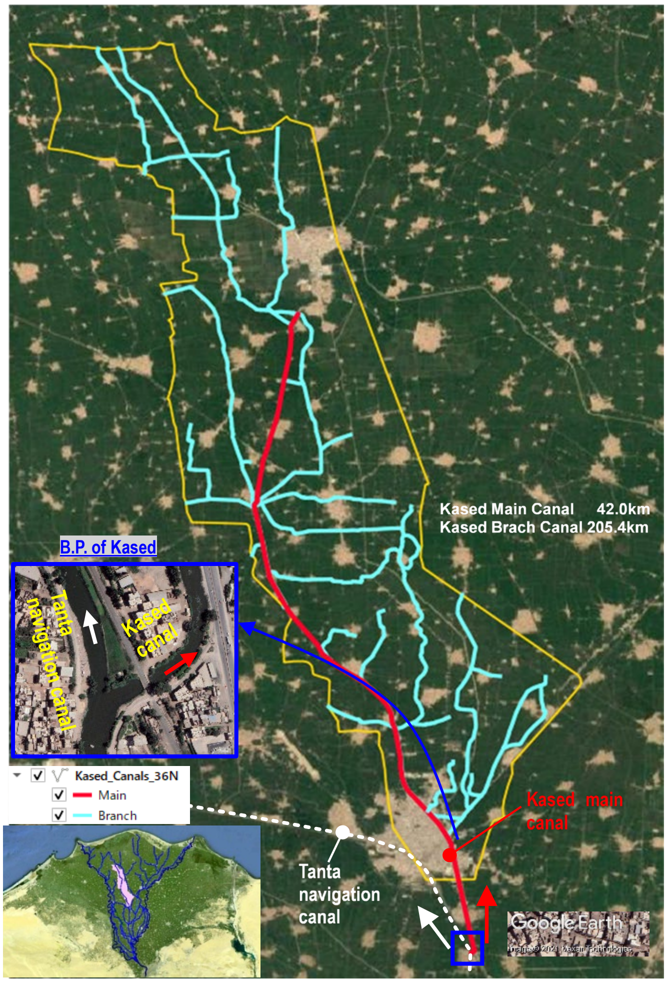


Figure 3.3.2 Canal Diagram on Satellite Map of Kased
Source: JICA Survey Team with a Google Earth base map

There is no intake structure at the intake point of the Kased Irrigation System. The water is naturally diverted from the Tanta Navigation Canal back-watered by a regulator equipped with navigation lock constructed at about 7.9 km downstream from the intake of the Kased

[1] In Egypt, there are approximately 8,000 irrigation canals. The canals that are constructed to carry water from the Nile River are called Carriers, the bigger canals that branch off from the Carriers are called Principal Canals, and the canals that branch off from the Principal Canals are called main canals. Normally, the canals are operated under continuous flow up to the main canal, and then under intermittent flow from the secondary canals below thereof. There are 6 carrier canals and 35 principal canals in Egypt.

Main Canal. However, this diversion seems not suitable, and accordingly the intake amount of Kased Main Canal is not enough to irrigate the whole command area according to a report from the General Directorate of Irrigation, Gharbia.

To mitigate above problem, an option is to raise the water level at the intake point of the Kased Canal higher than the existing level, yet that way is difficult as the side slope of the Tanta Navigation Canal is not stable and its height is not enough to keep water level higher, according to the observation at the site. If the water level of the canal is kept in such higher level, the risks of leakage and collapse of the embankment may be increased.

Accordingly, it is found that the water conveyance to the Kased Main Canal by controlling existing regulator at Tanta Navigation Canal is difficult to manage water distribution appropriately into Kased Main Canal. Therefore, the construction of a new regulator at the intake point of Kased Main Canal is required. Following table and figure show the summary of the canals, beneficiary area and schematic diagram of the Kased sub-region. Note that the areas in Figure 3.3.3 are not net irrigated area, as detected by satellite, but indicative ones (for the net, irrigated area, see Tables 3.3.1 & 2).

Table 3.3.1 Summary of the Kased Sub-region

General (Kased)	Indicators	Remarks
Service Area (by MWRI)	95,461 feddan (40,094 ha)	
Service Area (Gross, by satellite)	111,551 feddan (46,851 ha)	Net/ 0.86
Service Area (Net, by satellite)	95,976 feddan (40,310 ha)	Av. of 3 yrs winter crop
Major Irrigation Method (To the Farm)	Pump up from Branches/Meska	
Major Irrigation Method (On-farm)	Furrow/ Basin	Some improved Meska
Rotational Irrigation	5-day ON 5-day OFF, 5-day ON 10-day OFF	Summer, winter
Facilities (Kased)		
Total Length of Main Canal (Nos)	42.2 km (1)	
Total Length of Branch Canals (Nos)	262.9 km (46)	
Nos of Regulators on the Main Canal	3 (Gharbia), 1 (Kafr El Sheik)	
Nos of Feeding Pump Stations	0	
Nos of Re-use Pump Stations	6	

Source: General Directorate of Irrigation, Gharbia, Kafr El Sheik

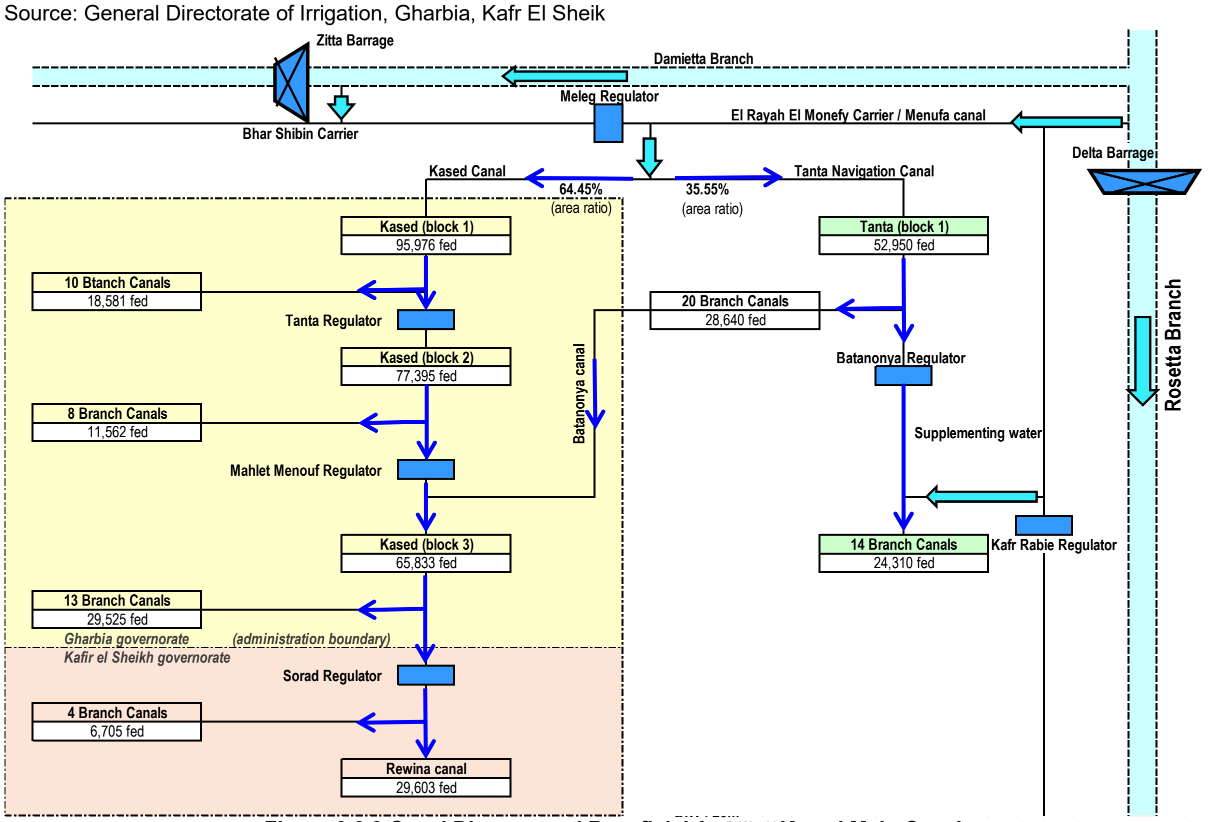


Figure 3.3.3 Canal Diagram and Beneficial Area on Kased Main Canal

Source: Modification of Figure 4.18 the JICA cooperation planning survey final report on the irrigation sector (upper Egypt and middle Delta) in Egypt (JICA, 2018)

Table 3.3.2 shows detail information for the canals in Kased sub-region, showing canal length and area which has been estimated by satellite image analysis. These areas are shown in net, not in gross. Figure 3.3.4 illustrates the canal schematic diagram and also the rotational irrigation system. There are 2 types of rotational system in this sub-region, namely, by season. During summer season, all the branches area grouped into 2, and 5-day ON and 5-day OFF rotation is conducted. During winter, the branch canals are grouped into 3, whereby 5-day ON and 10-day OFF rotation is practiced.

Table 3.3.2 Detail Information for Canals in Kased Sub-region (Gharbia Governorate)

No.	Canal name	Length km	Area (Satellite) feddan	Area, ha	Remarks
	Kased Main Canal	42.0			
①	Al kased	7.2	2,463	1,034.5	
②	Qaem Tanta	1.4	561	235.6	
③	Ekhnway	4.4	1,442	605.6	
④	Qohafa El Gedida	2.6	350	147.0	
⑤	Al Awqaf	2.9	851	357.4	
⑥	El Melqa	5.1	3,554	1,492.7	
⑦	Gann. Shabashir	11.2	1,151	483.4	
⑧	Abo Kharouf	2.8	851	357.4	
⑨	Sbrebay	14.1	4,905	2,060.1	
⑩	Ganbia1 of Shabsher	7.2	2,453	1,030.3	
⑪	Qahafa new	1.7	300	126.0	
⑫	Om Rabee	3.7	1,001	420.4	
⑬	El Wrety	2.0	501	210.4	
⑭	Smella	10.3	4,299	1,805.6	
⑮	Segen	3.6	706	296.5	
⑯	Ganbia2 of Kased	3.5	1,001	420.4	
⑰	El Nashw	4.2	1,902	798.8	
⑱	Boreg	3.6	1,852	777.8	
⑲	Ganbia4 of Kased	3.4	360	151.2	
⑳	Damat	11.5	4,655	1,955.1	
㉑	Waslet Damat	2.1	651	273.4	
㉒	Ganbia5 of Kased	1.8	671	281.8	
㉓	Ganbia6 of Kased	1.7	185	77.7	
㉔	Shoubra Baloola	6.7	1,902	798.8	
㉕	Qotor	7.5	3,153	1,324.3	
㉖	Sourad	7.9	3,904	1,639.7	
㉗	Negreeg	1.2	1,101	462.4	
㉘	Al Samahat	15.2	6,307	2,648.9	
㉙	El Taaleb	10.1	2,302	966.8	
㉚	El Fahimia	2.3	1,101	462.4	
㉛	Al Gamayel Al Qebliya	3.0	1,552	651.8	
㉜	Shenno	5.6	998	419.2	
㉝	Al Gamayel Al Bahiriya	4.2	1,652	693.8	
㉞	El Shakria	14.0	2,503	1,051.3	
㉟	Rewina	20.2	12,295	5,163.9	
㊱	Mehdet el kasab	4.1	1,261	529.6	
㊲	Al Muit Al Sharkqi	4.3	996	418.3	
㊳	Shaboora	1.9	871	365.8	
㊴	Dalil El Ghamia	2.3	350	147.0	
㊵	EL Ghamria	6.0	2,382	1,000.4	
㊶	Sandella	9.1	9,019	3,788.0	
㊷	El Khraba	5.0	701	294.4	
㊸	Om Dokhan	3.0	1,031	433.0	
㊹	Al Saath	2.7	551	231.4	
㊺	Al Saath Feeder	1.0	147	61.7	
㊻	G1 Elyosra for Elkased	Cancel			

No.	Canal name	Length km	Area (Satellite) feddan	Area, ha	Remarks
㊼	Direct btw G6 and Sorad Regulator	14.1	3,233	1,357.9	
	Total	263.4	95,976	40,309.9	

Source: Irrigation Directorate (Gharbia), and the area by satellite image analysis conducted by JICA Survey Team

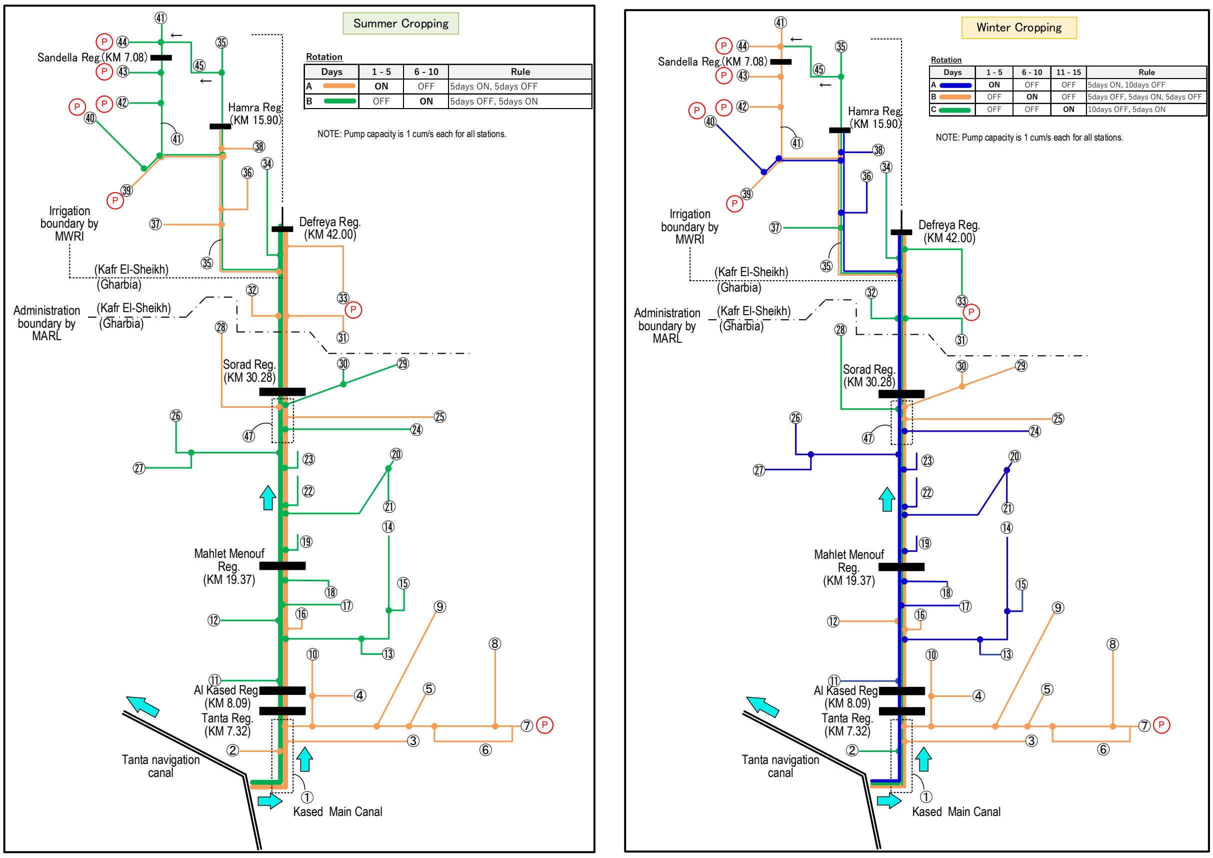


Figure 3.3.4 Schematic Diagram of Kased Irrigation Network

Source: JICA Survey Team, prepared based on the information by General Directorate of Irrigation (Gharbia)

3.4 Maintenance of Irrigation Facilities

3.4.1 Organizational Setting for Maintenance Works

Maintenance of irrigation facilities (e.g., periodic dredging of canals) is often outsourced to private companies or undertaken by the Central Directorate for Canal Maintenance. The Central Directorate for Canal Maintenance is under the Irrigation Affairs Sector of the Irrigation Department. At the regional level (the General Directorate Level), there are six offices throughout the country, each with its own workshop for the repair of maintenance machinery and the manufacturing of the steel structure, etc. (see Figure 3.4.1).

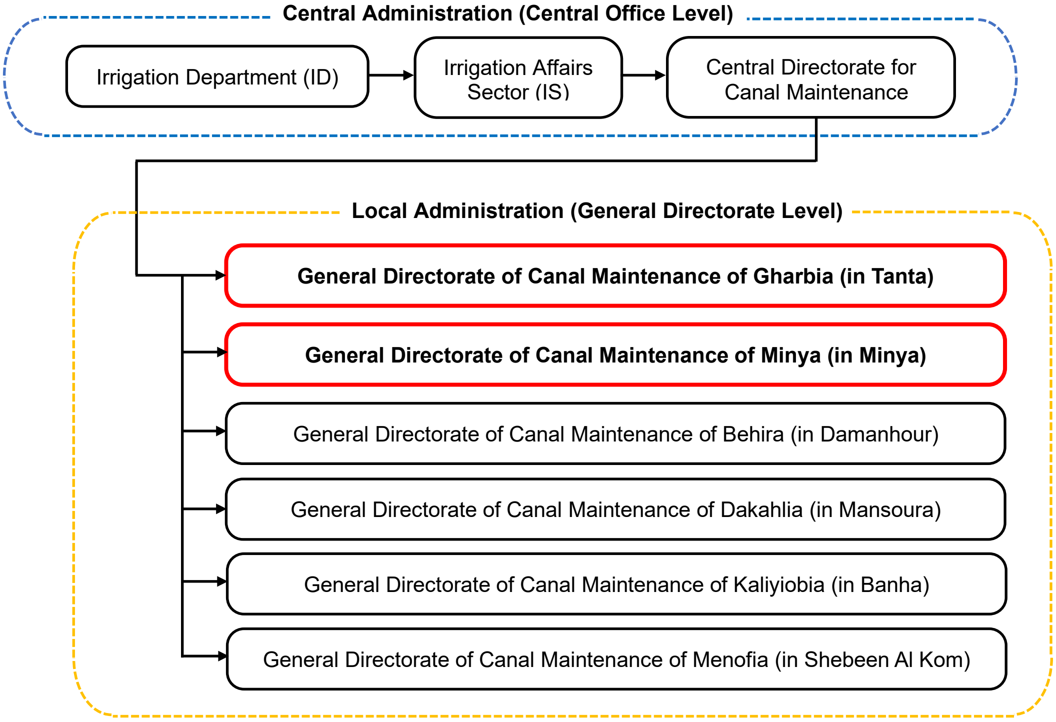


Figure 3.4.1 Canal Maintenance Authority Organizational Chart
Source: Ministry of Water Resources and Irrigation

3.4.2 General Directorate of Canal Maintenance

1) Duties of the General Directorate of Canal Maintenance

The maintenance of the Bahr Yusef and Ibrahimia Principal Canals is carried out by the Minya Office (located in Minya City), and the Kased Canal is maintained by the Gharbia Office (located in Tanta City). The main activities of each regional office are maintenance of irrigation canals (e.g., removal of sediment, weeds, garbage, etc.), repair of canal banks and slopes, maintenance and repair of maintenance machinery and equipment (backhoes, wheel loaders, etc.), fabrication and repair of steel structures such as gates and screens installed in irrigation facilities, and simple repair of concrete structures.

Maintenance and repair of equipment are conducted at the workshop, and repairs requiring special skills (e.g., electrical system repairs) are outsourced to private sectors specializing in those areas. When maintenance equipment malfunctions during on-site work, the equipment is transported from the site to the workshop for its repair, which interferes with the progress of the maintenance work. For this reason, the workshop staff raised an issue advocating for the introduction of mobile service vehicles.

Steel slide gates and garbage screens installed at the regulators and intake facilities are in most cases fabricated in the workshop of the General Directorate of Canal Maintenance, and the fabrication of the large-scale radial gates is outsourced to the private companies. Other steel structures such as steel pipes, steel siphons, etc. are procured from the Ministry of Trade and Industry's (MTI) steel factory.

2) Personnel for the Canal Maintenance Directorates

Table 3.4.1 shows the engineers and technicians assigned to the Gharbia and Minya Canal Maintenance Offices that have jurisdiction for the maintenance works. Under the supervision of the Director General, engineers, technicians, and others are engaged in the maintenance of canals, maintenance and repair of equipment, and fabrication of steel structures in each office. Note that the table below does not include administrative and clerical staff.

Table 3.4.1 Staffing of General Directorates of Canal Maintenance (Minya, Gharbia)

No.	Gharbia Office		Minya Office	
	Position	Number of Staff	Position	Number of Staff
1	Director General	1	Director General	-
2	Mechanical Engineer	2	Mechanical Engineer	7
3	Electric Engineer	1	Technician (Electricity Equipment)	3
4	Agriculture Engineer	1	Technician (Steel Structure & Equipment)	10
5	Technician (Steel Structure & Equipment)	4	Technician (Lathe Machine)	3
6	Technician (Lathe Machine)	2	Technician (Carpenter)	4
7	Technician (Rubber Work)	4	Technician (Gate Facilities)	4
8	Technician (Electric Work)	3	Technician (Civil Work)	7
9	Technician (Maintenance)	5	Technician (Rubber Work)	1
10	Technician (Workshop)	3		
11	Technician (Mechanic)	3		
12	Driver/Truck Driver	13		
	Total	**42**	**Total**	**39**

Source: General Directorate of Canal Maintenance

3) Machineries Owned by the Canal Maintenance Directorates

The names, year of manufacture, and condition of equipment owned by the Gharbia and Minya Offices are summarized in Tables 3.4.2 and 3.4.3. Overall, it is clear that the current equipment is aging, and therefore maintenance and repairs may be time-consuming. In addition, there are several pieces of equipment that have broken down and cannot be repaired or are no longer repairable due to the unavailability of spare parts and consumables. This equipment is left unattended at the office premises.

Table 3.4.2 Maintenance Equipment for General Directorate of Canal Maintenance (Gharbia Office)

No.	Name of Machinery	Year of Manufacture	Condition	Others
1	Wheel Excavator	2009	Active	Aged, maintenance and repair are frequently required.
2	Hydraulic Excavator	2004	Active	
3	Long Armed Hydraulic Excavator	2003	Active	
4	Backhoe Loader	2012	Active	
5	Backhoe Loader	2010	Not active	Broken and irreparable
6	Backhoe Loader	2009	Active	Aged, maintenance and repair are frequently required.
7	Wheel Loader	1998	Active	
8	Wheel Loader	2010	Active	
9	Wheel Loader	2007	Active	
10	Sweeper	1995	Active	
11	Truck Crane (Loading capacity: 25 ton)	No data	Not active	Broken and irreparable
12	Dozer	No data	Good, but not active	Irreparable due to the lack of spare parts or consumables
13	Agricultural Tractor	No data	Active	
14	Agricultural Tractor	No data	Active	
15	Forklift Truck	1991	Active	Aged, maintenance and repair are frequently required.

No.	Name of Machinery	Year of Manufacture	Condition	Others
16	Motor Grader	1991	Good, but not active	Irreparable due to the lack of spare parts or consumables
17	Motor Grader	1987	Good, but not active	Irreparable due to the lack of spare parts or consumables

Source: General Directorate of Canal Maintenance

Table 3.4.3 Maintenance Equipment for General Directorate of Canal Maintenance (Minya Office)

No.	Name of Machinery	Year of Manufacture	Condition	Others
1	Hydraulic Excavator	1998	Active	Aged, maintenance and repair are frequently required.
2	Hydraulic Excavator	1998	Active	
3	Hydraulic Excavator	1998	Good, but not active	Hydraulic cylinder needs to be filled with hydraulic oil
4	Long Armed Hydraulic Excavator	2010	Good, but not active	Attachments (backet etc.) are required.
5	Dozer	2005	Active	
6	Dozer	1991	Active	
7	Backhoe Loader	1991	Active	Aged, maintenance and repair are frequently required.
8	Backhoe Loader	1991	Good, but not active	Hydraulic cylinder needs to be filled with hydraulic oil
9	Motor Grader	2005	Active	
10	Forklift Truck	1991	Active	Aged, maintenance and repair are frequently required.
11	Truck Crane (Loading capacity: 25 ton)	1991	Good, but not active	Hydraulic cylinder needs to be filled with hydraulic oil
12	Sweeper	1998	Active	
13	Dump Truck	1990	Active	Aged, maintenance and repair are frequently required.
14	Dump Truck	1998	Active	
15	Dump Truck	1998	Active	
16	Dump Truck	2008	Active	
17	Pick-up Truck	2000	Active	
18	Pick-up Truck	2000	Active	

Source: General Directorate of Canal Maintenance

Long Armed Hydraulic Excavator (Active)

Wheel Excavator (Active)

Backhoe Loader (Active)

Wheel Loader (Active)

Dozer (Not active)

Backhoe Loader (Not active)

Figure 3.4.2 Maintenance Equipment at the Canal Maintenance Directorate (Gharbia office)

Source: JICA Survey Team

4) Workshop Equipment Owned by the Canal Maintenance Directorates

The equipment in the workshop is very old, having been provided by USAID in 1984 and procured by MWRI in the 1980s and 1990s. The JICA Survey Team has interviewed the workshop engineers and technicians on the conditions of the workshop equipment. From the interviews, it was confirmed that there are requests for updating existing equipment and installing new equipment (see Table 3.4.4).

Table 3.4.4 Conditions of Workshop Equipment (Gharbia and Minya Offices)

No.	Name of Workshop Equipment	Year of Manufacture	Conditions
1	Hydraulic Press Machine	1984 (USAID)	The pressing capacity of existing equipment is 25 tons. The workshop engineers and technicians want to use a 100 - 200 tons pressing machine.
2	Engine Lathe	1984 (USAID)	It is functioning, due to periodic maintenance and repair.
3	Cylinder Boring Machine	1984 (USAID)	It is functioning, due to periodic maintenance and repair.
4	Bench Electric Grinder	1984 (USAID)	It is functioning, due to periodic maintenance and repair.
5	Welding Machine with Diesel Engine	1984 (USAID)	It is broken and irreparable.
6	Welding Machine on Electricity	1988 (MWRI)	It is functioning. However, the workshop engineers and technicians want more high-performance equipment.
7	Air Compressor with Engine	1984 (USAID)	It is functioning, due to periodic maintenance and repair.
8	Electric Cutter	1984 (USAID)	It is functioning. However, the workshop engineers and technicians want the latest high-power type.
9	Portable Crane	1984 (USAID)	It is broken and irreparable. The workshop engineers and technicians want a crane with higher lifting capacity.
10	Steel Plate Cutting Machine	NA	The workshop engineers and technicians want a steel plate cutting machine for the manufacturing of gate bodies, etc.
11	Hydraulic Hose Fitting Press Machine	NA	The workshop engineers and technicians want a hydraulic hose press machine to repair the hydraulic system of the maintenance machinery and the workshop equipment.

Source: JICA Survey Team


Outside View of Workshop


Inside View of Workshop


Welding Machine with Diesel Engine


Hydraulic Press Machine

Cylinder Boring Machine


Bench Electric Grinder

Figure 3.4.3 Workshop Equipment of General Directorate of Canal Maintenance (Gharbia Office)

Source: JICA Survey Team

3.5 Meska Improvement and Modern On-Farm Irrigation Practices

Efforts toward equal water distribution and efficient use of irrigation water will continue to be increasingly important in Egypt. This section summarizes the Meska improvement projects and modern irrigation developments that have been implemented to date.

3.5.1 Irrigation Improvement Project (IIP)

1) IIP

The Irrigation Improvement Project (IIP) was implemented in two phases, Phase 1 (IIS 1) and Phase 2 (IIS 2), with funds from the WB and the Kreditanstalt für Wiederaufbau (KfW). It aimed to improve the economic and social conditions of Egyptian farmers and increase crop production and farmers' income through improved irrigation water management. Both IIS were implemented as follows:

- ✓ IIS 1 was implemented between 1996 and 2006 and covered two Nile Delta governorates (Behera and Kafr El Sheikh). The project covered an area of 248,000 feddan at a total project cost of USD 182.3 million.
- ✓ IIS 2 was implemented by KfW, which took over the project that could not be completed under the original plan for IIS 1. IIS 2 continued to implement irrigation facility improvements until December 2014 and then continued until 2016 for activities such as constructing facilities that had been delayed in the handover to the Water Users' Associations (WUAs) due to power failures.

Many irrigation canals in Egypt are earthen canals constructed at lower elevations than the fields. Therefore, farmers need to pump water out of the canals to irrigate their fields. To implement equitable water allocation, the IIP has constructed a pumping station for farmers to use together and supported the establishment and formation of WUAs. In addition to supporting the establishment of WUAs, the IIP supported a series of activities, from the design and construction of the pumping station to Meska improvement.

There are two types of Meska improvement: the open canal type, for which the Meska is newly constructed above the field elevation, and the low-pressure pipeline type, in which the Meska is replaced by a low-pressure pipeline buried underground. In the former type, an open canal is constructed with a bedding height of 0.15 m higher than the field, and the Meska is improved so that the field can be irrigated by gravity. In the pipeline type, a pipeline is constructed at the location of the existing Meska. In both cases, a pumping station is constructed at the beginning of the improved Meska to pump water from the branch canal to the improved Meska.

2) Integrated Irrigation Improvement and Management Project (IIIMP)

The Integrated Irrigation Improvement and Management Project (IIIMP) was the successor to IIP 1 and IIP 2. This was a 7-year multi-donor project implemented from 2006 to 2016. IIIMP was funded by the WB, KfW, the Netherlands, and the Egyptian government. The project covered Mahmoudia and Mit Yazid in the Central and Western Delta (550,000 feddan), and aimed to strengthen the capacity to management irrigation and drainage and improve water use efficiency. As with the preceding IIP, the project's approach emphasized the integration of irrigation water use and implementation based on the farmers' participation.

Table 3.5.1 shows the breakdown of IIIMP funds, and Table 3.5.2 shows each implementing partner's activity component. The IIIMP began in 2006, and although the project was temporarily suspended (January 2011 to June 2013) due to political unrest, the construction period was extended, and the project was completed in 2016. In addition to MWRI's IIS, various institutions, such as the MALR and the Ministry of Electricity and Energy, also participated in the IIIMP.

Table 3.5.1 Overview of the IIIMP Funding Arrangement

Financing Source	Amount	Remarks	Effective	Original Closing Dates	Extension
World Bank	USD 120,000,000	IBRD Loan	May 2006	Mar 2014	Mar 2016
Kreditanstalt für	EUR 38,800,000	Loan (tranche I)	Dec 2008	Dec 2015	Dec 2016
Wiederaufbau	EUR 25,000,000	Loan (tranche II)	Feb 2012	Dec 2015	Dec 2016
(KfW)	EUR 2,000,000	Grant for Technical Assistance	Dec 2008	Dec 2015	Dec 2016
Netherlands	EUR 14,900,000	Grant for Financial Assistance	Jan 2007	Dec 2013	Mar 2014
GOE	EGP 575,000,000	National budget	May 2006	n/a	n/a

Source: PMU COMPLETION REPORT IBRD Loan no 7291-EGTIIS, Ministry of Water Resources and Irrigation, Integrated Irrigation Improvement and Management Project, August 2016

Table 3.5.2 Breakdown of Implementing Partners and Activities

Partners	Activities
WB (IBRD)	A loan for infrastructural improvements and equipment
KfW	A loan from KfW for financing infrastructural improvements
KfW	A grant from KFW for financing the TA services
Netherlands	A grant from the Netherlands Government for the preparatory phase and institutional development and capacity-building activities relating to WUOs (water users' organizations) on the one hand and MWRI on the other, as well as to the rehabilitation of district buildings
GOE	GOE with a national counterpart fund budget

Source: PMU COMPLETION REPORT IBRD Loan no 7291-EGTIIS, Ministry of Water Resources and Irrigation, Integrated Irrigation Improvement and Management Project, August 2016

Table 3.5.3 shows the status of the implementation of the IIIMP's Meska improvement projects. EGP 857 million was invested in the Meska improvement, and construction work was carried out over an area of 95,532 feddan. The amount of construction per unit area was EGP 10,464/feddan for KfW, EGP 7,909/feddan for WB, and an average of EGP 8,966/feddan for both projects. The reason for the higher project cost per unit area funded by KfW is that the construction of the Marwa Pipeline was included in Mahmoud Governorate as additional work.

Table 3.5.3 Summary of IIIMP Meska Improvement Works

Donor	Command area	Number of contracts	Combined final Expected area (fed)	Total final Expected cost (EGP)
KfW	Mahmoud	36	32,579	323,973,048
	Met Yazd	11	6,931	89,450,537
	KfW subtotal	47	39,510	413,423,585
Word Bank	Mahmoud	26	20,378	160,575,850
	Met Yazd	52	35,644	282,501,600
	World Bank subtotal	78	56,022	443,077,450
Grand total		125	95,532	856,501,035

Source: PMU COMPLETION REPORT IBRD Loan no 7291-EGTIIS, Ministry of Water Resources and Irrigation, Integrated Irrigation Improvement and Management Project, August 2016

The Meska Improvement Project and the IIP were carried out with farmers' participation. The establishment of Meska WUAs is mandatory for Meska improvement, as per Law 213 (1994). The condition for the establishment of the Meska WUA is with the consent of more than 50% of the farmers involved[1]. Meska WUAs participate in the planning and design process of the Meska improvement, and play an important role in the operation and maintenance of the facilities. The Irrigation Advisory Service (IAS) under the IIS is responsible for these processes. Like the IIP, the IIIMP's Meska improvement is also based on a cost-recovery system. Farmers pay the investment costs added to the land tax. Law 213 (1994) stipulates that the cost of the Meska improvement is to be recovered from the landowner who benefits from the investment. The cost of civil works is repaid over 20 years, in interest-free payments.

The IAS has determined the Meska improvement will be carried out in 5 stages (see Table 3.5.4). Once the improved Meska irrigation facilities are handed over to the Meska WUAs, the subsequent support to the Meska WUAs will focus on agricultural extension activities to improve crop production by MALR.

[1] The Meska improvement will use pump at a single location; namely, it is necessary to jointly operate and maintain the pump system, thus the Meska WUA is established to realize this joint work. The condition for this is the consent of more than 50% of the farmers involved.

As the farmers themselves will be responsible for irrigation water management, the Meska WUAs need to collect information on irrigation water uses from MWRI and MALR to implement proper water management.

Table 3.5.4 Steps and Contents of Each Stage of IAS Meska Improvement

Stage	Process
Stage 1	Collection of physical and social data, farmer names and land holdings, project awareness, obligations of the Meska WUAs, and project involvement
Stage 2	Establishment of the Meska WUA, adoption of the standard constitution, and election of office bearers (chairman, treasurer, secretary/vice-chairman, and pump operator/maintenance person)
Stage 3	Beneficiary participation in the planning and design of the physical works in consultation with IAS and IIS, and written approval by Meska WUA of the proposed layout; PMU Completion Report for IBRD Loan IIIMP
Stage 4	Assisting IIS by IAS in supervision of the construction, recommendation of design modifications, and familiarization with the O&M of the system
Stage 5	Handover of the physical infrastructure to the Meska WUA and formal registration of the WUA

Source: PMU COMPLETION REPORT IBRD Loan no 7291-EGTIIS, Ministry of Water Resources and Irrigation, Integrated Irrigation Improvement and Management Project, August 2016

Table 3.5.5 shows the construction specifications for the Meska improvements implemented on the Serenbay 1 Branch Line in Mahmoudia Governorate. This is an example of 15 Meska improvements implemented in a target area of 766 feddan. The design was completed in 2014, and construction was completed from March 2015 to November 2016, at a total project cost of EGP 6,389,750. Based on the targeted area (766 feddan) and Meska improvements (15 locations), the targeted size of Meska improvements per location was about 50 feddan, and the average construction cost was EGP 8,341/feddan.

Table 3.5.5 Examples of Meska Improvement Project Specifications

Construction	Specification
Lifting pump	3 lifting pumps (2 electric-operated, 1 diesel-operated) Head: 10.5 - 13 m Area covered: 50 to 100 feddan (minimum area: 15 feddan)
Pump station building	4 m x 4.5 m (reinforced concrete with brick walls)
Suction sump	Concrete sump with a diameter of 2.25 m (gate and screen at the border between the canal and the sump)
Pipeline	Diameter: 200 - 400 mm; material: PVC
Field hydrant	Diameter: 150 mm; material: PVC

Source: PMU COMPLETION REPORT IBRD Loan no 7291-EGTIIS, Ministry of Water Resources and Irrigation, Integrated Irrigation Improvement and Management Project, August 2016

Table 3.5.6 shows the lessons learned from Meska improvements. These lessons will not only improve crop productivity, but also increase land-use area and strengthen organizations such as Meska WUAs. These lessons should also be referred to in planning any future irrigation management improvements in Egypt.

Table 3.5.6 Lessons Learned from Meska Improvements

Lessons Learned
Early IIIMP changes include reduced irrigation costs and time after Meska improvement and establishment of Meska WUAs.
Improved flow rates have increased crop yields, especially for farmers at the ends of branch canals.
Increased participation of women in some WUAs and Branch Canal Water Users' Associations (BCWUAs).
Conflicts between farmers using the same Meska have decreased since the completion of the Meska improvement works.
The installation of a communal pumping station in each Meska has reduced the likelihood of water quality deterioration in the irrigation water at the end of the line due to garbage, etc.
Pipelining of Meskas and Marwas has increased the area of land used.

Source: PMU COMPLETION REPORT IBRD Loan no 7291-EGTIIS, Ministry of Water Resources and Irrigation, Integrated Irrigation Improvement and Management Project, August 2016

3.5.2 Modern On-Farm Irrigation Practices

Sprinkler irrigation and drip irrigation have already been introduced in Egypt's New Lands and also in small parts of Old Lands. In the New Lands, which extends to the west of the Bahr Yusef Canal, private companies and farmers are using the water delivered from the Bahr Yusef Canal and some groundwater as water sources. In the Old Lands, some farmers, especially those at the end of the canals, where water shortages and water quality deterioration are severe, have started introducing modern on-farm irrigation facilities on their own.

With this background, a state program for the development of a modern irrigation system was launched in 2021, with the agreement of MALR, MWRI, MOF (the Ministry of Finance), and CBE (the Central Bank of Egypt). The program plans to install a modern irrigation system for 3.7 million feddan and construct 22,000 km of canal linings in four years. The Egyptian government estimates that the introduction of a modern irrigation system will cost EGP 30,000 - 40,000/feddan, amounting to a total cost of approximately EGP 11 billion to EGP 15 billion. The national government has already provided EGP 60 million, but no donors or other funding sources have been identified at this time. Farmers will be able to borrow for the modern irrigation system through this program, with 0% interest and a 10-year repayment term.

According to the above agreement, MWRI will be responsible for lining the canals, while MWRI and MALR will share about 2 million feddan each for modern irrigation developments. MWRI and MALR have already started studies in Qalyubia and Beni Suef Governorates, respectively. As of April 2022, MWRI has started planning for modern irrigation development, and MALR has started preparing technical design documents and procuring contractors. According to interviews with MALR, the unit cost for the modern irrigation development is estimated at EGP 35,000 to EGP 50,000/feddan. This includes the installation of one-limiting pumps, Meska and Marwa improvements, and hydrants for conventional basin irrigation.

The past practices of modern on-farm irrigation by MWRI and MALR are briefly shared below. Note that the following examples do not fall under the above-noted state program targeting about 4 million feddan, but are ones implemented before that program was announced:

1) Example from MWRI (IIS)

The first WUA where modern irrigation facilities were installed by MWRI was in Fayoum. MWRI's GDIAS (Governorate Directorate for Irrigation Advisory Services) provided modern irrigation development support to this Meska WUA. This Meska WUA was established in 2018 after 12 farmers who wanted to install modern irrigation left the existing Meska WUA. Previously, they had been using basin irrigation from the existing Meska, but were unable to plant in the entire area due to a lack of water for irrigation. Therefore, a request for assistance in introducing modern irrigation development was made through GDIAS, and a project to improve modern irrigation development was implemented.

The modern irrigation facilities were planned, designed, and constructed under MWRI supervision and build by a construction company. As in the case of IIS and IIIMP, the WUA participated in the planning and design with the support of GDIAS. The area covered by the modern irrigation improvement was 77 feddan and consisted of 12 farms. Compared to the typical field size of around 1feddan per farmer, this Meska WUA was a group of farmers with large farms. A series of modern irrigation facilities were installed, including one-lifting pump, filters, pipelines, and sprinklers.

The main crops grown are forage crops with sprinkler irrigation. Sprinklers installed at 12-meter intervals and at a height of 80 cm irrigate a variety of crops. Concrete-lined canals enable gravity irrigation too. The sprinklers are used for 5 out of 6 irrigations in maize cultivation, and the sixth irrigation is conducted by basin irrigation from the canal, which also serves as leaching to wash away salt and other substances that have accumulated in the soil.

It is reported that the introduction of modern irrigation systems has increased crop production by 30%. Furthermore, the use of liquid fertilizer has saved labor for fertilizer application; saved irrigation water and solved water shortages; and diversified crops to include tomatoes and other vegetables, medicinal herbs, and aromatic plants in addition to traditional crops. According to the interview with the head of the Meska WUA, the introduction of modern irrigation facilities would go smoothly in a group of large farmers, but in a group of small farmers (1 - 2 feddan/farmer), it may be difficult to implement, so careful consideration would be necessary.

Table 3.5.7 Example of Modern Irrigation Introduction at the Individual Farm Level

Item	Specifications	Remarks
Farmers	・ Irrigated area: 77 feddan ・ Target farmers: 12 farmers (average area: 6.4 fed/farmer)	・ Al-Mahmoud WUA, Silah Village, Fayoum Governorate ・ Target crops: Traditional crops such as maize, wheat, and grass ・ After the introduction of the facility, vegetables such as tomatoes and medicinal and aromatic herbs are also cultivated.
Water source	・ Surface water	・ Silah Al Omoumi Branch Canal
Pumps	・ Electric power pumps (2 units, 60 HP)	・ Approx. 1 km from the pumping station to the field ・ Pumping by 2 lines (1) to sprinkler and (2) to improve the Meska
Irrigation method	・ Sprinkler irrigation	・ The Meska WUA requested MWRI's Governorate Directorate for Irrigation Advisory Services (GDIAS). ・ In 2018, the first protocol for the introduction of modern irrigation by MWRI was prepared. Construction was managed by MWRI and constructed by the Ministry of Army Production (MARP). The Meska WUA participated in the planning and design. ・ Sprinklers are installed at 12 m intervals and are 80 cm high. ・ In the case of the maze, there are 6 irrigations (5 sprinkler irrigations and the last one with basin irrigation for leaching purposes).
Changes after introduction	・ Pipelining of existing Meska in open canals ・ Reduction of fertilizer application labor (labor cost) by using liquid fertilizer ・ Diversification of crops	・ Crop productivity increased by 30%. Crop area increased by 10%. ・ Basin irrigation originally took 93 minutes/feddan to provide the amount of water needed for crop growth, but this was reduced to 53 minutes/feddan. It was determined that about 40% of water could be saved. ・ The number of pests and weeds proliferating in the open canal Meska has been reduced. ・ The land increased by 10% due to Meska improvement by constructing culvert drainage and open drainage canals. ・ The system is capable of both sprinkler irrigation and gravity irrigation with concrete-lined canals and can be used for basin irrigation and leaching. ・ In addition to traditional crops such as maize, wheat, and grass, vegetables such as tomatoes and medicinal and aromatic herbs are planned.

Source: Interview by JICA Survey Team

2) Example from MALR (Field Irrigation Development Project Management Unit)

MALR's department in charge of modern irrigation development is the Field Irrigation Development PMU. This unit was established as an official department in 2011, after MALR conducted a field irrigation development project. Three projects have been implemented so far, as shown in Table 3.5.8. Each project has already been completed, and no donor projects are currently being implemented (as of March 2022). Currently, the unit is working on the state program for the development of modern on-farm irrigation facilities, which was agreed upon by the government in 2021.

Table 3.5.8 Field Irrigation Development PMU's Implementation Projects

Funding Source	Project Name	Status
World Bank	Farm-Level Irrigation Modernization Project (FIMP)	2010–2017
IFAD	On-Farm Irrigation Development in the Old Lands (OFIDO)	2009–2020
OPEC Fund	On-Farm Irrigation Development Project (OFIDP)	2012 (Completed)

Source: Interview with MARL staff

All of the above were Meska or Marwa improvement projects and were implemented on a cost-recovery basis. This is the same method used for the IIS's Meska improvement projects. In the group of farmers who wanted to improve their Meska, the per capita project cost was calculated based on the size of each farm area, and each farmer paid the cost of the Meska improvement project as a top-up to their land tax payment.

The repayment period is set at 20 years for an improved Meska and 10 years for an improved Marwa, with an interest rate of 0%. As of April 2022, MALR is planning a pilot project for modern irrigation in

Beni Suef Governorate. The government has already allocated EGP 60 billion to the Agricultural Bank of Egypt and the National Bank of Egypt for the next 4 years. Table 3.5.9 shows the steps of the program for the introduction of modern irrigation facilities.

Table 3.5.9 Steps in the Program to Introduce Modern Irrigation Facilities

Step	Process
1	A group of farmers who want to install modern irrigation facilities applies to the Agricultural Cooperative Association*).
2	The staff of the Ministry of Agriculture and Land Development surveys the land and calculates the installation cost.
3	Ministry of Agriculture and Land Development staff obtain agreement documents from the farmer group for the introduction of modern irrigation facilities.
4	The Ministry of Agriculture and Land Development applies for a bank loan based on the agreement document from the farmer group.
5	At the same time, the Ministry of Agriculture and Land Development selects the contractor.
6	The bank transfers the construction cost to the selected contractor, and construction begins.
7	The Ministry of Agriculture and Land Development procures a consultant to supervise the construction.
8	After the installation of modern irrigation facilities, the agricultural cooperative collects money from farmers and repays the bank.

*) In the MALR project, the application is made by a voluntary group of farmers, not by Meska WUA.
Source: Interview with MARL staff

In Beni Suef Governorate, 2,000 feddan of Old Lands are being prepared for modern irrigation installation (as of March 2022). The design of 600 feddan has been completed (as of October 2021), and the design of the remaining area is ongoing. For the 2,000 feddan, farmer groups have already agreed to install modern irrigation facilities and will proceed according to the above-mentioned procedure.

3) Example from EU Water Sector Technical Assistance and Reforms Support (EU Water STARS)

EU STARS is a technical cooperation project aimed at creating practical perspectives on and methods for the transition from conventional basin irrigation to modern irrigated agriculture and sharing them among stakeholders involved in agriculture, finance, planning, and water resource management (Irrigation and Agriculture Modernization Program (IAMP)). The research concept is to modernize agricultural production by integrating agriculture and water management. The project began in February 2018 and was completed in September 2021, extending the original completion schedule of December 2020. The five main components of the study are listed in Table 3.5.10.

Table 3.5.10 IAMP Components

Components	Scope
A	Contributing to an enabling institutional and financial environment
B	Modernization of the Water Management Framework
C	Capacity development of the relevant institutions
D	Developing communication and information plans for public awareness
E	Preparing technical studies for integrated resource management

Source: EU Water Sector Technical Assistance and Reforms Support (EU Water STARS), Irrigation Modernization in the Nile Delta and Valley, December 2020, EU

Through this study, it was concluded that the introduction of modern irrigation facilities (drip irrigation or sprinkler irrigation) requires continuous water flow at the branch canal level, which makes it difficult to accomplish with the current rotation irrigation methods.[2] According to interviews with EU Water STAR staff, shortening the irrigation interval to about 3 days ON and 3 days OFF is also an option. The pumps that have been proposed through IIS and IIIP are electric power-driven ones. However, since sufficient electric lines to reach rural areas have not been constructed yet, it is necessary to consider how to drive the pumps in the future.

In addition, the report states that the introduction of modern irrigation requires not only the installation

[2] P.xiv, EU Water Sector Technical Assistance and Reforms Support (EU Water STARS), Irrigation Modernization in the Nile Delta and Valley, December 2020, EU.

of equipment in the field but also upstream canals and facilities to ensure that water is distributed to the field. The EU, through the EIB and the EBRD, plans to implement 150,000 feddan (63,000 ha) demonstration projects to introduce modern irrigation. The implementation areas are those in rehabilitation projects such as canal lining have been implemented by the Egyptian government. The projects will be allocated to the Delta, Middle Egypt (north of Upper Egypt: Assiut, Minia, Beni Suef, Fayoum, and Giza), and Upper Egypt, respectively. Table 3.5.11 shows the recommendations for project implementation by the EU Water STAR staff.

Table 3.5.11 Key Recommendations for Project Implementation by EU Water STAR

	Recommendation
Size of the Project	・ Several smaller areas of 10,000 to 15,000 - 20,000 feddan, adding up to 50,000 - 60,000 feddan.
Delivery-scheme level	・ Adoption of “continuous flow” where possible. ・ Replacement of earth Meska and Marwa canals by low-pressure PVC pipes. ・ Installation of electric pump stations at Meskas’ heads. ・ Establishment of Meska water users’ associations (WUAs)
On-farm level	・ Technical assistance at the farm level is required to select a new irrigation system. ・ Value-chain enhancement. ・ Private sector engagement. ・ Farm business plan, farm budgeting, and financial reporting and recording procedures are needed.
Finance	・ Financial (single donor, multiple finances, co-financing) and benefit analyses shall be carried out.
Training	・ Extensive training is required for the irrigation sector engineers at the MWRI, district engineers, and the leaders of the WUAs and BCWUAs. ・ Implementation of a farmers’ field school (FFS).

Source: EU Water Sector Technical Assistance and Reforms Support (EU Water STARS), Irrigation Modernization in the Nile Delta and Valley, December 2020, EU

3.6 Current Irrigation Efficiencies Based on Actually Withdrawn Water and Cropped Area

Along the Bahr Yusef Principal Canal and Ibrahimia Principal Canal, there are regulators where discharge data have been recorded based on the water levels measured, including the intake points of these 2 canals. On the other hand, if there are cropping patterns and also actually cropped/ harvested area available, consumed water volume by those crops can be estimated with reference to a standard water requirement table established by MWRI. By making a comparison between the discharge data and the probable consumed water, actual irrigation efficiency can be estimated.

3.6.1 Procedure of Estimating the Current Irrigation Efficiency

The basic concept is to compare the recorded discharges which have been utilized at certain point of the command area to the estimated crop water consumption volumes which are calculated based on the cropping pattern and the cropped area. The data utilized in this trial are as follows:

Table 3.6.1 Data and Methodology of Estimating Current Irrigation Efficiency

No.	Particular	Content and data source
1	Discharge (withdrawn water volume)	Daily basis discharge data recorded at regulators of Bahr Yusef and Ibrahimia Principal Canals including the intake of Bahr Yusef and Ibrahimia (available for years of 1999 to 2020).
2	Cropping Pattern	Bulletin of Important Indicators of the Agricultural Statistics Winter Crops, Summer and Nile Crops, MALR
3	Cropped Area	Cropped area detected by satellite image analysis using the Sentinel-2 data from 2017/18 to 2019/20 (see 4.1.1 Project Target Area and the Net Irrigation Area). Note that though in '3.7 Trend of Cropped Area by Satellite Image Analysis' Landsat satellite images were utilized due to its long data availability (but the resolution is only 30m x 30m), in this analysis, Sentinel-2 data were utilized due to its higher resolution of 10m x 10m. The Sentinel-2 data are available only from year 2017, so that the data from 2017/18 were utilized in this analysis. The cropped areas estimated in this trial is the average cropped area for the 3 years of 2017/18 to 2019/20 by season (summer season and winter season).
4	Standard water requirement by crop	Based on the standard water requirement table established by MWRI (2010).
5	Crop consumed water volume	According to the cropping pattern, the crop planted is first identified, and then we multiply the standard water requirement for the crop (as indicated in above No.4) into the cropped area detected by satellite image analysis as in above No.3.

Source: JICA Survey Team

The procedure of estimating the current efficiency is illustrated in the following chart of Figure 3.6.1 and detailed as below:

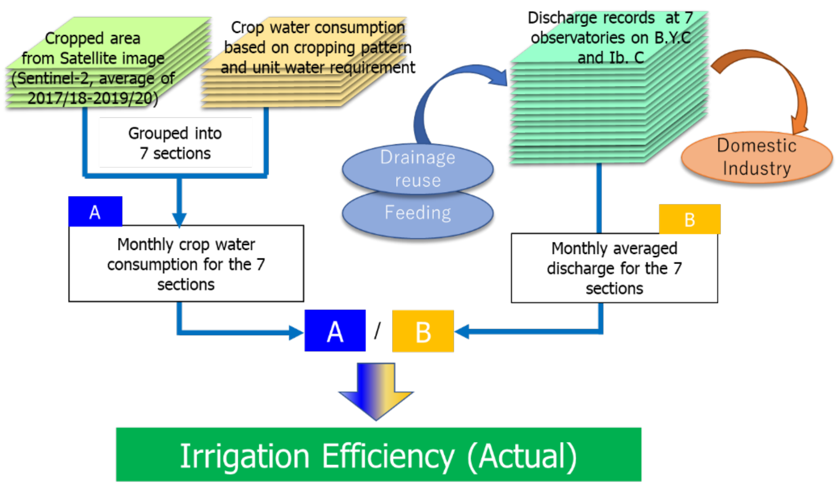


Figure 3.6.1 Flow of Estimating the Current Irrigation Efficiency (Ie)

Source: JICA Survey Team

1) Referring to the intakes and regulators where discharge data are available, the command area of Bahr Yusef and Ibrahimia Principal Canals is divided into 7 sections as illustrated in Figure 3.6.2. Thus, the Bahr Yusef Command Area is divided into 5 sections while that of Ibrahimia is into 3 sections with the last section No.7 somewhat merged (difficult to segregate this

area by canal).

2) There is a total of 5 regulators or intakes where discharge data are available along the Bahr Yusef Canal while there are only one regulator and one weir where the discharge data are available on the Ibrahimia Principal Canal. Based on the discharge data recorded at such regulators, intakes, and weirs, discharge utilized by a section (block) can be calculated by simply subtracting the discharge data recorded at the end of the section from the one recorded at the beginning point of the section. For example, in order to estimate the discharge volume utilized within the Section No.1 area, discharge data recorded at Sakoula Regulator should be subtracted from the discharge data recorded at the intake of Bahr Yusef Canal. Note that discharge data at the El Wasta Regulator on the Ibrahimia Canal is not available, and accordingly discharge utilized within the Section No.6 area cannot be calculated. This calculation of estimating the discharge utilized by each section is made by month as average of the 3 years of 2018 - 2020 corresponding to the cropped area data detected by satellite, and summarized as in the following tables:

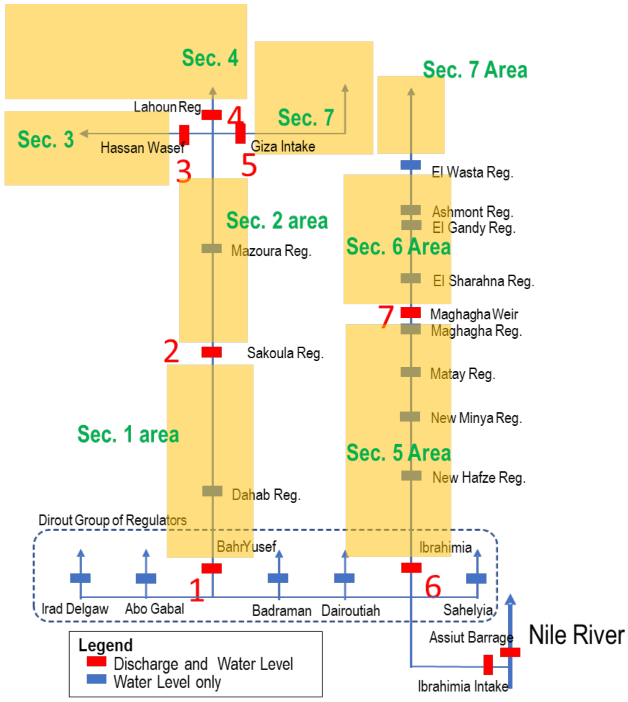


Figure 3.6.2 Discharge Available Regulators/Intakes and those Command Areas

Source: JICA Survey Team based on MWRI Information

Table 3.6.2 Discharge by Section and by Month for Bahr Yusef Command Area

Section	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sec.1 area (m3/s)	9.3	20.0	22.3	25.5	33.6	52.1	55.2	56.8	35.6	19.1	27.2	11.6
Sec.2 area (m3/s)	N/A	13.9	12.4	15.9	23.2	39.3	40.3	35.0	21.6	7.6	1.4	0.1
Sec.3 area (m3/s)	18.9	32.7	31.4	32.4	40.4	49.0	46.8	43.1	40.3	37.5	32.4	27.1
Sec.4 area (m3/s)	14.9	39.6	40.1	37.7	50.8	65.8	65.7	63.5	54.1	49.4	42.1	37.1
Sec.7 area (m3/s)	8.5	11.0	13.2	11.1	8.7	8.0	6.8	10.3	10.2	15.4	11.4	8.2

Source: Average Discharge data for 2018 to 2020, provided by MWRI

Table 3.6.3 Discharge by Section and by Month for Ibrahimia Command Area

Section	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sec.5 area (m3/s)	1.5	53.2	50.7	63.2	75.5	95.4	97.3	86.7	74.2	60.0	60.9	41.6
Sec.6+7 area (m3/s)	13.6	39.4	44.5	44.0	52.7	101.2	98.0	92.6	61.2	51.8	41.3	33.9
Sec.7 area (m3/s)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source: Average Discharge data for 2018 to 2020, provided by MWRI

3) Actual cropped areas are estimated by satellite image analysis of Sentinel-2 covering the years of 2017/18 to 2019/20 (for detail, see 4.1.1 Project Target Area and the Net Irrigation Area). Statistics Yearbook also provides cropped areas; however, the data are summarized by governorate, not by irrigation canal command area basis. Therefore, the cropped area utilized in this trial, which is estimated based on Sentinel-2 satellite image analysis, is more suitable for the purpose of estimating the actual irrigation efficiency. The

Table 3.6.4 Area Detected by Satellite Images

P. Canal	Section	Area, feddan	Area, ha
B.Y.C	Sec.1 area	133,050	55,881
	Sec.2 area	78,244	32,862
	Sec.3 area	138,595	58,210
	Sec.4 area	232,410	97,612
Ib.C	Sec.5 area	258,852	108,718
	Sec.6 area	220,976	92,810
Sub. Total		**1,062,126**	**431,033**
B.Y.C	Sec.7 area /1	88,099	37,002
Ib.C	Sec.7 area /2	11,814	4,962
Total (++Sec.7 area)		**1,162,039**	**440,379**

1/: this area includes from the Giza Intake to the end, while the area from the Giza Intake to the El Ayat PS is only 10,203 feddans.
2/: this area includes only from the El Wasta to El Ayat PS.
Source: Satellite Images

cropped areas detected by the satellite image analysis are summarized by section as shown in Table 3.6.4.

4) To know the cropping patterns, i.e., crop types and those planned seasons, MALR data is referred, e.g., Bulletin of Important Indicators of the Agricultural Statistics Winter Crops, Summer and Nile Crops, which is published every year. As an example, a typical summer cropping pattern is indicated in Figure 3.6.3. With the standard water consumption table utilized in MWRI (see Table 3.6.5), a unit of water consumption is obtained according to the crop type and its season represented by month.

5) By multiplying the cropped area detected by the satellite image analysis into the unit water consumption above-mentioned, now, crop water consumption in a section area (block area) can be estimated. This crop water consumption is compared with the discharge utilized within the section, and thus overall irrigation efficiency pertinent to the section can be estimated. This efficiency estimation is made by month and by section (block), and then by the principal canal, further by the overall Bahr Yusef and Ibrahimia Command Area.

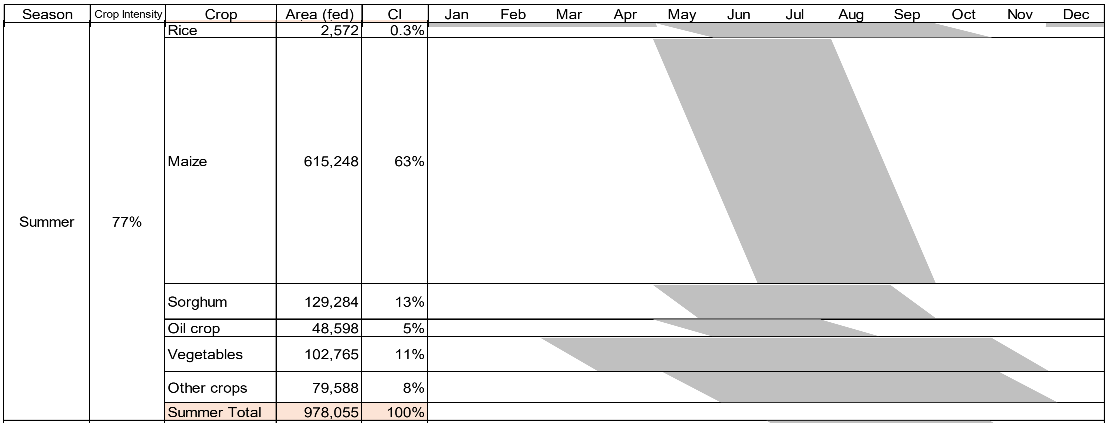


Figure 3.6.3 Typical Summer Cropping Pattern in Upper Egypt

Source: Bulletin of Important Indicators of the Agricultural Statistics Winter Crops, Summer and Nile Crops, MALR

Table 3.6.5 Standard Crop Water Consumption Table Established by MWRI, CUM/feddan

Crop Type	Crop	January	February	March	April	May	June	July	August	September	October	November	December
Winter Crops	Wheat	265.4	328.0	557.3	485.1	71.0						47.5	242.3
	Beans	272.2	302.4	500.2	101.6							142.8	248.6
	Barley		495.0	325.0								480.0	500.0
	Fenugreek	230.0	265.0	300.0									285.0
	Lupines	220.0	270.0	300.0									290.0
	Chick beans	230.0	265.0	310.0									300.0
	Lentil	357.0	357.0	151.2							58.8	201.6	378.0
	S. Berseem	247.8	352.8									235.2	256.2
	L. Berseem	247.8	352.8	541.8	663.6	550.2						231.6	252.0
	Flax	399.0	430.0	273.0								147.0	273.0
	W. Onion	315.0	373.8	466.2	378.0								189.0
	Garlic	117.6	67.2	71.4	58.8				29.4	210.0	394.8	373.8	285.6
	W. Vegetables	117.6	67.2	71.4	58.8				29.4	210.0	394.8	373.8	285.6
	Others	420.0	399.0	273.0									146.0
Summer Crops	Cotton			127.7	390.6	664.0	806.4	915.2	429.7	207.6			
	Rice					21.0	130.2	1,289.4	1,457.4	1,423.8	369.6		
	Maize					205.8	638.4	640.8	680.4	147.0			
	Sorghum					194.3	620.1	930.0	660.8	140.0			
	Soya Beans					575.4	945.0	890.4	176.4				
	Sugarcane	195.3	294.0	428.4	516.6	716.1	768.6	859.3	950.5	894.6	690.1	541.8	312.5
	Sesame					300.0	520.0	550.0	520.0	365.0			
	Peanut					500.0	580.0	1,200.0	1,400.0				
	Onions												
	S. Vegetables			92.4	142.8	260.4	697.2	432.6	201.6	184.8	197.4	117.6	
	Others			-				147.0	520.8	609.0	537.6	474.6	113.4
Nili Crops	N. Maize							252.0	663.6	751.8	529.2	163.4	
	Sorghum							241.3	650.2	740.0	515.1	110.2	
	N.Vegetables					21.0	100.8	260.4	403.2	344.4	277.0	197.4	
	Gardens			298.0	449.4	478.8	520.8	600.6	680.4	659.4	453.0		

Source: Ministry of Water Resources and Irrigation

6) In estimating the current irrigation efficiency, there are water utilizations which have to be considered in addition to the irrigation water. They are; 1) domestic and industrial water use, 2) drainage reuse, and 3) feeding water from one canal to another or from Nile River. The domestic and industrial water should be subtracted from the water discharged, drainage re-use can be considered in estimating the overall irrigation efficiency and also is not needed to consider in case of estimating irrigation efficiency against only fresh water originally discharged, and then, the feeding water should be subtracted from the supply side discharge and added to the received side. Those waters are summarized in the following Table 3.6.6.

Table 3.6.6 Other Water Uses than Irrigation; Domestic & Industry, Drainage Re-use and Feeding

Governorate	Domestic + Industry Use, CUM/s	Drainage Reuse, CUM/s		Feeding, CUM/s	
		Bahr Yusef (BY), (a/)	Ibrahimia (IB), (b/)	From BY to IB (c/)	From Nile to IB (c)
Minya	4.98 (1/)	23.02 (3/)	21.80 (1/)	-	-
Beni Suef	2.86 (2/)	11.70 (3/)	35.25 (2/)	4.50 (2/)	2.85 (2/)
Fayoum	8.01 (3/)	17.36 (3/)	0.00	-	-
Sum	15.84	52.08	57.05	4.50	2.85

Source: 1/: Calculated by JICA Survey Team based on the pumping station data provided by Undersecretary of Water Resources and Irrigation in Minya
2/: Calculated by JICA Survey Team based on the pumping station data provided by Undersecretary of Water Resources and Irrigation in Beni Suef
3/: Head of Central Directorate of Water Distribution (Undersecretary of Central Directorate of Water Distribution)
Remarks: a/: To consider the drainage re-use, it is assumed that the re-sued is practiced from May to mid-September, about 4 and half months per annum as average according to the interviews to the relevant Irrigation Directorate officers including pump operators.
b/: In estimating the drainage re-use based on the pumping station data, the operation hour per day is assumed to be 12 hours per day and the operation is from the beginning of May to mid-September, total 4 and half months per annum. In addition, the pump efficiency is assumed to be 80% of those of specifications taking into account wear of the pumps.
c/: In estimating the feeding amount based on the pumping station data, the operation hour per day is assumed to be 12 hours per day and the operation is from the beginning of May to mid-September, total 4 and half months per annum. The pump efficiency is assumed to be 100% of the specifications taking into account the conditions of relatively new facilities.

3.6.2 Estimation of Current Irrigation Efficiency

Following the procedure aforementioned, the overall irrigation efficiencies are calculated and summarized in Figures 3.6.4 and 3.6.5 with the details in Tables 3.6.7 and 3.6.8. Note that as January corresponds to canal closure period, the irrigation efficiency of this month is not calculated. Figure 3.6.4 and Table 3.6.7 show the irrigation efficiency against fresh water, meaning that drainage reuse is not considered while Figure 3.6.5 and Table 3.6.8 considers the drainage reuse. With the drainage reuse considered, the water available for crops becomes more, so that the irrigation efficiency becomes low. The following can be found:

1) Irrigation efficiency for Ibrahimia Principal Canal is a bit bigger than that of Bahr Yusef Principal Canal. The Bahr Yusef Principal Canal originates in natural river, showing meandering at many places, while Ibrahimia Principal Canal is an artificial canal presenting very straight alignment. Such difference in terms of alignment may presents the difference in irrigation efficiency.

2) Irrigation efficiencies against fresh water, not considering drainage reuse, are 0.560, 0.577, and 0.567 for Bahr Yusef, Ibrahimia and whole Bahr Yusef and Ibrahimia as annual average (average from February to December). If we refer to the irrigation efficiencies during the summer season, say from June to August where the highest efficiency takes place, the efficiencies are 0.692, 0.721, and 0.705 for Bahr Yusef, Ibrahimia and whole Bahr Yusef and Ibrahimia respectively.

3) If we consider the reuse of drainage water, the irrigation efficiencies come to 0.505, 0.522, and 0.510 for Bahr Yusef, Ibrahimia and whole Bahr Yusef and Ibrahimia as annual average (average from February to December). If we refer to the irrigation efficiencies during the summer season, say from June to August where the highest efficiency takes place, the efficiencies arrive at 0.515,

0.547, and 0.548 for Bahr Yusef, Ibrahimia and whole Bahr Yusef and Ibrahimia respectively.

4) As indicated in the figures, there are such months as May, October and November when the irrigation efficiency goes down to around 0.30 only. However, this may not necessarily mean the irrigation efficiency in those months are so low, rather there is a possibility that the change of the cropping pattern between summer season and winter season may not have been well referred in the calculation, i.e., in the actual farmlands, the summer crops may be changing to winter crops gradually, vice versa, including some overlaps.

5) By section, though most of the sections show more or less similar tendency of irrigation efficiencies, the efficiency for Section 2 is low while efficiency for Section 1 is relatively high. For this, there could be a possibility that the discharge at the Sakoula Regulator might have been overestimated. With the overestimated discharge at Sakoula Regulator, the water utilized in Section 1 becomes smaller than what is actually utilized, leading to higher efficiency for Section 1 and lower efficiency for Section 2.

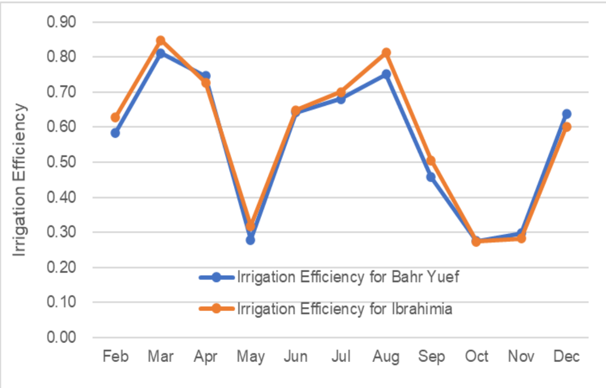


Figure 3.6.4 Overall Efficiency for Bahr Yusef & Ibrahimia against Fresh Water

Source: JICA Survey Team

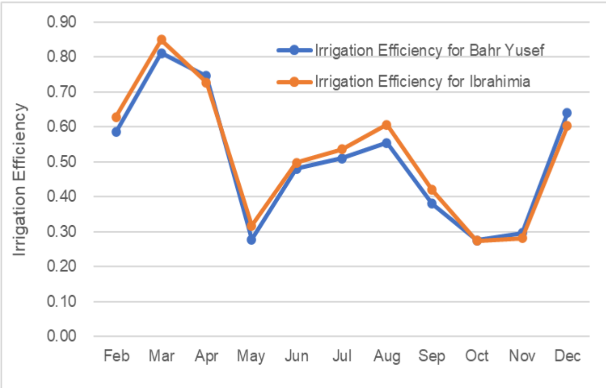


Figure 3.6.5 Overall Efficiency by Bahr Yusef & Ibrahimia with Drainage Re-use (June – Mid Sep)

Source: JICA Survey Team based on MWRI Data

Table 3.6.7 Overall Irrigation Efficiencies Against Fresh Water (NOT Considering Drainage Re-use)

Canals	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg* (2-12)	Avg** (6-8)
Whole Bahr Yusef	0.585	0.811	0.746	0.278	0.643	0.681	0.751	0.458	0.275	0.297	0.639	**0.560**	**0.692**
Whole Ibrahimia	0.629	0.849	0.727	0.318	0.649	0.700	0.813	0.506	0.274	0.282	0.602	**0.577**	**0.721**
Whole BY + IB	0.605	0.828	0.737	0.297	0.648	0.689	0.778	0.479	0.273	0.289	0.619	**0.567**	**0.705**
Section 1	0.666	0.831	0.699	0.259	0.730	0.700	0.690	0.495	0.341	0.243	0.900	**0.596**	**0.707**
Section 2	0.473	0.732	0.552	0.189	0.384	0.395	0.493	0.386	0.432	0.000	0.000	**0.367**	**0.424**
Section 1 + 2	0.587	0.795	0.643	0.231	0.561	0.556	0.609	0.452	0.367	0.343	0.000	**0.468**	**0.575**
Section 3	0.464	0.668	0.626	0.247	0.567	0.635	0.726	0.376	0.203	0.228	0.435	**0.470**	**0.643**
Section 4	0.683	0.936	0.959	0.355	0.796	0.849	0.919	0.517	0.276	0.316	0.569	**0.652**	**0.855**
Section 3 + 4	0.584	0.818	0.805	0.307	0.695	0.757	0.839	0.456	0.244	0.278	0.513	**0.572**	**0.764**
Section 5 (US of IB)	0.574	0.839	0.649	0.284	0.663	0.689	0.823	0.454	0.270	0.250	0.577	**0.552**	**0.725**
Section 6+7 (MS-DS of IB)	0.698	0.858	0.839	0.362	0.636	0.708	0.796	0.569	0.280	0.327	0.631	**0.609**	**0.713**

Remarks: * means the average from February to December, ** means the average from June to August, the summer season.
Source: JICA Survey Team based on the discharge data provided by MWRI, cropped area by satellite images, etc.

Table 3.6.8 Overall Irrigation Efficiencies Considering Drainage Re-use

Canals	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg (2-12)	Avg (6-8)
Whole Bahr Yusef	0.585	0.811	0.746	0.278	0.480	0.510	0.554	0.380	0.275	0.297	0.639	**0.505**	**0.515**
Whole Ibrahimia	0.629	0.849	0.727	0.318	0.498	0.536	0.606	0.420	0.274	0.282	0.602	**0.522**	**0.547**
Whole BY + IB	0.591	0.809	0.721	0.292	0.507	0.540	0.598	0.403	0.268	0.283	0.600	**0.510**	**0.548**
Section 1	0.666	0.831	0.699	0.259	0.407	0.408	0.410	0.335	0.341	0.243	0.900	**0.500**	**0.408**
Section 2	0.473	0.732	0.552	0.189	0.269	0.280	0.328	0.282	0.432	0.000	0.000	**0.322**	**0.292**
Section 1 + 2	0.587	0.795	0.643	0.231	0.348	0.354	0.379	0.315	0.367	0.343	0.000	**0.397**	**0.360**
Section 3	0.464	0.668	0.626	0.247	0.496	0.551	0.621	0.347	0.203	0.228	0.435	**0.444**	**0.556**
Section 4	0.683	0.936	0.959	0.355	0.661	0.705	0.757	0.464	0.276	0.316	0.569	**0.607**	**0.708**
Section 3 + 4	0.584	0.818	0.805	0.307	0.590	0.641	0.702	0.414	0.244	0.278	0.513	**0.536**	**0.644**
Section 5 (US of IB)	0.574	0.839	0.649	0.284	0.542	0.565	0.657	0.400	0.270	0.250	0.577	**0.510**	**0.588**
Section 6 + 7 (Mid-DS of IB)	0.698	0.858	0.839	0.362	0.459	0.504	0.553	0.438	0.280	0.327	0.631	**0.541**	**0.505**

Remarks: * means the average from February to December, ** means the average from June to August, the summer season.
Source: JICA Survey Team based on the discharge data provided by MWRI, cropped area by satellite images, etc.

3.6.3 Irrigation Efficiency to Be Employed in Planning

In planning irrigation improvement, there should be base irrigation efficiencies with which the target irrigation efficiency should be set. For this survey, the base irrigation efficiencies should refer to the efficiencies during the summer season as the discharge becomes the largest and such largest discharge is referred to facility designing. Therefore, the average irrigation efficiency during the summer season of June to August should be set as the base irrigation efficiency.

Then, there are 2 cases of irrigation efficiencies; 1) efficiency against fresh water and 2) efficiency against whole water available including drainage re-use. In the planning, the latter is first referred simply because irrigation efficiency is defined by a ratio between the crop water consumption and water available for the crop irrespective of which source the water originates from (see Table 3.6.9).

Table 3.6.9 Base Irrigation Efficiency Employed in Planning

Irrigation Efficiency	JICA	Applied in Planning	Remarks
Not Considering Drainage Re-use	0.705	-	Against fresh water only
Considering Drainage Re-use	0.548	**Say, 0.55**	Against whole water available

Source: JICA Survey Team

3.6.4 Comparison with Irrigation Efficiencies Estimated by Planning Sector

Planning Sector under MWRI has conducted water accounting study targeting Fayoum (Water Accounting Plus in Fayoum, Egypt, October 2020). In this accounting study, crop water consumption was estimated by the Wapor_V2 model with reference to the satellite data in 2010. The study estimated overall water utilization efficiency for the Fayoum area, but not only for irrigation efficiency. Therefore, with the data provided in the study, efficiency only for irrigation is estimated below:

Table 3.6.10 shows the evapotranspiration provided in the study, which was estimated by the Wapor_V2 model. As the satellite data was for 2010, the discharge data availed for the Fayoum area in 2010 is indicated in the 2nd row of the table. With the drinking water data and drainage reuse for the Fayoum area provided by the Water Distribution Sector of MWRI, the irrigation efficiency is calculated as in Table 3.6.9 by 2 cases; 1) efficiency against fresh water, not considering drainage re-use, and 2) efficiency considering drainage re-use.

Further, Table 3.6.11 shows the efficiencies estimated by JICA Survey Team and by the Planning Sector comparatively. From the comparison table, the irrigation efficiency for annual basis is found very much close for the 2 estimations, indicating the difference is only 4%. On the other hand, irrigation efficiency for summer, from June to August, presents about 21% difference with JICA Survey Team's estimation higher.

This difference comes mainly from the difference of evapotranspiration that the both examinations applied; JICA Survey Team's evapotranspiration by MWRI's standard crop consumption table while Planning Sector's evapotranspiration by the Wapor_V2 model. Figure 3.6.6 indicates both evapotranspiration comparatively, showing the evapotranspiration calculated by MWRI table higher during the summer season of June to August, hence resulting in higher irrigation efficiency for the JICA's estimation.

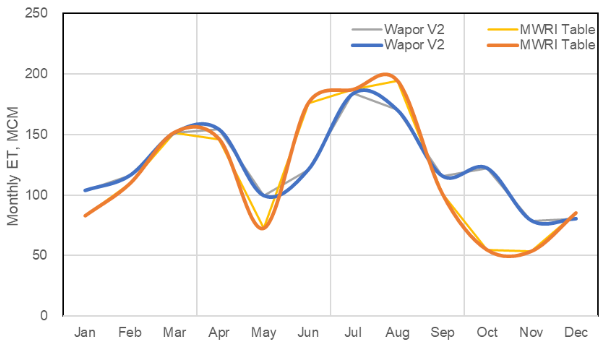


Figure 3.6.6 Comparison of Evapotranspiration for JICA Team's estimation and Planning Sector of MWRI

Source: MWRI Crop Consumption Table and Water Accounting Plus in Fayoum

Table 3.6.10 Irrigation Efficiencies for Fayoum Area by Planning Sector

Month	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ET (Wapor_V2), MCM	116	152	154	100	121	184	170	116	122	79	80	1,394
H.Wassef+Lahoun 2010, MCM	224	224	196	220	259	274	279	238	243	221	195	2,573
Drinking+Industry, MCM	19.38	21.45	20.76	21.45	20.76	21.45	21.45	20.76	21.45	20.76	21.45	231.13
(H.Wassef+Lahoun 2010) - Drink-Industry, MCM	205	203	175	199	238	253	258	217	222	200	174	2,342
Overall IE** (ET/(H.W.+Lah-Drink-Industy))	0.567	0.748	0.880	0.501	0.508	0.728	0.661	0.533	0.552	0.394	0.463	0.595
Average IE for Summer						0.632						
Drainage Re-use, MCM (2,931,241 m3/day)					45	47	47	23				161
(H.Wassef+Lahoun 2010-D-I)+Re-use, MCM	205	203	175	199	283	299	304	240	222	200	174	2,502
Overall IE incl. Re-use	0.567	0.748	0.880	0.501	0.427	0.615	0.560	0.483	0.552	0.394	0.463	0.557
Average IE for Summer, incl. Re-use						0.534						
Ratio of Drainage Re-use	0%	0%	0%	0%	19%	18%	18%	10%	0%	0%	0%	7%

Note: ET (evapotranspiration) was referred to Water Accounting Plus in Fayoum, Egypt, October 2020. ET and discharge to Fayoum area, composed of H. Wassef and Lahoun, are for 2010 while drinking & industry water use and drainage re-use data are for 2019 provided by Water Distribution Section of MWRI.

Table 3.6.11 Comparison with Irrigation Efficiencies by Planning Sector of MWRI

Irrigation Efficiency	JICA	Planning Sector	Ratio	Remarks
Against Fresh Water (Annual)	0.572	0.595	96%	
Against Fresh Water (Summer)	0.764	0.632	121%	
Against whole water (Annual)	0.536	0.557	96%	
Against whole water (Summer)	0.644	0.534	121%	

Source: JICA Survey Team, Planning Sector of MWRI

3.7 Agriculture in the Project Area

This sub-chapter describes the current status of agriculture in the Project area. It also describes the use of farmland and soil conditions, cropping systems and production conditions, as well as the current status of distribution and agricultural extension. The area under cultivation in this sub-chapter is based on agricultural statistics compiled by the governorate, and the changes in the area under cultivation by irrigation area using satellite image analysis are described in the next sub-chapter.

3.7.1 Agricultural Land Use and Land Holdings

1) Agricultural Land Use

The arable land in the target area occupies around 90% though the expansion of the residential and commercial areas including road networks and also industrial zones is taking up. Table 3.7.1 shows the land use of the districts, in which the target canal service areas are located. Except for the administrative area of Tanta city, where Kased Main Canal starts, 86% to 93% of the governorates/districts are counted as arable land.

Table 3.7.1 Land Use in the Districts of the Project Area including the Target Canal Service Areas

Target Area	Governorate	District	Land Use (feddan)				
			Arable		Non-arable		Total
Area including Kased Main Canal Service Area	Gharbia	Tanta	57,354	90.4%	6,062	9.6%	63,416
		Tanta (city)	3,058	56.2%	2,386	43.8%	5,444
		Kotor	51,055	93.1%	3,759	6.9%	54,814
	Kafr El Sheikh	Kafr El Sheikh	82,399	93.3%	5,927	6.7%	88,326
		Kelel	63,964	90.4%	6,758	9.6%	70,722
	Total		257,830	91.2%	24,892	8.8%	282,722
Area including Bahr Yousef and Ibrahimia Principal Canal Service Area	Fayoum	All	404,861	91.7%	36,466	8.3%	441,327
	Giza	All	290,426	86.7%	44,409	13.3%	334,835
	Beni Suef	All	284,882	88.1%	38,407	11.9%	323,289
	Minya	All	526,504	90.3%	56,799	9.7%	583,303
	Total		1,506,673	89.5%	176,081	10.5%	1,682,754

Source: Bulletin of Agricultural Boundaries and Properties 2017, July 2017, CAPMAS

2) Land Holdings

Land fragmentation in Egypt has been a crucial issue for agriculture production and thus poverty of farmers due mainly to the heritage system in Egypt, which divides the land into all the children[1]. The number of agricultural landholders with less than 1 feddan shares 50% to nearly 70% in the target governorates/ districts. In the Kased Area, the number of landholders with less than 3 feddan reaches to as high as 89%. In all the governorates of Bahr Yousef and Ibrahimia Principal Canal service areas, the number of landholders with less than 3 feddan already shares more than 80%.

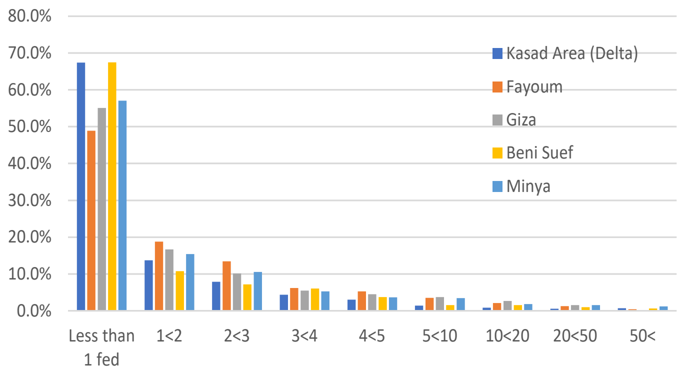


Figure 3.7.1 Share of No. of Land Holder by Land Holding Size
Source: Bulletin of Agricultural Boundaries and Properties 2017

The statistics show the number of landholders, implying that there are farmers who rent land to expand

[1] A boy heir takes double size of girl heir in Egypt.

their farming area. It is practiced that the landholder rents out their lands and does not cultivate themselves. With such practice, the distribution of the landholder with their cultivation area would differ from the figure above. It is, however, still characterized that most of the farmers in rural Egypt are of small-scale [2] and therefore, the introduction of modern irrigation needs to take into consideration this issue from the technical and economic feasibility point of view.

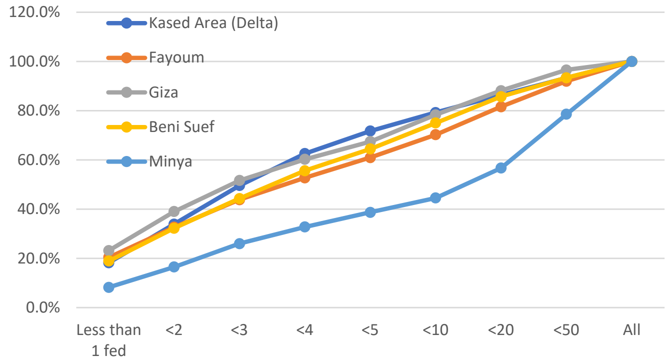


Figure 3.7.2 Accumulated Area by the Size of Landholder

Source: Bulletin of Agricultural Boundaries and Properties 2017

As for the accumulated total area by the size of the landholder, 40% to 50% of the arable lands are owned by the landholders with less than 3 feddan in Kased area, Fayoum, Giza and Beni Suef, while for Minya, the area owned by the landholder with less than 3 feddan is 26% (refer to Figure 3.7.2). To introduce modern irrigation throughout the farmlands needs definitely to involve small-scale farmers a lot. Or, otherwise, introducing modern irrigation to only relatively large-scale farmers would cover the arable land of about a half and a little over.

3) Soil Characteristics[3]

The Project area lies on the Old Lands in Egypt, which is located in the Nile Valley and Delta Regions. The soils in the Old Lands originate in alluvial soils (clay to loamy). According to the "Legend of the Soil Map of the World" (UNESCO, 1974), the soils in the Delta and the Nile Valley are classified as Calcaric Fluvisols (Jc), which is a calcareous soil, showing up at least between 20 and 50 cm from the surface of the land.

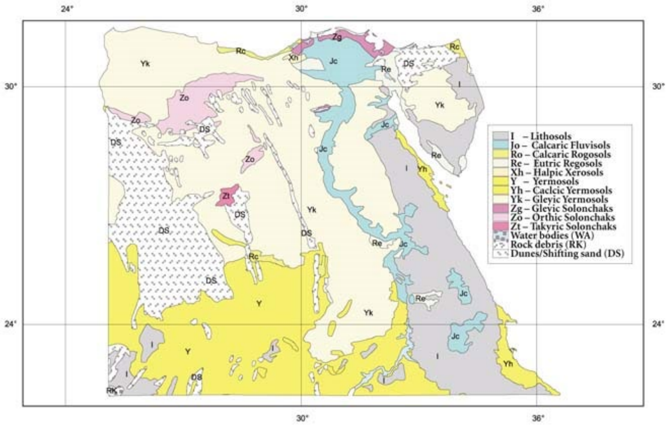


Figure 3.7.3 Soil Characteristics in Egypt

Source: DSMW-FAO-UNESCO, quoted from "Fertilizer use by crop in Egypt", FAO 2005

Table 3.7.2 shows the average results of physical and chemical analyses of the soils, sampled at various locations to represent the various types of soils. The soil characteristics are described as: "the organic matter content is low and so, accordingly, is the concentration of total nitrogen. As regards the alluvial soils (clay and loamy clay), available phosphorous determined by Olsen's method is generally moderate. The results indicate that available (soluble and exchangeable) potassium extracted with a neutral solution of ammonium acetate is high, and this is a typical characteristic of most Egyptian alluvial soils. Micronutrients are above the critical limits, as determined by the DTPA method. Levels of available phosphorus, potassium and micronutrients are fairly low for the calcareous and sandy soils[4]."

Table 3.7.2 Physical and Chemical Analysis of Various Soil Types

Region	North Delta	South Delta	Upper Egypt	East Delta	West Delta
Texture	Clayey	Clayey	Loamy clay	Sandy	Calcareous
PH	7.9-8.5	7.8-8.2	7.7-8.0	7.6-7.9	7.7-8.1
Percent total soluble salts	0.2-0.5	0.2-0.4	0.1-0.5	0.1-0.6	0.2-0.6
Percent calcium carbonate	2.6-4.4	2.0-3.1	2.6-5.3	1.0-5.1	11.0-30.0

[2] MALR defines the farmers cultivating less than 3 feddan as small-scale farmer.

[3] This section is described based on "Fertilizer use by crop in Egypt", Land and Plant Nutrition Management Service, Land and Water Development Division, FAO, Rome, 2005

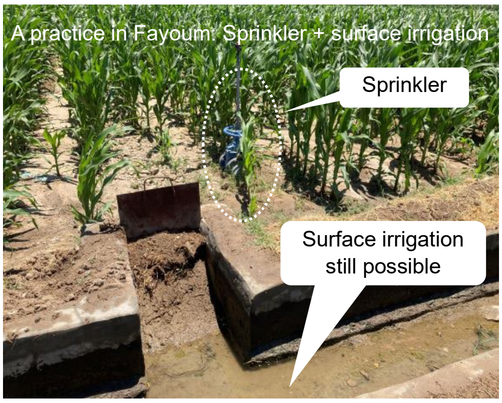
[4] "Fertilizer use by crop in Egypt", Land and Plant Nutrition Management Service, Land and Water Development Division, FAO, Rome, 2005

Percent organic matter	1.9-2.6	1.8-2.8	1.5-2.7	0.35-0.8	0.7-1.5
Total soluble N (ppm)	25-50	30-60	15-40	10-20	10-30
ppm available P (Olsen)	5.4 -10	3.5-15.0	2.5-16	2-5.0	1.5-10.5
ppm available K (amm. acetate)	250-500	300-550	280-700	105-350	100-300
Available Zn (DTPA) (ppm)	0.5-4.0	0.6-6.0	0.5-3.9	0.6-1.2	0.5-1.2
Available Fe (DTPA) (ppm)	20.8-63.4	19.0-27.4	12.4-40.8	6.7-16.4	12-18
Available Mn (DTPA) (ppm)	13.1-45	11.2-37.2	8.2-51.6	3-16.7	10-20

Source: Taha, Soil fertility management in Egypt. Regional Workshop on Soil Fertility Management Through Farmer Field Schools in the Near East, Amman, Jordan, 2-5 October 2000.

Salinization has been an issue especially in the northern part of the Nile Delta Regions. The issue of salinity might be aggravated by promoting modern irrigation in the Old Lands, and therefore EU Water STARS[5] has studied the salinity issue with modern irrigation introduction. The following are the major recommendations by STARS, and thus periodical surface irrigation mentioned below being practiced in Fayoum should be considered:

- ✓ Soil salinity is expected to increase after irrigation modernization, so that a monitoring mechanism of the salt content in the soil, a corresponding leaching requirement quantification, and the modality of leaching need to be properly designed and operationalized,
- ✓ Gypsum amendment associated with intermittent leaching is a common method applied to in reclaiming salt-affected soils in Egypt,
- ✓ Cultivating rice in crop rotations over a couple of years may be recommended, or to adopt periodical surface irrigation should be applied; i.e., leaching salt deposits needs to be addressed,
- ✓ It is thus recommended that the Meska and Marwa modernization be designed in order to allow not only pressurized irrigation systems but also surface irrigation in order to leach out salts (see the photo as an example), and



- ✓ Drainage systems should be modernized (or restored) to carry the flow derived by the leaching process out from the agricultural systems. Controlled drainage can be one of such new practices, which may result in real water savings while providing required leaching, at least to some extent.

3.7.2 Cropping Patterns and Productions

1) Cropping Patterns and Intensity of the Target Area

There are three crop seasons defined in Egypt, namely summer crop season (March/April to September), winter crop season (November to May) and Nile crop season (May to October). Summer and winter crop seasons are the major ones while the cultivated area for Nile crop season is much smaller than those two seasons. There are also farmlands for permanent crops such as fruit trees. In the agricultural statistics in Egypt, sugarcane and cotton are categorized as permanent crops.

Present cropping patterns of the target areas are estimated based on the agricultural statistics of MALR at governorate level. The following are the process of building the cropping patterns:

1) "The Bulletin of Important Indicators of the Agricultural Statistics Winter Crops, Summer and Nile Crops" published by MALR shows the cultivated area, production and yield by crop at governorate level. The basic data are, therefore, summarized by governorate from these official statistics.

2) Based on the crop categories defined by MALR, average cultivated areas of representative crops

[5] "EU Water Sector Technical Assistance and Reforms Support (EU Water STARS), Irrigation Modernization in the Nile Delta and Valley, December 2020"

from 2010/11 to 2015/16 (available published data) are calculated by crop season.

3) Data on the service area of Bahr Yousef and Ibrahimia Principal Canals are represented by the ones of Old Lands for Giza, Beni Suef, Fayoum and Minya Governorates, while the service area of Kased Main Canal is represented by the data of Gharbia and Kafr El Sheikh Governorates.

The following tables and figures show the present cropping patterns. In Upper Egypt, where Bahr Yousef and Ibrahimia Principal Canals are located, the major crop in the summer season is maize while rice is hardly cultivated. Especially in recent years, the Government has applied a strong measure to restrict the rice cultivation for the purpose of saving water, and thus the rice cultivation has been abandoned in Upper Egypt. The cropping intensities in Upper Egypt and Delta are as high as 196% and 200% respectively as shown in Figures 3.7.4 and 3.7.5.

The major crops in winter season in Upper Egypt are wheat and berseem (Egyptian clover). The share of horticulture in the region counts 13% for summer crop and 11% for winter crop. Sugarcane crop is popular in Upper Egypt. However, the government is encouraging farmers to shift from sugarcane to sugar beet to reduce the water requirement as sugarcane requires much water. Sugar beet has been well promoted in the Delta, and in recent years, the cultivated area of sugar beet has also grown in Upper Egypt. The total cultivated area of sugar beet in the 4 governorates of Upper Egypt in 2003/04 was 11,490 feddan (4,825ha) and it increased to 85,847 feddan (36,055ha), as much as 7 times in 12 years.

In the Central Nile Delta, where the Kased Main Canal service area is located, the major summer crop is rice. Especially, Kafr El sheikh governorate located in the downstream reaches of the Delta is the most rice producing governorate in Egypt. Major winter crops in the Delta are wheat and berseem as in the Upper Egypt. Sugar beet has been promoted as an alternative crop to the sugarcane in the Delta from early time and nowadays the share of cultivated area of sugar beet in the 2 governorates of the Central Delta reaches 17%. The share of horticulture crop in winter and summer are 8% and 14% respectively. The cropping intensity in the two governorates is calculated at 201%.

Table 3.7.3 Cultivated Area in the 4 Governorates in Upper Egypt (Average of 2010/11 to 2015/16)

Governorate	Cropped Area (fed) and Share (%) in Winter Season													
	Wheat		L. Berseem		Sugar beet		Legums		Vegetables		Other crops		Total	
Giza	31,790	21%	41,678	28%	528	0%	1,999	1%	61,914	42%	9,980	7%	147,888	100%
Beni Suef	126,640	53%	38,347	16%	27,165	11%	245	0%	34,335	14%	11,889	5%	238,621	100%
Fayoum	193,378	50%	91,935	24%	32,234	8%	1,134	0%	29,954	8%	37,408	10%	386,043	100%
Minya	215,651	63%	83,810	24%	19,921	6%	890	0%	14,631	4%	9,300	3%	344,203	100%
Total	**567,459**	**51%**	**255,769**	**23%**	**79,847**	**7%**	**4,268**	**0.4%**	**140,835**	**13%**	**68,577**	**6%**	**1,116,754**	**100%**
	Cropped Area (fed) and Share (%) in Summer Season													
	Rice		Maize		Sorghum		Oil Crops		Vegetables		Other Crops		Total	
Giza	0	0%	45,783	35%	814	1%	5,211	4%	52,542	40%	25,891	20%	130,240	100%
Beni Suef	1,149	1%	168,334	86%	4,026	2%	5,882	3%	8,190	4%	8,991	5%	196,573	100%
Fayoum	1,423	0%	119,137	40%	113,659	38%	6,095	2%	16,335	6%	40,047	13%	296,695	100%
Minya	0	0%	281,994	80%	10,786	3%	31,410	9%	25,698	7%	4,659	1%	354,546	100%
Total	**2,572**	**0.3%**	**615,248**	**63%**	**129,284**	**13%**	**48,598**	**5%**	**102,765**	**11%**	**79,588**	**8%**	**978,054**	**100%**
	Cropped Area (fed) and Share (%) in Nile Season													
	Maize		Sorghum		Vegetables		Other Crops		Total					
Giza	19,360	38%	0	0%	24,163	47%	7,591	15%	51,114	100%				
Beni Suef	35,677	85%	1,667	4%	2,177	5%	2,473	6%	41,994	100%				
Fayoum	37,946	61%	239	0%	17,430	28%	6,657	11%	62,272	100%				
Minya	0	0%	0	0%	37,341	100%	109	0%	37,450	100%				
Total	**92,983**	**48%**	**1,906**	**1%**	**81,112**	**42%**	**16,829**	**9%**	**192,830**	**100%**				
	Cropped Area (fed) and Share (%) of Perennial Crop													
	Sugar cane		Cotton		Fruit trees		Total							
Giza	1,704	4%	0	0%	37,387	96%	39,091	100%						
Beni Suef	387	2%	4,880	25%	14,391	73%	19,657	100%						
Fayoum	478	1%	47,928	70%	20,437	30%	68,843	100%						
Minya	37,200	53%	487	1%	32,058	46%	69,745	100%						
Total	**39,768**	**20%**	**53,296**	**27%**	**104,273**	**53%**	**197,337**	**100%**						

Cultivated Area: 1,268,321 fed
Cropping Intensity: 196 %

Source: Bulletin of Important Indicators of the Agricultural Statistics Winter Crops, Summer and Nile Crops, MALR

Table 3.7.4 Cultivated Area in the 2 Governorates in the Delta (Average of 2010/11 to 2015/16)

Governorate	Cropped Area (fed) and Share (%) in Winter Season													
	Wheat		L. Berseem		Sugar beet		Legums		Vegetables		Other crops		Total	
Garbia	152,986	46%	94,692	29%	13,423	4%	1,496	0%	59,750	18%	9,333	3%	331,680	100%
Kafr El Sheikh	235,303	45%	97,377	19%	129,183	25%	14,867	3%	10,957	2%	32,993	6%	520,680	100%
Total	**388,289**	**46%**	**192,069**	**23%**	**142,606**	**17%**	**16,363**	**1.9%**	**70,707**	**8%**	**42,326**	**5%**	**852,360**	**100%**

	Cropped Area (fed) and Share (%) in Summer Season													
	Rice		Maize		Sorghum		Oil Crops		Vegetables		Other Crops		Total	
Garbia	136,285	43%	66,276	21%	0	0%	193	0%	40,134	13%	77,134	24%	320,023	100%
Kafr El Sheikh	271,863	60%	70,496	16%	0	0%	504	0%	70,130	16%	36,996	8%	449,990	100%
Total	**408,149**	**53%**	**136,772**	**18%**	**0**	**0%**	**698**	**0%**	**110,264**	**14%**	**114,130**	**15%**	**770,013**	**100%**

	Cropped Area (fed) and Share (%) in Nile Season									
	Maize		Sorghum		Vegetables		Other Crops		Total	
Garbia	19,246	53%	0	0%	1,685	5%	15,582	43%	36,512	100%
Kafr El Sheikh	3,914	98%	0	0%	74	2%	0	0%	3,988	100%
Total	**23,160**	**57%**	**0**	**0%**	**1,758**	**4%**	**15,582**	**38%**	**40,500**	**100%**

	Cropped Area (fed) and Share (%) of Perennial Crop							
	Sugar cane		Cotton		Fruit trees		Total	
Garbia	1,181	3%	12,018	30%	27,203	67%	40,401	100%
Kafr El Sheikh	154	0%	79,568	88%	10,518	12%	90,239	100%
Total	**1,334**	**1%**	**91,585**	**70%**	**37,721**	**29%**	**130,640**	**100%**

Cultivated Area: 895,894 fed
Cropping Intensity: 200 %

Source: Bulletin of Important Indicators of the Agricultural Statistics Winter Crops, Summer and Nile Crops, MALR

Season	Crop Intensity	Crop	Area (fed)	CI
Winter	88%	Wheat	567,459	51%
		Long berseem	255,769	23%
		Sugar beet	79,847	7%
		Legums	4,268	0.4%
		Vegetables	140,835	13%
		Other crops	68,577	6%
		Winter Total	1,116,754	100%
Summer	77%	Rice	2,572	0.3%
		Maize	615,248	63%
		Sorghum	129,284	13%
		Oil crop	48,598	5%
		Vegetables	102,765	11%
		Other crops	79,588	8%
		Summer Total	978,055	100%
Nile	15%	Maize	92,983	48%
		Sorghum	1,906	1%
		Vegetables	81,112	42%
		Other crops	16,829	9%
		Nile Total	192,830	100%
Permanent	16%	Sugar cane	39,768	20%
		Cotton	53,296	27%
		Fruit trees	104,273	53%
		Permanent Total	197,337	100%
Grand Total	196%		2,484,976	
Cultivated area (fed)			1,268,321	

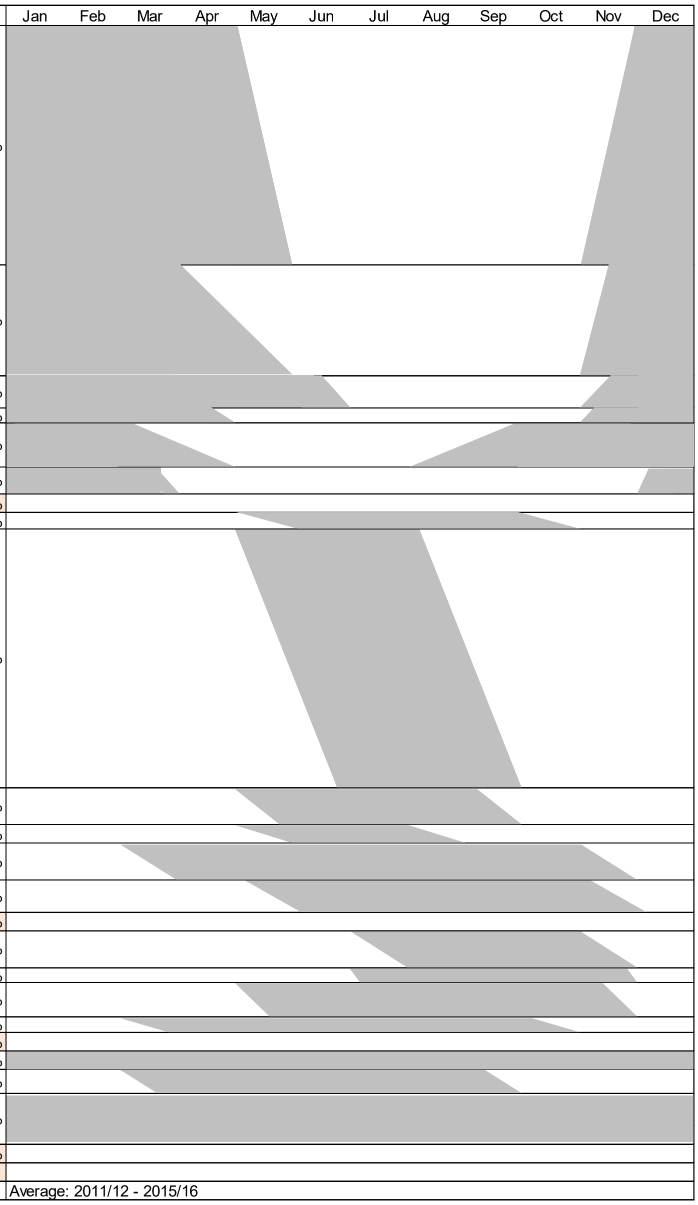


Figure 3.7.4 Present Cropping Pattern in the 4 Governorates of Upper Egypt (Old Lands)

Source: Made based on Table 3.7.3 by the JICA Survey Team

Season	Crop Intensity	Crop	Area (fed)	CI	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winter	95%	Wheat	388,289	46%												
		Long berseem	192,069	23%												
		Sugar beet	142,606	17%												
		Legums	16,364	2%												
		Vegetables	70,706	8%												
		Other crops	42,326	5%												
		Winter Total	852,360	100%												
Summer	86%	Rice	408,149	53%												
		Maize	136,772	18%												
		Oil crop	698	0.1%												
		Vegetables	110,264	14%												
		Other crops	114,130	15%												
		Summer Total	770,013	100%												
Nile	5%	Maize	23,160	57%												
		Vegetables	1,758	4%												
		Other crops	15,582	38%												
		Nile Total	40,500	100%												
Permanent	15%	Sugar cane	1,334	1%												
		Cotton	91,585	70%												
		Fruit trees	37,721	29%												
		Permanent Total	130,640	100%												
Grand Total	200%		1,793,513													
Cultivated area (fed)			895,894		Average: 2011/12 - 2015/16											

Figure 3.7.5 Present Cropping Pattern in the 2 Governorates of the Delta (Old Lands)

Source: Made based on Table 3.7.4 by the JICA Survey Team

As for rice, the restriction of rice cultivation area by the government has been getting so strict due to its high consumption of water that the area of rice cultivation is drastically decreasing. In the Kased Main Canal service area, the latest regulation as of 2022 season allows only 10% of the farmland to cultivate rice. In consideration of this condition, the cropping pattern of the Kased Main Canal service area at the latest status is adjusted to limit the cropping intensity of rice at 10% while allocating the remaining area according to the intensity of each category of summer crops shown in Figure 3.7.5. The adjusted cropping pattern for the Kased Main Canal area is shown in Table 3.7.5 and Figure 3.7.6.

Table 3.7.5 Cultivated Area in the Kased Main Canal Service Area (Rice Cultivation Area Adjusted)

Governorate	Cropped Area (fed) and Share (%) in Winter Season													
	Wheat		L. Berseem		Sugar beet		Legums		Vegetables		Other crops		Total	
Garbia	152,986	46%	94,692	29%	13,423	4%	1,496	0%	59,750	18%	9,333	3%	331,680	100%
Kafr El Sheikh	235,303	45%	97,377	19%	129,183	25%	14,867	3%	10,957	2%	32,993	6%	520,680	100%
Total	**388,289**	**46%**	**192,069**	**23%**	**142,606**	**17%**	**16,363**	**1.9%**	**70,707**	**8%**	**42,326**	**5%**	**852,360**	**100%**
	Cropped Area (fed) and Share (%) in Summer Season													
	Rice		Maize		Sorghum		Oil Crops		Vegetables		Other Crops		Total	
Garbia	25,711	7%	128,337	34%	0	0%	408	0%	74,977	20%	149,162	39%	378,595	100%
Kafr El Sheikh	51,290	13%	136,508	35%	0	0%	1,063	0%	131,014	33%	71,543	18%	391,418	100%
Total	**77,001**	**10%**	**264,845**	**34%**	**0**	**0%**	**1,471**	**0%**	**205,991**	**27%**	**220,705**	**29%**	**770,013**	**100%**
	Cropped Area (fed) and Share (%) in Nile Season													
	Maize		Sorghum		Vegetables		Other Crops		Total					
Garbia	19,246	53%	0	0%	1,685	5%	15,582	43%	36,512	100%				
Kafr El Sheikh	3,914	98%	0	0%	74	2%	0	0%	3,988	100%				
Total	**23,160**	**57%**	**0**	**0%**	**1,758**	**4%**	**15,582**	**38%**	**40,500**	**100%**				
	Cropped Area (fed) and Share (%) of Perennial Crop													
	Sugar cane		Cotton		Fruit trees		Total							
Garbia	1,181	3%	12,018	30%	27,203	67%	40,401	100%			Cultivated Area:		895,894 fed	
Kafr El Sheikh	154	0%	79,568	88%	10,518	12%	90,239	100%			Cropping Intensity:		200 %	
Total	**1,334**	**1%**	**91,585**	**70%**	**37,721**	**29%**	**130,640**	**100%**						

Source: Bulletin of Important Indicators of the Agricultural Statistics Winter Crops, Summer and Nile Crops, MALR

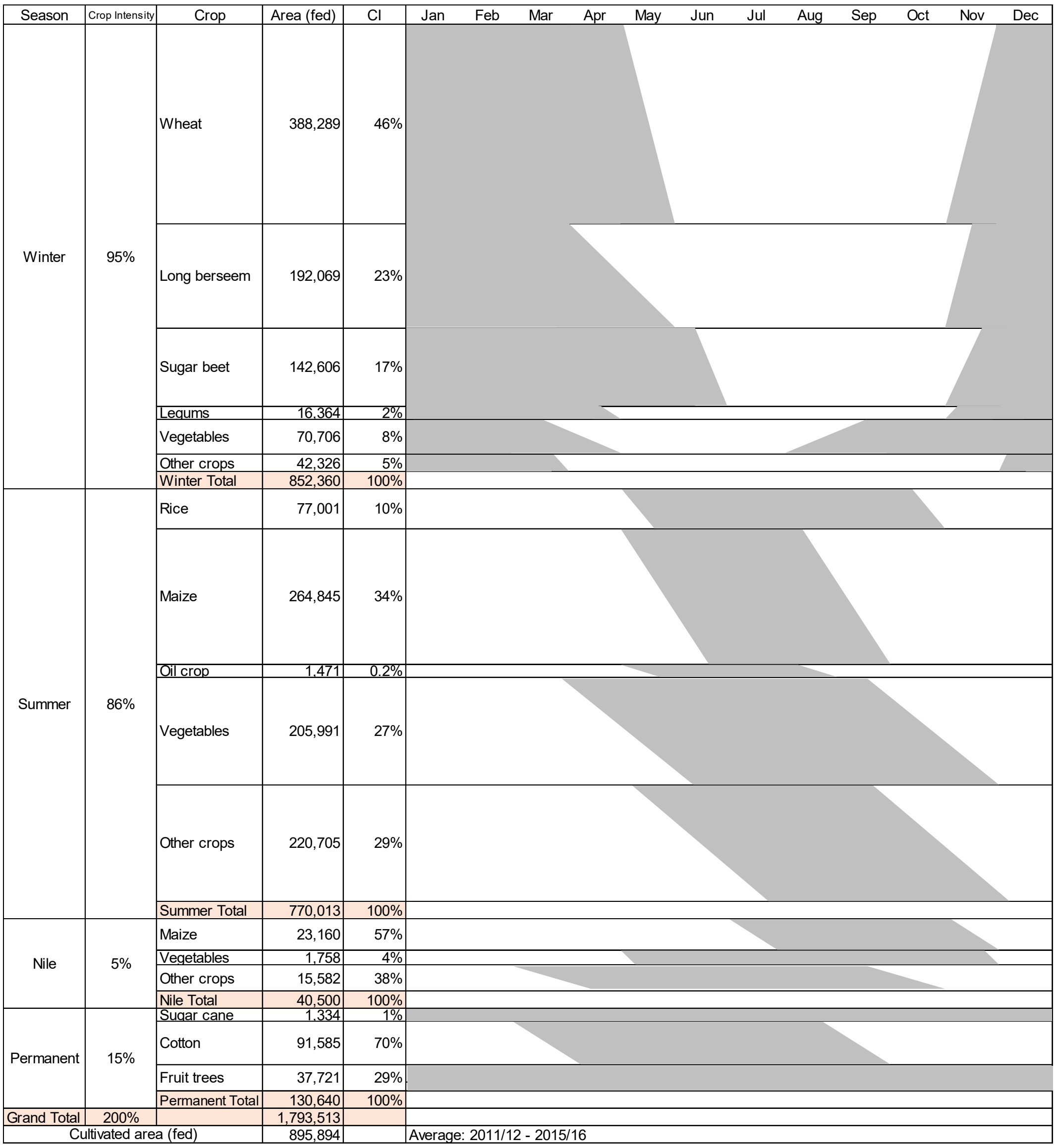


Figure 3.7.6 Cropping Pattern in the Kased Main Canal Service Area (Rice Cultivated Area Adjusted)

Source: Made based on Table 3.7.5 by the JICA Survey Team

2) Production of Major Crops in the Target Area

In general, crop productivity in Egypt is very high compared to the world average thanks to the rich in irrigation water, solar radiation and temperature (see Table 3.7.6). Yield level of the target governorates differs among others. Some of the crops in the target governorates exceed the average national yield. Though the productivity is relatively very high in Egypt, farmers in the target governorates, especially located downstream reaches of the canals, are often suffering from water shortage and therefore still have the potential to increase productivity given enough water.

Table 3.7.6 Yield of Major Crops in the Old Lands and Comparison with the World Average (Unit: t/ha)

Crop	Giza	Beni Suef	Fayoum	Minya	Gharbia	Kafr El Sheikh	Egypt	World
Wheat	7.10	6.38	6.88	6.79	6.88	6.40	6.81	3.32
Maize	8.05	7.57	6.40	8.00	8.67	8.55	7.79	5.50
Rice (Paddy)	-	-	-	-	8.60	9.38	9.48	4.57
Garlic	21.83	17.19	22.14	27.26	17.93	9.52	21.26	18.00
Onion	27.69	35.48	31.74	39.43	37.21	33.90	35.07	20.72
Summer Potato	23.57	23.05	-	20.24	33.69	39.31	28.86	20.26
Sugar beet	56.83	48.29	70.67	71.07	60.71	42.98	47.76	57.13
Winter Tomato	49.38	37.02	43.26	40.45	22.36	40.12	45.31	36.59
Summer Tomato	46.67	42.69	30.19	42.40	41.07	40.55	39.95	36.59

Source: Bulletin of Important Indicators of the Agricultural Statistics Winter Crops, Summer and Nile Crops, MALR; World data from FAOSTAT
(Unit: t/ha) The data is as of Year 2015 except for wheat (2014)

3.7.3 Distribution Channel and Marketing of Major Produces

1) Cereals

Wheat produced in winter as the material of *aish baladi,* Egyptian local bread, and maize, which is produced in the summer, are the two staple foods of Egyptian. Maize flour is mixed with wheat to bake the bread, and maize stems are used for animal feed. Rice is also popular staple food in Egypt and cultivated exclusively in the Nile Delta Regions, especially northern Delta. The distribution is liberalized; however, the Government intervenes in regulating the production and export to reduce the cultivated area of rice to save water.

Egypt is ranked second or third in the world for wheat imports. Out of the total consumption of wheat in Egypt, around 40% is imported. The Government sets the producer price of wheat every year prior to the crop season. Farmers are by this way encouraged to cultivate wheat in their major part of the farmland. Wheat is therefore still regulated by the Government as a strategic crop. As for the distribution of wheat, the Agricultural Bank of Egypt (ABE) plays the role of purchasing and storing the produce from the farmers and selling it to wheat mill. In addition, at the same time, traders have been doing business in these distributions, as well.

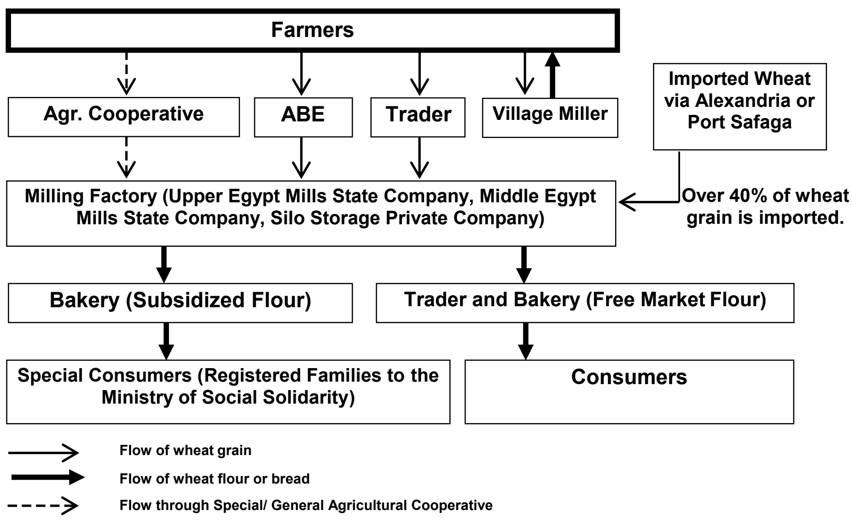


Figure 3.7.7 Distribution Channel of Wheat
Source: JICA Survey Team

Farmers used to ship their products to general cooperatives and specialized cooperatives; however, at present, they are shipping their products through traders or by themselves to the village branch of the ABE, which is well equipped with storehouse and storage yard. Storing of wheat takes three to four months from collection to shipment. The quality of wheat can deteriorate during the storage at the collection places as it is mostly stored in open spaces.

In almost all villages, there are small mills. Farmers store their wheat in their own houses, and they use the mills when they bake *aish baladi*[6]. In some cases, wheat producers sell their products to landless villagers. There are also large-scale milling factories and silos owned by the Ministry of Supply and Internal Trade or private companies. Traders who transport wheat can chose which factory to bring it.

Consumers of *aish baladi* are categorized into two groups: "subsidizers" and "non-subsidizers." Qualified subsidizers are registered by the Ministry of Supply, and they are able to get access to cheap *aish baladi* in the special bakery (Figure 3.7.7).

2) Horticultural Crops (Fruits and Vegetables)

The distribution of fruits and vegetables is based on traders and wholesalers. There are some processing facilities and companies in the governorates, such as a garlic and onion slicing company, cold storage facilities for potatoes, grading and pre-cooling companies for fruits, and companies that produce pickles all contributing to distribution of these crops for farmers and traders. When the production of horticultural crops increases with project, farmers are supposed to sell their produces basically through the following distribution system with observing the market prices.

Harvest season is different even for the same products from place to place as the latitude of each production area is different. In the governorate capital cities, there is usually a large wholesale market managed by the local government. The local government prepares the land and warehouses for the market, and they provide these facilities to wholesalers. Wholesalers contact first traders by using mobile phones, and then they decide the dealing volume and the prices of fruits and vegetables, along with the prediction of the sales volume on these days.

There are also kinds of local make-shift wholesale market operated by private wholesalers known as "Shona" or "Wekala". This market is usually installed on the farmland after harvest. Farmers bring their produce to this market and traders gathering the market make auction to purchase the produce. Then, the produce will be transported to anywhere all over Egypt.

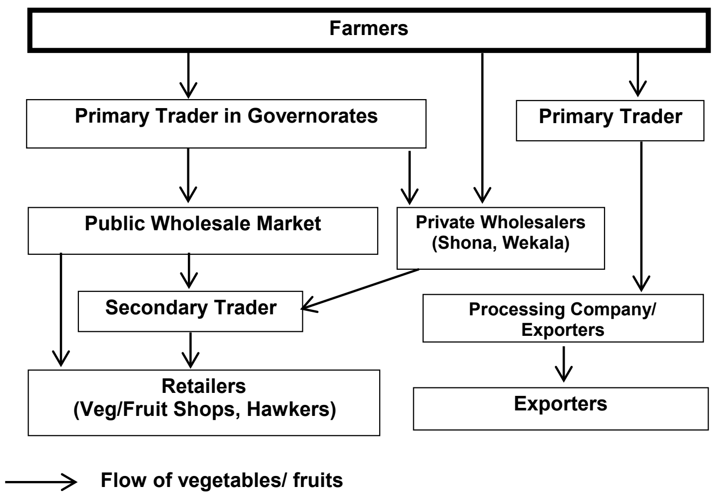


Figure 3.7.8 Distribution Channel of Fruits and Vegetables

Source: JICA Survey Team

As for the export, there is a specific distribution route for the produces. The traders first select and purchase products from the farmers and sell them to agro-processing companies and/or exporters. This distribution includes grapes (raw), pomegranates (raw), garlic (raw), and onion (dried powder). Producers of these products are concentrated in specific areas. These areas are gradually being formed as special production areas at the village and district levels (refer to Figure 3.7.8).

6 When baking *aish baladi,* usually, 20% of white maize is mixed with.

3.7.4 Agriculture Extension Services to Farmers

The Agricultural Extension Sector of MALR is responsible for agricultural Extension Services. Agricultural Extension Sector collaborates with the Agricultural Research Center (ARC); namely, the cultivation technologies and new crop varieties developed by ARC are disseminated by the agricultural extension workers of the sector.

According to the Extension Sector of the MALR, aging agricultural extension workers are the major challenge in the extension services and there is no recruitment of new workers after the retirement of the workers, hence the agricultural extension workers are decreasing in number. According to an officer in the sector, the total number of agricultural extension workers is currently less than 1,600. The average number of extension workers per governorate excluding desert and urban ones is, therefore, estimated at around only 90 workers per governorate. Total agricultural landowners are counted around 4.99 million, hence, an agricultural extension officer has to cover around 3,000 landowners.

Although the agricultural extension workers have accumulated their knowledge and skills through the work experiences and obtained training, these assets are diminishing in the rural area. Nevertheless, the role of agricultural extension workers is indispensable to promote modern irrigation. There are agricultural extension centers at district level in each governorate to provide trainings to farmers and some of the agricultural extension workers are deployed in the centers. Table 3.7.7 shows the number of extension centers in the target governorates/districts. Also, there is agricultural cooperative in each village and the agricultural extension workers at village level is posted in the cooperative office. They are paid by the Government.

Table 3.7.7 Number of Agricultural Extension Center in the Project Area

Ibrahimia & Bahr Yousef Command Areas						Kased Command Area			
Minya		Beni Suef		Fayoum		Gharbiya		Kafr El Shake	
District	No.	District	No.	District	No.	District	No.	District	No.
El-Edwa	1	El Wasta	1	El Fayoum	2	Tnata	4	Kelel	3
Maghagha	1	Beba	1	Sanors	1	Kotor	2	Kafr El Shake	5
Beni Mazar	1	Beni Suef	1	Yousef Sedek	3				
Matai	1	Semesta	1	Tamya	1				
Samalout	1	Naser	2	Ebshoaye	2				
El-Minya	1	El Fashen	1	Etsa	1				
Abokorkus	1	Ehnasya	2						
Mallawi	1								
Total	8	Total	9	Total	10	Total	6	Total	8

Source: MALR (Data is shown only in the Districts, which are located within the command Areas)

3.7.5 Agriculture Cooperative

MWRI does not directly deal with agriculture cooperatives, which are under the authority of MALR. Introduction of modern on-farm irrigation system may need facilitation of farmers through the farmer groups already existing under cooperative. Historically, the first agricultural cooperative in Egypt was established in 1910 as a mutual cooperation of the farmers. Then, the agricultural cooperatives were established in each and every village as an agent to control farmers in order to execute the agricultural production plan of the Government from the 1950s to 1960s.

Liberalization policy for production and marketing started from the late 1980s and the farmers became free to choose what to cultivate and started selling their produce to private traders. Under such policy introduced, nowadays, the agricultural cooperatives have been circumscribed in their duty of distribution of agriculture inputs and also administration of farmlands (the owner of the farmland is basically the member of the agricultural cooperative).

The officers of the Cooperative are paid by the Government and therefore, it is considered as an administrative office at village level, though the decision-making of the cooperative is made by the board members, who are the representatives of farmers. As mentioned above, agricultural extension workers are also posted in the agricultural cooperative and they collect statistical data and also provide technical assistance to the farmers.

The cooperatives are the sole source for information on land holdings. Any dealings, inheritance and changes of area plots are made official by the intervention of the cooperative. All dealings have to be recorded by the cooperatives and are certified by the cooperatives. That is why the cooperative can guarantee farmers the ability to take out loans against their land ownership. As agricultural extension workers, the cooperative staff at the village level are also aging and decreasing in number[7].

The major business of the village cooperative is the distribution of agricultural inputs particularly fertilizers, some pesticides and seeds of grains introduced by the Agricultural Research Center. There is a minimum quota that the cooperatives provide to farmers at subsidized rates of pesticides and fertilizers, as well as some obligatory pesticides in conjunction with the cooperative pest control, such as the case with cotton. The number of the village agricultural cooperative in the governorates, in which the priority sub-regions are located, is shown in the Table 3.7.8.

Table 3.7.8 Village Agricultural Cooperatives in the Governorates

Governorate	No. of Coop.
Gharbia	327
Kafr El Sheikh	249
Giza	154
Fayoum	221
Beni Suef	169
Minya	342

Source: Central Administration for Agriculture Cooperation (CAAC), MALR

7 Hearing from the Central Administration for Agricultural Cooperation, MALR

3.8 Long-Term Trend in Cropped Area by Satellite Image Analysis

This section discusses the change in cropped area, equal to the irrigated area in Egypt, over years under the Dirout Regulators and in the Central Delta. The purpose of the analysis is to know the actual cropped (irrigated) area and the trend over years. The analysis covers 21 years from 2000 to 2020. It is applied to the whole irrigated area under the Assuit Barrage and an area in the Central Delta and evaluates the cropped (irrigated) area of each irrigation section/block. The cropped area derived from the analysis is then compared with the agriculture statistics summarized by the governorate.

3.8.1 Methodology

The satellite images used in the analysis are multispectral images from Landsat 5, 7, and 8, which have a spatial resolution of 30 meters by 30 meters. The main indexes adopted in the analysis are the Normalized Difference Vegetation Index (NDVI) and the Modified Normalized Difference Water Index (MNDWI). The NDVI is calculated from the values of red and near-infrared bands, while the MNDWI is determined by the values of green and short-wave infrared bands. As is widely known, the NDVI and MNDWI detect areas of vegetation and water bodies, respectively.

In the analysis, the agricultural year is divided into 2 seasons, namely the winter cropping season and the summer/Nile cropping season. It has been established that the winter cropping season starts on November 1 and ends on May 14 of the following year. The summer and Nile crops are cultivated from May 15 to October 31.[1]

The procedure of the analysis is explained below. The results show not only the total cropped area in the winter cropping season and summer/Nile cropping season, but also the paddy cropped area within the total summer/Nile cropped area. An example of cropped area map is shown in Figure 3.8.1. Due to the huge area and the long period of the analysis, the image processing and computation of irrigated areas were conducted on Google Earth Engine[2].

The methodology of the analysis was:

i) to calculate the maximum value of NDVI in each cropping season;

ii) to identify such open water bodies as rivers and lakes by using MNDWI images;

iii) to identify the paddy cropped area by observing watering/flooding in paddy fields by MNDWI images;

iv) to divide the maximum NDVI image by Otsu's method [3] into 2 classes, i.e., cropped and non-cropped areas;

v) to exclude green parks and golf courses, which also show high NDVI values, by checking Google Earth images visually;

vi) to exclude illegal cropped areas irrigated

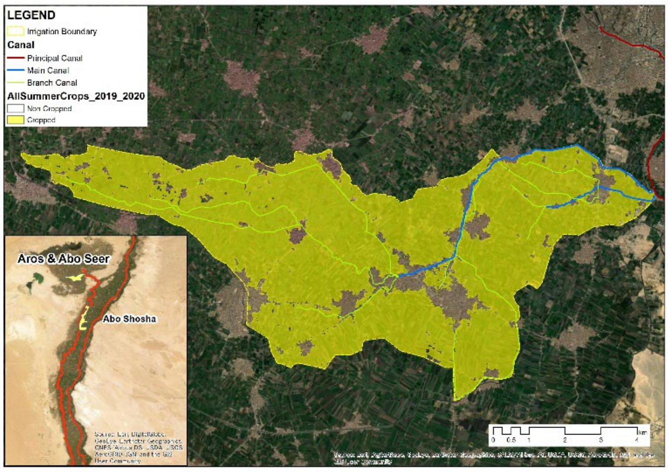


Figure 3.8.1 An Example of Cropped Area Map
Source: JICA Survey Team

[1] Major crops of the winter season, which starts in November and ends in May, are wheat, long berseem, sugar beets, and other vegetables. Major crops of the summer season, which starts in May and ends in October, are maize, sorghum, and vegetables in upper Egypt, and rice and maize in the Delta. The Nile crop is a unique cropping season in Egypt, which overlaps with the summer cropping season. Major crops of Nile cropping season are maize and vegetables (refer to Section 3.7.2).

[2] The Google Earth Engine is a cloud-based spatial analysis platform, on which users are able to process satellite images without downloading the images.

[3] Otsu's method is a statistical means of dividing a histogram of pixel values into 2 classes. A threshold is given by calculating the minimum dispersion of each class and maximum dispersion between the classes.

by pumping and located beside the Nile River by checking Google Earth images visually; and

vii) to compute the cropped, i.e., irrigated, area in each section[4] and governorate by year.

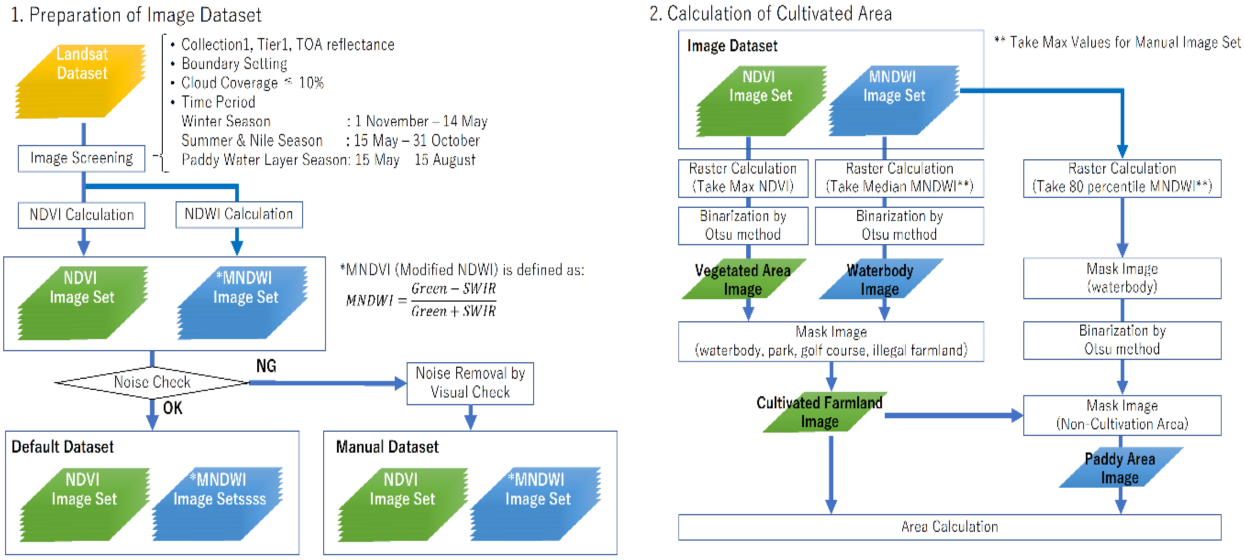


Figure 3.8.2 Flow Chart of the Satellite Image Analysis

Source: JICA Survey Team

The analysis has 4 limitations:

i) Some noises are observed on images from Landsat 7. These occurred due to the breakdown of the imaging sensor in 2003. Therefore, it is possible that the noises have affected the results of the analysis. Fewer quality images from Landsat 5 and 7, particularly in the period from 2003 to around 2012, are available, so images with noises are also included in the analysis. Note, however, that to the extent possible, noises have been removed manually by visual checks.

ii) The boundaries of the irrigable areas (section), which are shown in Figure 3.8.3, are determined by GIS files made as part of a former JICA study (Cooperation Planning Survey on the Irrigation Sector, February 2018), a digital elevation model (SRTM DEM), and visual checks of Google Earth images.

iii) Trees, along with irrigation/drainage canals, may enlarge the cropped areas detected (irrigated areas) as they also show higher NDVI values.

iv) Only the winter and summer/ Nile cropping seasons are considered; 3-time cropping in a year is not taken into account in the analysis.[5]

3.8.2 Irrigation and Cropped Area by Irrigation Section

The irrigation sections under Bahr Yusef Principal Canal, corresponding to sections 1, 2, 3, and 4 in Figure 3.8.3, are located in the Minia, Faiyum, and Beni Suef Governorates. The results of the analysis of these sections are described in Figure 3.8.4. As the sections lie in Upper Egypt, the major winter season and summer/Nile season crops are wheat/long berseem and maize/sorghum/vegetables.

[4] There are 9 irrigation sections (areas) addressed in this analysis. One of them, Section 9 (Ibrahimia Upper) is NOT irrigated by the Dirout Regulators, and lies in the upstream area (refer to Figure 3.8.3). The analysis aims to understand the irrigated area under the Dirout Regulators, so the result of the assessment of Section 9 is excluded from the discussions in Section 3.7.2. Note, however, that the irrigated area in Section 9 is considered in the discussions on irrigated areas by governorate (Section 3.7.3 below).

[5] It is known that some farmers adopt triple-cropping in an agricultural year, planting a first crop in the winter season, and a second and third one in the summer/Nile season. In the case that lots of quality satellite images are available, it may be possible to identify the triple-cropping. However, due to cloud covers and noises on images, fewer images (e.g., only one in a month) are analyzed for some years, which is not enough to detect second and third crops.

It is observed that in sections 1, 2, and 3, the total cropped areas in the winter and summer/Nile seasons have increased in the 21 years covered by this analysis. On the other hand, the total area of Section 4 has declined in the winter season and remained almost unchanged in the summer/Nile season. The paddy cropping in the upstream part, i.e., sections 1 and 2, is very limited. The paddy cropped area is only observed in Hassan Wasef (Section 3) and Lahoun (Section 4) from the agricultural years 2000/2001 to 2007/2008. In 2000/2001, the paddy area was around 10,000 to 15,000 feddan. It increased to around 21,000 to 25,000 feddan by 2007/2008.[6]

In Section 1 (between Dirout and Sakoula), increases of 23,762 feddan (9,980 ha) of winter crop and 14,852 feddan (6,238 ha) of summer/Nile crop have occurred over 21 years. The growth of winter crop area in Section 2 (between Sakoula and Lahoun) has reached 15,323 feddan (6,436 ha) in the winter season and 13,948 feddan (5,858 ha) in summer/Nile season. The rise in the cropped area in Section 3 (Hassan Wasef) has been a bit smaller, resulting in 10,366 feddan (4,354 ha) of cropped land in the winter season and 6,618 feddan (2,780 ha) in the summer/Nile season. The area of winter crop in Section 4 (Lahoun) has decreased by 7,571 feddan (3,180 ha), and the summer/Nile crop area has stayed around 200,000 to 210,000 feddan (84,000 to 88,200 ha) during the years covered by this analysis.

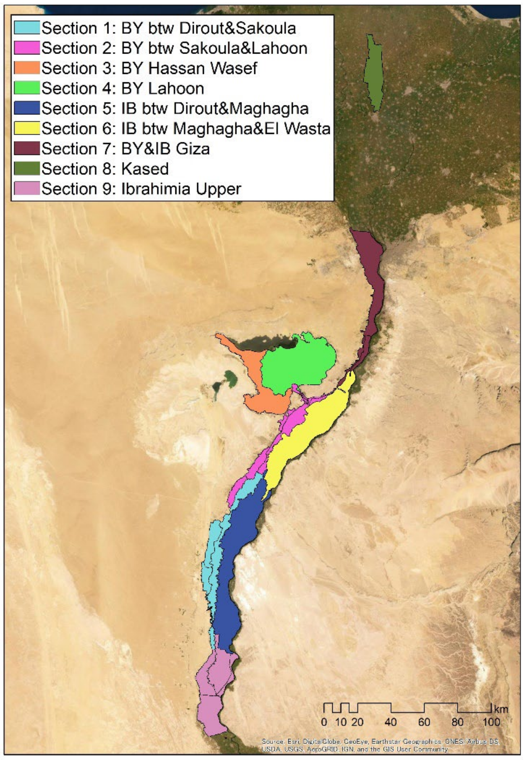


Figure 3.8.3 Irrigation Sections

Note: BY= Bahr Yusef Principal Canal, IB= Ibrahimia Principal Canal

Source: JICA Survey Team

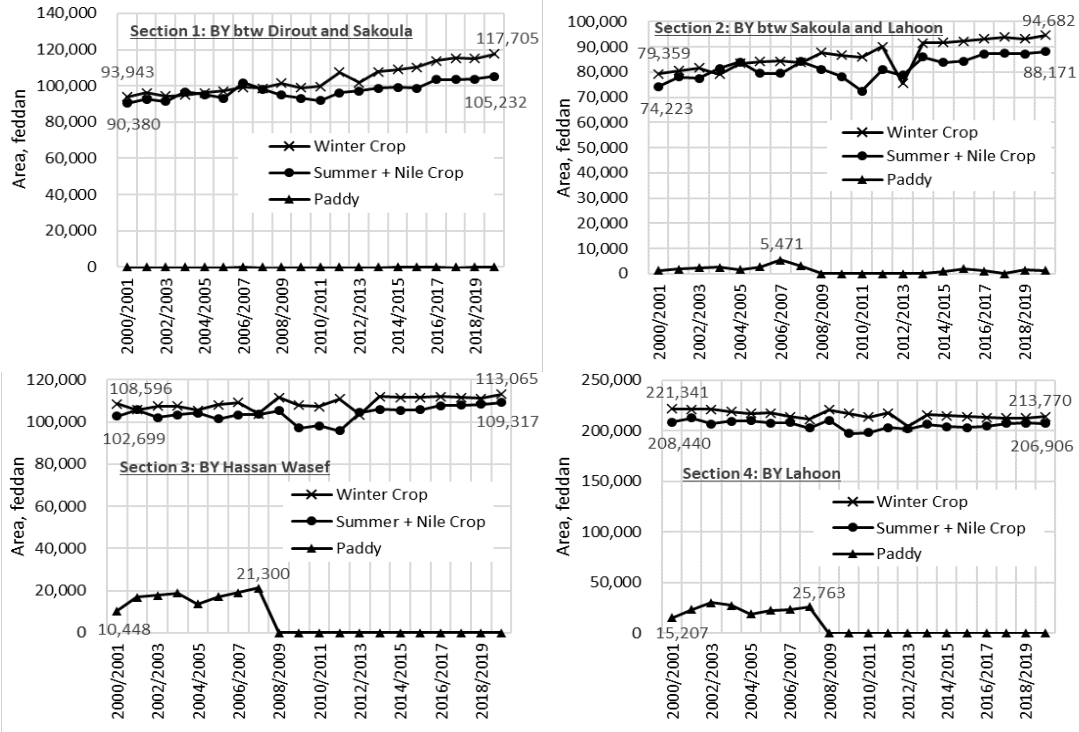


Figure 3.8.4 Cropped Area by Irrigation Section Under the Bahr Yusef Principal Canal

Source: JICA Survey Team

[6] Paddy production in Fayoum Governorate, where sections 3 and 4 are located, was restricted by the government from the 2008/2009 cropping season onward, so the paddy cropping area is not observed after that season.

Section 5 and 6, irrigated by the Ibrahimia Principal Canal, lie on Minia, Beni Suef, and Giza Governorates. As shown in Figure 3.8.5, in both sections, the winter crop areas (wheat/long berseem) are almost equal to those of the summer/Nile crop area (maize/ sorghum/vegetables) throughout the analysis period. The irrigated area in the winter and summer/Nile seasons has declined. The paddy area is quite limited, amounting to 0 to 50 feddan in Section 5 and 0 to 1,000 feddan in Section 6. The decrease in cropped area in both sections and both cropping seasons between 2000 and 2020 has amounted to approximately 10,000 feddan (4,200 ha).

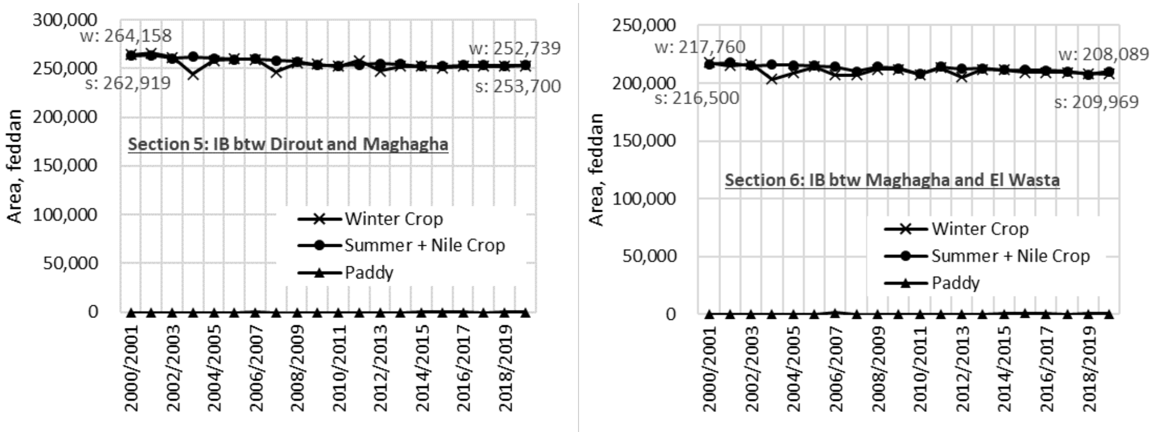


Figure 3.8.5 Irrigation and Cropped Area in Irrigation Sections Under the Ibrahimia Principal Canal

Source: JICA Survey Team

The Giza irrigation area (Section 7) is irrigated by both the Bahr Yusef Principal Canal and the Ibrahimia Principal Canal. The left chart in Figure 3.8.6 depicts the change in cropped area in the Giza area. The cropped area in the summer/Nile season (maize/ sorghum/ vegetables) usually exceeds that in the winter season (wheat/ long berseem) every year. The summer/Nile crop area has decreased by 13,637 feddan (5,728 ha) during the analysis period. The winter crop area has also declined by 15,975 feddan (6,710-ha). Paddy cultivation has not been observed.

The right chart in Figure 3.8.6 shows the irrigated portion of the Kased area, which is the only irrigation section in the Nile Delta. The major cultivated crops in the area are wheat/long berseem in the winter and rice/maize/vegetables in the summer/Nile season. Over the 21 years analyzed, the area cropped in both seasons has decreased by 8,541 feddan (3,587 ha) in the summer/Nile season and 1,614 feddan (677 ha) in the winter season. Paddy cropping in the area reached a maximum extent of 39,781 feddan (16,708 ha) in 2007/2008, and then decreased to 17,748 feddan (7,454 ha) in 2019/2020. There were a few drops in the paddy cropping area in 2010/2011, 2014/2015, and 2017/2018, which might have been caused by the lower availability of quality satellite images.

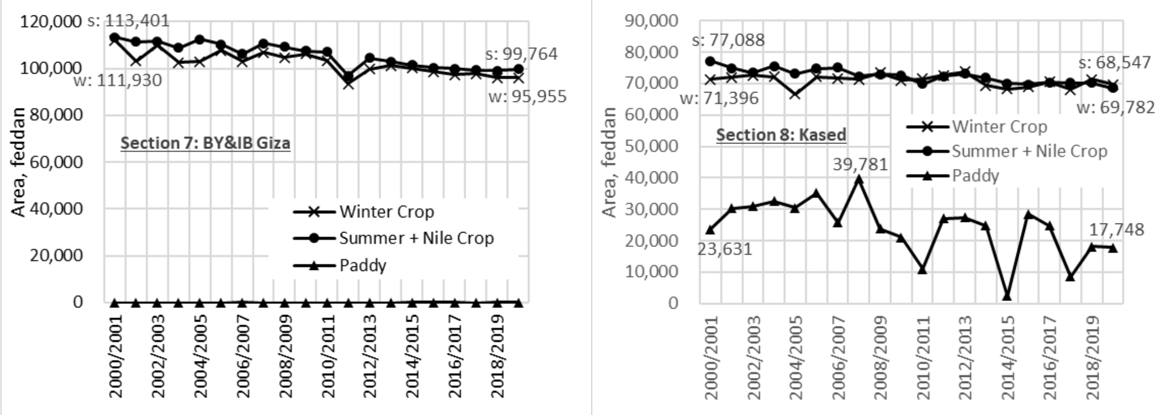


Figure 3.8.6 Irrigation and Cropped Area in the Giza and Kased Irrigation Sections

Source: JICA Survey Team

3.8.3 Irrigation and Cropped Area by Governorate

This section provides a comparison between the results of satellite image analysis and the agricultural statistics of MALR. As the statistics summarize the cultivated areas of crops by governorate, the analysis computes the cropped area in each of the governorates. The areas obtained in the analysis are here compared to those cropped areas recorded in the statistics. Figure 3.8.7 shows the boundaries of the target governorates of the analysis, on which the target irrigation sections are also layered.

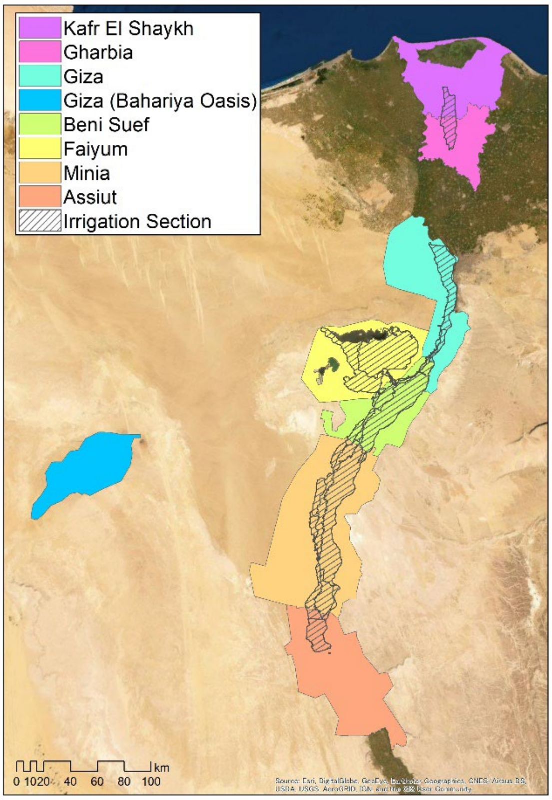


Figure 3.8.7 Target Governorates and Irrigation Sections
Source: JICA Survey Team

The cropped area analyzed is therefore indicated by the governorate boundary, not by the irrigation section, so that the cultivated areas outside of the target irrigated area, which are irrigated by underground water, or lie in the Delta area and north of the Assuit Intake, are also considered. Though the satellite image analysis covers the agricultural years from 2000/2001 to 2019/2020, the agricultural statistics only cover the period from 2003/2004 to 2015/2016 (statistics after 2015/16 are not published as of 2022, and are thus not available in this survey). Therefore, the comparison between the satellite image analysis and statistical data can be made until 2015/16.

Figure 3.8.8 depicts the changes in cropped area. The analysis results are indicated by black solid lines and the statistical areas by red dotted lines (see the legend in the figure of Assuit). Note that the summer/Nile crop area includes the paddy cultivation area. The figure reveals that:

i. The statistics of Kahr El Shaikh and Gharbia Governorates in the Nile Delta show drops in the summer crop area in 2006/2007. However, the drop is not detected in the analysis. Furthermore, though there are also years with less summer crop area observed in the statistics between 2005/2006 and 2010/2011 in Gharbia, the analysis result does not show the decreases and presents a gradual downward trend.

ii. According to the statistics, approximately 250,000 to 350,000 feddan (105,000 to 147,000 ha) in Kahr El Shaikh and 100,000 to 200,000 feddan (42,000 to 84,000 ha) in Gharbia are cultivated. Although in some cases, e.g., 2005/2006 in Kahr El Shaikh and 2007/2008 in Gharbia, the paddy areas shown in the analysis are close to those in the statistics, there are many gaps between them during the analysis period. It is possible that the flooding in paddy fields may have not been well detected by the MNDWI because of less availability of quality images in the series of Landsat imagery.

iii. The statistical data from Giza Governorate includes the cultivated area in Bahariya Oasis area (refer to Figure 3.8.7 for the location). The statistics and the result of the analysis from the whole Giza Governorate and the result of the analysis from only the Bahariya Oasis area are described in the middle of Figure 3.8.8. The statistics only from Bahariya Oasis area is unavailable. In the whole Giza Governorate, the area of analysis has increased slightly in the 21 years under consideration, which must be understood as a result of the increase in cropped area in the Bahariya Oasis area and the cultivation of New Lands in the governorate. Although the statistics show peaks in the winter crop area in 2008/2009 and 2014/2015 and drops in the summer crop area in 2008/2009 and the period from 2012 to 2015, these are not observed in the analysis.

iv. In Beni Suef Governorate, there is a gap of approximately 50,000 to 200,000 feddan (21,000 to 84,000 ha) in summer/Nile crop area between the analysis and the statistics. As the analysis basically observes the greenness of ground as measured by the NDVI, it is assumed that the analysis result does not involve a big misestimation. Therefore, it may be said that the statistics could have underestimated the cultivated area of summer/ Nile crop. According to the analysis, the winter crop area accounts for a 17,313 feddan (7,271 ha) increase in the 21 years analyzed, from 287,475 feddan (116,960 ha) in 2000/2001 to 304,788 feddan (128,011 ha) in 2019/2020. The results for the summer/Nile crop area likewise demonstrates 19,291 feddan (8,102 ha) of growth.

v. In Fayoum Governorate, on the other hand, there are broad gaps in areas of winter cropping. The average of the gaps is 77,932 feddan (32,731 ha). Though the winter crop area jumps up from 2007/2008 to 2008/2009, the rise is not detected in the satellite image analysis. The analysis result shows that both winter crop and summer/Nile crop areas stay almost unchanged during the analysis period. The winter crop area is more or less 340,000 feddan (142,800 ha), while the summer/Nile crop area is approximately 325,000 feddan (136,500 ha). The summer/Nile crop area indicated in the statistics shows a similar trend to that in the analysis results.

vi. The paddy area in Fayoum Governorate detected by the satellite image analysis always exceeds that in the statistical data. The maximum paddy area in both the analysis and the statistics is recorded in the same agriculture year, 2007/2008. It is measured at 50,378 feddan (21,158 ha) in the analysis and 30,253 feddan (12,706 ha) in the statistics. After 2008/2009, fewer areas of paddy cultivation are recorded in the statistics, but no paddy cultivation is observed in the satellite image analysis.

vii. The statistical data for the winter and summer/Nile crop areas of Minia Governorate fluctuates during the period that the statistics are available. The areas reach their maximum sizes in 2008/2009, i.e., 457,891 feddan (192,314 ha) in winter season and 486,401 feddan (204,228 ha) in summer/Nile season. On the other hand, in the results of the analysis, the areas of both winter and summer/Nile crops remain constant at approximately 480,000 feddan (201,600 ha), and rise gradually from 2012/2013 to 588,371 feddan (247,116 ha) of winter crop and 532,520 feddan (223,658 ha) of summer/Nile crop in 2019/2020.

viii. The data from Assuit Governorate shows that both the areas obtained from the analysis and those in the statistics have increased steadily. However, after 2008/2009, the areas in the statistical data surpass those indicated in the analysis. In the case of the winter crop area, the statistics show a maximum area of 359,363 feddan (150,932 ha) in 2013/2014. On the other hand, the analysis presents a smaller area, 349,012 feddan (146,585 ha), even in 2019/2020. When it comes to the summer/Nile crop area, the statistics and the analysis show the highest values in different years: 348,283 feddan (146,278 ha) in 2014/2015 and 329,571 feddan (138,420 ha) in 2019/2020, respectively.

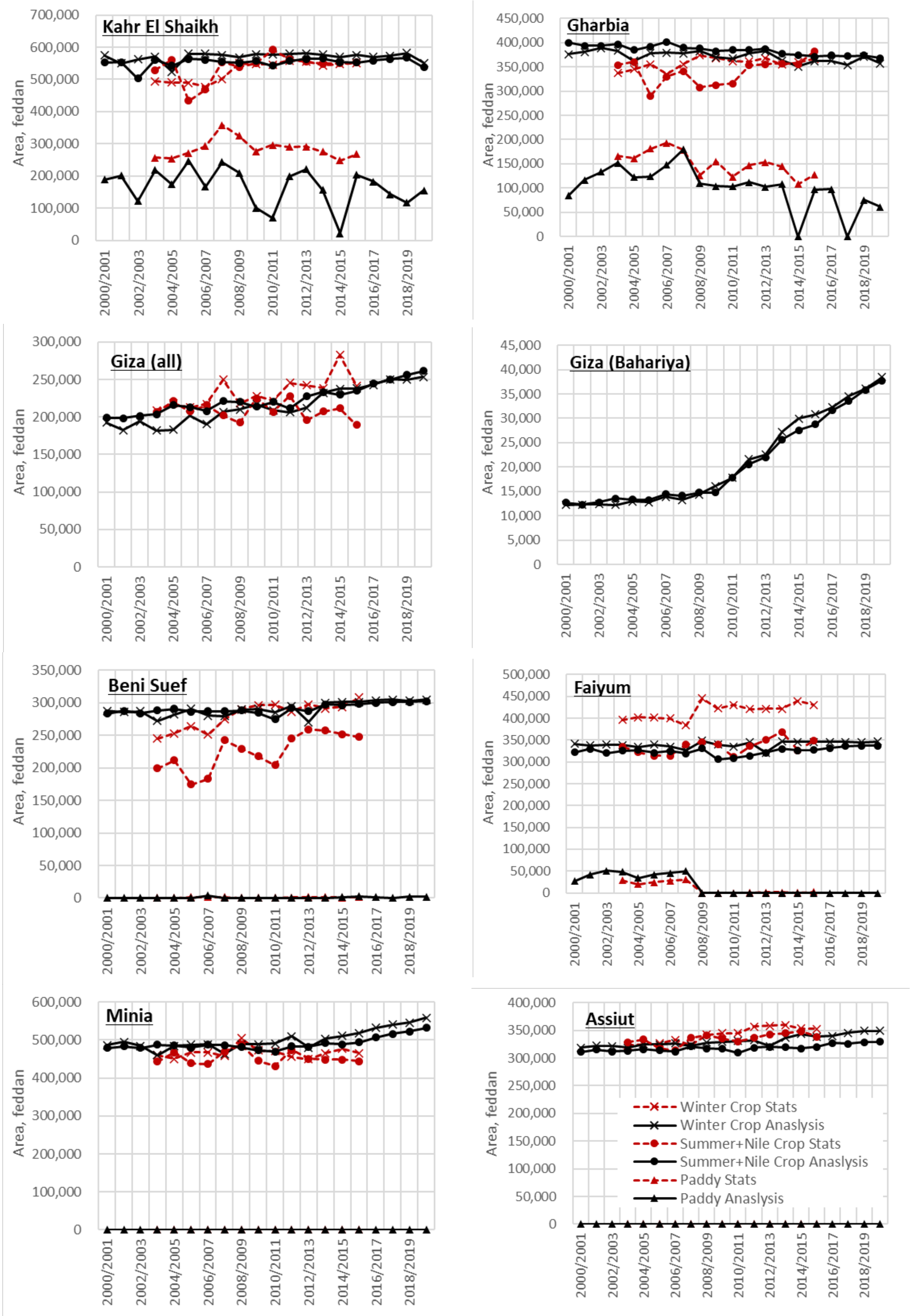


Figure 3.8.8 Irrigation and Cropped Area by Governorate

Source: Bulletin of the Agriculture Statistics (MALR 2004 to 2016) and JICA Survey Team

3.9 Farm Household Economy and Farmers' Opinion on the Introduction of Modern On-farm Irrigation

This section describes the results of the questionnaire-based farm household economic survey and the farmers' intentions and willingness regarding the introduction of modern on-farm irrigation facilities. The farmers' intention and willingness to adopt modern on-farm irrigation facilities were also obtained through a series of stakeholder meetings with beneficiary farmers conducted as part of the environmental and social consideration survey.

3.9.1 Methodology of the Farm Household Economic Survey

A farm economy survey was carried out by the JICA Survey Team from September to October 2021 to capture the present status of farming of the farmers in the three priority sub-regions. The villages for the survey were selected by recommendations of the irrigation officers in the three sub-regions. Three villages in each sub-region were selected so as to represent such villages with good water distribution conditions, moderate conditions and suffering from water shortage (see Table 3.9.1).

Table 3.9.1 Villages for the Farm Economy Survey

Village with Water Condition	Abo Shosha (Beni Suef)	Aros & Abo Seer (Fayoum)	Kased (Gharbia)
Good	Dashtot	Masara Arfa	Mahlet Menouf
Moderate	El Mahmodya	El Gafra	Shobra barola
Shortage	Mazora	Bahr Abo Elmer	Damat

Source: JICA Survey Team

Such classification of the villages depended on the recommendation of the irrigation officers in each irrigation directorate. 30 farmers from each village totaling 270 farmers have been selected for a questionnaire survey to capture the situation of family labor force, farming land size, crops, yield level, production cost, farm income, off-farm income, knowledge on modern irrigation, access to agricultural finance, etc. This section summarizes the feature of the farmers in the priority sub-regions based on the survey results.

3.9.2 Basic Features of the Sample Farm Households

1) Land Holding

Table 3.9.2 summarizes the distribution of the sample farm households by the size of farming land. The farming land is defined as Own farmland + renting farmland – rented out farmland. 80% to 90% of the samples cultivate less than 3 feddans of farmland. Average farming land is from 1.38 fed/HH to 1.62 fed/HH. Comparing the governorate statistics, the distribution of the sample farm households by farming land size could be said well-representing the land fragmentation of the area, as the share of the sample farmers with less than 3 feddan for the farm economy survey is close to the share in the governorate.

Table 3.9.2 Distribution of the Sample by Farming Land Size

Site	Ave. fed	< 1 fed	1 < 2 fed	2 < 3 fed	3 < 4 fed	4 < 5 fed	5 fed <	Total
Abo Shosha	1.41	26 (29%)	40 (44%) (73%)	15 (17%) (90%)	5 (6%) (96%)	2 (2%) (98%)	2 (2%) (100%)	90
Beni Suef		*68%*	*79%*	*86%*	*92%*	*96%*	*100%*	
Aros & Abo Seer	1.62	40 (44%)	18 (20%) (64%)	14 (16%) (80%)	9 (10%) (90%)	4 (4%) (94%)	5 (6%) (100%)	90
Fayoum		*49%*	*68%*	*81%*	*87%*	*93%*	*100%*	
Kased	1.38	40 (44%)	22 (24%) (68%)	19 (21%) (89%)	8 (9%) (98%)	0 (0%) (98%)	1 (1%) (100%)	90
Gharbia		*67%*	*81%*	*89%*	*93%*	*96%*	*100%*	

Source: Farm Economy Survey by JICA Survey Team; Data of the governorates are from MALR.

As for the number of farm plots per farm household and their location, 56% to 66% of the sample households have only one piece of the farm plot (see Figure 3.9.1). Although some farm households have more than 2 pieces of farm plot, the majority of their farm plots are concentrated in one area as the shares of the sample whose farm plot is only in one place in Abo Shosha, Aros & Abo Seer and Kased are 87%, 77% and 83% respectively. It is thus indicated that the majority of farmers are small-scale farming and their farm plots are either single or concentrated in one place.

2) Family Members Engaged in Farming

The average household size is 5.5 family members per household. The average family members who engage in agriculture is 2.3 members out of the 5.5 members. The family members who engage in agriculture is categorized into two types: 1) full-time and 2) part-time engagement. Full-time members mean that they work fully in agriculture activities and do not have any other jobs. On the other hand, the part-time members partly engage in agriculture while having other income sources.

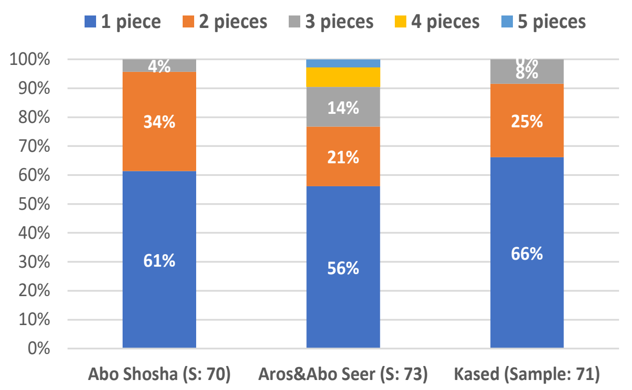


Figure 3.9.1 Share of Sample Household by the Number of Farm Plot

Source: Farm Economy Survey by JICA Survey Team

Approximately, 65% of the respondents engage in farming full-time, while 27% of the respondents engage in farming part-time. The remaining respondents, about 8%, do not engage in farming at all. Then, looking into the family members, the average full-time family member is 1.1 members per household while the number of part-time members is 1.2 members per household. In most cases, one of the family members fully engages in agriculture and one more member engages in agriculture part-time. This trend is the same for all the 3 sub-regions. Yet, the number of full-time family members in Aros & Abo Seer is slightly less than that in Abo Shosha and Kased as shown in Table 3.9.3.

Table 3.9.3 Family Members Engaged in Farming (asking about family members)

Area	Ave. Family members	Ave. Full-time members	Ave. Part-time members, 1/	No. of members in Agriculture
Abo Shosha	6.1	1.3	1.2	2.5
Aros & Abo Seer	5.7	0.9	1.3	2.2
Kased	4.6	1.1	1.2	2.3
Average	5.5	1.1	1.2	2.3

Note: The numbers indicate family members per household. 1/ Part-time members mean the ones who actually do the farming work. In Egypt, conventionally, a farmland owner who rents out his/her farmland and does not any farming is often taken as a part-time farmer, but the number in the table shows the ones who actually do the farming work.
Source: Farm Economy Survey by JICA Survey Team

3) Cultivated Crop

Majority of the sample farmers cultivate one single crop per season. In Kased, 88 sample farmers out of 90 cultivated only a single crop both in summer and winter in 2019/2020, whereas in Abo Shosha and Aros & Abo Seer, 14 farmers cultivated more than 2 crops in summer. As for winter crops in Abo Shosha and Aros & Abo Seer, 15 and 38 farmers cultivated more than 2 crops in winter respectively. Crop diversification is still not so prevalent.

Major crops in summer and Nile seasons are maize in Upper Egypt and rice in the Delta area. It is significant that farmers in Fayoum are cultivating sorghum as the major crop in summer. Recently, maize is cultivated for animal feed rather than human consumption and sorghum is also cultivated for animal feed and it is said to require less water than maize. There are few farmers cultivating vegetables such as tomato and cucumber in summer cropping season.

As for winter crops, wheat and berseem[1] are the major crops and sugar beet has been increasing as a winter crop as an alternative crop to sugarcane. There are also a few farmers who cultivate winter vegetables such as onions.

Table 3.9.4 Major Crops Cultivated by the Sample Farmers

Area	Season	1st crop		2nd Crop		3rd Crop	
		No.	Crop	No.	Crop	No.	Crop
Abo Shosha	Summer	90	Maize, Sesame	14	Green fodder, Onions, Cucumber, Basil, Sesame	2	Basil, Green fodder
	Winter	90	Wheat, Sugar beet, Tomato, Berseem	15	Wheat, Berseem, Sugar beet	2	Berseem, Sugar beet
	Nile	2	Maize	-	-	-	-
Aros & Abo Seer	Summer	90	Sorghum, Maize	14	Cotton, Green fodder, Pineapple, Maize	2	Fodder, Zucchini
	Winter	90	Wheat, Berseem	38	Berseem, Wheat, Green fodder, Sugar beet	2	Berseem
	Nile	42	Maize, Green fodder	1	Berseem	-	-
Kased	Summer	90	Rice, Jasmine, Maize, Orange	2	Maize	-	-
	Winter	90	Wheat, Jasmine, Orange, Berseem, Onion	2	Berseem, Wheat	-	-
	Nile	-	-	-	-	-	-

Note: No.: number of farmers who cultivated more than 1 crop or 2 crops or 3 crops
Source: Farm Economy Survey by JICA Survey Team

4) Large Livestock

The numbers of the interviewed farmers who keep large animals, i.e., milk cattle, beef cattle and buffalo in Abo Shosha, Aros & Abo Seer and Kased are 54 (60%), 70 (78%) and 54 households (60%), respectively. They are the major income source, too. Among the farmers who keep cattle and buffalo, the average number of heads is 2.4 in Abo Shosha, 3.1 heads in Aros & Abo Seer and 3.8 in Kased. As the majority of farm households keep cattle or buffalo, cultivating fodder crops such as maize, sorghum and berseem should remain important for the farmers. Such a share of fodder crops should be taken into consideration in introducing modern irrigation systems.

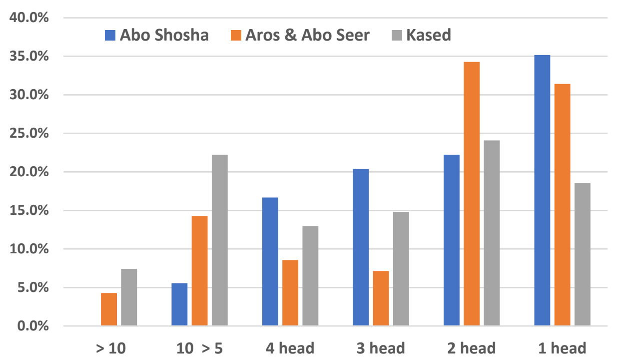


Figure 3.9.2 Share of Household by Number of Cattle/Buffalo
Source: Farm Economy Survey by JICA Survey Team

3.9.3 State of Water Shortage Based on Farm Household Economic Survey

Sample farmers were asked about the degree of water shortage in summer and winter crop seasons with the category of always, frequently, sometimes and no shortage. Figure 3.9.3 shows the number of farmers by the degree of water shortage. As this survey intentionally selected the sample three villages per region with heavy, moderate and little water shortages, farmers in each state of the village responded as expected according to the degree of water shortage in summer crop season, e.g. in Aros & Abo Seer, most of the sample farmers in the village with heavy water shortage responded they always suffer from water shortage, and so did the farmers in the village with moderate water shortage that they frequently suffer from water shortage and then the farmers in the village with little water shortage responded that most of them sometimes suffer from water shortage.

[1] It is a member of the legume family, grown in winter as a pasture grass and green manure crop. Also, it is called Egyptian clover.

Significant point observed is the less water shortage in the winter crop season. For all the priority sub-regions, farmers who responded always and frequent water shortage in winter is much less than in summer and more than half of the sample farmers replied that there is no water shortage during winter crop season. Due to low temperatures, i.e., low evapotranspiration and less water required for crops cultivated in the winter season, water shortage is not as severe as in the summer season.

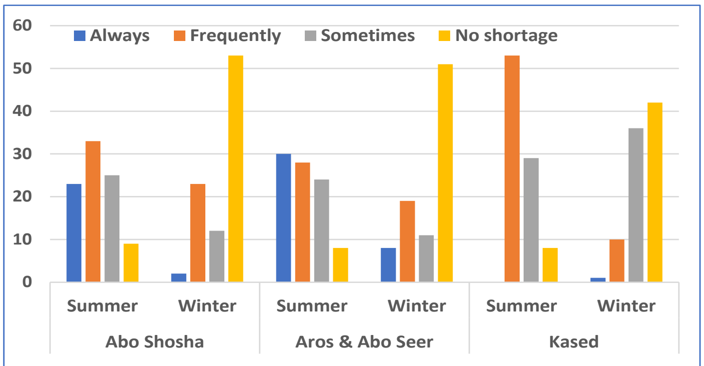


Figure 3.9.3 Degree of Water Shortage by Farmer
Source: Farm Economy Survey by JICA Survey Team

To supplement the water shortage, farmers practice the reuse of drain water available nearby for irrigation. Among the sample farmers, 32 farmers out of 90 in Aros & Abo Seer (Fayoum) replied that they reuse drain water, while only 2 farmers in Abo Shosha said they reuse drain water and no farmer replied to reuse drain water in Kased sub-region.

3.9.4 Crop Yield Level Based on Farm Household Economic Survey

Average yields of the major crops cultivated by the sample farmers according to the location of their farmland were analyzed. Location of the farmlands of the sample farmers is classified as upstream of branch canal and upstream of Meska (U-U), upstream of branch canal and downstream of Meska (U-D), downstream of branch canal and upstream of Meska (D-U), and downstream of branch canal and downstream of Meska (D-D). Then, the average yields of the sample farmers according to the location were compared.

Tables 3.9.5 and 3.9.6 below summarize the average yield of valid responses of the sample farmers by location of their farmland. As a tendency clearly shows up, the yield level of farmland in U-U is higher than other locations, especially as compared to that of D-D. For maize in summer, the average difference in the yield between U-U and D-D reaches as much as 35%, while the difference in the average yield of wheat was 18%, though the gap in the yield between U-U and D-D differs by the priority sub-region.

The difference showed bigger in the summer season, which is correspondent to the situation of water shortage by season as observed above. As Table 3.9.6 shows, the gaps in the yield between U-U and D-D are narrower for rice, onion and sorghum, whose yields were also captured by this farm economy survey. The result may imply that if irrigation water is equally distributed along the canal with suitable amount of water, the yield of most downstream farmland can increase up to the level of the upstream farm as a potential yield increase.

Table 3.9.5 Average Yield of Sample Farmers by the Location of Farmland (1)

Region	Unit	Maize (summer)				Wheat (Winter)			
		U-U	U-D	D-U	D-D	U-U	U-D	D-U	D-D
Abo Shosha	No. of Sample	18	21	15	15	16	16	12	14
	Kg/fed	2,072	1,933	1,747	1,495	2,850	2,574	2,570	2,240
	Difference (%)	**139%**	**129%**	**117%**	**100%**	**127%**	**115%**	**115%**	**100%**
Aros & Abo Seer	No. of Sample	16	5	2	4	27	12	15	16
	Kg/fed	1,812	1,735	1,733	1,507	2,031	1,780	1,756	1,803
	Difference (%)	**120%**	**115%**	**115%**	**100%**	**113%**	**99%**	**97%**	**100%**
Kased	No. of Sample	9	7	3	2	12	9	10	3
	Kg/fed	2,655	2,784	2,500	2,100	2,632	2,655	2,846	2,320
	Difference (%)	**126%**	**133%**	**119%**	**100%**	**113%**	**114%**	**123%**	**100%**
Average	No. of Sample	43	33	20	21	55	37	37	33
	Kg/fed	2,097	2,084	1,859	1,555	2,400	2,336	2,315	2,035

	Difference (%)	**135%**	**134%**	**120%**	**100%**	**118%**	**115%**	**114%**	**100%**

U-U: upstream of branch canal and upstream of Meska
U-D: upstream of branch canal and downstream of Meska
D-U: downstream of branch canal and upstream of Meska
D-D: downstream of branch canal and downstream of Meska
Source: Farm Economy Survey by JICA Survey Team

Table 3.9.6 Average Yield of Sample Farmers by the Location of Farmland (2)

Region	Crop	Unit	Location of Farmland				Remarks
			U-U	U-D	D-U	D-D	
Aros & Abo Seer	Sorghum	No. of Sample	11	6	13	9	
		Kg/fed	1,378	979	1,244	1,196	
		Difference (%)	115%	82%	104%	100%	
Kased	Rice	No. of Sample	14	12	11	8	
		Kg/fed	3,621	4,041	3,775	3,708	
		Difference (%)	98%	109%	102%	100%	
	Onion	No. of Sample	6	4	3	5	
		Kg/fed	12,437	11,720	12,000	11,919	
		Difference (%)	104%	98%	101%	100%	

Note: U-U, U-D, D-U and D-D mean the same as Table 3.9.5.
Source: Farm Economy Survey by JICA Survey Team

3.9.5 Farm Income, Off-farm Income and Expenditure Based on Farm Household Economic Survey

1) Farm Income

The average annual gross farm income per feddan is 23,563 LE and the average annual net farm income per feddan comes to 10,107 LE. The gross farm income varies between 78,450 LE and 5,000 LE with the mean value of 24,750 LE. The average gross farm income in Kased is the highest with 28,691 LE among the 3 sub-regions followed by Abo Shosha with 22,185 LE and Aros & Abo Seer with 19,781 LE as shown in Figure 3.9.4. This is because some of the respondents in Kased cultivate high value crops such as onion and jasmine; on the other hand, most of the respondents in Abo Shosha and Aros & Abo Seer cultivate traditional crops such as maize and wheat.

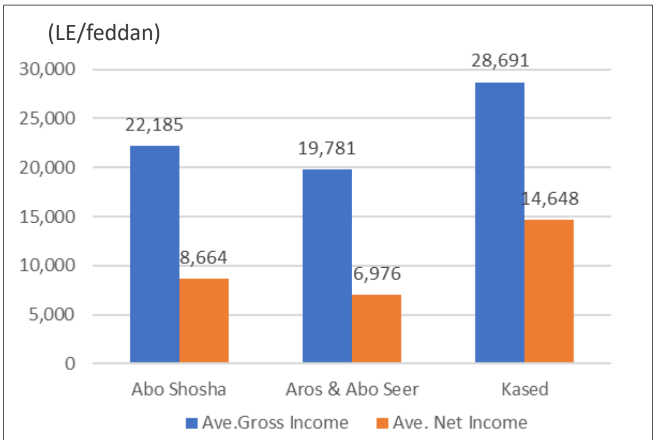


Figure 3.9.4 Annual Gross Income and Net Income per feddan
Source: Farm Economy Survey by JICA Survey Team

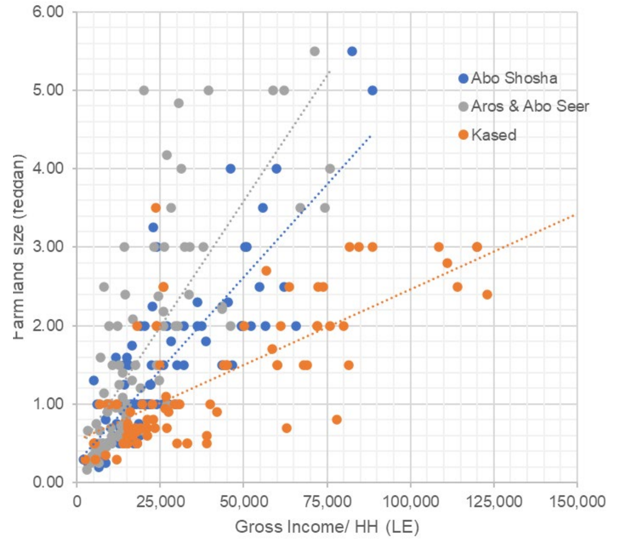


Figure 3.9.5 Gross Income per HH and Farmland Size
Source: Farm Economy Survey by JICA Survey Team

The largest gross farm income per household is approximately 208,000 LE/HH, while the minimum gross farm income per household is 1,980 LE/HH. The average gross income per household is 29,495 LE/HH and the median value is 18,000 LE/HH. Figure 3.9.5 indicates the gross income level per household and their land size. Approximately 60% of the respondents answered that their gross farm income level is less than 25,000 LE/HH. Also, this scatter graph shows that the gross farm income level is almost the same among the farmers who own farmland less than 1 feddan in all the sub-regions. Yet, the larger the farmland area, the greater the gap in gross income level among the farmers.

Figure 3.9.6 shows the number of respondents in each gross income level per feddan. The gross income level varies depending on the types of crops farmers cultivate. 109 sample farmers (approximately 40% of the respondents) replied that their annual gross income per feddan is less than 20,000 LE per year. In this gross income level, most farmers cultivate only traditional crops such as maize and wheat. 122 sample farmers (46% of the respondents) earned annual gross income between 20,000 LE and 35,000 LE per feddan. Farmers in this category cultivate high-value crops in addition to the traditional crops such as sugar beet and rice in Kased. 27 sample farmers (10% of the respondents) earned gross income between 35,000 LE and 50,000 LE per feddan. In this category, farmers cultivate horticulture crops such as onion. Only 7 sample farmers (approximately 3% of the respondents) reached their gross income over 65,000 LE per feddan. These farmers cultivate jasmine in the Kased sun-region.

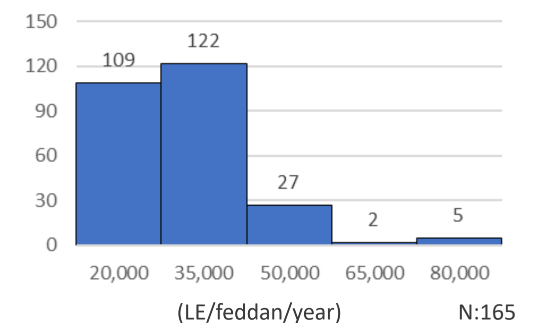


Figure 3.9.6 Distribution of Gross Income Level per feddan
Source: Farm Economy Survey by JICA Survey Team

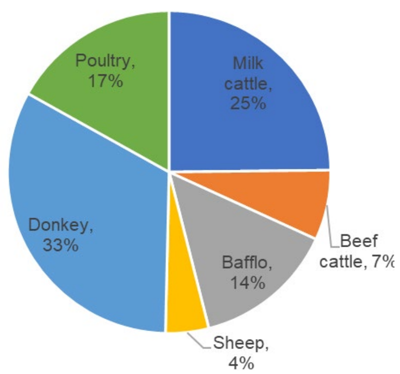


Figure 3.9.7 Livestock Ownership
Source: Farm Economy Survey by JICA Survey Team

2) Livestock

One of the most major livestock in the survey villages is the donkey. 67% of the respondents own a donkey, which is a draft animal for transportation, followed by milk cattle with 51% and poultry with 35%. There are 3 major income sources from livestock; namely 1) milk processing, 2) beef cattle and 3) poultry. The highest average income from livestock is beef cattle with 19,682 LE followed by milk processing with 9,638 LE. The average income from poultry is approximately 1,000 LE. It is noted that these incomes do not consider their home consumption values; thus, the economic values of livestock could be higher than the incomes indicated above.

3) Off-farm Income

Approximately 50% of the respondents answered that they have off-farm income. The highest average off-farm income is 34,786 LE/year/HH in Abo Shosha followed by 29,084 LE/year/HH in Kased and 20,770 LE/year/HH in Aros & Abo Seer. In total, the average off-farm income is around 26,000 LE/year/HH. The most common off-farm activity is "employment". Approximately 70% of the respondents who have

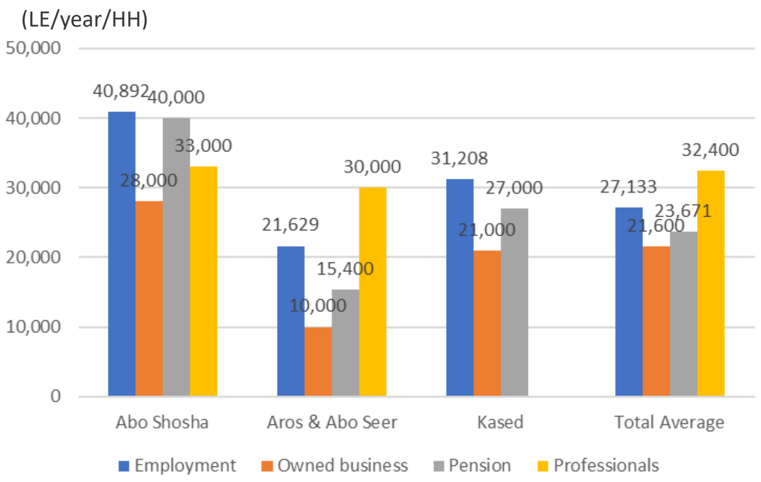


Figure 3.9.8 Average Off-farm Income
Source: Farm Economy Survey by JICA Survey Team

off-farm income answered "employment" as their off-farm income source.

"Employment" includes teachers, office workers and drivers. The average annual income of "employment" is around 27,000 LE/year. For "employment", the highest average income is 40,000 LE/year in Abo Shosha and the lowest is 21,000 LE/year in Aros & Abo Seer. Another common off-farm income source is "pension" with an average annual income of 23,000 LE/year.

The highest average annual off-farm income (except income as an army force sergeant) is approximately 32,400 LE/year. This comes from professional occupations such as doctors, lawyers, engineers, and accountants. Although the average income is high, the number of these professionals is quite a few: only 8 respondents in Abo Shosha, 2 respondents in Aros & Abo Seer and no respondents in Kased.

4) Expenditure

Average expenditure in a month is approximately 4,600 LE/month/ HH[2]. This average expenditure is almost the same across the 3 sub-regions. The highest expenditure is around 2,000 LE/ month for food and beverage. It accounts for 44% of the total monthly expenditure. The second largest expenditure is 710 LE/ month for education followed by 650 LE/month for medical care. These are approximately accounting for 15% of the total monthly expenditures respectively.

According to the survey result, variation of the expenditure is large in beverage, education, and medical care. On the other hand, variations of the expenditure in electricity, drinking water, and wastewater treatment are small as compared to other items. This is because most of these costs are utility costs, for the prices would be fixed in all the villages.

Table 3.9.7 Average Monthly Expenditure (LE)

Item	Abo Shosha	Aros & Abo Seer	Kased	Total Average	%
Food and beverage	2,118	2,354	1,672	2,048	44
Clothing	706	502	585	598	13
Education	627	581	921	709	15
Electricity	334	343	341	339	7
Drinking water	145	186	158	163	3
Wastewater treatment	63	33	56	50	1
Medical care	519	589	839	649	14
Others	173	101	77	117	3
Total	**4,683**	**4,689**	**4,648**	**4,673**	**100**

Source: Farm Economy Survey by JICA Survey Team

3.9.6 Other Features Based on Farm Household Economic Survey

1) Marketing of Agricultural Produces

According to the farm economy survey, majority of the sample farmers sell their major produces such as maize, rice, sorghum, onion, to middlemen in the village. There are some cases that they also sell the produces to the middlemen outside the village, or they ferry the produces to local wholesale market by themselves. As for market information, the sample farmers obtain it mainly from middlemen, neighbor farmers and local wholesalers.

In most of the case, the sample farmers sell their produces individually. In fact, here are a few farmers who sell their produces collectively, but in most cases only with their relatives or with neighbor farmers. Collective marketing is more reported when they sell the produce to the middlemen outside the village. The existence of collective marketing practice, albeit it seems still minority of the farmers, would be an encouraging factor to promote irrigation improvement with Meska improvement, which requires collective action of the farmers.

[2] Expenditure was answered per month, thus the respondent answers often do not include some of the items such as medical care and clothing, not spent every month regularly.

2) Mechanization

Among the sample farmers, those who own a tractor (65HP) are 9 (30%) in Kased, 1 (3%) in Abo Shosha and zero in Aros & Abo Seer sub-regions respectively. The farmers who own tractors are not necessarily the large-scale farmers as their farming land are less than 3.5 feddan and most of them cultivate around 2 feddan only. It is said that they would be renting out their tractor to neighbors.

Most of the farmers own diesel pumps and no farmers own electric pumps. It was also found among the sample farmers that many of them keep using the pump for more than 20 years. In Kased and Abo Shosha, 50 farmers (56%) and 33 farmers (39%) purchased their pumps before the year 2000. Farmers would try to well maintain the machines to use them beyond their durable life and this could decrease the cost for depreciation though there could be a trade-off with the maintenance cost.

As for Aros & Abo Seer in Fayoum, 58 farmers out of 90 or 64% of the sample farmers do not own pumps. As gravity irrigation is possible in major parts of Fayoum, many farmers do not even use diesel pumps for irrigating their farmlands unlike other Nile Valley and delta regions. The difference in the investment and O&M cost between current irrigation practice and modern irrigation system may, therefore, become bigger in Fayoum, which could raise the hurdle to motivate farmers to introduce modern irrigation system in Fayoum.

3) Rural Finance

In total approximately 16% of the respondents are borrowing money from financial institutions. In Abo Shosha, the percentage of farmers borrowing money is 20% of farmers (18 respondents out of 90), Aros & Abo Seer is 18% of farmers (18 respondents out of 90) and Kased is 10% of farmers (9 respondents out of 90). The number of farmers who are borrowing money is the smallest in Kased; however, the average loan amount is the largest in Kased with 65,875 LE/HH followed by Abo Shosha with 42,375 LE/HH and Aros & Abo Seer with 32,118 LE/HH.

The most common financial institution among the respondents is the Agricultural Bank of Egypt (ABE) with more than 85% of the respondents followed by private commercial banks such as Banque Misr with 7% and Qahera Bank with 7%. The main purpose of the loans is agriculture with nearly 70% of the respondents followed by livestock with 14%. Only a few respondents have some other reasons such as buying a new car and other improvement of living conditions.

The total average loan amount is approximately 42,000 LE. In Abo Shosha and Aros & Abo Seer, the average loan amount ranges from 42,375 LE and 32,118 LE respectively. The average loan amount of Kased is the highest with 65,875 LE. In Kased, there are many farmers cultivating high value crops such as onion as compared to other regions. These farmers borrow more money than those farmers who cultivate traditional crops. For this reason, the average loan amount of Kased area is higher than that of the other 2 sub-regions.

The most frequently answered for interest rate is 5% per year. Approximately 30% of the borrowing farmers answered that their interest rate is 5% followed by 12% and 16% interest rate. Simple average interest rate arrives at 12%, and the maximum interest rate is 30%.

3.9.7 Opinions about Modern On-farm Irrigation Facilities and Intention to Introduce Them

The farmers' perception of modern on-farm irrigation facilities and their opinions on the introduction of modern on-farm irrigation facilities were obtained through a questionnaire in the farm household economic survey. In addition to this, opinions and intentions regarding the introduction of modern on-farm irrigation facilities were also obtained through stakeholder meetings conducted as a part of the environmental and social considerations. These results are discussed below:

1) Results based on Farm Household Economic Survey

Figure 3.9.9 shows the share of the sample farm households who know about the drip and sprinkler irrigation systems. On average of the three priority areas, 64% of the sample households know about drip irrigation systems. As for sprinkler irrigation systems, 43% of households as average know it, less than the drip system. Most of them know the modern irrigation system from the actual practice in the New Lands in desert, thus it is indicated that the drip irrigation is more practiced in the New Lands.

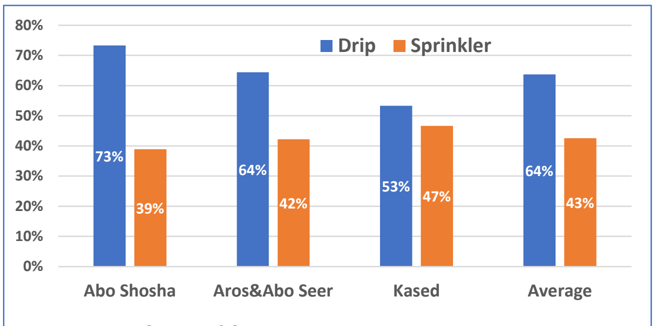


Figure 3.9.9 Share of Sample HHs who know Modern Irrigation
Source: Farm Economy Survey by JICA Survey Team

Although none of the sample farmers practices modern irrigation, their perception on the modern irrigation is summarized in Figures 3.9.10 to 3.9.13 below. For both drip and sprinkler irrigation, the advantage they think the most is 'saving water' followed by 'saving fertilizers' or 'high production'. As for disadvantages, farmers mostly raise the issue of high cost in investment and operation and maintenance. Some farmers are in fact anxious for suitability of the modern irrigation in the Old Lands. In promoting the modern irrigation system in the Old Lands, these issues of suitability such as soil conditions as well as the cost-benefit should be well addressed to the farmers, who are wondering the investment in modern irrigation system.

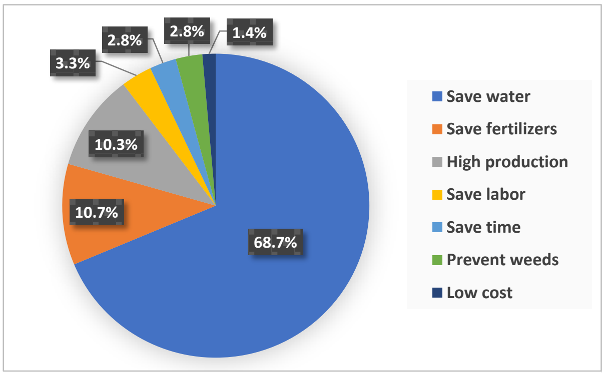


Figure 3.9.10 Perception of Farmers on Drip: Advantage
Source: Farm Economy Survey by JICA Survey Team

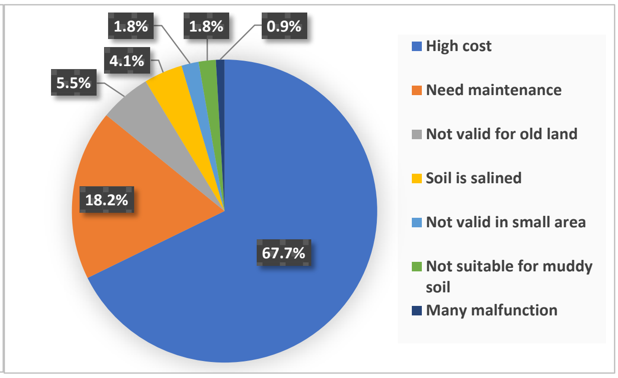


Figure 3.9.11 Perception of Farmers on Drip: Disadvantage
Source: Farm Economy Survey by JICA Survey Team

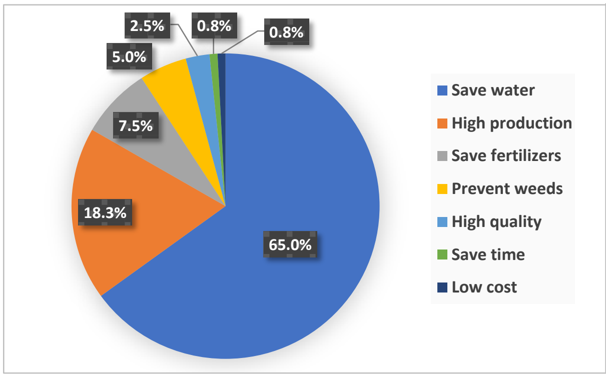


Figure 3.9.12 Perception of Farmers on Sprinkler: Advantage
Source: Farm Economy Survey by JICA Survey Team

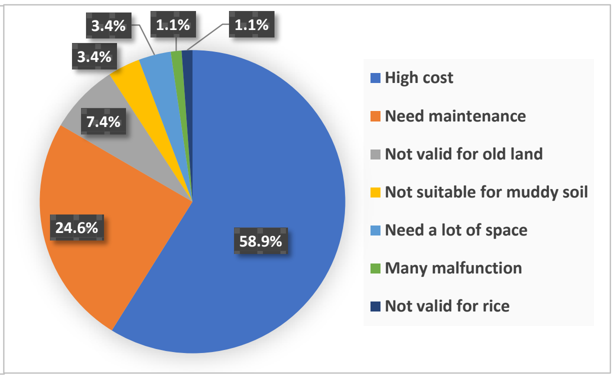


Figure 3.9.13 Perception of Farmers on Sprinkler: Disadvantage
Source: Farm Economy Survey by JICA Survey Team

The respondents were also asked that "if drip irrigation system costs 42,900 - 57,000 LE/ha (around18,000 - 24,000LE/fed)[3], do you want to introduce it?". As a result, approximately 90% of the farmers answered "No". The most common reason for this answer "No" is the high cost of the drip irrigation system accounting for 73% out of these 90% respondents. The same question was also asked for sprinkler irrigation system "If sprinkler irrigation system costs 42,900 - 57,000 LE/ha, do you want to introduce it?". The result was almost the same as drip irrigation: 96% of the farmers answered "No" and most common reason for this answer is "high cost" accounting for 64% out of these 96% farmers.

Above results indicate that the high cost is one of the main constraints for the farmers to introduce the modern irrigation system. Therefore, it needs financial schemes which can facilitate farmers to introduce the modern irrigation system. Possible financial schemes could be an arrangement of concessional loans, uncollateralized loans and also cost recovery together with the collection of land tax, etc. On the uncollateralized loans, the current loan scheme available, e.g., in the Agricultural Bank of Egypt requires farmers to submit their land as collateral, which very much makes farmers reluctant to borrow the loan. The last scheme, collection of the loan repayment together with the land tax, has already been practiced in the Meska improvement project under IIS.

2) Results of Hearing During the Stakeholder Meetings

Stakeholder meetings[4] were held in a total of 9 villages where farm economy survey was conducted. Stakeholder meetings were held with 3 villages in Abo Shosha (Beni Suef) on November 13-15, 2022, 3 villages in Aros & Abo Seer (Fayoum) on December 4-6, 2022, and 3 villages in Kased (Gharbia) on December 27-29, 2022.

Stakeholder meetings were organized by the IIS (Irrigation Improvement Sector) of MWRI and held with village cooperatives, agricultural cooperatives, water users' associations (WUAs), farmers participating in WUAs, and other farmers in each village. The meetings were held at public facilities (municipality office, youth center, etc.) or the house of the farmer representative and carried out in the form of meetings. The number of participants in each village was 16 - 39 farmers, a total of 260 farmers participated in the series of meetings.

Following issues related to the introduction of modern on-farm irrigation facilities were discussed in the stakeholder meetings.

- Explanation of facility configuration of modern on-farm irrigation facilities (Introduction cost was not explained in the meeting)
- Collection and consolidation of detailed opinions on the introduction of modern field irrigation facilities
  - ✓ Introduction of WUA-based facilities
  - ✓ Type of Meska Improvements
  - ✓ Type of field equipment (sprinkler, drip, or combination use)
  - ✓ Repayment method
  - ✓ Confirmation of willingness to introduction

Detailed questions and opinions collection/consolidation results are shown in Tables 3.9.8-3.9.10. Motivation for the introduction of modern on-farm irrigation varied among the areas. The most positive

[3] This questionnaire was carried out based on the orally collected information from MWRI as of September 2021 before the JICA Survey Team surveyed and estimated the cost with year 2022 price. Because the project cost estimate and economic evaluation of the project are carried out based on the additional surveys with year 2022 prices, the price level of modern on-farm irrigation cost and farm income for the planning of the project is different from the level in this farm economy survey.

[4] Stakeholder meetings are conducted as part of environmental and social considerations to confirm the willingness and opinions of beneficial farmers and to reflect it to the project planning.

stance for introduction of modern on-farm irrigation was found in Kased (Gharbia) in Delta, followed by Abo Shosha (Beni Suef) in Upper Egypt, and the most conservative stance was found in Aros & Abo Seer (Fayoum) in Upper Egypt.

In Aros & Abo Seer, it was raised as a problem that size of farmlands owned by each farmer in this area is too small to introduce modern on-farm irrigation system by group basis. Because of this reason, some of farmers raised concerns about introduction of modern on-farm irrigation system. If modern on-farm irrigation will be promoted in this area, such features should be considered. (It is noted that JICA Survey Team proposed that introduction of modern on-farm irrigation in Fayoum should be not included in the project components with reasons of adverse impacts on Qarun and Rayan Lakes. Refer to Chapter 4.10).

As one of the most common requests raised at meetings, setting up of demonstration farms by the Project are necessary to show the success cases by applying modern on-farm irrigation techniques. This is because that most of farmers had seen and heard of successful examples in New Lands[5], however, they had not experienced successful examples in Old Lands. They also expressed their requests for cultivation and marketing technical support after the introduction of modern on-farm irrigation. As the conclusion, it was confirmed that implementation of the soft support program (technical assistance) by the project are essential and important.

Table 3.9.8 Collection and Consolidation Results of Particpants' Opinions for Introduction of Modern On-Farm Irrigation Facility (Abo Shosha, Beni Suef)

Items	Dashtot (Water condition/ Good)	El Mahmodya (Water condition/ Moderate)	Mazora (Water condition/ Shortage)
1. Do you favor the introduction of modern on-farm irrigation facility WUA basis (or farmer group basis)? (Yes/No)	Yes	Yes	Yes
	【Major Opinions】 • Agree to the operation and management by WUA. • Experienced farmers with modern on-farm irrigation facility (including large farmers) are encouraged to participate in the WUA.		
2. Which do you prefer "Open canal" or "Close canal" for Meska improvements?	Open canal	Closed canal	Open canal
	【Major Opinions】 • (Reason for selecting "Open canal") Easy to repair in case of blockage of meska, and easy to watch water by eyes. • (Reason for selecting "Closed canal") Garbage dumping into the canal is problem, and we want to prevent this by culverting.		
3. Which do you prefer for the field equipment? (Drip or Sprinkler or Combination use)	Combination use	Combination use	Combination use
	【Major Opinions】 • We want to request to set up demonstration farms to demonstrate which type of water saving devices are most effective for each crop. • We want to see methods and techniques in the above demonstration farms to select best devises. • Considering water management, it would be preferable to grow the same crop by group, but it would be difficult to get the consensus of all farmers.		
4. What crops do you prefer to cultivate by modern on-farm irrigation facility?	Sugar beet, wheat, berseem, aromatic plant	Wheat, berseem, potatoes, maize	Wheat, berseem, maize, potato, aromatic plant
	【Major Opinions】 • We want to continue growing the same crops as existing. (Above crops are existing crops).		
5. Which way do you prefer for the repayment method? (Through "bank" or "collection at same timing of land tax")	Either way is fine	Either way is fine	Either way is fine
	【Major Opinions】 • We don't know specific difference between "bank" or "same timing as land tax". • We don't care which repayment method is adapted as long as the interest rate is zero.		
6. Do you agree to install modern on-farm irrigation facility? (Yes/No)	Yes, with condition	Yes, with condition	Yes, with condition
	【Major Opinions】		

5 It refers to irrigated agricultural development in the desert areas. The Horizontal Expansion Sector under MWRI is responsible for the development of irrigation facilities, while the Executive Authority for Land Improvement Projects under MALR is responsible for the reclamation of agricultural land. After irrigable farmland is developed, farmers are settled in the area. Since there are no special subsidies for the settlement, large farmers and corporate entities have installed modern on-farm irrigation facilities and are growing crops for the market and for export.

<table>
<tr><td></td><td>【Dashhot village】
We have no knowledge of modern on-farm irrigation. Thus, we want to gain the knowledge of the benefits and profitability of it.
We know examples of tomato cultivation on reclaimed farmland (New Lands) and it is successful. We have visited New Lands and learned of the benefits of low fertilizer application and high yields. However, there are no examples in our village (Old Lands). Farmers needs to learn from the examples.
We want to see demonstration farms set up in the village to show best practices and to see the results if it is suitable for Old Lands <u>(Conditions for introduction)</u>.
【El Mahmodya village】
We know that modern on-farm irrigation has many advantages (increased yields, greater water savings, consumption saving (fertilizer, labor, etc)). However, we don’t know if it is effective in Old Lands or not. We want to see demonstration farms set up <u>(Conditions for introduction)</u>.
It is possible to offer our own farmland for the establishment of demonstration farms.
【Mazora village】
In our village, there are many farmers who have New Lands, and we know successful cases of modern on-farm irrigation in New Lands. However, we don’t know if it is effective in Old Lands or not. We want to see success examples at demonstration farms (for example: 2 feddans) <u>(Conditions for introduction)</u>.</td></tr>
</table>

Source: JICA Survey Team

<u>Table 3.9.9 Collection and Consolidation Results of Particpants’ Opinions for Introduction of Modern On-Farm Irrigation Facility (Aros & Abo Seer, Fayoum)</u>

<table>
<tr><th>Items</th><th>Masara Arfa
(Water condition/Good)</th><th>El Gafra
(Water condition/ Moderate)</th><th>Bahr Abo Elmer
(Water condition/ Shortage)</th></tr>
<tr><td rowspan="2">1. Do you favor the introduction of modern on-farm irrigation facility WUA basis (or farmer group basis)? (Yes/No)</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td colspan="3">【Major Opinions】
(Reason of “No”) The scale of the modern on-farm irrigation facility to be introduced seems too large. There are many farmers with less than 5 karat (5/24 feddan) of farmland. So, if the size of the facilities to be introduced is too large, the number of farmers will increase. There is concern about group based installation and management of the facility.
(Reason of “No”) Even in neighboring farmers, there is concern that farmers may not agree to the introduction of the system by group.</td></tr>
<tr><td rowspan="2">2. Which do you prefer “Open canal” or “Close canal” for Meska improvements?</td><td>Open canal</td><td>Open canal</td><td>Open canal</td></tr>
<tr><td colspan="3">【Major Opinions】
(Reason for selecting “Open canal”) Easy to repair in case of blockage of meska, and easy to watch water by eyes. Less sedimentation is expected.</td></tr>
<tr><td rowspan="2">3. Which do you prefer for the field equipment? (Drip or Sprinkler or Combination use)</td><td>Depend on crops</td><td>Depend on crops</td><td>Combination use</td></tr>
<tr><td colspan="3">【Major Opinions】
(Reason for selecting “Depend on crops”) It seems that Drip is more expensive than Sprinkler. Equipment to be installed depends on the crop to be grown.
(Reason for selecting “Depend on crops”) No knowledge of the modern on-farm irrigation.
(Reason for selecting “Combination use”) Certain crops such as Berseem are suitable for sprinklers. Combination use, which can be selected depending on the crop, would be optimal.</td></tr>
<tr><td rowspan="2">4. What crops do you prefer to cultivate by modern on-farm irrigation facility?</td><td>Wheat, berseem, maize, cabbage, tomato, leek, onion and cucumber</td><td>Wheat, berseem, potatoes, maize</td><td>Wheat, berseem, maize</td></tr>
<tr><td colspan="3">【Major Opinions】
We want to continue growing the same crops as existing. (Above crops are existing crops).</td></tr>
<tr><td rowspan="2">5. Which way do you prefer for the repayment method? (Through “bank” or “collection at same timing of land tax”)</td><td>Agricultural bank</td><td>Agricultural bank</td><td>Agricultural bank</td></tr>
<tr><td colspan="3">【Major Opinions】
Not familiar with the system of “collection at same timing of land tax”. Don’t know what difference between land tax and bank.</td></tr>
<tr><td rowspan="2">6. Do you agree to install modern on-farm irrigation facility? (Yes/No)</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td colspan="3">【Major Opinions】
【Masara Arfa village】
We know that modern on-farm irrigation has many advantages (increased yields, greater water savings, consumption saving (fertilizer, labor, etc)). However, we</td></tr>
</table>

<table>
<tr><td></td><td>
have not seen the example adapting Old Lands.
• There are differences in farmland size among the various farmers. There are also differences in the elevation of the farmland. Because of these conditions, we are concerned about whether the introduction of modern on-farm irrigation facility will be successful.

【El Gafra village】
• I have seen examples of modern on-farm irrigation facility in New Lands, but have not seen any in Old Lands and am concerned about their success.
• I feel that the introduction of modern on-farm irrigation may be difficult for Old Lands because of the high cost.
• I feel that it may be difficult to introduce modern on-farm irrigation because each farmer's land is small.
• I would like to see demonstration farms set up.

【Bahr Abo Elmer village】
• I feel that it may be difficult to introduce modern on-farm irrigation facility because each farmer's land is small. The maximum facility configuration should be less than 10 feddan.
• It is depending on the costs.
</td></tr>
</table>

Source: JICA Survey Team

Table 3.9.10 Collection and Consolidation Results of Particpants' Opinions for Introduction of Modern On-Farm Irrigation Facility (Kased, Gharbia)

<table>
<tr><th>Items</th><th>Mahlet Menouf
(Water condition/ Good)</th><th>Shobra barola
(Water condition/ Moderate)</th><th>Damat
(Water condition/ Shortage)</th></tr>
<tr><td rowspan="2">1. Do you favor the introduction of modern on-farm irrigation facility WUA basis (or farmer group basis)? (Yes/No)</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td colspan="3">【Major Opinions】
• it would be easy to implement and operate the facility on a WUA basis.</td></tr>
<tr><td rowspan="2">2. Which do you prefer "Open canal" or "Close canal" for Meska improvements?</td><td>Both type</td><td>Both type</td><td>Both type</td></tr>
<tr><td colspan="3">【Major Opinions】
• (Reason for selecting "Both type") Only Meskas passing through residential areas should be culverted, while Meskas passing through farmland should be open. Open canal is easier to maintain and check water levels. On the other hand, culvert canal is to be used in residential areas to prevent dumping of household garbage.</td></tr>
<tr><td rowspan="2">3. Which do you prefer for the field equipment? (Drip or Sprinkler or Combination use)</td><td>Combination use</td><td>Depend on crops</td><td>Depend on crops</td></tr>
<tr><td colspan="3">【Major Opinions】
• We want to request to set up demonstration farms to demonstrate which type of water saving devices are most effective for each crop.
• We want to select best devises for each crop.
• We want to request the project to recommend best matching of devices and crops, if possible.</td></tr>
<tr><td rowspan="2">4. What crops do you prefer to cultivate by modern on-farm irrigation facility?</td><td>Same as existing crops (Traditional cops and vegetables)</td><td>Same as existing crops (Traditional cops and vegetables)</td><td>Same as existing crops (Traditional cops and vegetables)</td></tr>
<tr><td colspan="3">【Major Opinions】
• We want to continue growing the same crops as existing.</td></tr>
<tr><td rowspan="2">5. Which way do you prefer for the repayment method? (Through "bank" or "collection at same timing of land tax")</td><td>Agricultural bank</td><td>Collection by tax authority</td><td>Collection by tax authority</td></tr>
<tr><td colspan="3">【Major Opinions】
• (Reason for selecting "Agricultural bank") Because we are familiar with agricultural banks.
• (Reason for selecting "collection at same timing of land tax") Because it is same method used in case of introducing Improved Meska. Also, in the case of bank, the land must be pledged as collateral. In case of tax authority, there is no such concern.</td></tr>
<tr><td rowspan="2">6. Do you agree to install modern on-farm irrigation facility? (Yes/No)</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td colspan="3">【Major Opinions】
【Mahlet Menouf village】
• We know applications in New Lands. We have high hopes that it may be successful in Olds lands. We have great interest in the introduction of modern on-farm irrigation facilities under the project.
• We would like to see a trial run of operations and best practices in Old Lands through the establishment of demonstration farms.

【Shobra barola village】</td></tr>
</table>

	• We are expecting to the introduction of modern on-farm irrigation facilities through this project. • We would like to know the success case by setting up demonstration farms. 【Damat village】 • We are expecting to the introduction of modern on-farm irrigation facility through this project. • We would like to request demonstration farms incorporated into the project component.

Source: JICA Survey Team

3.10 Overview of Rural and Agricultural Development Finance in Egypt

This section summarizes the development of the Egyptian financial market, financial services for the agricultural sector, and the regulatory framework for agricultural finance. This section focuses mainly on financial institutions and financial service support related to the introduction of modern on-farm irrigation facilities.

3.10.1 Financial Market Development in Egypt

The relevant statistic in the Central Bank of Egypt (CBE)'s 'Monthly Statistical Bulletin No. 308' (November 2022) suggests that the financial market development phase has been coming to maturity in Egypt. First, there are total deposits of EGP7,369.6 billion as of the end-FY2021/22, which is 94.0 percent of nominal GDP of EGP7,842.5 billion. Judging from the level of nominal GDP per capita at US$4,504, the level of total deposits can be recognized to be relatively high. At this point in time, 73.3 percent of banking sector's liabilities are deposits, and moreover the share of local currency-dominated deposits is high at 85.4 percent.

In addition, the domestic credit has reached EGP6,757.6 billion (equivalent to 86.2 percent of GDP), which implies that the level of financial deepening has been relatively high. However, there is a challenge that the government sector seems to dominate the financial asset structure, i.e., by small domestic credit to the private sector of only EGP2,178.2 billion (equivalent to only 32.2 percent of the domestic credit).

3.10.2 Current Situation of Rural and Agricultural Finance Services

In terms of the financial inclusion, key statistical data shows that the Egyptian banking sector has recently developed its financial services for the individuals (see the figure below).

<table>
<tr><td colspan="2">Account Penetration (financial institution account % age15+)</td><td rowspan="4">Total Number of Banks in Egypt:
37
(Sept 2022)</td><td rowspan="4">Total Number of Bank Branches:
4,628
(Sept 2022)
Incl. 1,017 village banks</td></tr>
<tr><td>20114</td><td>14%</td></tr>
<tr><td>2017</td><td>32%</td></tr>
<tr><td rowspan="2">2021</td><td rowspan="2">26%</td></tr>
<tr><td>Number of Debit Cards
23 million
(June 2022)</td><td>Number of ATMs
21,459
(June 2022)</td></tr>
</table>

Figure 3.10.1 Financial Inclusion in Egypt

Sources: World Bank's Global Findex Database 2021 (2022)[1], CBE's Monthly Statistical Bulletin No.308 (November 2022)[2].
Note 1: Account penetration in rural area is 6% in 2011, 10% in 2014, and 29% in 2017.
Note 2: According to CBE's Annual Report 2017/18 (p.8), the mobile wallet users exceed 12 million persons.

However, when it comes to rural and agricultural finance services in Egypt, the data of loans to agricultural sector implies that the banking sector doesn't necessarily meet the potential financial demand for farmers. Lending for non-government sector is EGP2,208.1 billion in the total lending of EGP3,564.7 billion (as of end-June 2022), and lending for agriculture sector is only EGP52.7 billion (2.4 percent of lending for non-government sector). Judging from the fact that the share of agriculture in GDP at factor cost is 12.1 percent (FY2020/21) (Source: IMF Country Report No.21/163 Arab Republic of Egypt (July 2021), p.34 [3]), the lending for agriculture sector seems to be minimal in Egypt.

In general, banks face with the difficulty in agricultural lending, which are associated with agricultural inherent risks such as volatility risk of production amount and market prices affected by weather

1 https://www.worldbank.org/en/publication/globalfindex/Data
2 https://www.cbe.org.eg/en/EconomicResearch/Publications/Pages/MonthlyStatisticaclBulletin.aspx
3 https://www.elibrary.imf.org/view/journals/002/2021/163/002.2021.issue-163-en.xml

fluctuation, production risk and operational risk. Therefore, an agriculture-specialized state-owned commercial bank or a government-linked financial institution has played a critically important role in agricultural loan markets around the world.

In Egypt, Agricultural Bank of Egypt (ABE), a governmental bank, dominates the agricultural loan market. ABE has its market share of about 70 percent in the agricultural loans, with 1,207 branches (i.e., 26.4 percent of total bank branches in Egypt). ABE also has 2.7 million depositors and 1.7 million loan customers (half of whom live in the so-called ‘poorest area’).

On the other hand, there are about 450 microfinance institutions (MFIs) as of May 2015, under the legal framework of Presidential Decree No.141 of 2014 on regulating microfinance activity (13th November 2014) and the Financial Regulatory Authority (FRA)’s regulations. All MFIs have 840 thousand borrowers, and the total loan outstanding of MFIs is US$ 285.4 million (equivalent to EGP4.5 billion), which is absolutely small comparing to the Egyptian loan market and even the agricultural loan market. Also, due to the lack of relevant data, it is not necessarily clear that MFIs have played a significant role of complementing quantitatively and qualitatively in the rural and agricultural loan market.

3.10.3 Regulatory Framework of Rural and Agricultural Finance and Its Supporting Policies

Considering that ABE plays a critically important role in the agricultural loan market with its market share of about 70 percent in the market, it is firstly essential to understand the CBE’s regulatory framework (Law No.88 of 2003 promulgating the Law on the Central Bank) that supervises the ABE’s activities.

According to the CBE’s Annual Report 2019/20, in order to ensure Egyptian banks’ financial soundness, CBE has established regulatory standards, including the minimum reserve requirement and liquidity ratios, the maximum limits of a bank’s concentration of investments with a single customer, along with its related parties, and investments abroad, as well as the digestion of asset-liability mismatches in terms of maturity and currency.

Under the current prudential regulations, the banks including ABE are required to meet the minimum capital adequacy ratio (CAR) of 10 percent. The banks are also required to meet the Basel III’s leverage ratio. In addition, in terms of liquidity risk management, the banks need to maintain a minimum ‘Liquidity Coverage Ratio’ (LCR) of 100 percent (since 2019), as well as a minimum ‘Net Stable Funding Ratio’ (NSRF) of 100 percent for each of local and foreign currencies. Furthermore, in order to verify the financial data of each bank, CBE has required the banks to conduct their internal capital adequacy assessment process (ICAAP) and prepare their financial statements in accordance with IFRS 9.

While ABE needs to be in compliance with the CBE’s prudential regulations, ABE, as an agriculture-specialized governmental bank, is highly expected to realize its mission; “ABE works on achieving added value to the national economy through deepening the financial inclusion in the society. It works on supporting and developing the agricultural sector by providing an integrated package of banking and agricultural services to meet the needs of its customers (farmers and citizens), and it also works on supporting and financing small and medium enterprises especially in the field of agricultural activity and its related activities.” (Source: website of ABE[4]). It is not an easy task for ABE to successively meet both of the expectations at the same time.

From the perspective of agricultural sector development in Egypt, the government/MALR currently implements the financial support schemes for the farmers. ABE, as the main player in the Egyptian agricultural loan market, currently provides farmers with the following policy-based loan program.

[4] https://abe.com.eg/vision-mission-and-mission/?lang=en

Table 3.10.1 Policy-based Loan Program for Farmers

1	Eligibility of beneficiary farmers	Egyptian farmers
2	Loan purpose	Equipment for modern irrigation (drip, sprinkler, solar system pump, etc.)
3	Maximum loan amount	EGP15,000 (/fed for drip irrigation), EGP20,000 (/fed for sprinkler)
4	Loan maturity	5 years
5	Grace period	6 months
6	Interest rate	5%
7	Collateral objective and requirement	No collateral (but CBE facilitates credit guarantees to ABE)
8	Requirement for credit guarantor(s)	n.a
9	Criteria for a sub-loan decision-making	n.a
10	Performance of the Loan Scheme (6 months since the launch of the program)	No. of disbursed loans (No.): 1,000 Disbursed loan amount (LE): n.a Repayment ratio of the loan (%): n.a

Source: Interview with ABE (July 2021)

3.10.4 Outline of Current Financial Schemes for Modern On-Farm Irrigation Development

1) Meska Repayment System

Meska Repayment System has worked well for enhancing farmer-level irrigation development in Egypt. In the process of improving farm-level irrigation, when a farmer wants to irrigate his/her farmland from target Meska, he/she initially makes a consensus with related farmers as well as MWRI. Secondly, the farmer organizes a water users' association (WUA). Thirdly, MWRI implements the design and construction of the improved Meska by the MWRI's budget. Those beneficiary farmers bear the construction costs. The shared costs for each beneficiary farmer are decided in accordance with the size of their farmland.

In terms of the repayment burden, when each farmer pays the land tax to the tax office each year (i.e., the tax office's regional office staff collects the land tax), he/she pays the redemption for Meska improvement. In other words, the farmer will reimburse the government for the cost of the Meska improvements over a 5-year period (for pumps) or a 20-year period (for canal facilities). Under this repayment system, farmers will not easily default on their land tax payments because they cannot purchase government-subsidized fertilizer without a land tax payment receipt, and severe collection of the Meska improvement reimbursement that is collected accordingly could reduce the risk of bad debts which is a concern under the loan scheme.

If the government agrees on applying the Meska repayment system to the modern on-farm development where farmers will purchase equipment (sprinkler and drip irrigation, etc.), the system could be the most desirable for the beneficiary farmers firstly because each farmer's repayment burden would be reduced dramatically (within 10 years, without interest rates). In order for the farmers to come together and receive pressurized water to operate sprinklers and drips from a single collective pump, it is essential that the farmers concerned with the pumps should come together and establish a WUA.

2) Financial Scheme Under the Corporation Between MWRI and NBE/ABE

Under an agreement between MWRI and the National Bank of Egypt (NEB) (June 2018), when a farmer wants to apply for loans for installing a modern irrigation system, firstly he requests for MWRI's acceptance on his plan details (area, irrigation source, facility, etc.). Secondly, MWRI makes an appraisal on his request based on the submitted plan details. Then, finally NBE takes its internal lending procedures based on the MWRI's acceptance on the irrigation plan. Regarding the loan conditions, the loan interest rate is 5 percent, and the loan maturity is 5 years under this agreement.

This scheme is a typical policy-based lending system where a bank entrusts its function of appraising farmer's irrigation plan to a government body (MWRI in this case). In that sense, any banks can implement it if they have a strong intention to corporate with MWRI for supporting end-user farmers as well as agricultural finance know-how. Yet, the concern is that the expected net interest margin (NIM; Net Interest Incomes / Interest Earning Assets) in this scheme will be much narrower than the bank's normal spread margin, depending on the bank's funding costs.[5] Thus, in its reality, NBE, a state-owned commercial bank, or ABE, the only agriculture-specialized policy bank is the only participating bank candidate for this type of financial scheme.

In that context, according to a field interview with MALR (October 2021), MALR, MWRI, MOF and ABE & NBE have agreed on a program for the introduction of modern on-farm irrigation facilities, and the program started on September 1, 2021. This is a four-year program that will introduce modern on-farm irrigation facilities to 3.7 million feddan (about 1.55 million ha), which could cover about 40% of Egypt's total agricultural land area of about 3.84 million ha (Source: Central Bureau of Statistics, 2017). However, the total budget required for the project is estimated at about EGP110-150 billion (about US$7.0-9.6 billion), and EGP60 million have just been earmarked from the government budget as of October 2021. The two financial institutions handling the loan program are NBE and ABE, and they offer preferential terms to the farmers, such as zero interest rate and 10-year loan repayment period.

3) Financial Support Scheme Agreed Among MWRI, MALR, NBE/ABE, and MOF

The following is a summary of the financial assistance to the farmers who are to introduce modern on-farm irrigation facilities agreed upon in the current arrangement by MALR, MWRI, MOF, and ABE and NBE:

- ✓ MALR and MWRI will be responsible for the technical design of the modern on-farm irrigation facilities, preparation of construction specifications and contracts, supervision of construction, and completion inspection of the facilities. For the introduction of the modern on-farm irrigation facilities, the farmer groups (WUAs) will prepare the documents specified by the banks (ABE and NBE), which will be submitted to the banks through MALR and MWRI, and the construction will be commenced after approval by the banks.
- ✓ As a pilot implementation, the introduction of modern on-farm irrigation facilities will begin in Qalyubia and Beni Suef Governorates. The target for each governorate is, in principle, all farmlands, with 158,000 feddan for the former and 275,000 feddan for the latter, or 2.8 billion EGP and 5.0 billion EGP, respectively, for a total budget of 7.8 billion EGP. The unit cost is estimated at 15,000-18,000 EGP per feddan, which seems extremely small.
- ✓ The terms of the ABE or NBE loan to the farmers or WUAs are interest-free, collateral-free, and require pay-back to the banks within 10 years following the completion of the facilities. Ministry of Finance (MOF) will pay ABE and NBE an interest equivalent of 3%.
- ✓ In the event of delinquent repayments from the farmers or WUAs that have received loans, as no collateral has been set aside, such farmers may be refused to access government-subsidized bread and chemical fertilizers.

Three types of implementation methods have been defined for the introduction of modern on-farm irrigation facilities. The three methods are: 1) MALR or MWRI implements the works related to the modern on-farm irrigation facilities on behalf of the farmers, which may include Meska improvement; 2) WUAs may install modern field irrigation facilities on their own, which can include Meska improvement; and 3) Loan financing for the installation of modern field irrigation facilities is provided to individual farmers.

In the case of 1) above, in which MALR or MWRI constructs the modern on-farm irrigation facilities on behalf of farmers, a loan agreement between the WUA and the bank (ABE or NBE) is still required, but MALR or MWRI is responsible for the design, specification, procurement of contractors and

[5] The market rate of deposits at banks (more than 6 months and less than or equal to one year) is 8.7 percent on average as of 27 October 2022, while the market interest rate of bank loans (less than or equal to one year) is 11.2 percent on average. (Source: CBE's Monthly Statistical Bulletin No.308, November 2022)

equipment suppliers, construction supervision, and completion inspection of the modern irrigation facilities. In the case of above method 2), farmers and WUAs themselves are responsible for the implementation of the modern on-farm irrigation with advice from MALR and MWRI.

The method described in 1) above is similar to the Meska method that has been used in the past, as MALR or MWRI procures contractors and constructs modern field irrigation facilities based on an agreement with the farmers/ farmer groups. In this method of above 1), farmers and WUAs are not required to provide collateral, but are still required to enter into a loan agreement with ABE or NBE, and the loan is paid back to the bank. Therefore, comparing to the Meska method, the process of dealing with the bank is additionally required.

3.10.5 Household Survey Results on Financing

According to the results of the household survey conducted by the JICA Survey Team, the proportion of farmers with bank loans is 16% of the total, of which 85% of farmers source their loans from ABE. The average loan amount per loan is 42,000 EGP, compared to 65,875 EGP in the Kased area, where high value-added products such as onions are produced, and 32,118 EGP in Abor Seer, showing regional variations. The average loan amount appears to be related to the size and profitability of farmland owned by farmers in each region, and naturally there are both large and small farmers in the same region, and disparities in financing conditions are recognized. The most common interest rate condition for loans was 5% (30% of all respondents; public loans via MWRI), with the rest in the range of interest rate between 12% and 30%.

Of the farmers with bank loans above-mentioned, 36% of them indicated that they have had delays in repaying their loans in the past, which raises concerns about farmers' ability to repay loans and their administrative skills. In this regard, it will depend on the ability of agriculture-focused banks to provide attentive support to their farmer customers in the formulation of realistic repayment plans and execution of repayments in the lending practices. Therefore, when cooperating with banks, it is essential to strengthen the banks' ability to provide such customer support. On the other hand, in terms of financing needs, the proportion of farmers who have not installed modern on-farm irrigation equipment such as irrigation drip and sprinklers is 36% and 96% respectively, with high costs being the main reason for not installing those irrigation systems.

CHAPTER 4 PROJECT PLANNING AND DESIGNING

This chapter undertakes the project plan formulation based on the examination results in the previous chapters. The plan consists of an agricultural development plan, irrigation improvement plan targeting 3 priority sub-regions, water management plan, introduction of modern on-farm irrigation, procurement of maintenance machines, water users' association establishment, etc. In addition, possible drainage change for the lakes, Qarun and Rayan Lakes, in Fayoum Governorate with the introduction of modern on-farm irrigation is examined.

4.1 Direction of Project Planning and Establishment of a Basis for Planning

4.1.1 Direction of Project Planning and Possible Project Components

Based on the results of the surveys mentioned in Chapter 3, Table 4.1.1 shows the framework of the project plan, including alternatives. Alternative 1 focuses on MWRI-managed irrigation facilities, while Alternative 3 focuses on the effective use of irrigation water at the on-farm level based on the introduction of modern on-farm irrigation facilities. Alternative 2 is an option that balances both MWRI-governed irrigation facilities and the introduction of modern on-farm irrigation facilities.

Among the components envisioned, it is anticipated that moderate rehabilitation of facilities will be included on the principal and main canals. Rehabilitation or renewal of hydraulic facilities with many operational obstructions identified on the same canals, and restoration of the cross-sections that impede water flow, are likely to be considered. Since the principal and main canals are operated under continuous flow, maintenance such as dredging is possible, but concrete lining and other works are very difficult because of the need for water diversion. On the other hand, branch canals are operated under intermittent flow, so civil engineering works including concrete lining are relatively easy.

For effective use of irrigation water and water saving in the fields, the introduction of modern on-farm irrigation facilities such as sprinklers and drips is recommended. Usually, the water saving effect by the modern on-farm irrigation facilities is higher than the water saving effect through improvements from the principal canals to main canals and then to branch canals, etc.

However, without improved irrigation facilities and better water management through those principal canals, main canals and branch canals, there will be an imbalance in water allocation upstream and downstream of the canals, resulting in significant water shortages especially in the downstream areas. As a result, it becomes difficult to increase agricultural production at the downstream areas.

Therefore, the project plan formulation will proceed on the basis of Alternative 2, which combines the improvement and renewal of irrigation facilities in the MWRI jurisdictional areas and the introduction of modern on-farm irrigation facilities.

Table 4.1.1 Direction of Project Planning (Alternative 2 adopted)

Alternative	Contents	Expected Components
Alternative-1 Equitable water distribution up to the terminal fields	The canal will be rehabilitated to achieve an average conveyance efficiency of 85%. Meska improvements and modern irrigation will not be included. A maximum irrigation efficiency of 55% could be expected.	**[Civil]** Principal canals: Rehabilitation of not-fully functional waterway and dangerous sections of the canals. Main canals: Rehabilitation of not-fully functional waterway and dangerous sections of the canals, repair of intake and diversion facilities, and leakage countermeasures and partial concrete lining. Branch canals: Rehabilitation of not-fully functional waterway, repair of intake and diversion facilities, and leakage countermeasures and partial concrete lining. **[Machinery/equipment]** Renewal and procurement of maintenance machineries, renewal and procurement of workshop equipment.
Alternative-1A Equitable water distribution to the	This alternative plan will be based on the Alternative-1 and will consider efficient use of	**[Civil]** Principal canals: Rehabilitation of not-fully functional waterway and dangerous sections of the canals.

Alternative	Contents	Expected Components
terminal fields. Also, improvement of water use efficiency in the field.	water in the fields. The plan will include rehabilitation to achieve an average canal conveyance efficiency of 85%, with a target improvement level of at least 60% of the total irrigation efficiency.	Main canals: Rehabilitation of not-fully functional waterway and dangerous sections of the canals, repair of intake and diversion facilities, and leakage countermeasures and partial concrete lining. Branch canals: Rehabilitation of not-fully functional waterway, repair of intake and diversion facilities, and leakage countermeasures and partial concrete lining. On-farm: Partial Meska improvement and installation of sprinkler or drip irrigation facilities **[Machinery/equipment]** Renewal and procurement of maintenance machineries, renewal and procurement of workshop equipment.
Alternative-2 Equitable water distribution to the end fields and improvement of water use efficiency within fields	The alternative plan will rehabilitate the canals to achieve an average conveyance efficiency of 80%, with a target improvement level of about 60-65% of the total irrigation efficiency for the canals and also the on-farm irrigation.	**[Civil]** Principal canals: Rehabilitation of not-fully functional waterway and dangerous sections of the canals. Main canals: Rehabilitation of not-fully functional waterway and dangerous sections of the canals, repair of intake and diversion facilities, and leakage countermeasures and partial concrete lining. Branch canals: Rehabilitation of not-fully functional waterway, repair of intake and diversion facilities, and leakage countermeasures and partial concrete lining. On-farm: Meska improvement and installation of sprinkler or drip irrigation facilities **[Machinery/equipment]** Renewal and procurement of maintenance machineries, renewal and procurement of workshop equipment.
Alternative-3 Improved on-farm water use efficiency	Meska improvement and modern on-farm irrigation will be applied in the terminal fields. Irrigation efficiency is expected to be about 55%.	**[Civil]** On-farm: Partial Meska improvement and installation of sprinkler or drip irrigation facilities. **[Machinery/equipment]** Renewal and procurement of maintenance machineries, renewal and procurement of workshop equipment.
Alternative-3A Improved water use efficiency within the field, and equitable distribution of water to the end fields (not whole area).	The plan will be based on Alternative-3, and include securing of the canal's water passage cross section. The plan will be carried out at an improved level with about 55-60% of the total irrigation efficiency.	**[Civil]** Main canals: Rehabilitation of not-fully functional waterway and dangerous sections of the canals. Branch canals: Rehabilitation of not-fully functional waterway and dangerous sections of the canals. On-farm: Partial Meska improvement and installation of sprinkler or drip irrigation facilities. [Machinery/equipment] Renewal and procurement of maintenance machineries, renewal and procurement of workshop equipment.

Source: JICA Survey Team

Table 4.1.2 shows the envisioned project components. Based on the Alternative-2 plan described above, the components have been identified through results of the field survey described in Chapter 3. Components 1-6 shown in the table are new construction, renewal, and rehabilitation related to irrigation canals and irrigation facilities under the jurisdiction of MWRI, as well as concrete lining and other works related to branch canals.

Components 1-6 above are primarily a series of civil works, but are planned under different components due to the different scales and nature of the works. Component 6 is the water management, which involves the procurement and installation of equipment, and with improved irrigation facilities, the component will ensure proper water distribution. Component 7 is the procurement of machinery and equipment for maintenance works, and the last component 8 is the introduction of modern on-farm irrigation facilities.

Table 4.1.2 Components Proposed Under the Project Plan

No.	Component	Contents
1	Large Hydraulic Structure Construction (LHSC)	Construction of; 1) Kased Intake, 2) Mahlet Menouf Regulator, and 3) Sorad Regulator.
2	Small Hydraulic Structure Construction (SHSC)	Construction of; 1) Beni Hedear Weir of Ibrahimia, 2) intakes of, e.g., Abo Seer, Omar Bek, Bahr El Kasheir, etc., 3) tail escapes, 4) culvert and aqueduct, etc.

No.	Component	Contents
3	Hydraulic Structure Rehabilitation (HSR)	Rehabilitation of Hydraulic Structures assessed as S2 including replacement of gates, gate appurtenant.
4	Large Canal Rehabilitation (LCR)	Rehabilitation including canal sectioning and slope protection, and/or partial lining for large canals, e.g., Bahr Yusef and Ibrahimia Principal Canals and Kased Main Canal.
5	Branch Canal Rehabilitation and Lining (SCRL)	Rehabilitation including canal sectioning and concrete lining for the canals other than above, e.g., branch canals, small main canals. Note that concrete lining work is on-going covering around 20,000 km nationwide, so this component will be managed with the state budget.
6	Water Management Improvement (WMI)	Procurement and installation of water management equipment, and development of visual on-time monitoring system. Note that the system concerning Bahr Yusef and Ibrahimia Command Areas are included in the Project for Construction of the New Dirout Group of Regulators, and therefore, the system here to be introduced in Kased Command Area.
7	Procurement of Maintenance Machineries (PMM)	Procurement of maintenance machinery specifically for the purpose of concrete lined canals, and also machinery required for urgent repairment. Note that periodic and ordinally maintenance works are out-soured to private companies.
8	Modern On-farm Irrigation (MOI)	Installment of modern on-farm irrigation system composed of sprinkler and drip facilities, including one-lifting pump stations and pipelines, improvement of Meska by means of lining or installation of pipes, and on-farm irrigation training to the farmers.

Source: JICA Survey Team

4.1.2 Decision of Net Irrigation Area for the Project Target Area

One of the issues raised by JICA Survey Team and the concerned MWRI officers beforehand the planning is the net beneficial area, or irrigated area. As there are different numbers in terms of irrigation area and also MWRI officers do not respond when the irrigation areas were first decided and when and how updated, the JICA Survey Team employed Sentinel-2 satellite image analysis in order to explore the real irrigated area, or net irrigation area, as the first step of the planning.

1) Satellite Image Analysis for the Estimation of Actual Irrigation Area

The methodology to calculate the planted area is principally same as explained in Chapter 3.3, which purpose is to know the approximate irrigation area in a long time series. In this study, examination irrigation area is calculated with higher accuracy with more frequent and higher resolution images. Furthermore, Ground Truth (GT) survey was conducted to verify the result of analysis from the technical point of view. The main differences of the analysis in Chapter 3.3 are summarized in Table 4.1.3:

Table 4.1.3 Comparison of 2 Cases of Satellite Image Analysis

Item		Analysis in Chapter 3.7	This Analysis
Analysis Conditions	Satellite	LANDSAT5, 7 and 8	Sentinel-2
	Resolution	30m x 30m	10m x 10m
	Revisit Frequency	18 days	5 days
	Availability	1984 ~ Present	2015 ~ Present
Analysis Period		21 Seasons (2000 – 2020)	3 Seasons (2017-2019)
Validation		Statistics (Governorate-wise)	GT Survey & Analysis Result of Planning Sector

Source: JICA Survey Team

The validation by the GT survey for the winter, summer, and permanent crops from October 2021 to September 2022. A total of 100 farmlands have been collated between on-site confirmation and satellite images, and all the major crops are properly evaluated as plant area as shown in Table 4.1.4 below:

Table 4.1.4 Summary of GT Survey Result (NDVI peak value) by Crop and Sub-Region

Crops		Abo Shosha			Aros & Abo Seer			Kased		
		Th	Max NDVI	Verdict	Th	Max NDVI	Verdict	Th	Max NDVI	Verdict
Winter	Wheat	0.40	0.68 - 0.80	OK	0.40	0.68 - 0.81	OK	0.36 ～ 0.42	0.68 - 0.82	OK
	Clover		0.66 - 0.78	OK		0.76 - 0.81	OK		0.54 - 0.82	OK
	Garlic		0.73 - 0.73	OK					0.45 - 0.45	OK
	Potato		0.73 - 0.81	OK					0.79 - 0.79	OK
	Sugar Beet		0.64 - 0.70	OK		0.78 - 0.81	OK		0.79 - 0.81	OK
	Onion					0.79 - 0.79	OK		0.48 - 0.83	OK
Summer	Maize	0.35	0.47 - 0.47	OK	0.35	0.48 - 0.50	OK	0.33 ～ 0.37	0.49 - 0.51	OK
	Corn		0.39 - 0.50	OK					0.42 - 0.42	OK
	Sorghum					0.52 - 0.52	OK			
	Rice								0.38 - 0.51	OK
	Corn								0.42 - 0.42	OK
	Watermelon								0.39 - 0.39	OK
	Cotton		0.50 - 0.53	OK		0.53 - 0.55	OK		0.45 - 0.53	OK
Permanent	Grapes	0.40	0.51 - 0.75	OK	0.40			0.36 ～ 0.42		
	Mango					0.60 - 0.68	OK			
	Olive					0.61 - 0.72	OK			
	Palm		0.51 - 0.80	OK					0.37 - 0.44	OK
	Laring								0.59 - 0.79	OK

Source: JICA Survey Team

2) Comparison of the MWRI Area and Satellite Image Analyzed Area

Table 4.1.5 shows the irrigation area given by MWRI in comparison with those obtained by satellite image analysis. At glance obviously is the bigger areas of MWRI as compared to those by satellite image analysis. For example, irrigation area within Minya is 650,000 feddan by MWRI while the satellite detected only 472,395 feddan and 488,232 feddan for summer crop and winter crop respectively (see Nr.1). Likewise, the irrigation area in Beni Suef is 349,823 feddan as compared to 285,779 and 290,020 feddan by satellite image analysis (see Nr.2), and the area in Fayoum is 490,000 feddan by MWRI while they are 354,965 feddan and 376,904 feddan for summer and winter detected by satellite (see Nr.3).

The Bahr Yusef Command Area within the 3 governorates of Minya, Beni Suef and Fayoum arrives at 778,102 feddan by MWRI while the satellite image analysis gave 547,013 feddan and 582,298 feddan for summer and winter crops. It means the satellite image analyzed area is much smaller than MWRI's area to be 70 - 75% (see No.4). Likewise, the Ibrahimia Command Area within the 3 governorates is 669,072 feddan while the satellite image analysis detected 476,439 feddan and 479,828 feddan for summer and winter crops respectively, approximately only 71 - 72% for the satellite image analyzed area.

Looking into the area for the 3 priority sub-regions such as Abo Shosha, Aros & Abo Seer and Kased, though the difference between MWRI area and the satellite image analyzed area is now small, still the former areas are bigger except for winter crop area of Kased (see Nr.6, 7, 8). The Abo Shosha Irrigation Area by satellite image analysis is about 90% of that of MWRI, and Aros & Abo Seer is about 95 - 98% of that of MWRI.

Why there is so a big difference between the MWRI's irrigation area and the satellite detected area may be that MWRI has not updated the irrigation area over long years, and/other gross area may have been taken as the irrigation service area. Gross area includes dwelling areas, roads, and other utility facility areas, which in general is bigger by 10-20 % than the net irrigation area in most cases. As aforementioned in '3.3 Trend of Cropped Area by Satellite Image Analysis', cropped area especially under Ibrahimia Command Area has been diminishing due probably to the effect of urbanization with population increase.

There is a bit of difference between the cropped area of summer season and winter season. The latter area is usually bigger than that of summer season by around 4 % for the total area of Bahr Yusef and Ibrahimia Command Area. This is understandable because there is very little water shortage during winter season, so the potential farmland area could be irrigated and planted with crops during the winter season. Therefore, the designed irrigation area or irrigable area should be the one for winter cropped area detected by satellite image analysis.

Table 4.1.5 Net Irrigation Area Based on Satellite Image Analysis, Compared with MWRI Numbers

Nr	Particulars	Hydraulic Boundary					
		Service Area (MWRI), feddan	S.Net Cropped Area (Satellite) feddan	W.Net Cropped Area (Satellite) feddan	Ratio, Summer (Net/MWRI, %)	Ratio, Winter (Net/MWRI, %)	Ratio (W.Net/S.Net, %)
1	Minya (incl. Nile)	650,000	472,395	488,232	73%	75%	103%
	by Nile	33,199					
	by Bahr Yusef	216,050					
	by Ibrahimia	400,751					
2	Beni Suef (incl. Nile)	349,823	285,779	290,020	82%	83%	101%
	by Nile	9,450					
	by Bahr Yusef	72,052					
	by Ibrahimia	268,321					
3	Fayoum (Bahr Yusef)	490,000	354,965	376,904	72%	77%	106%
	for Old Lands	420,000	324,968	342,838	77%	82%	105%
	for New Lands	70,000	29,997	34,066	43%	49%	114%
4	Bahr Yusef (3 Governorates)	778,102	546,013	582,298	70%	75%	107%
5	Ibrahimia (3 Governorates)	669,072	476,439	479,828	71%	72%	101%
6	Bahr Yusef + Ibrahimia (3 Gov.)	1,447,174	1,022,452	1,062,126	71%	73%	104%
7	Abo Shosha	19,870	17,693	17,881	89%	90%	101%
8	Aros & Abo Seer (10,974f & 2,591f)	13,565	12,900	13,330	95%	98%	103%
9	Kased	95,461	93,412	95,976	98%	101%	103%
11	Sec.1 (Dirout - Sakoula)	156,505	121,698	133,050	78%	85%	109%
	Sec.1' (Dirout - Sakoula: Old Lands)		87,166	91,753			105%
	Sec.1' (Dirout - Sakoula: New Lands_Kmadir)		12,466	14,541			117%
	Sec.1' (Dirout - Sakoula: New Lands_Turfa)		22,066	26,756			121%
12	Sec.2 (Sakoula - Lahoun)	149,594	73,839	78,244	49%	52%	106%
	Sec.2' (Sakoula - Lahoun, Old Lands)		32,284	33,052			102%
	Sec.2' (Sakoula - Lahoun, New Lands)		41,555	45,192			109%
13	Sec.3 (Hassan Wasef - End)	141,640	130,488	138,594	92%	98%	106%
	Sec.3' (Hassan Wasef - End, Old Lands)		110,778	117,314			106%
	Sec.3' (Hassan Wasef - End, New Lands)		19,710	21,280			108%
14	Sec.4 (Lahoun - End)	232,419	219,988	232,410	95%	100%	106%
	Sec.4' (Lahoun - End, Old Lands)		212,992	224,315			105%
	Sec.4' (Lahoun - End, New Lands)		6,996	8,095			116%
15	Sec.5 (Dirout - Maghagha)	299,711	257,370	258,852	86%	86%	101%
16	Sec.6 (Maghagha - El Wasta)	291,989	219,069	220,976	75%	76%	101%
17	Sec.7.1 (Giza Right-End, incl. Sec.7.1')	139,627	87,232	88,099	62%	63%	101%
	Sec.7.1' (Giza Intake-El Ayat PS)	NA	10,131	10,203			101%
18	Sec.7.2 (El Wasta-El Ayat PS)	19,731	11,762	11,814	60%	60%	100%
19	Sum of Sec.1-4 (Bahr Yusef)	680,158	546,013	582,298	80%	86%	107%
20	Sum of Sec.5-6 (Ibrahimia)	591,700	476,439	479,828	81%	81%	101%
21	Sum of Sec.1-6 (BY+Ib in 3 Gov.)	1,271,858	1,022,452	1,062,126	80%	84%	104%
	Sum of Sec.1-4 + Sec.7.1	819,785	633,245	670,397	77%	82%	106%
	Sum of Sec.5-6 + Sec.7.2	611,431	488,201	491,642	80%	80%	101%

Note 1: S.Net means Summer Net (cropped area), W.Net stands for Winter Net (cropped area).
Note 2: Section is defined as an area demarcated by regulator where discharge data are available.
Note 3: Even within MWRI, there are discrepancies in the number of areas, e.g., irrigation area by governorate was given as 778,102 feddan and 669,072 feddan for Bahr Yusef and Ibrahimia (see Nr.4 and 5 under Service Area (MWRI) but the area by hydraulic boundary gave 680,158 feddan and 591,700 feddan (see Nr.19 and 20).
Source: Water Distribution Sector of MWRI, JICA Survey Team based on Sentinel 2 satellite image analysis

3) Comparison with MWRI Planning Sector's Satellite Image Analysis Result

As the irrigation area is one of the most essential data in planning, Planning Sector under MWRI undertook almost same satellite image analysis covering 3 governorates of Minya, Beni Suef and Fayoum. The difference in the analysis between the JICA Survey Team and the Planning Sector is the image quantity used in the analysis. JICA Survey Team examined approximately 1,000 images for 3 seasons (2,000 images for 3 years) calculated pixel by pixel with Google Earth Engine while the Planning sector took one timing images in a year calculated scene by scene.

Table 4.1.6 shows comparatively the irrigation service areas by MWRI, cropped areas by Planning Sector and the areas by JICA Survey Team. It is found that the irrigation service area by MWRI is much bigger than the areas estimated by Planning Sector and also by JICA Survey Team, except for Kased Command Area. The Planning Sector analyzed area is only 76.3% of that of MWRI for the total of 3 governorates of Minya, Beni Suef and Fayoum, and it is only 77.5% for JICA Survey Team. Thus, there is almost no difference in between the Planning Sector's area and the JICA Survey Team's area. It is therefore the MWRI should update their official irrigation service area at an earliest date.

Table 4.1.6 Comparative Areas by MWRI, Planning Sector and JICA Survey Team

Governorate	MWRI (feddan), (a)	Planning Sec. (fed), (b)	JICA Survey Team (fed), (c)	Ratio, a/b	Ratio, a/c	Ratio, b/c
Minya	650,000	489,620	488,232	75.3%	75.1%	100%
Beni Suef	349,823	300,790	290,020	86.0%	82.9%	104%
Fayoum	490,000	346,640	376,904	70.7%	76.9%	92%
Total of above	1,489,823	1,137,050	1,155,156	76.3%	77.5%	98%
Kased	95,461	94,200	95,976	101.3%	99.4%	98%

Source: Water Distribution Sector of MWRI, Planning Sector of MWRI, and JICA Survey Team

One thing noticed is that such a bigger irrigation area would mislead MWRI to estimate very high irrigation efficiency. Irrigation efficiency is estimated as a ratio between the water actually provided/discharged and water actually consumed by crops. The latter, the water actually consumed by crops, is usually estimated by the crop's unit water consumption multiplied by area planted. If the planted area is overestimated, the actually consumed water by crop is automatically overestimated, thus leading MWRI to overestimated high irrigation efficiency.

4) Summary of the Target Area

Table 4.1.7 summarizes the characteristics of the Bahr Yusef and Ibrahimia Principal Canals, which are both huge canals with 313 km length for Bahr Yusef and 256 km for Ibrahimia. The beneficial areas are about 582,000 feddans (245,000 ha) for Bahr Yusef and 480,000 feddans (202,000 ha) for Ibrahimia, totaling 1.06 million feddans (446,000 ha) within the 3 governorates of Minya, Bene Suef and Fayoum. The annual allocated water amount is 5 billion CUM in the Bahr Yusef beneficial area and 3.6 billion CUM in the Ibrahimia Beneficial Area, thereby totaling to 8.6 billion CUM for both canals, and more than 90% is consumed for irrigation purpose.

The amount of water consumption per annum calculated by water depth is 188 cm in the Bahr Yusef Beneficial Area and 164 cm in the Ibrahimia Beneficial Area. Cropping patterns are similar in both areas, hence, there are feeding stations from Bahr Yusef Command Area to Ibrahimia Command Area. In another point of view, for Bahr Yusef, 500 million CUM should be discharged annually into the Qarun Lake and Wadi El Rayan Lake to keep water level constant since these lakes are located at the end of the Bahr Yusef in Fayoum.

Table 4.1.8 summarizes the overview of the three priority sub-regions, namely Abo Shosha (Beni Suef), Aros & Abo Seer (Fayoum), and Kased (Central Delta). Those net irrigated areas are about 18 thousand feddan (7,500 ha), 13 thousand feddan (5,600 ha), and 96 thousand feddans (40,000 ha), respectively. Kased is the largest irrigation sub-region among them, which extends in Gharbia and Kafr El Sheik Governorates. Total lengths of main canals are about 34 km for Abo Shosha, 14 km for Aros & Abo Sheer (Aros: 10km and Abo Sheer: 4 km) and about 42 km for Kased Main Canal. Beneficial farmer households are about 17 thousand HHs, 10 thousand HHs and 117 thousand HHs, respectively. Crop area per farmer household in Kased is small, e.g., only around 0.82 feddan/HH.

Table 4.1.7 Summary of the Project Target Area (Bahr Yusef and Ibrahimia Principal Canals)

General	Bahr Yusef	Ibrahimia	Remarks
Service Area (by MWRI) *	778,102 feddan (326,803 ha)	669,072 feddan (281,010 ha)	Only Minya, Beni Suef, and Fayoum, excluding Giza
	1,447,174 feddan (607,813 ha)		
Service Area (Net, by satellite)	582,298 feddan (244,565 ha)	479,828 feddan (201,528 ha)	
	1,062,126 feddan (446,093 ha)		
Design Discharge	227 m^3/s	186 m^3/s	Provided by MWRI
Unit Design Discharge	0.3898 l/s/F (0.928 /ha)	0.3876 l/s/F (0.923 /ha)	
Water Allocated (Annual Total)	5,000 MCM	3,600 MCM	From NWRP2017
Water Allocated (Annual, Irrigation)	approx. 4,600MCM	approx. 3,312 MCM	92%** of total assumed
Water Allocated (cm for Irrigation)	188 cm/ annual	164 cm/annual	Divided by Net SA
Drainage W. for Qarun & Rayan	500 MCM	—	Per annum
Facilities			
Total Length of the Canal	313 km	256 km ***	
Nos of Regulators on the Canal	4	8	
Nos of Feeding Pump Stations	14	None	
Farmers			
Nos of Beneficiary Farmer Households	892,543		Divided by A. farmland
Nos of Beneficiary Population	5,265,750		HH members: 5.9****
Estimated Average Farmland****	1.19 feddan (0.50 ha)		Ave of B. Suef&Fayoum

Source: MWRI, General Directorates of Beni Suef, Fayum, Gharbia and satellite image analysis data

Note: * the area provided by MWRI is very big from the area detected by satellite image analysis, so the MWRI Service Area is not taken for the planning purpose.

** Domestic and industrial water are provided by Bahr Yusef and Ibrahimia Principal Canals for the 3 governorates of Minya, Beni Suef and Fayoum, and the ratio is reported at around 8% by relevant irrigation directorate office.

*** Ibrahimia Principal Canal extends upstream of the Dirout Regulator, while this table shows only the part of canal after Dirout Regulator.

**** Average number of members per household for Abo Shosha and Aros & Abo Seer obtained from Farm Economic Survey results (see Table 3.9.3).

***** Average farmland area provided from Agriculture Directorate (Cooperative) (see Table 3.1.1).

Table 4.1.8 Summary of the Project Target Area (3 Priority Sub-regions)

Abo Shosa, Beni Suef Governorate	Indicators		Remarks
Service Area (by MWRI) *	19,870 feddan (8,345 ha)		
Service Area (Net, by satellite)	17,881 feddan (7,510 ha)		
Total Length of Main Canal (Nos)	34.4 km (1)		
Total Length & Nos of Branch Canals (Nos)	53.27 km (20)		Excl. Sub-branches
Nos of Farmer Households	16,600		Divided by A. farmland
Nos of Population	101,260		HH members: 6.1**
Estimated Average Farmland	1.08 feddan		Cooperative data
Aros & Abo Seer, Faiyum Governorate	Aros	Abo Sheer	Remarks
Service Area (by MWRI)	13,565 feddan (5,697 ha)		
Service Area (Net, by satellite)	13,330 feddan (5,599 ha)		
Total Length of Main Canal (Nos)	9.8 km (1)	3.5 km (1)	
Total Length of Branches (Nos)	40.4 km (4)	6.4 km (3)	Incl. sub-branches
Nos of Beneficiary Farmer Households	10,300		Divided by A. farmland
Nos of Beneficiary Population	58,710		HH members: 5.7**
Estimated Average Farmland	1.3 feddan		Cooperative data
Kased, Gharbia & Kafr El Sheik Governorates	Indicators		Remarks
Service Area (by MWRI)	95,461 feddan (40,094 ha)		
Service Area (Net, by satellite)	95,976 feddan (40,310 ha)		
Total Length of Main Canal (Nos)	42.2 km (1)		
Total Length of Branch Canals (Nos)	262.9 km (46)		Excl. Sub-branches
Nos of Beneficiary Farmer Households	117,000		Divided by A. farmland
Nos of Beneficiary Population	538,200		HH members: 4.6**
Estimated Average Farmland	0.82 feddan (based on Koror data)		Cooperative data
Total of 3 Priority Sub-regions			
Service Area (by MWRI) *	128,896 feddan (54,136 ha)		
Service Area (Net, by satellite)	127,187 feddan (53,419 ha)		
Total Length of Main Canal (Nos)	89.9 km		
Total Length of Branch Canals (Nos)	362.97 km		Excl. Sub-branches

Nos of Beneficiary Farmer Households	143,900	Divided by A. farmland
Nos of Beneficiary Population	698,170	HH members: 4.9**
Estimated Average Farmland***	0.88 feddan	Cooperative data

Source: MWRI, General Directorates of Beni Suef, Fayum, Gharbia and satellite image analysis data
Note: * the area provided by MWRI is mostly big from the area detected by satellite image analysis, so the MWRI Service Area is not taken for the planning purpose. ** household members came from Farm Household Survey conducted by JICA Survey Team (see Table 3.9.3). *** Average farmland area provided from Agriculture Directorate (Cooperative) (see Table 3.1.1).

4.1.3 Target Irrigation Efficiencies

1) Setting of the Current Irrigation Efficiencies

In general, irrigation efficiency is determined considering three aspects, 1) conveyance efficiency, 2) distribution efficiency, and then 3) field application efficiency as summarized in the following table. Thus, the overall irrigation efficiency is calculated by multiplying those three efficiencies.

Table 4.1.9 Type of Efficiencies for Calculating the Irrigation Efficiency

Type of Efficiency	Applicable Irrigation Facilities
Conveyance Efficiency	Principal Canal and Main Canal (continuous flow)
Distribution Efficiency	Branch Canal and Meska (rotational irrigation in most cases)
Field Application efficiency	Field Irrigation Facilities including Marwa

Source: e.g., FAO Guideline (No.24), ILRI NO.19 On Irrigation Efficiencies

Conveyance efficiency is usually affected by the length of the canal, the size of the irrigation area, and the water management technics, while the distribution efficiency is usually affected by the length of canals, rotational or continuous water allocation, scale of seepage loss from the canals and water management of the canals[1]. Field application efficiency depends on the on-farm irrigation method, which efficiency varies greatly among surface irrigation, sprinkler irrigation and drip irrigation.

The existing irrigation system in Egypt has already been systematically developed as “a series of irrigation systems” consisting of the Principal canals – Main canals – Branch Canals – Meska – Marwa (and to farmlands). In addition, drainage water reuse for irrigation purpose is being practiced especially at the downstream areas.

Thus, it is assumed that the current irrigation efficiency must be already high. In fact, current irrigation efficiency of Bahr Yusef and Ibrahimia Irrigated Areas is around 0.51 – 0.60 with drainage reuse and 0.65 – 0.78 without drainage reuse in June - August, which is the most critical period for securing irrigation water (see sub-chapter 3.9). According to FAO standards, common irrigation efficiency of earth canal is around 0.5, hence, the irrigation efficiency of 0.51 - 0.60 or 0.65 – 0.78 can be said already high.

Three kinds of efficiencies, which are the conveyance efficiency, distribution efficiency and the field application efficiency, are at first referred to the ones mentioned in FAO standards and ILRI for the base value of the examination. As shown in Table 4.1.10, the irrigation efficiency applying said conditions is calculated as 0.55, which is very similar to the current irrigation efficiency from June to August discussed in Chapter 3.8. Thus, the current irrigation efficiency in the Project area can be rationally set at 0.55 and related three kinds of efficiencies can also be set as shown in Table 4.1.10.

Table 4.1.10 Current Efficiencies and Irrigation Efficiency

Type of Efficiency	Target Irrigation Facilities	Current Efficiency	Remarks
Conveyance Efficiency	Principal Canal and Main Canal	0.90	FAO Paper No. 24 (Applying the maximum efficiency of 0.90 for 24-hour water flow and stable flow rate)
Distribution Efficiency	Branch Canal and Meska	0.88	Applying the maximum efficiency of 0.88 under rotational irrigation covering 4,000 - 6,000 ha defined by ILRI

[1] Doorenbos, J. and Pruitt, W. O., 1977. Crop water requirements. Irrigation and Drainage Paper No. 24,(rev.) FAO, 80 p.

Type of Efficiency	Target Irrigation Facilities	Current Efficiency	Remarks
Field Application Efficiency	Field Irrigation Facilities including Marwa	0.70	Applying the maximum efficiency of 0.70 referred to in FAO Paper No. 24, US Dept. of Agriculture (USDA) Soil Conservation Service (SCS)
Irrigation Efficiency		0.55	Current irrigation efficiency during peak period of June to August is 0.55 considering drainage re-use, equivalent to the left.

Source: FAO Irrigation and Drainage Paper No. 24, ILRI Publication 19 On Irrigation Efficiencies

2) Setting of the Target Irrigation Efficiency

As mentioned in Chapter 2.1.3 “Future Water Uses, and Implications to Improving Irrigation Efficiency”, target increase of irrigation efficiency shall be set at 14 % at minimum. To achieve such target increase, improving only by canal and structure rehabilitation would not be enough, but it should be essential to change the on-farm irrigation system, i.e., from the current surface irrigation to sprinkler irrigation and/or the drip irrigation. In addition, conversion of crops with the introduction of sprinkler/ drip system should also be considered.

2.1) Setting of the Target Conveyance Efficiency and Distribution Efficiency

Concrete lining work of the branch canals with bed width of not more than 6.0 meters has been ongoing in many areas since August 2020 (as of September 2021, lining work of branch canals in Kased Command Area was also started). Total of 20,000 km of branch canals are planned to be concrete-lined nationwide. Concrete lining works for principal canals and main canals, which are large-scale and operated under continuous flow, are not carried out according to a government decision.

A remarkable improvement of conveyance and distribution efficiency can be expected by converting the current earth canals to the concrete lining canals. Table 4.1.11 shows an example of conveyance efficiency given by FAO. It is said that the original 70 - 90% conveyance efficiency will be increased to 95% with the lining for clay soils. However, the current conveyance efficiency is estimated already high as much as 90% (see previous Table 4.1.10). In this case, improved efficiency with lining could be assumed at 95% at maximum, with the increasing ratio of about 5%.

Table 4.1.11 An Example of Improving Conveyance Efficiency by Concrete Lining (FAO)

Canal Length	Sand, %	Loam, %	Clay, %	Lined Canal	Increment ag/C Clay
> 2,000 m	60	70	**70**	**95**	1.357 (36%)
200 – 2,000 m	70	75	**85**	**95**	1.117 (12%)
< 200 m	80	85	**90**	**95**	1.056 (5.6%)

Source: FAO Technical Manual No.4, Annex I: Irrigation Efficiencies

In case of embankment canals which may generate more seepage or canals with lower conveyance efficiencies, more than 10% increase may be expected as shown in Table 4.1.11 above. However, most of the canals in Egypt are constructed at a lower level than the farm level. In this situation, leakage from the canals into the surrounding area could be assumed not so high.

In addition, under the situation of both high current conveyance and distribution efficiencies, increase ratio of the conveyance and distribution efficiencies by the concrete lining will be limited as compared to other countries’ common examples. In this reason, the maximum increase ratio in conveyance and distribution efficiency with the concrete lining should be determined at 5%, or the maximum conveyance efficiency and distribution efficiency after the concrete lining be limited to 95%.

2.2) Setting of the Target Field Application Efficiency

Table 4.1.12 shows the planned field application efficiencies before and after the implementation of the Irrigation Improvement Project (IIP) in Egypt. Improvement of the field application efficiency is expected through the lining of Meska, leveling of farmlands and improvement of water management as the result of implementing IIP.

Likewise, based on the existing related studies conducted in Egypt in the past, the target field application efficiency after the implementation of IIP is designed to be 0.67 - 0.95, compared to the current range of 0.53 - 0.70. Therefore, further improvement of field application efficiency can be expected by introducing modern on-farm irrigation systems in addition to the improvement of Meska.

Table 4.1.12 Field Application Efficiency in Related Studies in the Past

Name of Study	Before Implementation of IIP	After Implementation of IIP
World Bank (1994)	0.70	0.75
MWRI (1994)	0.61	0.74
Sogreah (2005)	0.70	-
Mossison and Louis (1990)	0.53	0.95
Ibrahim (2006)	0.60	-
Abou Kheira (2009)	0.65	0.75
ENGELS (2006)	0.60	0.67

Source: Francois Molle et.al.; An exploratory survey of water management in the Meet Yazid Canal Command Area of the Nile Delta, International Water Management Institute (IWMI), Final Report, January 2013

Table 4.1.13 shows the target field application efficiencies in other countries and by FAO standards. The target efficiency ranges from 0.60 to 0.85 for sprinkler irrigation and 0.70 to 0.95 for drip irrigation, which are much higher than 0.40 to 0.70 for surface irrigation. The FAO standard, which was originally referred to the Egyptian design, shows similar trends to the case studies of other countries. Therefore, the target of the field application efficiency in this Survey is determined at 0.7 for conventional surface irrigation, 0.8 for sprinkler irrigation, and 0.9 for drip irrigation.

Table 4.1.13 Field Application Efficiency

Irrigation method	U.S.A 1)	New Zealand 2)	Spain 3)	Israel 4)	FAO		ILRI 7)	Planned Value for Preparatory Survey
					Training Manual No.4 5)	Crop Water Requirement No.24 6)		
Surface Irrigation	0.5-0.7	-	0.4-0.6	0.4	0.6	0.55-0.7	0.53	**0.7**
Sprinkler Irrigation	0.6-0.85	0.8-0.9 (Avg.0.85)	0.8	-	0.75	0.6-0.8	0.67	**0.8**
Drip Irrigation	0.8-0.95	0.75-0.95 (Avg.0.9)	-	0.7-0.8	0.90	-	-	**0.9**

1) Bjorneberg D. L.; USDA Agricultural Research Service, Kimberly, ID, USA; Irrigation Methods, Reference Module in Earth Systems and Environmental Sciences, Elsevier, 2013;11-Sep-13
2) IRRIGATION NEW ZEALAND INC; Irrigation Code of Practice and Irrigation Design Standards; 2004,
3) S. LECINA et.al.; Irrigation Modernization in Spain: Effects on Water Quantity and Quality—A Conceptual Approach, Water Resources Development, Vol. 26, No. 2, 265–282, June 2010
4) Megersa Girma, et.al,: Irrigation system in Israel: International Journal of Water Resources and Environmental Engineering 7(3):29-37, March 2015
5) C. Brouwer et.al.; Irrigation Water Management: Irrigation Scheduling (Training manual no. 4): FAO; 1989 (http://www.fao.org/3/t7202e/t7202e08.htm#annex i: irrigation efficiencies)
6) FAO; Crop Water Requirements; revised 1977
7) ILRI publication 19; On irrigation efficiencies; ILRI;1990

3) Setting of the Target Irrigation Efficiency

The results of above examination are summarized in Table 4.1.14. Under the various conditions shown in the table, the overall efficiency is determined based on the combination of the increase ratio of conveyance efficiency, distribution efficiency and field application efficiency.

Table 4.1.14 Various Conditions for Setting Target Irrigation Efficiency

Particular	Conveyance Efficiency	Distribution Efficiency	On-farm Efficiency	Overall Efficiency
Current Efficiency	0.90	0.88	0.70	0.55
Increment, or max efficiency	Max. 5% increase from the current, or	Max. 5% increase from the current, or	Surface: 0.70	Max: 0.63
			Sprinkler: 0.80	Max: 0.72

Particular	Conveyance Efficiency	Distribution Efficiency	On-farm Efficiency	Overall Efficiency
	Limited to Max. 0.95	Limited to Max. 0.95	Drip: 0.90	Max: 0.81
Target Improvement	-	-	-	14% increase

Source: JICA Survey Team

The estimated overall irrigation efficiency and the increment from the current efficiency under various conditions are examined in Table 4.1.15 Cases A - D shown in the table refer to the examination cases of conveyance and distribution efficiencies. For example, in Case A: both conveyance and distribution are same as the current efficiencies (no lining work conducted), in Case B: the distribution efficiency is increased by 5% considering the lining work of branch canals but not all, in Case C: the distribution efficiency is increased by 8% considering all the branches to be lined, and in Case D: in addition to Case C, even the conveyance efficiency is increased by 5%, meaning principal and main canals are to be lined.

On the other hand, a total of six cases are examined for field efficiency improvement including current condition. Case 1 refers to the current on-farm irrigation method (basin or furrow), and the area of modern irrigation is increased from Case 2 to Case 6, respectively. In other words, modern irrigation is introduced to 20% of the area in Case 2, 40% in Case 3, 60% in Case 4, 80% in Case 5, and 100% in Case 6.

Modern irrigation can be categorized into sprinkler and drip system, the former being applicable to all crops while the latter is used, as a rule, for crops that are planted in lines. Drip irrigation is more efficient than sprinkler irrigation in terms of water saving. Therefore, drip should be introduced in preference to sprinklers in order to increase water savings, but farmers may choose the latter because sprinklers have a longer life span. In addition, sprinklers with higher flow rates should be taken into account to some extent in the design. For this reason, the Team allocates 1/2 each for sprinklers and drips.

Following are the findings identified as the results of calculating overall irrigation efficiency under the cases of different conveyance and distribution efficiencies, and on-farm irrigation efficiencies.

1) If the conveyance and distribution efficiencies are maintained at existing level, the overall irrigation efficiency can be increased to around 14% with the introduction of modern on-farm irrigation by about 60% (Case A-4). In this case, the target of 14% increase in irrigation efficiency can be achieved even without introducing concrete lining.
2) In case that the distribution efficiency is increased by 5% considering current on-going lining works of branch canals with bed width of not more than 6 m, the target of 14% increase in irrigation efficiency is achievable with the introduction of modern on-farm irrigation to 40% of the area (Case B-3). The JICA Survey Team recommends this scenario (Case B-3) as the government intends to implement the concrete lining on almost all the branch canals, except large ones, while there may be difficulties of convincing farmers in introducing the modern on-farm irrigation.
3) If the distribution efficiency is increased to the maximum 95% (increase by 8%) and also the modern on-farm irrigation is introduced to allover the area except the lower Delta (Case C-6), which is also an intension of the Government, the irrigation efficiency could be increased by as much as 32%. This scenario could be an ideal future in the long run.
4) Under Case D, conveyance efficiency is increased by 5%, meaning that principal and main canals are also to be concrete lined. In this case, the increment of irrigation efficiency is not so big from the ones of Case C, e.g., from 32.2% to 38.8%, increase only by 6.6%. To introduce concrete lining to principal and main canals, operated under continuous flow, would be a very hard work, raising the cost. Therefore, JICA Survey Team does not recommend introducing lining to such continuous flow canals. Note that branch canals are operated with intermittent irrigation, which makes it easy to carry out works during the water cut-off. Therefore, ongoing lining of branch canals should be continued.

Table 4.1.15 Setting of Target Irrigation Efficiency

	Category	Efficiency Current	Increment	Efficiency Improved	On-farm & Overall	On-farm Efficiency	Cases and Shares by On-farm Irrigation Method					
							Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Case A	Conveyance	0.90	0%	0.90	Surface	0.70	100%	80%	60%	40%	20%	0%
	Distribution	0.88	0%	0.88	Sprinkler	0.80	0%	10%	20%	30%	40%	50%
					Drip	0.90	0%	10%	20%	30%	40%	50%
					On-farm E.	-	0.70	0.73	0.76	0.79	0.82	0.85
	Effi. before On-farm	**0.79**		**0.79**	Overall E.	-	0.55	0.58	0.60	0.63	0.65	0.67
	Increment					-	0.0%	5.1%	9.4%	13.8%	18.1%	22.4%
Case B	Conveyance	0.90	0%	0.90	Surface	0.70	100%	80%	**60%**	40%	20%	0%
	Distribution	0.88	**5%**	0.92	Sprinkler	0.80	0%	10%	**20%**	30%	40%	50%
					Drip	0.90	0%	10%	**20%**	30%	40%	50%
					On-farm E.	-	0.70	0.73	**0.76**	0.79	0.82	0.85
	Effi. before On-farm	**0.79**		**0.83**	Overall E.	-	0.58	0.61	**0.63**	0.66	0.68	0.71
	Increment					-	5.8%	10.4%	**14.9%**	-	24.0%	28.5%
Case C	Conveyance	0.90	0%	0.90	Surface	0.70	100%	80%	60%	40%	20%	**0%**
	Distribution	0.88	**8%**	0.95	Sprinkler	0.80	0%	10%	20%	30%	40%	**50%**
					Drip	0.90	0%	10%	20%	30%	40%	**50%**
					On-farm E.	-	0.70	0.73	0.76	0.79	0.82	**0.85**
	Effi. before On-farm	**0.79**		**0.86**	Overall E.	-	0.60	0.62	0.65	0.68	0.70	**0.73**
	Increment					-	8.9%	13.5%	18.2%	-	27.5%	**32.2%**
Case D	Conveyance	0.90	**5%**	0.95	Surface	0.70	100%	80%	60%	40%	20%	**0%**
	Distribution	0.88	**8%**	0.95	Sprinkler	0.80	0%	10%	20%	30%	40%	**50%**
					Drip	0.90	0%	10%	20%	30%	40%	**50%**
					On-farm E.	-	0.70	0.73	0.76	0.79	0.82	**0.85**
	Effi. before On-farm	**0.79**		**0.90**	Overall E.	-	0.63	0.66	0.68	0.71	0.74	**0.76**
	Increment					-	14.3%	19.2%	24.1%	-	33.9%	**38.8%**

Source: JICA Survey Team

4.1.4 Regulating Water Level (RWL) and Design Discharge

1) Discharge Setting the Regulating Water Level (RWL)

In planning the rehabilitation of a canal, it is necessary to determine the necessary regulating water level at the intake point to ensure the distribution of water to the lower cadre canals. However, in Egypt, this information is often not available. In such cases, it is necessary to establish the regulating water level (RWL) to ensure that sufficient water can be delivered to the lower canals, e.g., branch canals, even under future flow changes. The minimum flow rate to determine the regulating water level (RWL) is calculated by the following method:

- ✓ For the Bahr Yusef and Ibrahimia Principal Canals, there are a series of discharge data available at major regulators. Therefore, by referencing the discharge data, we can know the minimum water discharge, which can provide the RWL. The water requirement estimated on the basis of the MWRI crop water consumption table can also be determined.
- ✓ However, there is no such data series for the canal system in the 3 sub-regions. Therefore, the JICA Survey Team estimates the water requirement by crop based on the MWRI crop water consumption table. Then, unless otherwise specified, the Team applies the winter season crop water requirement as the minimum water discharge, e.g., discharge in February.

Table 4.1.16 summarizes the average monthly discharges from the Dirout Group of Regulators at the beginning points of the Bahr Yusef and Ibrahimia Principal Canals during the 3 years of 2018 - 2020, together with the ratio against the maximum discharge, which usually takes place in June or July. The minimum discharge takes place in December; its ratios against the maximum discharge are 53% and 54% for the Bahr Yusef and Ibrahimia Principal Canals, respectively. Therefore, the minimum discharge to keep the RWL is set at half (50%) of the maximum discharge.

Table 4.1.16 Average Monthly Discharge for 2018–2020 and Ratio Against the Peak Discharge, cum/s

Canal	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Bahr Yusef	Close	127.2	129.4	132.6	166.7	176.7	177.3	171.2	148.1	139.0	124.5	94.1	137.2
% ag/Max	NA	72%	73%	75%	94%	100%	100%	97%	84%	78%	70%	**53%**	77%
Ibrahimia	Close	98.4	101.0	113.0	134.0	149.4	148.1	132.1	114.7	117.6	108.0	81.3	109.8
% ag/Max	NA	66%	68%	76%	90%	100%	99%	88%	77%	79%	72%	**54%**	74%

Note: There is a 2- to 3-week canal closure period, mostly in January, and therefore the discharges in January are not taken into account in this lean water estimation.
Source: Water Distribution Section, MWRI

Table 4.1.17 shows water requirements for the Bahr Yusef and Ibrahimia Command Areas as estimated based on the MWRI crop water consumption table. In this case, the unit maximum water requirement, which is 1.0 l/s/ha gross, is registered in July, while the minimum requirement, 0.55 l/s/ha, is registered in February. The ratio between the minimum and the maximum unit water requirement comes to 55%, almost equal to those ratios indicated in Table 4.1.16.

Table 4.1.18 shows the water requirement for the Kased Command Area estimated based on the MWRI crop water consumption table. In this case, the unit maximum water requirement, which is 1.1 l/s/ha, is registered in July, while the minimum water requirement, 0.45 l/s/ha, takes place in February. The ratio between the minimum and the maximum unit water requirement comes to 41%. Therefore, the regulating water level (RWL) in the Kased Command Area is set as the water level at 41% of the maximum flow.

Table 4.1.17 Unit Water Requirement in Bahr Yusef and Ibrahimia for Summer and Winter and Comparison

Crop	Ratio	June	Jul	Aug	June	Jul	Aug
	%	cum/feddan/month			l/s/feddan, % Weighted		
Maize	63%	638.4	640.8	680.4	0.16	0.15	0.16
Sorghum	13%	620.1	930.0	660.8	0.03	0.05	0.03
Oil Crop	5%	520.0	550.0	520.0	0.01	0.01	0.01
Vegetables	11%	697.2	432.6	201.6	0.03	0.02	0.01
Others	8%	0.0	147.0	520.8	0.00	0.00	0.02
Total	100%						
Weighted, l/s/feddan, Net					0.23	0.23	0.23
Weighted, l/s/ha, Net					0.54	0.54	0.54
Unit W. Consumption, l/s/feddan						**0.42**	
Unit W. Consumption, l/s/ha, Gross						**1.00**	
Winter Crop	**Ratio**	**Feb**	**Mar**	**Apr**	**Feb**	**Mar**	**Apr**
	%	**cum/feddan/month**			**l/s/feddan, % Weighted**		
Wheat	51%	328.0	557.3	485.1	0.07	0.11	0.10
Long Berseem	23%	352.8	541.8	663.6	0.03	0.05	0.06
Sugar Beet	7%	373.8	466.2	378.0	0.01	0.01	0.01
Vegetables	13%	67.2	71.4	58.8	0.00	0.00	0.00
Others	6%	399.0	273.0	520.8	0.01	0.01	0.01
Total	100%						
Weighted, l/s/feddan, Net					0.13	0.17	0.18
Weighted, l/s/ha, Net					0.30	0.42	0.43
Unit W. Consumption, l/s/f, Gross					**0.23**	**55% ag/ Max (July)**	
Unit W. Consumption, l/s/ha, Gross					**0.55**		

Note: Gross water consumption is calculated considering irrigation efficiency of 0.55 to the net water consumption.
Source: JICA Survey Team, MWRI crop water consumption table.

Table 4.1.18 Unit Water Requirement in Kased for Summer and Winter Seasons and Comparison

Crop	Ratio	June	Jul	Aug	June	Jul	Aug
	%	CUM/Feddan/Month			l/s/feddan, % Weighted		
Maize	34%	558.6	843.36	693.42	0.07	0.11	0.09
Oil Crop	0%	428.4	507.8	504	0.00	0.00	0.00
Vegetables	27%	403.2	294	176.4	0.04	0.03	0.02
Others	29%	483	537.6	428.4	0.05	0.06	0.05
Rice	10%	130.2	1289.4	1457.4	0.01	0.05	0.06
Total	100%						
Weighted, l/s/feddan, Net					0.17	0.25	0.21

Crop	Ratio	June	Jul	Aug	June	Jul	Aug
	%	CUM/Feddan/Month			l/s/feddan, % Weighted		
Weighted, l/s/ha, Net					0.42	0.58	0.50
Unit W. Consumption, l/s/f, Gross						**0.45**	
Unit W. Consumption, l/s/ha, Gross						**1.1**	
Crop	**Ratio**	**Feb**	**Mar**	**Apr**	**Feb**	**Mar**	**Apr**
	%	**CUM/Feddan/Month**			**l/s/feddan, % Weighted**		
Wheat	46%	231	403.2	441	0.04	0.07	0.08
Long Berseem	23%	264.6	294.8	596.4	0.03	0.03	0.05
Sugar Beet	17%	319.2	445	323.4	0.02	0.03	0.02
Legumes	1%	357	153.2		0.00	0.00	0.00
Vegetables	8%	121.8	67.2	54.6	0.00	0.00	0.00
Others	5%	378	310		0.01	0.01	0.00
Total	100%						
Weighted, l/s/feddan, Net					0.10	0.13	0.15
Weighted, l/s/ha, Net					0.25	0.31	0.37
Unit W. Consumption, l/s/f, Gross					**0.19**	**41% ag/ Max (July)**	
Unit W. Consumption, l/s/ha, Gross					**0.45**		

Note: Gross water consumption is calculated considering irrigation efficiency of 0.55 to the net water consumption.
Source: JICA Survey Team, MWRI crop water consumption table.

2) Design Discharge

This section presents design discharge flow as the basic information for hydraulic simulation and design of hydraulic structures. Table 4.1.19 shows the unit design discharge for the Bahr Yusef and Ibrahimia Command Areas based on the MWRI crop water consumption table, which indicates a rate of 1.00 l/s/ha (0.42 l/s/feddan), while Table 4.1.20 shows the unit design discharge calculated based on the actual discharge. Although the unit discharge changes a little from canal to canal and from section to section, it can be set at 1.00 l/s/ha (0.42 l/s/feddan) gross, which is in fact the same as that calculated in the MWRI crop water consumption table.

Table 4.1.21 shows the unit design discharge for the Kased Command Area, where there is still rice cultivation. Rice used to be cultivated in a large portion of the area, but the area in which its cultivation is permitted has been reduced dramatically. As of 2022, only farmers in downstream parts of the Kased Command Area, mostly areas in Kafr El Sheik Governorate, are permitted to cultivate rice. The ratio for the rice cultivable area accounts for only 10% of the whole Kased Command Area as of summer 2022. With this cropping pattern, the unit design discharge is estimated at 1.1 l/s/ha (0.45 l/s/feddan), which is a little bigger than those of Bahr Yusef and Ibrahimia.

Table 4.1.19 Unit Design Discharge for Bahr Yusef and Ibrahimia Command Area by Crop Water Requirement Table

Crop	Ratio	June	Jul	Aug	June	Jul	Aug
	%	cum/feddan/month			l/s/feddan, % Weighted		
Maize	63%	638.4	640.8	680.4	0.16	0.15	0.16
Sorghum	13%	620.1	930.0	660.8	0.03	0.05	0.03
Oil Crop	5%	520.0	550.0	520.0	0.01	0.01	0.01
Vegetables	11%	697.2	432.6	201.6	0.03	0.02	0.01
Others	8%	0.0	147.0	520.8	0.00	0.00	0.02
Total	100%						
Weighted, l/s/feddan, Net					0.23	0.23	0.23
Weighted, l/s/ha, Net					0.54	0.54	0.54
Gross l/s/feddan (IE=0.55)					0.41	0.42	0.41
Gross l/s/ha (IE=0.55)					0.98	0.99	0.98
Unit W. Consumption, l/s/feddan, Gross (IE=0.55)						**0.42**	l/s/feddan
Unit W. Consumption, l/s/ha, Gross (IE=0.55)						**1.00**	l/s/ha
Unit W. Consump. m3/f/month, w/Re-use/Feed, Gross						**1,125**	m3/f/m

Note: To convert the net water requirement to the gross requirement, irrigation efficiency of 0.55 is applied.
Source: JICA Survey Team, MWRI crop water consumption table.

Table 4.1.20 Unit Design Discharge for Bahr Yusef and Ibrahimia Command Area by Actual Discharge

Particulars	Unit	Bahr Yusef			Ibrahimia		
		Bahr Yusef, /1	Excl. Fayoum, 1/	Fayoum, /2	Ibrahimia, 1/	Maghagha, /2	Maghagha, /3
Discharge	cum/s	192.60	85.20	114.50	165.10	97.40	67.90
Domestic/Industrial Water (DI)	cum/s	5.46	1.96	3.50	4.88	2.57	2.31
Discharge less DI Water	cum/s	187.14	83.24	111.00	160.22	94.83	65.59
Command Area	feddan	546,013	195,537	350,476	488,201	257,370	230,831
Unit W. Consumption, Gross	l/s/feddan	0.34	0.43	0.32	0.33	0.37	0.28
Unit W. Consumption, Gross	l/s/ha	0.82	1.01	0.75	0.78	0.88	0.68
Drainage reuse/Feed	l/s/feddan	0.05	-0.02	0.10	0.11	0.07	0.15
Drainage reuse/Feed	l/s/ha	0.13	-0.05	0.23	0.26	0.16	0.37
UWC. w/Reuse/Feed, Gross	l/s/feddan	0.40	0.40	0.41	0.44	0.44	0.44
UWC. w/Reuse/Feed, Gross	l/s/ha	0.95	0.96	0.98	1.04	1.04	1.04
UWC w/Reuse/Feed, Gross	l/s/feddan	**0.42**					
UWC. w/Reuse/Feed, Gross	l/s/ha	**1.00**					
UWC. w/Reuse/Feed, Gross	cum/f/mo	**1,091**					

Note: 1/ the discharge is the maximum for the last 10 years from 2011 to 2020.
2/ the discharge is the second maximum for the last 10 years (2011–2020), as the maximum may include a very large error.
3/ the discharge is the maximum for the last 3 years average from 2018 to 2020.
Note: UWC stands for "unit water consumption."
Source: JICA Survey Team, Water Distribution Sector for the discharges

Table 4.1.21 Unit Design Discharge for Kased Command Area by Crop Water Requirement Table

Crop	Ratio	June	Jul	Aug	June	Jul	Aug
	%	CUM/Feddan/Month			l/s/feddan, % Weighted		
Maize	34%	558.6	843.36	693.42	0.07	0.11	0.09
Oil Crop	0%	428.4	507.8	504	0.00	0.00	0.00
Vegetables	27%	403.2	294	176.4	0.04	0.03	0.02
Others	29%	483	53.6	428.4	0.05	0.06	0.05
Rice	10%	130.2	1289.4	1457.4	0.01	0.05	0.06
Total	100%						
Weighted, l/s/feddan, Net					0.17	0.25	0.21
Weighted, l/s/ha, Net					0.42	0.58	0.50
IE=0.55, Gross l/s/feddan					0.32	0.45	0.38
IE=0.55, Gross l/s/ha					0.76	1.06	0.90
Unit W. Consumption, l/s/feddan, Gross (IE=0.55)						**0.45**	l/s/feddan
Unit W. Consumption, l/s/ha, Gross (IE=0.55)						**1.10**	l/s/ha
Unit W. Consump. m3/f/month, w/Reuse/Feed, Gross						**1,205**	m3/f/m

Source: JICA Survey Team, MWRI crop water consumption table.

Based on the unit design flows calculated above and the benefited area, the maximum and minimum flows were calculated by each scenario, i.e., the current situation, 14% increase in irrigation efficiency, and 32% increase in irrigation efficiency. The 14% increase is the irrigation efficiency improvement required to meet the national water demand in the target year 2037 as indicated in the NWRP (see 2.1.3 Future Water Uses, and Implications to Improving Irrigation Efficiency), while the 32% increase is the rate of increase in irrigation efficiency when all branch canals are lined with concrete and modern on-farm irrigation is introduced throughout the entire area (see 4.1.3 Setting target irrigation efficiencies). Note that modern irrigation at the on-farm level is based on the introduction of sprinklers, and the irrigation efficiency in the on-farm is set at 0.80.

Table 4.1.22 Unit Design, Canal Level, and On-farm Level Discharges by Command Area

Particulars	Unit	Bahr Yusef	Ibra-himia	Abo Shosha	Aros & Abo Seer	Kased	Remarks
Service Area (Net)	feddan	582,298	491,642	17,881	13,330	95,976	1/, 2/
Service Area (Net)	ha	244,565	206,490	7,510	5,599	40,310	1/, 2/
Maximum Unit Discharge (Canal Design Purpose)							
Net Unit Discharge	l/s/feddan	0.23	0.23	0.23	0.23	0.25	
Gross Unit Discharge	l/s/feddan	0.42	0.42	0.42	0.42	0.45	IE=0.55
Net Unit Discharge	cum/day/f	20	20	20	20	21	
Gross Unit Discharge	cum/day/f	36	36	36	36	39	IE=0.55
Net Unit Discharge	cum/month/f	592	592	592	592	635	
Gross Unit Discharge	cum/month/f	1,089	1,089	1,089	1,089	1,166	IE=0.55

Particulars	Unit	Bahr Yusef	Ibra-himia	Abo Shosha	Aros & Abo Seer	Kased	Remarks
Net Unit Discharge	l/s/ha	0.54	0.54	0.54	0.54	0.58	
Gross Unit Discharge	l/s/ha	1.00	1.00	1.00	1.00	1.10	IE=0.55
Minimum Unit Discharge (for Regulating WL purpose)							
Net Unit Discharge	l/s/feddan	0.13	0.13	0.13	0.13	0.10	
Gross Unit Discharge	l/s/feddan	0.23	0.23	0.23	0.23	0.19	IE=0.55
Net Unit Discharge	cum/day/f	11	11	11	11	9	
Gross Unit Discharge	cum/day/f	20	20	20	20	16	IE=0.55
Net Unit Discharge	cum/month/f	329	329	329	329	272	
Gross Unit Discharge	cum/month/f	599	599	599	599	494	IE=0.55
Net Unit Discharge	l/s/ha	0.30	0.30	0.30	0.30	0.10	
Gross Unit Discharge	l/s/ha	0.55	0.55	0.55	0.55	0.45	IE=0.55
Canal Level Discharge (including Domestic and Industry Use)							
Max Discharge (current)	**cum/s**	**232**	**166**	**7.5**	**5.6**	**45**	**2022 assumed**
Max Q w/ 14% IE up	**cum/s**	**210**	**151**	**6.6**	**4.9**	**39**	**3/**
Max Q w/ 32% IE up	**cum/s**	**183**	**132**	**5.7**	**4.3**	**34**	**4/**
Min Q (winter) w/ 32% IE up	**cum/s**	**106**	**77**	**3.1**	**2.3**	**15**	
Ratio b/t Min and Max	**%**	**46%**	**46%**	**42%**	**42%**	**34%**	
On-farm Level Unit Discharge (Irrigation Use Only) in case of Sprinkler (0.80 efficiency)							
Summer Max Unit Discharge	l/s/feddan	0.29	0.29	0.29	0.29	0.27	
Summer Max Unit Discharge	l/s/ha	0.69	0.69	0.69	0.69	0.65	
Winter Max Unit Discharge	l/s/feddan	0.22	0.22	0.22	0.22	0.19	
Winter Max Unit Discharge	l/s/ha	0.47	0.47	0.47	0.47	0.41	

Source: JICA Survey Team

Note: 1/ The command area of Bahr Yusef is within the 3 governorates of Minya, Beni Suef, and Fayoum, but does not include Giza because the discharge to Giza has been decreasing and because the command area by the Giza Intake is not known.

2/ The command area of Ibrahimia covers the irrigation area within Minya Governorate, Beni Suef Governorate, and the area in Giza Governorate up to El Ayat PS.

3/ A 14% irrigation efficiency increase can be achieved with distribution canal (secondary canal) lining at a ratio of around 60%, which raises distribution efficiency by 5%, plus the introduction of modern on-farm irrigation facilities to 40% of the whole farmland area.

4/ A 32% irrigation efficiency increase can be achieved with full distribution canal (secondary canal) lining, which raises distribution efficiency by as much as 8%, plus the introduction of modern on-farm irrigation facilities to the whole farmland area.

IE stands for "irrigation efficiency."

4.2 Hydraulic Simulation and Examination of Canal Improvement

In this sub-chapter, hydraulic simulation of a series of canals including existing hydraulic structures are conducted in order to obtain basic data for the purpose of identifying rehabilitation of existing canals and hydraulic structures and also construction of additional hydraulic structures. The hydraulic simulation covers the Bahr Yusef and Ibrahimia Principal Canals, as well as the main and major secondary canals together with hydraulic structures in the three priority sub-regions such as Abo Shosha, Aros and Abo Seer, and Kased.

4.2.1 Approach, Design Discharge, Simulation Cases and Methodologies

The Government of Egypt decided to introduce concrete lining to a large number of branch canals, with a target of 20,000 km from the year 2020. Unlike the current earthen canals, the lined canals have a smooth surface of concrete whereby it is expected that the water level in the canal will decrease even with same amount of water being delivered.

When the water level in a canal is lowered, there may be such cases in which water distribution into the lower-level canals, e.g., sub-branch canals and Meska, could be hindered. In these cases, the water level should be raised by means of closing the gates of an existing regulator located downstream, or if there is no regulator within reach of a canal capable of adjusting the water level, an additional regulator should be put in place.

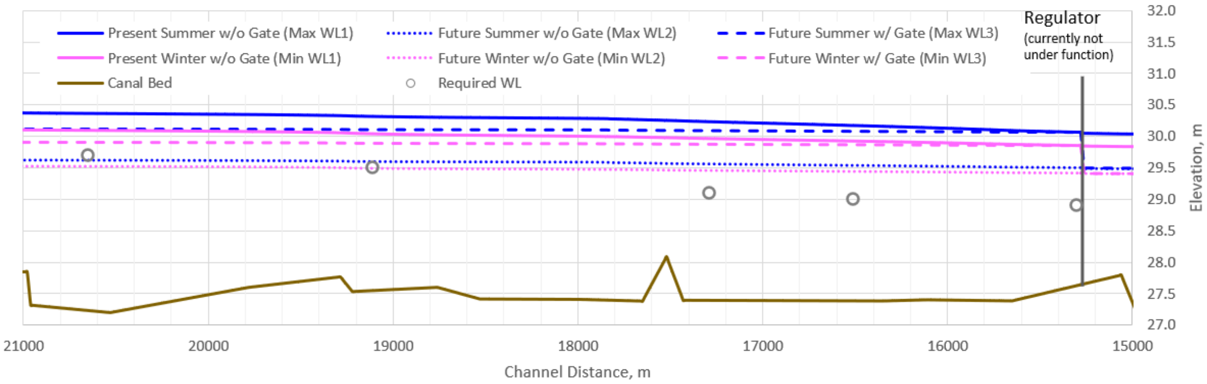


Figure 4.2.1 Conceptual Flow Regime Change with the Concrete Lining and Requirements of Regulators
Source: JICA Survey Team

In sum, non-uniform hydraulic simulation is conducted for the following reasons:

i. to determine the flow capacity of the canals, including the maximum water level with the designed discharge and the minimum water level (see Figure 4.2.1, Max WL1 and Min WL1);

ii. to know the change in the water regime, focusing on the water level with the introduction of a canal lining (see Figure 4.2.1 to compare WL1 and WL2);

iii. to assess the functional capacity of existing regulators to determine whether it is high enough to raise the water level to the required one, at which point the water can be diverted into lower-level canals (see Figure 4.2.1 to compare WL2, WL3, and required WL); and

iv. to judge the need to construct new regulators (in Figure 4.2.1, WL2 is lower than the required WL at the 20,650m section, which indicates the need for downstream water regulation).

1) Simulation Cases

Given the previously mentioned design discharges, basic factors to classify the simulation cases are as follows.

1) Cropping season: summer season (usually to confirm the maximum water level) or winter season (to confirm the minimum water level).

2) Canal condition: earthen (roughness coefficient n=0.030) or concrete-lined (n=0.015).

3) Rotation system: In many branch canal service areas, a rotation system is applied to keep the water level high until the downstream ends of canals. In this rotation system, all the branches are classified into 2 or 3 groups, and their 5-day on times are set so they take in the water one after another. Therefore, the required water volume should be more than required during on-time, but also take into account the volume during the off-time period.

4) Availability of hydraulic facilities: Currently, more than half of existing regulators/weirs are not functioning to raise the water level. The simulation considers both the cases when those regulators/weirs remain non-functioning and those in which they function after rehabilitation. The functionality of drainage pump stations can be included in some regions.

The water level under the condition of the current summer season with the earthen canal condition in each rotation system can be referenced to confirm the maximum flow capacity, whereas the minimum water level to evaluate the adequate water distribution to lower-level canals should be the condition in the winter season with the concrete-canal condition (i.e., 32% up). Detailed cases can be found in the section for each area.

2) Simulation Methodology

The simulation focuses on the evaluation of the impact of an improved and modern irrigation system, which includes the installation of concrete lining along the canals and modern on-farm irrigation. The simulation is conducted with HEC-RAS (ver.6.2) software, which was developed by US Corps of Engineers Hydraulic Engineering Center for 1D/2D, steady/unsteady hydraulic analysis for rivers/channels. It is non-commercial software, but very powerful and stable, with continuous updates since 1995, and is widely used all over the world.

The hydraulic analysis method used in this study is non-uniform flow analysis using the sequential computation method in order to understand the steady flow condition in the target canals. The canal cross-section changes position but the flow rate is constant by case. The sequential calculation method assumes the water depth at the next point sequentially from a known point, and proceeds with the calculation while matching the energy by applying Bernoulli's formula and the continuity equation. It is the prevailing method used for such computation. Water surface profiles are calculated in accordance with the following energy equation:

$$Z_2 + Y_2 + \frac{a_2 + V_2^2}{2g} = Z_1 + Y_1 + \frac{a_1 + V_1^2}{2g} + h_e \quad (1)$$

Where:
Z: elevation of the main channel inverts;
Y: depth of water at cross-sections;
V: average velocities (total discharge/total flow area);
a: velocity weighting coefficients;
g: gravitational acceleration; and
h_e: energy head loss.

Furthermore, the energy head loss, h_e, between the two cross-sections is calculated by the equation below:

$$h_e = L\bar{S_f} + C\left|\frac{a_2V_2^2}{2g} - \frac{a_1V_1^2}{2g}\right| \quad (2)$$

$$L = \frac{L_{lob}\overline{Q_{lob}} + L_{ch}\overline{Q_{ch}} + L_{rob}\overline{Q_{rob}}}{\overline{Q_{lob}} + \overline{Q_{ch}} + \overline{Q_{rob}}} \quad (3)$$

Where:

L: discharge weighted reach length;

$\bar{S_f}$: representative friction slope between two sections;

C: expansion or contraction loss coefficient;

L: cross-section reaches lengths specified for flow in the leftover bank (lob), main channel (ch), and right over bank (rob); and

Q: mathematical average of the flows between sections for the left over bank (lob), main channel (ch), and right over bank (rob).

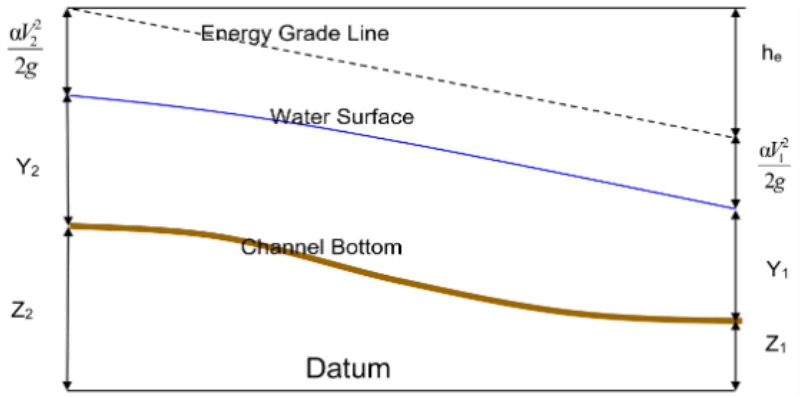


Figure 4.2.2 Example of Calculation Result by HEC-RAS (Energy Equation)

Source: HEC-RAS Hydraulic Reference Manual

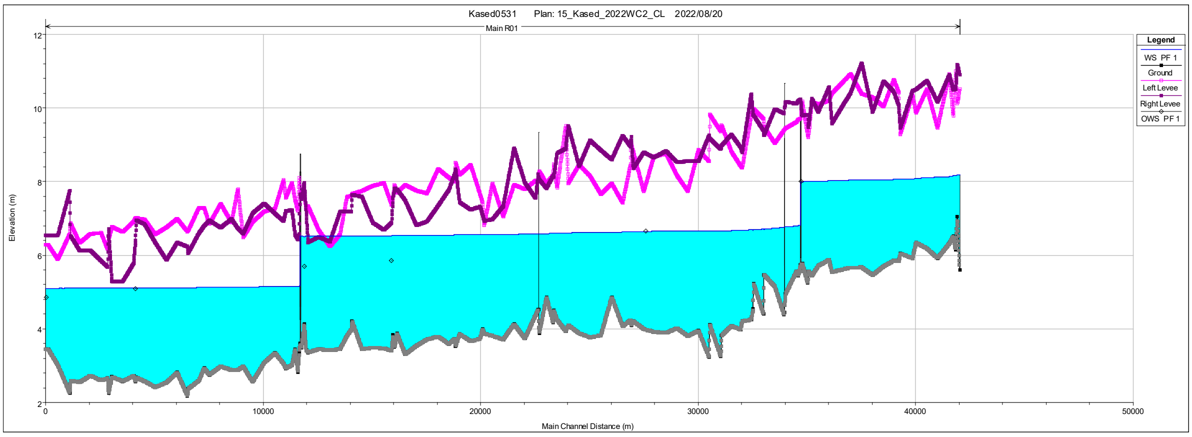


Figure 4.2.3 Example of Calculation Result by HEC-RAS (Hydraulic Profile)

Source: JICA Survey Team

Target canals for the modeling are limited to the principal, main, and branch canals. These require large facilities when constructed due to the change in future hydraulic conditions, as a result of which there could be a critical impact on the cost estimation.

Table 4.2.1 Target Canals for the Analysis

No.	Sub-Region/ Principal Canal	Number of Target Canals	Total Length	# of Cross Section
1	Bahr Yusef	1 Principal Canal	292.8 km	1,701
2	Ibrahimia	1 Principal Canal	223.6 km	728
3	Abo Shosha	1 Main Canal 4 Branch Canals	54.2 km	198
4	Aros and Abo Seer	2 Main Canal 4 Branch Canals	46.5 km	255
5	Kased	1 Main Canals 5 Branch Canals	135.8 km	470

Source: JICA Survey Team

4.2.2 Bahr Yusef and Ibrahimia Principal Canals

In this section, the current status of the Bahr Yusef and Ibrahimia Principal Canals is hydraulically evaluated, and the improvement plan for the principal canals, which corresponds to the maintenance level of the irrigation facilities, is hydraulically examined.

1) Analysis Conditions

The canal cross-sections used for the non-uniform flow analysis are as follows:

・Bahr Yusef Principal Canal: L = 292.79km (New Dirout Group Regulators - Lahoun Weir)
Source: "JICA cooperation planning survey report on the irrigation sector (upper Egypt and middle Delta) in Egypt" (JICA, 2018)

・Ibrahimia Principal Canal: L = 223.56km (New Dirout Group Regulators - Wasta Weir)
Source: MWRI

Discharge conditions for the analysis are summarized in the table below, which is calculated based on the irrigated area, standard water requirements per crop, and irrigation efficiency based on satellite image analysis (discharge for the detailed section is shown in the Appendix).

Table 4.2.2 Discharge for the Analysis of the Bahr Yusef and Ibrahimia Principal Canals

Principal name	Discharge at the NDGRs (m^3 /s)			
	Max.Q	Irrigation efficiency up 14%	Irrigation efficiency up 32%	Min.Q
Bahr Yusef Principal Canal	232.00	210.00	183.00	106.00
Ibrahimia Principal Canal	166.00	151.00	132.00	71.00

Note: Min.Q indicates winter flow rate at 32% higher irrigation efficiency.
Source: JICA Survey Team

The roughness coefficient under the current condition, "n" applied in the analysis, is n=0.030 based on the following references and reports from previous years, and considering the topographic (gentle slope with many curvatures and changes in the shapes of cross-sections), structural (many crossing facilities such as bridges), and environmental conditions (many aquatic plants and domestic garbage in the canals):

1) Refer to "Open Canal Hydraulics" (Ven Te Chow).

Table 4.2.3 Roughness Coefficient by Type of Structure Surface

Type of canal and description	Minimum	Normal	Maximum
C. Excavated or Dredged			
b. Earth, winding and sluggish			
2.Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep canals	0.030	0.035	0.040
D. Natural Streams			
D-1. minor streams (top width at flood stage < 100ft)			
a. Streams on plain			
1. clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
3. clean, winding, some pools and shoals	0.033	0.040	0.045
D-3. major streams (top width at flood stage > 100ft)			
The n value is less than that for minor streams of similar description, because banks offer less effective resistance.			

Note: Excerpt from "OPEN-CANAL HYDRAULICS" Table 5-6 Values of the roughness coefficient n.

2) Refer to the "Irrigation Development Plan for Bahr-Yusef District" (JICA 2019) survey report; the roughness coefficient n = 0.030 was obtained from the actual flow measurement.

3) In the "Detailed Design on the Project for Construction of New Dirout Group of Regulators (NDGRs)" (JICA 2017), the roughness coefficient of the Ibrahimia Principal Canal upstream of

the Dirout Group of Regulators was estimated as follows:

- ✓ Estimation by Discharge Volume: n = 0.0241-0.0361, and
- ✓ Estimation by Water Level: n = 0.0256-0.0300

2) Analysis Results

The results of the analysis are summarized in the hydraulic longitudinal profiles as follows: for the Bahr Yusef Principal Canal, see Figure 4.2.4, “Bahr Yusef Principal Canal hydraulic profile (current condition),” and for the Ibrahimia Principal Canal, see Figure 4.2.5, “Ibrahimia Principal Canal hydraulic profile (current condition).”

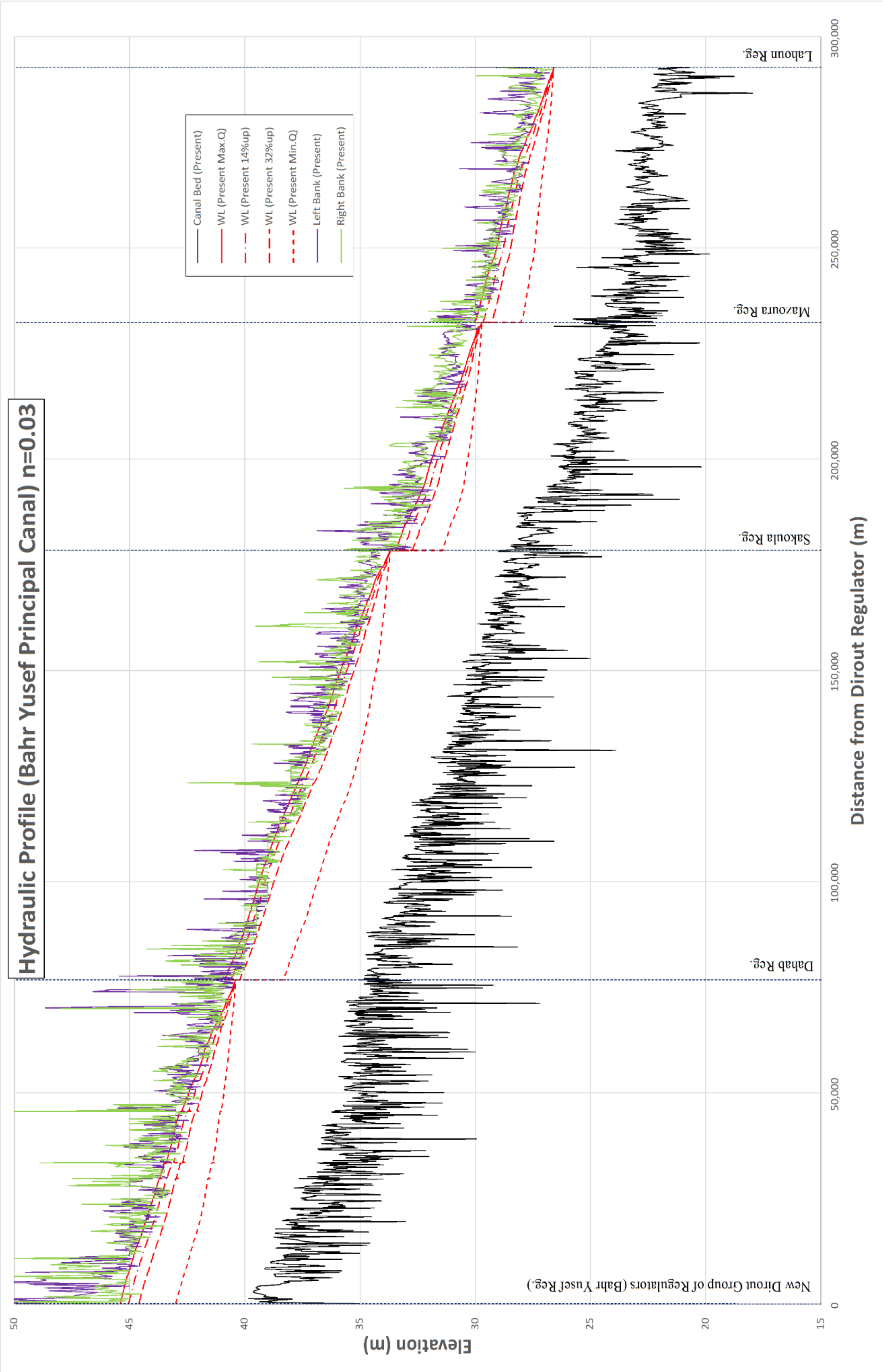


Figure 4.2.4 Bahr Yusef Principal Canal Hydraulic Profile (Current Condition)

Source: JICA Survey Team

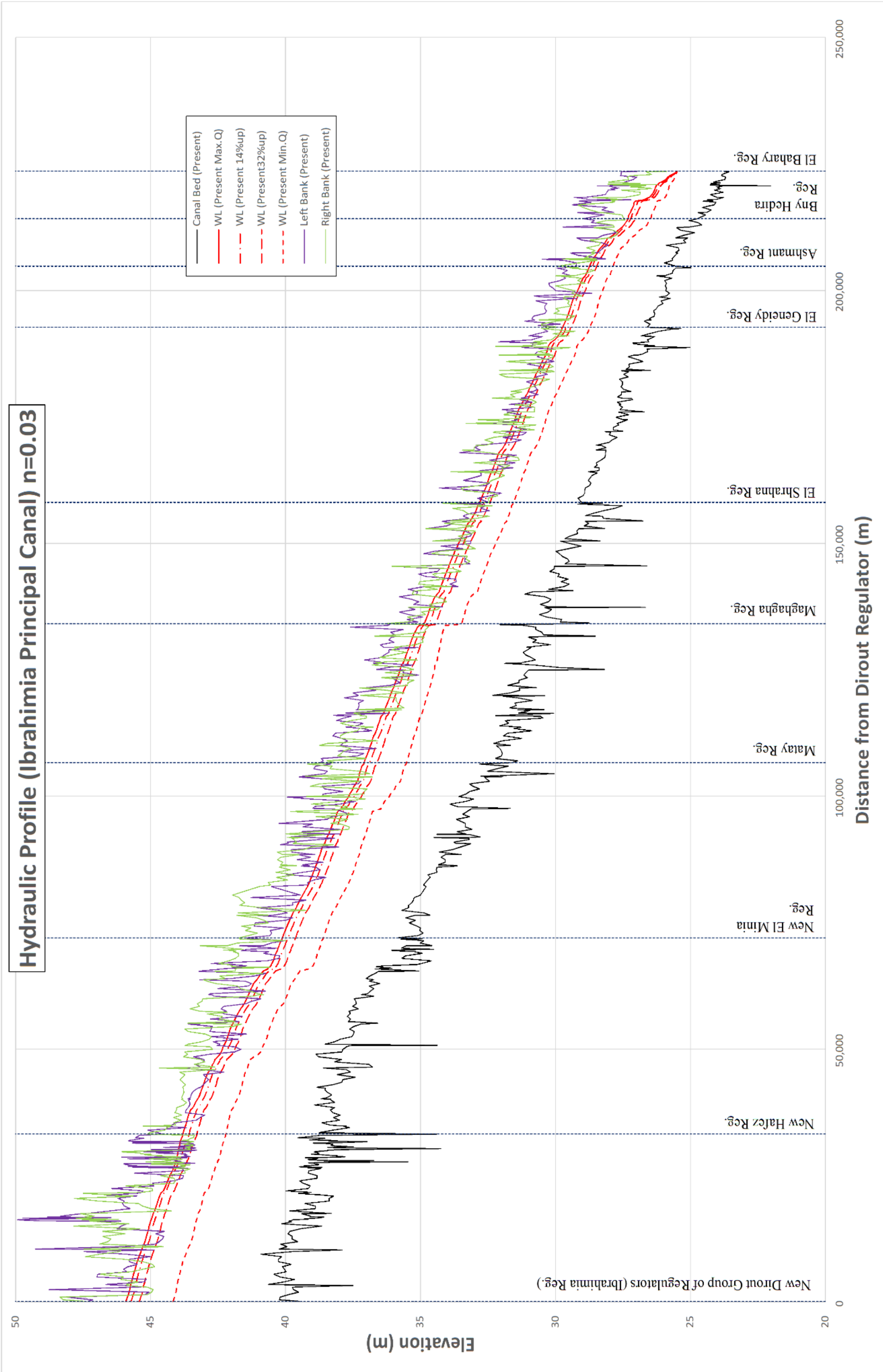


Figure 4.2.5 Ibrahimia Principal Canal Hydraulic Profile (Current Condition)

Source: JICA Survey Team

3) Evaluation of the Analysis Results

As shown in Figures 4.2.4 and 4.2.5, the analysis found that both the Bahr Yusef and Ibrahimia Principal Canals have the possibility of overflows due to inadequate flow capacity, which can be explained in detail as follows:

✓ The slope of the canals is generally very gentle (less than 1/10,000), and the average velocity at each cross-section is slow (0.60m/s). Therefore, sedimentation can easily occur throughout the entire reach of the canals. The current and planned latest bed elevations (canal bed slopes between regulators) are summarized in Figure 4.2.6, which indicates the obstruction to water flow.

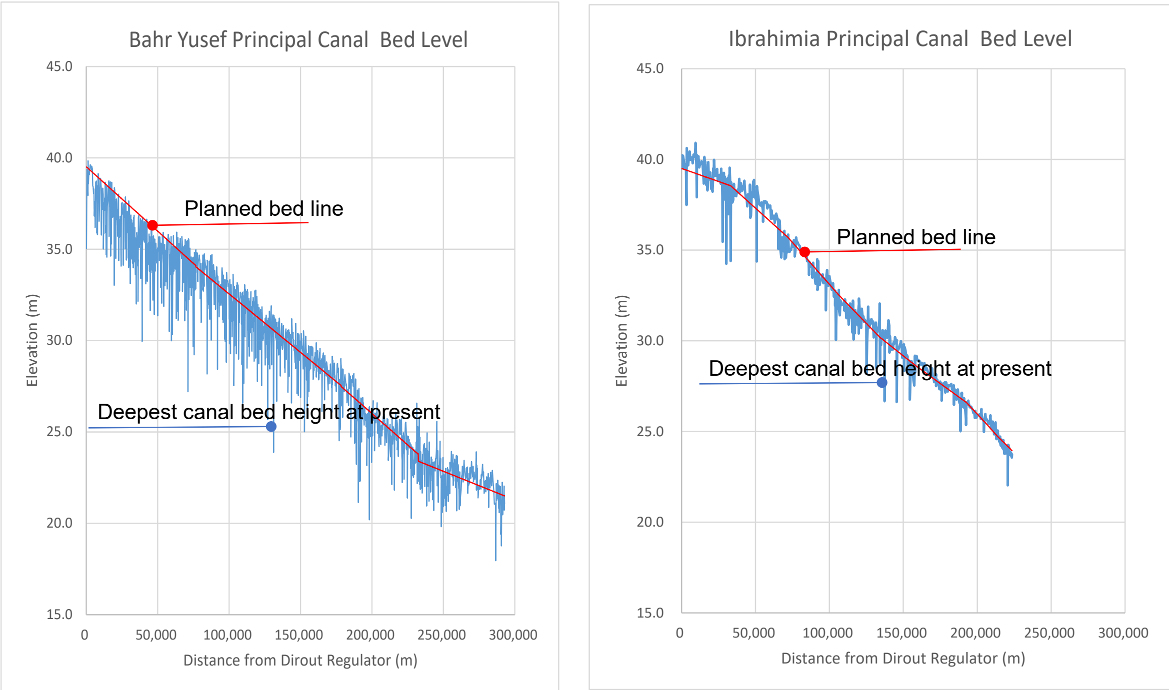


Figure 4.2.6 Relationship Between the Existing Canal and the Planned Canal Bed Heights

Source: JICA Survey Team

✓ The Bahr Yusef Principal Canal has about 200 curvatures, and the impact of scouring is revealed by the topographic survey, as indicated in Figure 4.2.7. Scouring is especially noticeable at the cross-sections of meandering parts of the canal. This situation could make the flow area and flow capacity smaller, and damage lands near the scouring point.

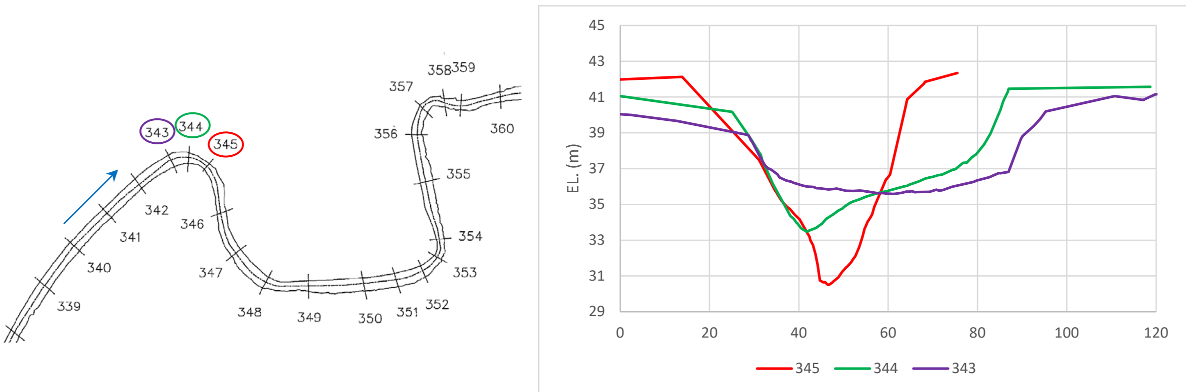


Figure 4.2.7 Bahr Yusef Principal Canal Curvature Cross-Sectional Diagram

Source: JICA Survey Team

4.2.3 The Abo Shosha Area

The Abo Shosha Main Canal covers 17,881 feddan of service area. Its water resources come from the Ibrahimia Principal Canal. In the area, the volume of irrigated water from the Abo Shosha Intake is not enough, and therefore does not reach farmlands at the downstream end. To compensate this situation, three feeder pumps which water resources are from the drainage water and the Bahr Yusef Principal Canal are used to supply additional water to the farmland. In addition, a unique rotation system is applied in the area to transport the water to the downstream end, which has 10 days on and 5 days off in the upstream of the Qoleia Regulator, and 5 days on and 10 days off in the downstream area. The introduction of modern irrigation is expected not only to save the water for irrigation, but also to solve the problems above.

However, modern irrigation with higher irrigation efficiency induces a decrease in water level due to a lower flow volume and lower roughness coefficient. In this context, the purpose of the simulation is 1) to confirm if adequate water distribution can be achieved even after the modern irrigation is completely introduced, and 2) if it is not achievable, to clarify the necessity of the construction or rehabilitation of new structures along the canals.

For the simulation, the following 5 canals are selected, and their lengths, widths, and service areas are considered: the Talt branch, the Sheikh Abid branch, Abo Shosha Branch 1, the Dushtoot Branch, and the Abo Shosha Main Canal. Table 4.2.4 summarizes the basic information about the canals and their service areas.

Table 4.2.4 Information of Canals for the Simulation (Abo Shosha Command Area)

No.	Name	Location	Slope	Length	Width	Service Area
1	Abo Shosha Canal	-	1/10000	33.56 km	12.79 m	19,870 feddan
2	Talt Branch	KM 8.26 of Abo Shosha	1/10000	7.50 km	9.68 m	4,580 feddan
3	Sheikh Abid Branch	KM 22.67 of Abo Shosha	2/10000	2.65 km	8.73 m	1,710 feddan
4	Abo Shosha Branch 1	KM 25.79 of Abo Shoha	1/10000	3.06 km	6.70 m	595 feddan
5	Dushtoot	KM 28.97 of Abo Shoha	1/10000	4.80 km	7.37 m	1,160 feddan

Source: JICA Survey Team

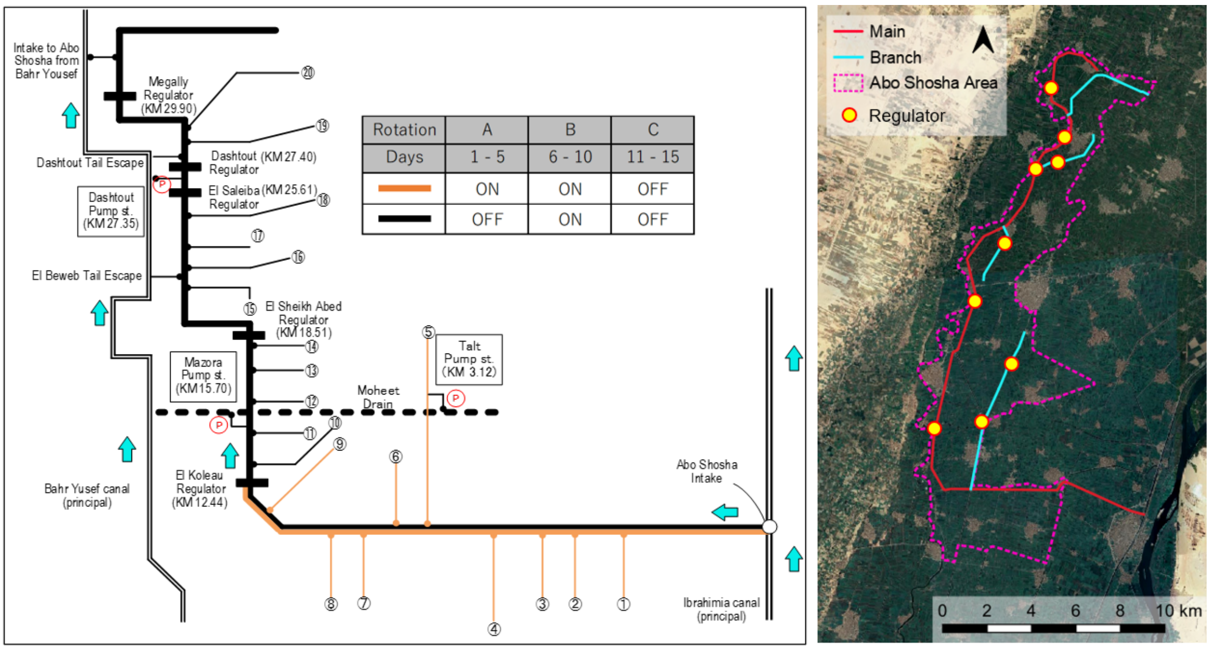


Figure 4.2.8 Schematic Diagram (left), and Location Map (right) of the Abo Shosha Command Area

Source: Irrigation Directorate of Beni Suef and JICA Survey Team

1) Simulation Cases

The discharge volume at the upstream of the Abo Shosha Main Canal is mainly determined by 3 factors, which are rotation (A and B), season (summer or winter), and condition of the hydraulic structure (with/without modern irrigation, and with/without feeder pumps). Considering the purpose of the simulation, the most significant case is the one with the lowest water level, which is the future condition during the winter season without a pump.

The rotation system in the Abo Shosha area is the same regardless of the season, and the canal is clearly separated into 2 sub-areas, upstream and downstream of the Qoleia Regulator (KM 12.64 of the Abo Shosha Main Canal). The upstream area includes the largest branch canal, the Talt Branch, which runs 3,899 feddan. Farmlands located in this sub-area can utilize the water 10 days out of 15 days; therefore, the required water discharge during the one season should be 1.5 times what is required. On the other hand, those in the downstream area can only utilize the water 5 days out of 15, so the intake water volume during the one season should be 3 times what is required.

Furthermore, the 2 sub-areas are in their 5-day off periods at the same time. At this time, there is no water available in the entire Abo Shosha Command Area, a fact that does not have to be considered in the simulation. The rotation system is illustrated in Figure 4.2.8 above. The largest discharge can be seen during rotation B, but the difference in water level between rotation A and B can be seen in the section from the upstream of the Abo Shosha Main Canal to the upstream of the Qoleia Regulator.

Table 4.2.5 organizes the cases for simulation intake volume at the most upstream point of the Abo Shosha Main Canal. As shown in the column “Discharge at the Intake Point,” the intake water volume has a wide range, from 2.34m^3/s to 12.80m^3/s depending on the rotation and feeder pump conditions. It is noted that the smallest and largest discharge conditions can be found in the future condition: the smallest condition in the future winter season, and the largest condition in the future summer condition without feeder pumps.

Table 4.2.5 Simulation Conditions (Abo Shosha Area)

Case No.	Discharge at the Intake Point	Summer Rotation		Winter Rotation		Canal Condition		Regulator Rehabilitation		Feeder Pumps	
						Earthen	Concrete-lined				
		A	B	A	B	(Present)	(Future)	YES	NO	ON	OFF
1	4.16 m^3/s	✓				✓			✓	✓	
2	10.84 m^3/s		✓			✓			✓	✓	
3	2.83 m^3/s			✓		✓			✓		✓
4	8.42 m^3/s				✓	✓			✓		✓
5	2.80 m^3/s	✓					✓	✓		✓	
6	7.30 m^3/s		✓				✓	✓		✓	
7	2.80 m^3/s	✓					✓		✓	✓	
8	7.30 m^3/s		✓				✓		✓	✓	
9	4.30 m^3/s	✓					✓		✓		✓
10	12.80 m^3/s		✓				✓		✓		✓
11	2.34 m^3/s			✓			✓	✓			✓
12	6.96 m^3/s				✓		✓	✓			✓
13	2.34 m^3/s			✓			✓		✓		✓
14	6.96 m^3/s				✓		✓		✓		✓

Source: JICA Survey Team

2) Boundary Conditions of Simulation

The simulation is conducted canal by the canal, which requires knowing the downstream boundary conditions for each canal. In the simulation, the downstream end of each canal is not the tail escape facility, but the connection to Meska. Therefore, the normal depth is applied as the boundary condition of the downstream end.

Table 4.2.6 Boundary Conditions in Abo Shosha Area

Name	Discharge during Summer Season	Discharge during Winter Season	DS Slope (Normal Depth)
Abo Shosha main	2.8 m^3/s – 12.8 m^3/s	2.3 m^3/s – 7.0 m^3/s	1/10,000
Talt branch	0.4 m^3/s – 1.0 m^3/s	1.0 m^3/s – 1.2 m^3/s	1/10,000
Sheikh Abid branch	1.8m^3/s – 2.4 m^3/s	1.0m^3/s – 1.2 m^3/s	1/10,000
Abo Shosha branch 1	0.6m^3/s – 0.8 m^3/s	0.3m^3/s – 0.4 m^3/s	1/10,000
Dushtoot	1.2m^3 – 1.5 m^3/s	0.5m^3/s – 0.8 m^3/s	1/10,000

Source: JICA Survey Team

3) Other Conditions Considered

Intake volumes along the simulation canals are also significant to the effort to simulate the water level at each point. Those intakes are for branches, sub-branches, and sometimes Meskas. In the simulation, a total of 148 intake points is detected by the field survey, and required intake volumes are calculated one by one based on the actual service area delineated in satellite images.

The locations and the intake volume of feeder pumps in the Abo Shosha Command Area are also confirmed and considered in the simulation. As shown in Table 4.2.7, 3 pump stations are found in the area: the Mazora Pump Station, the Dushtoot Pump Station, and the Talt Pump Station. The Mazora and Dushtoot Pump Stations have 6 pump units, and Talt Pump Station has 4 pumps. Their actual functioning condition during each period is set based on hearing from the staff members who are responsible for O/M.

Furthermore, the simulation also considers the actual conditions of regulators. Currently, only the El Qoleia Regulator is under-functioning, although one of two gates is always closed. Required water levels for each branch canal along the Abo Shosha Main Canal are designed by MWRI, so the opening of the gate on the Qoleia Regulator is adjusted as designed in order to ensure satisfactory water levels. Table 4.2.8 shows the required water levels for each branch along the Abo Shosha Main Canal.

Table 4.2.7 Information About Feeder Pump Stations for the Simulation (Abo Shosha Area)

No.	Name	Location	Capacity	Total Discharge	
				Summer	Winter
1	Mazora Pump St.	KM 15.70 of Abo Shosha	0.5 m^3/s x 6 units	2.0 m^3/s (4 units)	0 m^3/s
2	Dushtoot Pump St.	KM 27.35 of Abo Shosha	0.5 m^3/s x 6 units	2.5 m^3/s (5 units)	0 m^3/s
3	Talt Pump St.	KM 3.12 of Talt	0.5 m^3/s x 3 units	1.5 m^3/s (3 units)	0 m^3/s

Source: JICA Survey Team

Table 4.2.8 Information About Regulators for the Simulation (Abo Shosha Area)

No.	Name	Location	Remarks
1	El Qoleia Regulator	KM 12.64 of Abo Shosha	Max./ Min. WL is EL.30.65m / EL. 30.35m
2	El Sheikh Abid Regulator	KM 18.58 of Abo Shosha	Not functioning
3	El Saleiba Regulator	KM 25.80 of Abo Shosha	Not functioning
4	Dushtoot Regulator	KM 27.71 of Abo Shosha	Not functioning
5	Megally Regulator	KM 30.49 of Abo Shosha	Not functioning
6	Talt Regulator1	KM 3.37 of Talt	Not functioning
7	Talt Regulator2	KM 5.92 of Talt	Not functioning
8	Sheikh Abid Regulator	KM 0.82 of Sheikh Abid	Not functioning
9	Abo Shosha Branch1 Regulator	KM 1.13 of Abo Shosha Branch1	Not functioning

Source: JICA Survey Team

Table 4.2.9 Required Water Level at Each Location (Abo Shosha Area)

Name of Branch/Regulator	Location		Required Water Level (Max-Min)
Abo Shosha Branch 1 1st	Abo Shosha	KM 4.3	31.3 m - 30.3 m
Mesqa Aref	Abo Shosha	KM 4.6	31.2 m - 30.3 m
Abo Shosha Branch 2 1st	Abo Shosha	KM 5.4	31.2 m - 30.3 m
Abo Shosha Branch 3 1st	Abo Shosha	KM 6.7	31.1 m - 30.0 m
Talt	Abo Shosha	KM 8.1	30.9 m - 30.3 m
Shawky	Abo Shosha	KM 8.8	30.9 m - 29.8 m

Name of Branch/Regulator	Location		Required Water Level (Max-Min)
Hanna	Abo Shosha	KM 9.2	30.8 m - 29.8 m
Tawfik	Abo Shosha	KM 10.3	30.7 m - 29.8 m
Abo Shosha Branch 1 2nd	Abo Shosha	KM 12.9	30.7 m - 29.7 m
Kamoun	Abo Shosha	KM 14.5	30.3 m - 29.5 m
Mazoura	Abo Shosha	KM 16.3	30.1 m - 29.1 m
Nousir	Abo Shosha	KM 17.1	30.0 m - 29.0 m
Belani	Abo Shosha	KM 18.3	29.8 m - 28.9 m
El Shaikh Abid	Abo Shosha	KM 22.3	29.3 m - 28.5 m
Al Kassaba	Abo Shosha	KM 24.8	29.2 m - 28.3 m
Abo Shosha Branch 2 3rd	Abo Shosha	KM 28.0	28.8 m - 27.9 m
Dushtoot	Abo Shosha	KM 28.5	28.7 m - 27.9 m

Source: Irrigation Directorate of Beni Suef and JICA Survey Team

4) Simulation Result

4.1) Abo Shosha Main Canal

Figure 4.2.9 shows the water levels along the Abo Shosha Main Canal in the present condition. The result indicates the main canal has enough capacity for the maximum discharge condition (present summer condition in rotation B). It also shows that, even under the present minimum discharge condition (rotation A during the winter season), the water level is higher than required level at each intake point.

In the future condition (the condition with concrete lining works for branches and modern irrigation facilities such as sprinklers and drip irrigation for farmlands), the water level decreases by a maximum of 80 cm under rotation B during the summer season. However, considering the comparison between water level and design intake elevation at each intake point, adequate water distribution can be achieved even under the future condition, because there are 5 regulators along the Abo Shosha Main Canal (see Figure 4.2.10).

Currently, none of those regulators are under-functioning except for the Qoleia Regulator, but they will be rehabilitated at the same time as the lining work is performed. Figure 4.2.11 compares the water levels between the current condition and the rehabilitated condition under the future discharge volume. The calculation result indicates the necessity of rehabilitating the regulators, especially the El Sheikh Abid and Megally Regulators. If those regulators remain in their current condition in the future, the water level at some intake points will be lower than that required for adequate water distribution (see the red squares in Figure 4.2.11, Table 4.2.10 (case 8), and Table 4.2.11 (case 14) for more details).

Furthermore, it can be said that introduction of modern irrigation will save energy for the use of feeder pumps because it will help prevent them pumping up more water than required. Figure 4.2.12 compares the water levels with and without the effect of feeder pumps. Even without the feeder pumps, the Abo Shosha Main Canal has enough capacity to flow at the maximum discharge volume, although it will be larger than the current intake volume.

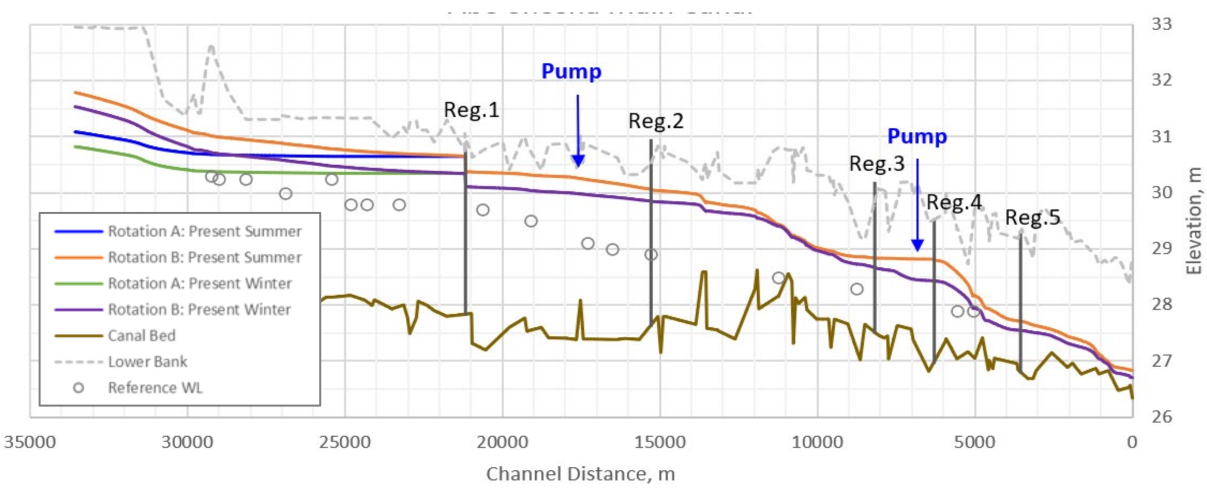


Figure 4.2.9 Water Level Profile Along Abo Shosha Main Canal in the Present Condition
Source: JICA Survey Team

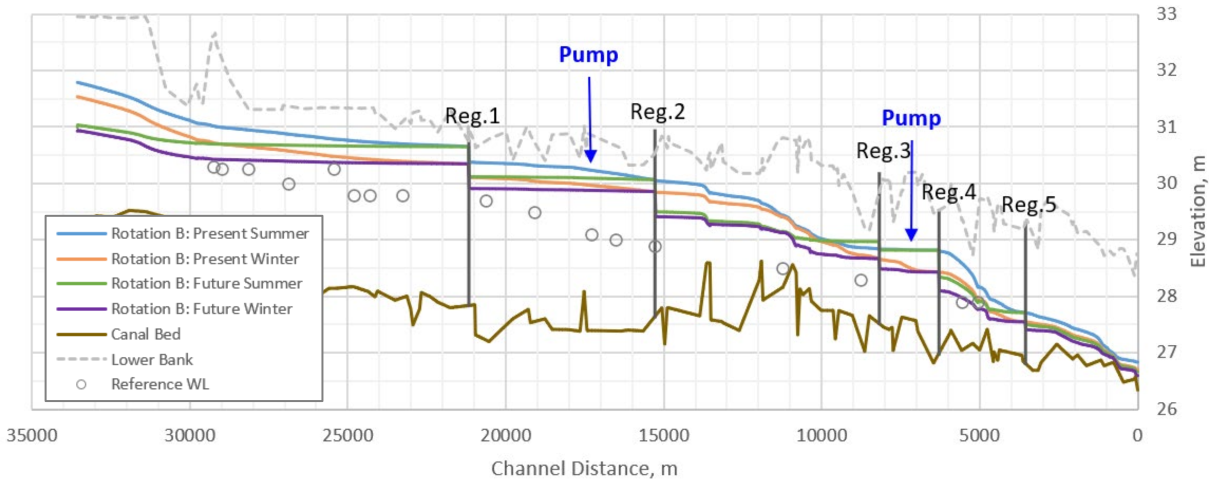


Figure 4.2.10 Water Level Profile Along the Abo Shosha Main Canal (Present vs Future Condition)
Source: JICA Survey Team

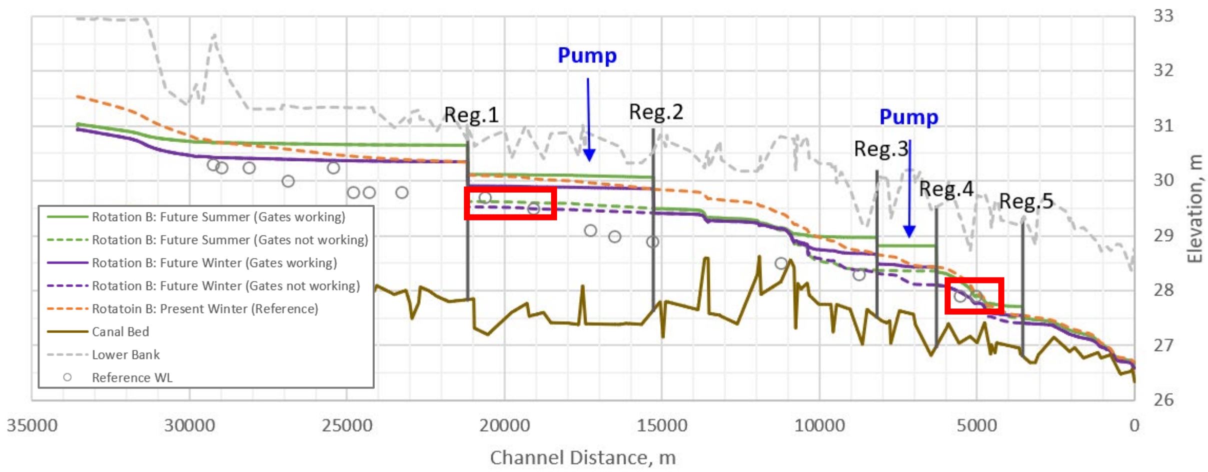


Figure 4.2.11 Water Level Profile Along the Abo Shosha Main Canal (Comparison of Gate Conditions)
Source: JICA Survey Team

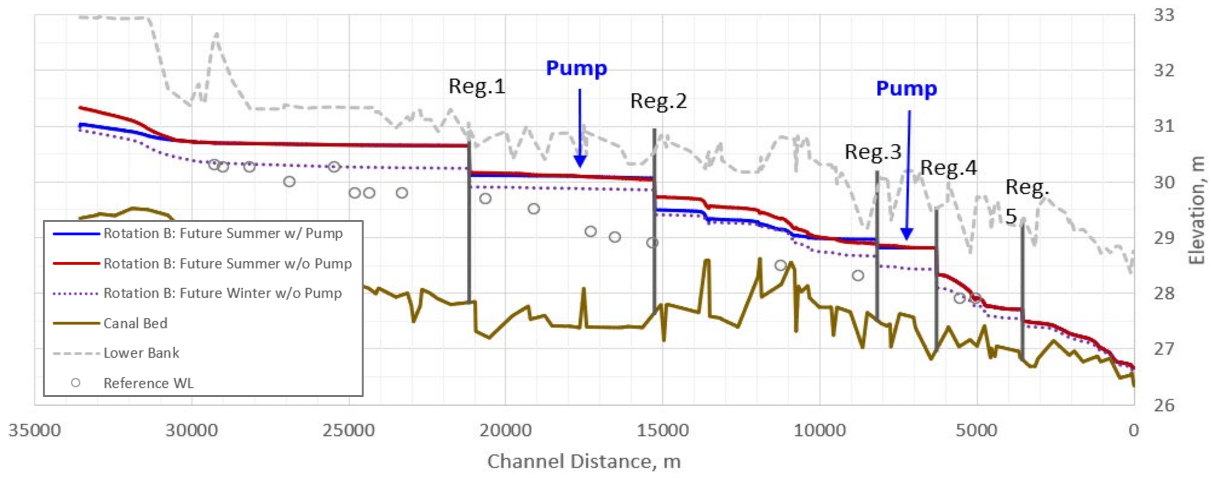


Figure 4.2.12 Water Level Profile Along the Abo Shosha Main Canal (with and without Feeder Pumps)

Source: JICA Survey Team

Table 4.2.10 Water Level at Each Branch and Regulator Along the Abo Shosha Main Canal (Case 1-Case 4)

Branch/ Regulator	Distance km	Intake Elevation EL.m	Water Level, EL.m			
			Case 1	Case 2	Case 3	Case 4
Abo Shosha Branch 1 1st	4.31	30.30	30.683	31.015	30.380	30.718
Mesqa Aref	4.57	30.25	30.679	30.993	30.375	30.695
Abo Shosha Branch 2 1st	5.42	30.25	30.671	30.947	30.368	30.649
Abo Shosha Branch 3 1st	6.68	30.00	30.660	30.874	30.359	30.576
Talt	8.12	30.25	30.651	30.784	30.349	30.477
Shawky	8.75	29.80	30.650	30.754	30.349	30.448
Hanna	9.24	29.80	30.650	30.734	30.349	30.427
Tawfik	10.28	29.80	30.650	30.700	30.349	30.391
US El Qoleia Regulator	12.38	-	30.650	30.655	30.349	30.342
DS El Qoleia Regulator	12.40	-	30.683	30.378	30.349	30.109
Abo Shosha Branch1 2nd	12.91	29.70	-	30.365	-	30.096
Kamoun	14.45	29.50	-	30.317	-	30.041
Mazoura	16.27	29.10	-	30.233	-	29.965
Nousir	17.05	29.00	-	30.173	-	29.925
Belani	18.26	28.90	-	30.067	-	29.855
US El Sheikh Abed Regulator	18.28	-	-	30.066	-	29.855
DS El Sheikh Abed Regulator	18.30	-	-	30.049	-	29.846
El Shaikh Abid	22.31	28.50	-	29.430	-	29.406
Al Kassaba	24.80	28.30	-	28.861	-	28.729
US El Saleiba Regulator	25.37	-	-	28.84	-	28.672
DS El Saleiba Regulator	25.39	-	-	28.837	-	28.657
US Dushtoot Regulator	27.26	-	-	28.814	-	28.432
DS Dushtoot Regulator	27.28	-	-	28.800	-	28.427
Abo Shosha Branch 2 3rd	28.01	27.90	-	28.575	-	28.261
Dushtoot	28.51	27.90	-	28.157	-	27.938
US Megally Regulator	30.00	-	-	27.711	-	27.548
DS Megally Regulator	30.02	-	-	27.707	-	27.546

Source: JICA Survey Team

Table 4.2.11 Water Level at Each Branch and Regulator Along Abo Shosha Main Canal (Case 5-Case 10)

Branch/Regulator	Distance km	Intake Elevation EL.m	Water Level, EL.m					
			Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
Abo Shosha Branch 1 1st	4.31	30.30	30.648	30.556	30.653	30.697	30.659	30.528
Mesqa Aref	4.57	30.25	30.648	30.553	30.653	30.695	30.658	30.518
Abo Shosha Branch 2 1st	5.42	30.25	30.647	30.544	30.652	30.688	30.656	30.484
Abo Shosha Branch 3 1st	6.68	30.00	30.646	30.53	30.651	30.677	30.653	30.427
Talt	8.12	30.25	30.645	30.514	30.650	30.665	30.650	30.355
Shawky	8.75	29.80	30.645	30.509	30.650	30.661	30.650	30.337
Hanna	9.24	29.80	30.645	30.506	30.650	30.658	30.650	30.323
Tawfik	10.28	29.80	30.645	30.501	30.650	30.654	30.650	30.300
US El Qoleia Regulator	12.38	-	30.645	30.494	30.650	30.649	30.650	30.267
DS El Qoleia Regulator	12.40	-	-	30.118	-	29.626	-	30.153
Abo Shosha Branch 1 2nd	12.91	29.70	-	30.116	-	29.622	-	30.147

Branch/Regulator	Distance km	Intake Elevation EL.m	Water Level, EL.m					
			Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
Kamoun	14.45	29.50	-	30.107	-	29.6	-	30.111
Mazoura	16.27	29.10	-	30.091	-	29.562	-	30.073
Nousir	17.05	29.00	-	30.081	-	29.539	-	30.054
Belani	18.26	28.90	-	30.066	-	29.503	-	30.021
US El Sheikh Abed Regulator	18.28	-	-	30.066	-	29.503	-	30.022
DS El Sheikh Abed Regulator	18.30	-	-	29.498	-	29.49	-	29.730
El Shaikh Abid	22.31	28.50	-	29.141	-	29.101	-	29.337
Al Kassaba	24.80	28.30	-	28.97	-	28.389	-	28.907
US El Saleiba Regulator	25.37	-	-	28.968	-	28.374	-	28.886
DS El Saleiba Regulator	25.39	-	-	28.818	-	28.368	-	28.863
US Dushtoot Regulator	27.26	-	-	28.814	-	28.353	-	28.814
DS Dushtoot Regulator	27.28	-	-	28.346	-	28.336	-	28.337
Abo Shosha Branch 2 3rd	28.01	27.90	-	28.189	-	28.17	-	28.172
Dushtoot	28.51	27.90	-	27.967	-	27.875	-	27.888
US Megally Regulator	30.00	-	-	27.900	-	27.501	-	27.711
DS Megally Regulator	30.02	-	-	27.499	-	27.499	-	27.499

Note: Values highlighted in red show the sections with lower water levels than the required level.
Source: JICA Survey Team

Table 4.2.12 Water Level at Each Branch and Regulator Along the Abo Shosha Main Canal (Case 11-Case 14)

Branch/ Regulator	Distance km	Intake Elevation EL.m	Water Level, EL.m			
			Case 11	Case 12	Case 13	Case 14
Abo Shosha Branch 1 1st	4.31	30.30	30.351	30.336	30.354	30.426
Mesqa Aref	4.57	30.25	30.351	30.332	30.354	30.422
Abo Shosha Branch 2 1st	5.42	30.25	30.349	30.318	30.353	30.411
Abo Shosha Branch 3 1st	6.68	30.00	30.348	30.296	30.351	30.392
Talt	8.12	30.25	30.346	30.271	30.349	30.371
Shawky	8.75	29.80	30.346	30.265	30.350	30.366
Hanna	9.24	29.80	30.346	30.260	30.350	30.362
Tawfik	10.28	29.80	30.346	30.253	30.350	30.356
US El Qoleia Regulator	12.38	-	30.346	30.242	30.350	30.347
DS El Qoleia Regulator	12.40	-	-	29.908	-	29.529
Abo Shosha Branch 1 2nd	12.91	29.70	-	29.906	-	29.524
Kamoun	14.45	29.50	-	29.890	-	29.492
Mazoura	16.27	29.10	-	29.875	-	29.459
Nousir	17.05	29.00	-	29.867	-	29.443
Belani	18.26	28.90	-	29.855	-	29.417
US El Sheikh Abed Regulator	18.28	-	-	29.855	-	29.418
DS El Sheikh Abed Regulator	18.30	-	-	29.411	-	29.41
El Shaikh Abid	22.31	28.50	-	29.129	-	29.126
Al Kassaba	24.80	28.30	-	28.693	-	28.375
US El Saleiba Regulator	25.37	-	-	28.682	-	28.331
DS El Saleiba Regulator	25.39	-	-	28.520	-	28.311
US Dushtoot Regulator	27.26	-	-	28.471	-	28.103
DS Dashtout Regulator	27.28	-	-	28.130	-	28.097
Abo Shosha Branch2 3rd	28.01	27.90	-	28.032	-	27.972
Dushtoot	28.51	27.90	-	27.923	-	27.765
US Megally Regulator	30.00	-	-	27.90	-	27.410
DS Megally Regulator	30.02	-	-	27.408	-	27.408

Note: Values highlighted in red show the sections with lower water levels than the required level.
Source: JICA Survey Team

4.2) Branch Canals Under the Abo Shosha Main Canal

The change in water level between the present and future conditions is examined for the Talt Branch, the Sheikh Abid Branch, Abo Shosha Branch 1, and the Dushtoot Branch. The cases given in the simulation for branch canals are summarized in Table 4.2.13. The cases considered for those branches are relatively simple because there is no change in discharge volume by rotation system. Note that the Talt Branch, the biggest branch in Abo Shosha Area, has one drainage pump, which is assumed to work in the present condition but not in the future condition.

Table 4.2.13 Simulation Conditions (Abo Shosha Area)

Case No.	Unit Discharge at the Intake Point	Season		Canal Condition		Regulator Rehabilitation		Remarks
		Summer	Winter	Earthen (Present)	Concrete-lined (Future)	YES	NO	
1	1.00 L/s/ha	✓		✓			✓	Drainage pump is OFF in future condition for Talt branch
2	0.50 L/s/ha		✓	✓			✓	
3	0.76 L/s/ha	✓			✓	✓		
4	0.41 L/s/ha		✓		✓	✓		

Source: JICA Survey Team

Figures 4.2.13 to 4.2.16 show the water profiles in each case. The results indicate that all the branches examined have enough capacity to flow at the maximum volume in the current summer season, and the decrease in water level between the present and future conditions will be 20cm to 25cm. Currently, all the regulators along the branch canals are not working, and those need to be rehabilitated to mitigate the negative impact of modern irrigation. Based on the bank elevation, there is no limitation on the ability of all the regulators examined to raise the water level up to the elevation that is recorded in the present condition.

However, branches where no regulator is equipped may have problems in water distribution. For example, the water level cannot be adjusted for more than 4.5km along the Dushtoot Branch Canal, which is much longer than the other branch in the model (less than 2km for other branches). Based on this result, the JICA Survey Team had discussions with the Irrigation Directorate in Beni Suef to inquire if there is any problem when the water level decreases by 20cm along all the sections of the Dushtoot Branch Canal, and determined the irrigation facilities for rehabilitation covered by the Japanese yen loan project, as shown in the previous sub-chapter, “4.3 Irrigation Improvement: Hydraulic Structure.”

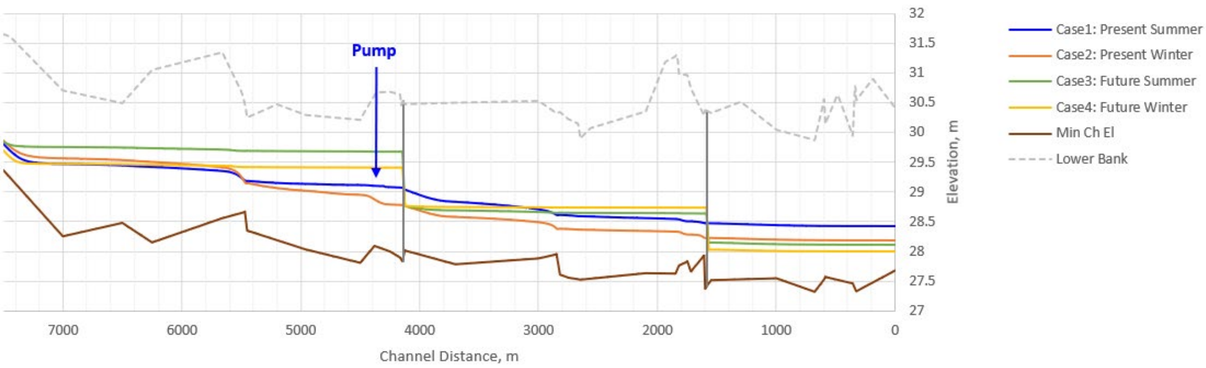


Figure 4.2.13 Water Level Profile Along the Talt Branch Canal (Present vs Future Condition)

Source: JICA Survey Team

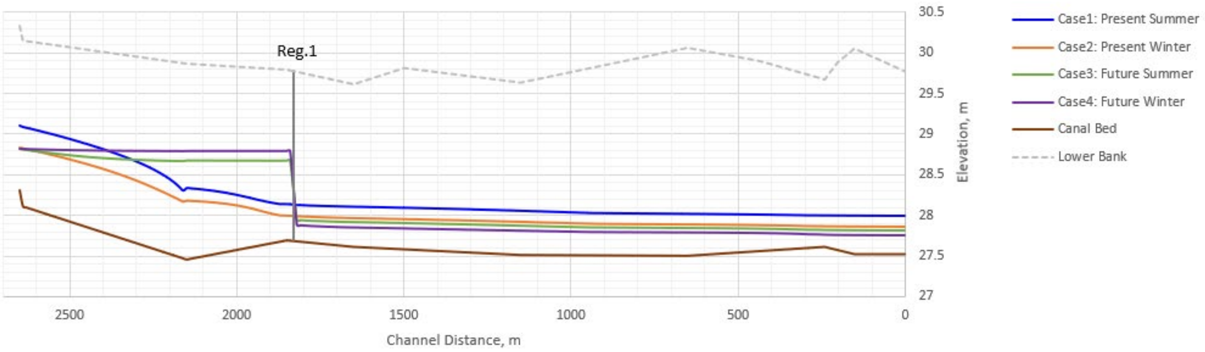


Figure 4.2.14 Water Level Profile Along the Sheikh Abid Branch Canal (Present vs Future Condition)

Source: JICA Survey Team

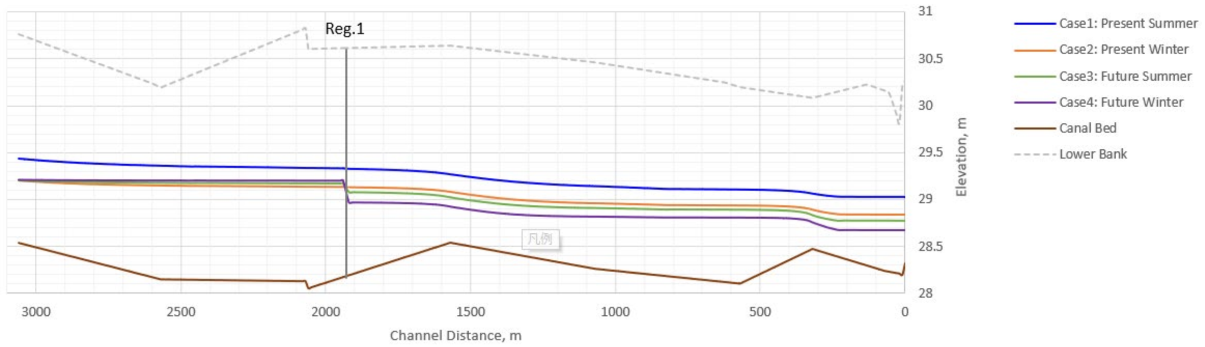


Figure 4.2.15 Water Level Profile Along Abo Shosha Branch Canal 1 (Present vs Future Condition)

Source: JICA Survey Team

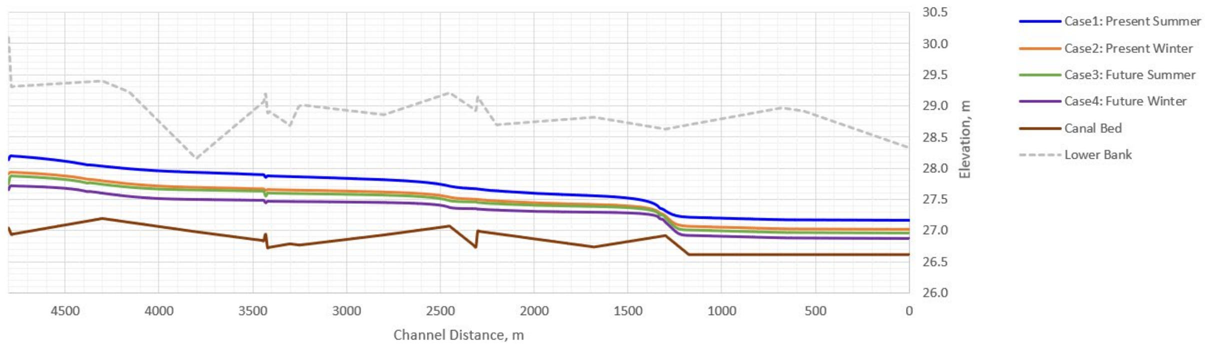


Figure 4.2.16 Water Level Profile Along the Dushtoot Branch Canal (Present vs Future Condition)

Source: JICA Survey Team

Table 4.2.14 Decrease in Water Level in the Future Condition (Abo Shosha Area)

Canal Name	Maximum Decrease in Water Level	Remarks
Abo Shosha Main Canal	60cm	Confirmed that no problem will occur in the intake structure if the current regulators are rehabilitated.
Talt Branch Canal	20cm	At the same time lining work is done, regulators should be rehabilitated to mitigate the impact of the decrease in water level.
Sheikh Abid Branch Canal	25cm	
Abo Shosha Branch Canal 1	20cm	
Dushtoot Branch Canal	22cm	There are no water regulating facilities

Source: JICA Survey Team

4.2.4 The Aros and Abo Seer Area

The Aros and Abo Seer Main Canal, located in Fayoum Governorate, cover a combined 13,565 feddan of the service area (10,974 feddan and 2,591 feddan, respectively). Their water resources come from the Bahr Yusef Principal Canal. One of the most distinct features of the irrigation canals in Fayoum is their slope. It ranges from a 5cm to an 11cm drop by 1km in Fayoum, compared to a 1cm drop by 1km in other areas (Kased, Abo Shosha, Ibrahimia, and Bahr Yusef Canals). That makes weirs and regulators more important in this area.

Another feature of the area is the type of weir facility. There is no weir with gates in the area, and the water level is raised by the width of weirs at the design stage (width B is designed from 0.3m to 7.7m according to discharge volume). MWRI staff responsible for operation and maintenance regularly check the water depth at the crests of weirs to confirm whether the required discharge volume (called the water duty) is secured.

In this context, the purpose of the hydraulic simulation is to confirm that adequate water distribution can be achieved even under the future condition. In the future condition (the condition under the most severe case for water levels), it is assumed that all the canal is concrete-lined and modern on-farm irrigation facilities have been built, which will improve irrigation efficiency by 32% compared to the current condition. A decrease in water level due to better irrigation efficiency is especially critical in the area because there is no gate on the weirs to adjust the water level.

For this simulation, the following 5 canals are selected, and their lengths, widths, and service areas are considered: the Aros Main Canal, the Defno and Dayr Defno Branch Canal, the Abo El Meir Branch Canal, the El Ghaba Branch Canal, and the Abo Seer Main Canal. Table 4.2.15 summarizes the basic information about the canals.

Table 4.2.15 Information About Canals for the Simulation (Aros and Abo Seer Area)

No.	Name	Location	Slope	Length	Width	Service Area
1	Aros Main Canal	KM 306.4 of Bahr Yusef	5/10000	9.60 km	12.0 m	10,974 feddan
2	Defno and Dayr Defno Branch Canal	KM 5.7 of Aros	6/10000	8.20 km	7.1 m	2,275 feddan
3	Abo El Meir Branch Canal	DS end of Aros	11/10000	7.59 km	8.2 m	2,619 feddan
4	El Ghaba Branch Canal	DS end of Aros	6/10000	10.00 km	6.39 m	2,076 feddan
5	Abo Seer Main Canal	KM 305.7 of Bahr Yusef	7/10000	4.50 km	8.38 m	2,591 feddan

Source: JICA Survey Team

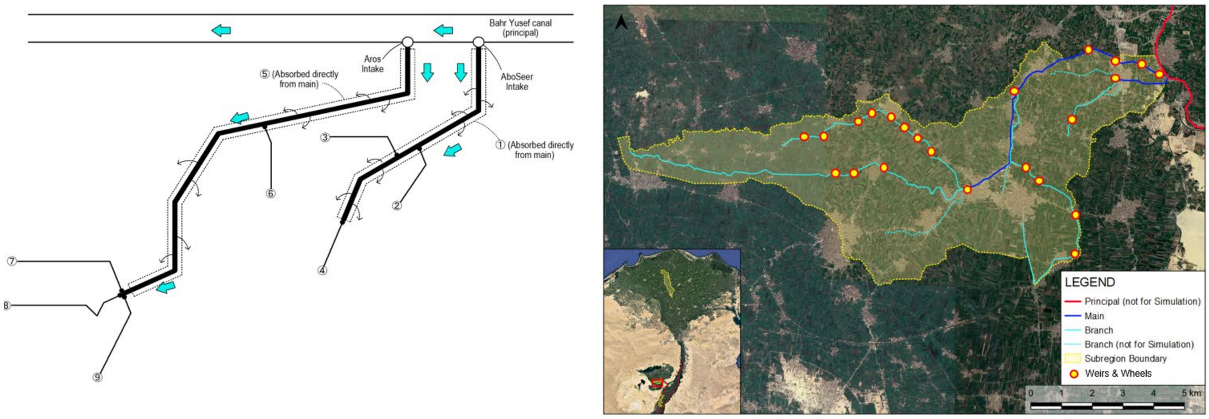


Figure 4.2.17 Schematic Diagram (left), and Location Map (right) of the Aros and Abo Seer Area

Source: JICA Survey Team

1) Simulation Cases

These simulation cases are very simple because continuous flow is applied in this area, unlike in the other regions, which have 2 or 3 rotation systems. In addition, there is no gate facility or drainage pump station in the area. A total of 4 cases are considered: the present summer condition, the present winter condition, the future summer condition, and the future winter condition. Future conditions are set as the most severe conditions, in which irrigation efficiency is up 32% compared to the present condition due to canal concrete-lining and modern on-farm irrigation facilities such as sprinklers and drip facilities. Furthermore, the design cross-section given by the Irrigation Directorate of Fayoum is applied, whereas the current cross-section is based on the result of the topographic survey.

Table 4.2.16 Simulation Conditions (Aros and Abo Seer Area)

Canal	Case No.	Discharge (m^3/s)	Season		Canal Condition		Remark
			Summer	Winter	Current Cross-section with Earthen (Present)	Design Cross-section with Concrete-lined (Future)	
Aros Main Canal	1	2.50	✓		✓		Obtained from Fayoum Irrigation Directorate
	2	1.90		✓	✓		
	3	1.92	✓			✓	Calculated discharge based on the increase in irrigation efficiency
	4	1.46		✓		✓	
Abo Seer Main Canal	1	0.59	✓		✓		Obtained from Fayoum Irrigation Directorate
	2	0.45		✓	✓		
	3	0.45	✓			✓	Calculated discharge based on the increase in irrigation efficiency
	4	0.34		✓		✓	

Source: Fayoum Irrigation Directorate and JICA Survey Team

2) Boundary Conditions of Simulation

The simulation is conducted canal by canal, which means the downstream boundary conditions for each canal are required. In the simulation, the downstream end of each canal is not the tail escape facility but the connection to Meska. Therefore, normal depth is applied as the boundary condition of the downstream end.

Table 4.2.17 Boundary Conditions in the Aros and Abo Seer Area

Name	Discharge During Summer Season	Discharge During Winter Season	DS Slope (Normal Depth)
Aros Main Canal	1.92 m^3/s – 2.50 m^3/s	1.46 m^3/s – 1.92 m^3/s	5/10,000
Defno & Dayr Defno Branch Canal	0.40 m^3/s – 0.52 m^3/s	0.30 m^3/s – 0.39 m^3/s	6/10,000
Abo El Meir Branch Canal	0.46 m^3/s – 0.60 m^3/s	0.35 m^3/s – 0.45 m^3/s	11/10,000
El Ghaba Branch Canal	0.36 m^3/s – 0.47 m^3/s	0.28 m^3/s – 0.36 m^3/s	6/10,000
Abo Seer Main Canal	0.45 m^3 – 0.59 m^3/s	0.34 m^3/s – 0.45 m^3/s	7/10,000

Source: JICA Survey Team

3) Other Conditions Considered

In the Aros and Abo Seer Area, the water level is controlled by checking the water depth at the crests of weirs, using a calculation table to convert from water depth to discharge. The JICA Survey Team obtained the calculation table from the Irrigation Directorate of Fayoum to adjust the weir coefficient and to make a model with better accuracy. Discharge volumes at each intake are calculated based on the service area for each branch and Meska, the boundary of which is delineated using satellite images. Those service areas are double the ones in the official document obtained from the Irrigation Directorate of Fayoum.

Furthermore, the Irrigation Directorate of Fayoum is planning to apply the original design cross-sections when canals are rehabilitated. Therefore, JICA Survey Team conducted the simulation based on the design cross-sections as much as possible, not on the cross-section for the future condition determined by the topographic survey. However, the design cross-section for El Ghaba Branch Canal was modified by JICA Survey Team because significant discrepancies in elevation between design and actual elevation were found (Figure 4.2.18).

As for the hydraulic structures, weirs and wheels (Sakias) are considered as elements of the present condition. Their dimensions are mainly based on the data provided by the Fayoum Irrigation Directorate. Earthen canals with a roughness coefficient of n=0.03 are included in the present condition, and concrete-lined canals with a coefficient of n=0.015 in the future condition.

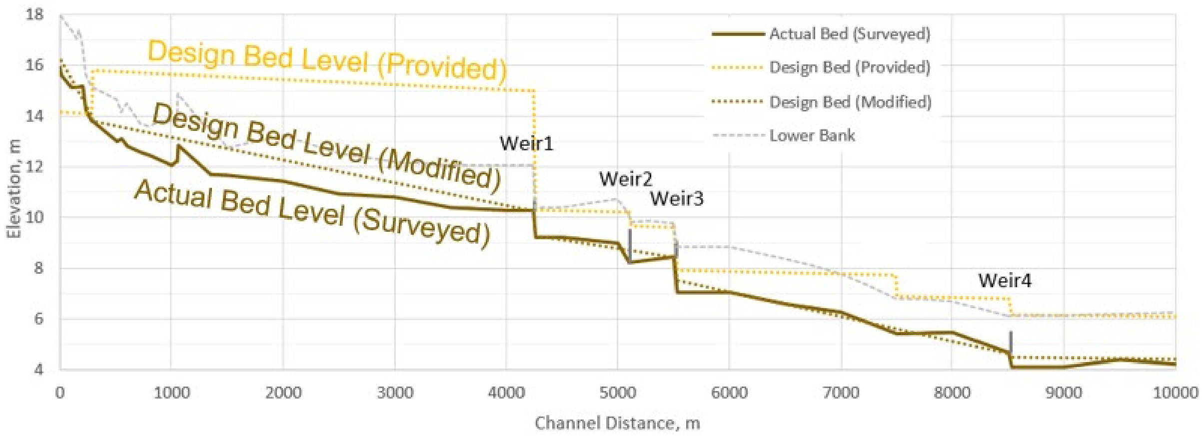


Figure 4.2.18 Comparison of Canal Bed Elevations Along the El Ghaba Branch Canal Among Actual (Brown Line), Original Design (Yellow Break Line), and Modified Design (Brown Break Line)

Source: Fayoum Irrigation Directorate, JICA Survey Team

Table 4.2.18 Information About Weirs and Wheels for the Simulation (Aros and Abo Seer Area)

No.	Name	Location	Remarks
1	Aros Weir	KM 0.23 of Aros	Crest Width = 6.50m. 2 pipes (R=0.6m) were illegally equipped by farmers
2	Water Wheel 1	KM 1.30 of Aros	Only 1 of 5 wheels is in operation
3	Water Wheel 2	KM 1.79 of Aros	None of the wheels is in operation
4	Water Wheel 3	KM 2.73 of Aros	None of the wheels is in operation
5	Bahr Defno Weir	KM 5.71 of Aros	Crest Width = 7.70m, No Gate
6	El Barq Weir	KM 6.03 of Aros	Crest Width = 6.65m, No Gate
7	El Kashef Weir	KM 1.78 of Abo Seer	Crest Width = 2.00m, No Gate
8	Abo Seer Extension Intake	KM 3.77 of Abo Seer	Crest Width = 0.35m, No Gate
9	Nasbet Isaak Pasha Weir	KM 1.81 of Abo El Meir	Crest Width = 2.30m
10	Nasbet El Nesf Weir	KM 3.21 of Abo El Meir	Crest Width = 0.75m
11	Nasbet El Elaw Weir	KM 3.67 of Abo El Meir	Crest Width = 0.70m
12	Nasbet El Qobaly Weir 1	KM 4.01 of Abo El Meir	Crest Width = 1.00m
13	Nasbet El Qobaly Weir 2	KM 4.40 of Abo El Meir	Crest Width = 0.50m
14	Nasbet El Khoms Weir	KM 4.94 of Abo El Meir	Crest Width = 0.45m
15	Nasbet Geaid Weir	KM 6.30 of Abo El Meir	Crest Width = 0.35m
16	Nasbet El Mahaosh Weir	KM 6.97 of Abo El Meir	Crest Width = 0.30m
17	El Wosta Weir	KM 4.25 of El Ghaba	Crest Width = 0.60m
18	Nasbet El Ramlaat Weir	KM 5.11 of El Ghaba	Crest Width = 0.60m
19	El Wosta Weir No.4	KM 5.52 of El Ghaba	Crest Width = 0.50m
20	El Wosta Weir No.5	KM 8.52 of El Ghaba	Crest Width = 0.45m
21	Dayr Defno Intake	KM 2.50 of Defno	Crest Width = 1.00m
22	Dayr Defno Weir	KM 1.21 of Dayr Defno	Crest Width = 2.50m
23	Dayr Defno Weir 2	KM 1.92 of Dayr Defno	Crest Width = 2.50m
24	Dayr Defno Weir 3	KM 2.91 of Dayr Defno	Crest Width = 0.75m
25	Dayr Defno Weir 4	KM 4.21 of Dayr Defno	Crest Width = 1.90m
26	Dayr Defno Weir 5	KM 4.71 of Dayr Defno	Crest Width = 1.00m

Source: JICA Survey Team

4) Simulation Result

The water level along each canal and condition is shown in Figures 4.2.19 to 4.2.24. As a result of hydraulic calculations under the present condition, the JICA Survey Team found all the target main canals and branches have enough capacity to flow at the maximum discharge without any overflow. Basically, the canal bed elevation of design cross-sections is higher than the current bed elevation for the most part, which indicates more dredging work than required has been done. However, given the condition of the weirs governing the water level, the impact of the difference in bed elevation on the water level is limited.

4.1) Aros Main Canal

A significant drop in water level is found downstream of the El Barq Weir (between 3,200m and 3,600m in Figure 4.2.19). According to the Irrigation Directorate, however, no problem occurs due to the drop in water level because no intake facility is constructed along this section.

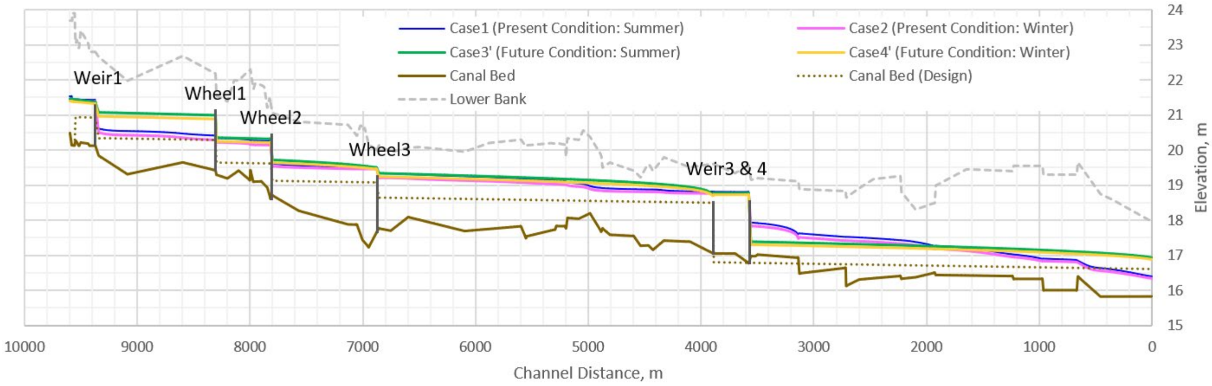


Figure 4.2.19 Water Level Profile Along the Aros Main Canal (Present vs Future Condition)
Source: JICA Survey Team

4.2) Abo Seer Main Canal

In the Abo Seer Main Canal, the difference between the design canal bed and the actual canal bed varies by section. Generally, the current canal bed is higher than the design bed in front of the weirs, whereas the design bed level is higher in the other sections. As a result, the future water level will be lower than the current water level by 30cm to 38cm. It should be noted that the Irrigation Directorate of Fayoum will check if this change in water level creates any problem with adequate water distribution.

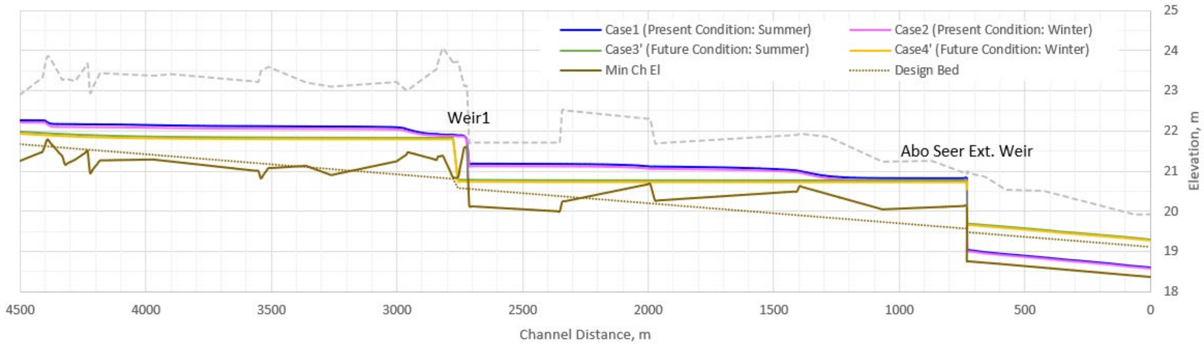


Figure 4.2.20 Water Level Profile Along the Abo Seer Main Canal (Present vs Future Condition)
Source: JICA Survey Team

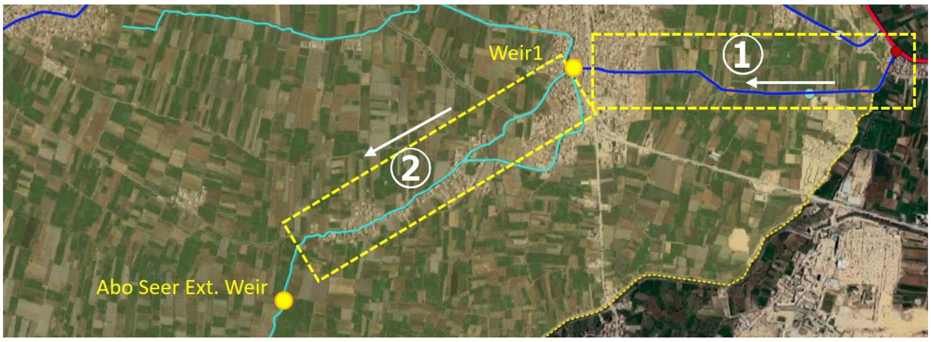


Figure 4.2.21 Section Where the Water Level Will Drop in the Future Condition (Abo Seer Main Canal)
Source: JICA Survey Team

4.3) Branch Canals under the Aros Main Canal

The Abo El Meir Branch Canal, El Ghaba Branch Canal, and Defno (with Dair Defno) Branch Canal are selected, and their canal lengths and service areas are considered in this simulation. Along those branch canals, the difference in water level between present and future conditions will basically be less than 10cm because there are many weirs, although the local differences will become large due to sudden changes in bed levels, such as those in the section 2,000m downstream of the Abo El Meir Branch Canal (30cm) and the section 3,000m downstream of the El Ghaba Branch Canal (23cm).

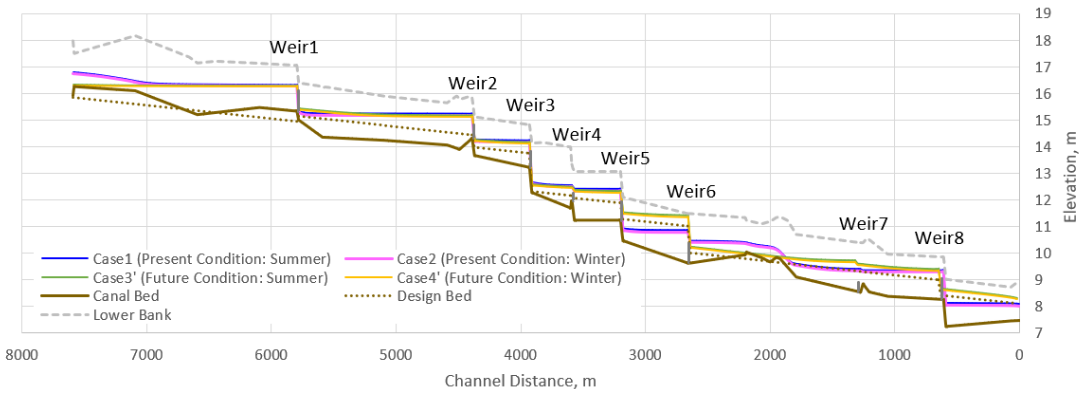


Figure 4.2.22 Water Level Profile Along the Abo El Meir Branch Canal (Present vs Future Condition)

Source: Irrigation Directorate of Fayoum and JICA Survey Team

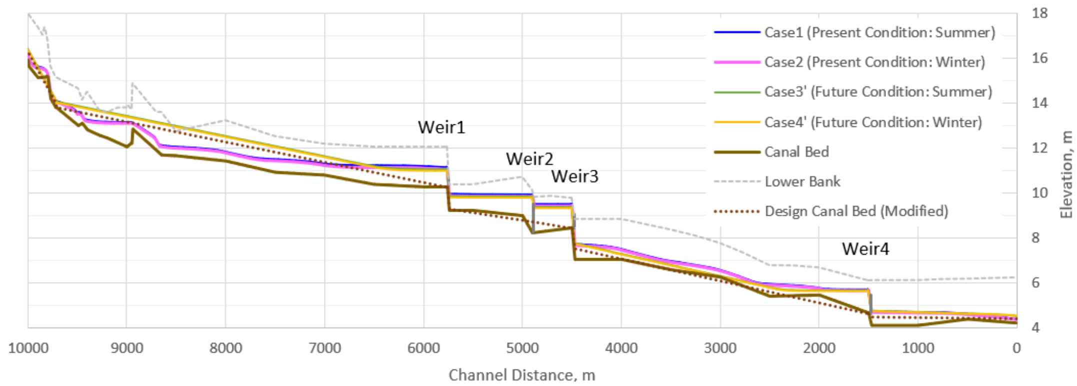


Figure 4.2.23 Water Level Profile Along the El Ghaba Branch Canal (Present vs Future Condition)

Source: Irrigation Directorate of Fayoum and JICA Survey Team

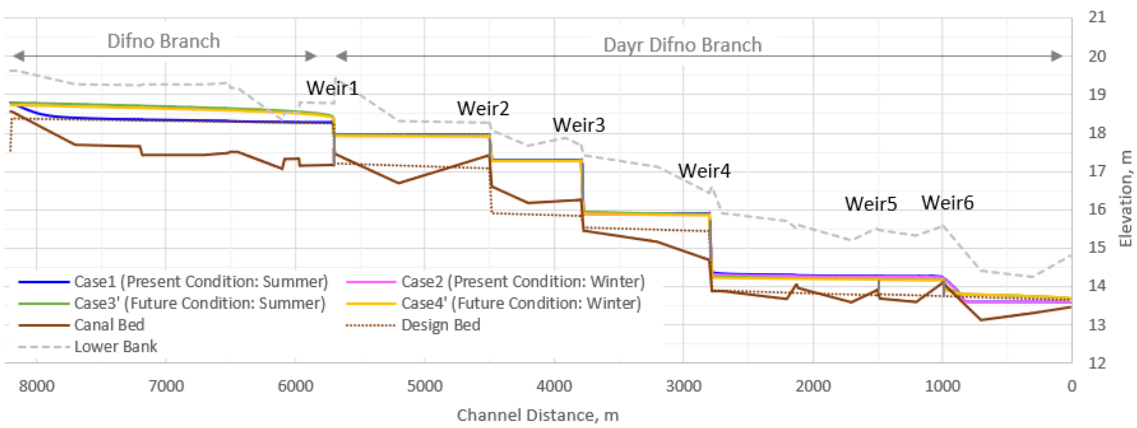


Figure 4.2.24 Water Level Profile Along the Defno and Dayr Defno Branch Canal (Present vs Future Condition)

Source: Irrigation Directorate of Fayoum and JICA Survey Team

Table 4.2.19 Decrease in Water Level in Future Condition (Abo Shosha Area)

Canal Name	Maximum decrease in Water Level	Remarks
Aros Main Canal	56cm	Along the section from 3,200m to 3,600m from the downstream end.
Abo Seer Main Canal	30cm and 38cm	Along the sections from 1,300m to 2,700m, and 2,900m to 4,500m, from the downstream end.
Abo El Meir Branch Canal	30cm	Along the section from 1,800m to 2,200m from the downstream end.
El Ghaba Branch Canal	23cm	At the section 3,000m from the downstream end.
Defno & Daur Defno Branch Canal	< 6cm	

Source: JICA Survey Team

4.2.5 Kased Main Canal Command Area

The Kased Main Canal covers 94,310 feddan of service area, and its water resources come from the Tanta Navigation Canal. The Kased Main Canal has 44 branches/sub-branches in the area flowing into one of the largest cities in the Nile Delta, Tanta. Of these, 5 branches are selected for simulation along with the Kased Main Canal, namely the Gannabeit Shabshir Branch Canal, the Smella Branch Canal, the Damat Branch Canal, and Samahat Branch Canal. Their lengths and service areas, and the balance of their rotation irrigation systems (see Figure 4.2.25), are considered. The slope of the main canal and branches is approximately 1/10,000, according to the result of topographic survey.

One of the features in the Kased Main Canal is that there is no intake facility at the confluence of the Tanta Navigation Canal and the Kased Main Canal. Currently, discharge volume toward the Kased Command Area is adjusted by the Batanonya Lock, located 9.4 km downstream from the confluence point of the Kased Command Area, which apparently makes adequate water distribution with high efficiency difficult. Therefore, the simulation also examines the need for a new intake facility together with maximum design water level at the intake point of the Kased Main Canal.

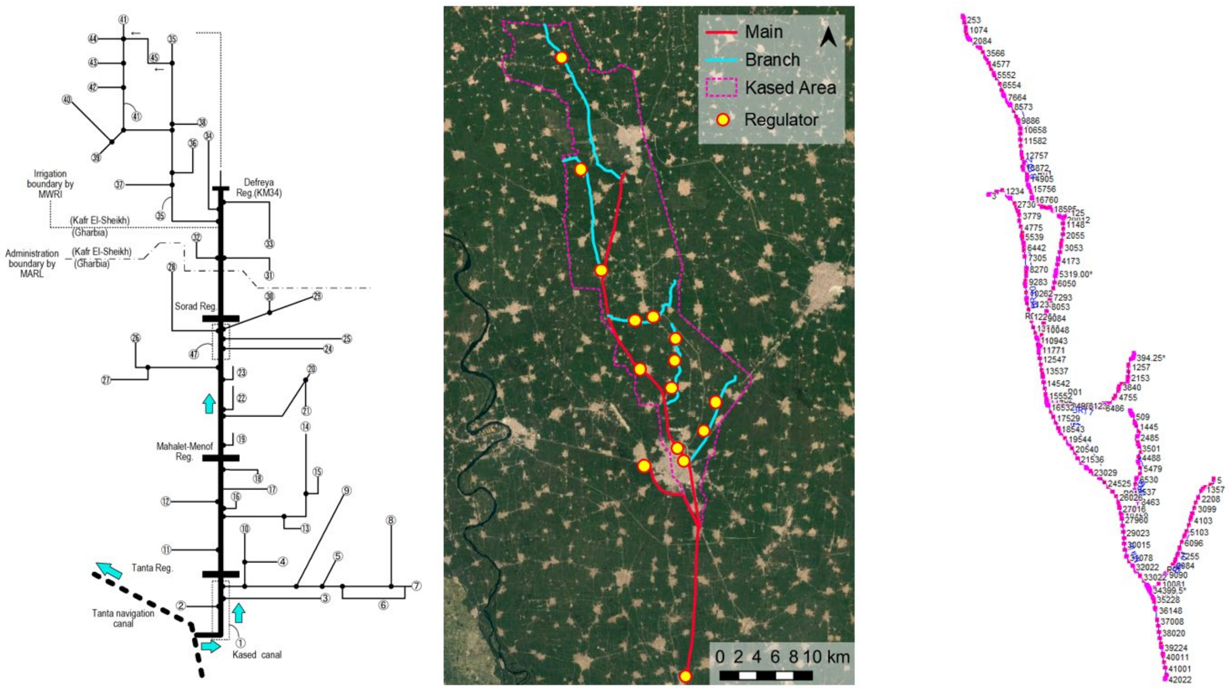


Figure 4.2.25 Schematic Diagram (left), Location Map (center), and Simulation Model of the Kased Area

Source: JICA Survey Team

Table 4.2.20 Information About Canals for the Simulation (Kased Area)

No.	Name	Location	Slope	Length	Width	Service Area
1	Tanta Navigation Canal	US of Kased	1/10000	25.6 km	45.8 m	-
2	Kased	-	1/10000	42.0 km	29.8 m	94,310 feddan
3	Gannabit Shabshir	KM 7.3 of Kased	1/10000	11.0 km	8.5 m	14,115 feddan
4	Smella	KM 14.4 of Kased	1/10000	10.5 km	8.8 m	5,506 feddan
5	Damat	KM 26.1 of Kased	1/10000	11.5 km	10.6 m	5,306 feddan
6	Al Samahat	KM 30.2 of Kased	1/10000	15.2 km	10.9 m	6,307 feddan
7	Rowena	KM 41.2 of Kased	1/10000	20.0 km	22.6 m,	29,604 feddan

Source: JICA Survey Team

Table 4.2.21 Information About Regulators for the Simulation

No.	Name	Location	Remarks
1	Intake of Tanta Nav. Canal	KM 0.0 of Tanta Nav.	Max. WL is EL.10.65 with 70m^3/s at the DS point
2	Batanonya Lock	KM 25.6 of Tanta Nav.	Max. WL is EL.8.6m
3	Tanta 1 Reg.	KM 7.3 of Kased	For facility stabilization, the difference in WL of US/DS should be less than 1.1m
4	Tanta 2 Reg.	KM 8.1 of Kased	Not functioning
5	Mahlet Menouf Reg.	KM 19.4 of Kased	Not functioning
6	Sorad Reg.	KM 30.3 of Kased	For facility stabilization, the difference in WL of US/DS should be less than 1.3m
7	Ragdeia Reg.	KM 4.3 of Gann. Shabshir	
8	Gannabeit Shabshir Reg.	KM 7.1 of Gann. Shabshir	
9	Smella Reg. 1	KM 2.9 of Smella	
10	Smella Reg. 2	KM 5.9 of Smella	There is no gate
11	Smella Reg. 3	KM 8.1 of Smella	Not functioning
12	Damat Reg. 1	KM 4.1 of Damat	Not functioning
13	Damat Reg. 2	KM 6.0 of Damat	There is no gate
14	Samahat Reg.	KM 13.3 of Samahat	There is no gate
15	Rowena Reg.	KM 16.0 of Rowena	

Source: JICA Survey Team

1) Simulation Cases

For the simulation cases, there are 3 discharge conditions (maximum and minimum Q in 2021, and minimum Q in 2022), 5 rotation system conditions (2 for the summer season and 3 for the winter season), 2 canal conditions (non-lined or concrete-lined), and 2 conditions for availability of existing regulators (functioning or not).

It is noted that the minimum Q in 2022 is applied only under the concrete-lined condition for branch canals, which is used to evaluate the most severe condition in the future to maintain the water level that enables the adequate water distribution. Furthermore, considering the off period of the rotation, discharge volume to the branches in Kased Command Area should be calculated as twice the one actually required for the summer and thrice that for winter season.

Figures 4.2.26 and 4.2.27 show the schematic diagram of the rotation system during the summer and winter seasons, which indicates that a change in rotation system can affect the water level along the main canal. For example, all the beneficiary areas upstream of the Tanta 1 Regulator belong to the area of rotation A during the summer season, which assumes a higher water level upstream of the Tanta 1 Regulator during the period of the summer rotation B. The evaluation should be done according to the most severe condition.

Table 4.2.22 Simulation Conditions for the Maximum Discharge in 2021 (52.0m^3/s)

Case	Summer Rotation		Winter Rotation			Canal Condition		Regulator	
	A	B	A	B	C	Non-Lined	Concrete-Lined	Present Condition	Improved Condition
2021Max_SA_NL_PC	✓					✓		✓	
2021Max_SB_NL_PC		✓				✓		✓	
2021Max_WA_NL_PC			✓			✓		✓	

Source: JICA Survey Team

Table 4.2.23 Simulation Conditions for the Minimum Discharge in 2021 (18.0m3/s)

Case	Summer Rotation		Winter Rotation			Canal Condition		Regulator	
	A	B	A	B	C	Non-Lined	Concrete-Lined	Present Condition	Improved Condition
2021Min_WA_NL_PC			✓			✓		✓	
2021Min_WB_NL_PC				✓		✓		✓	
2021Min_WC_NL_PC					✓	✓		✓	
2021Min_WA_NL_IC			✓			✓			✓
2021Min_WB_NL_IC				✓		✓			✓
2021Min_WC_NL_IC					✓	✓			✓

Source: JICA Survey Team

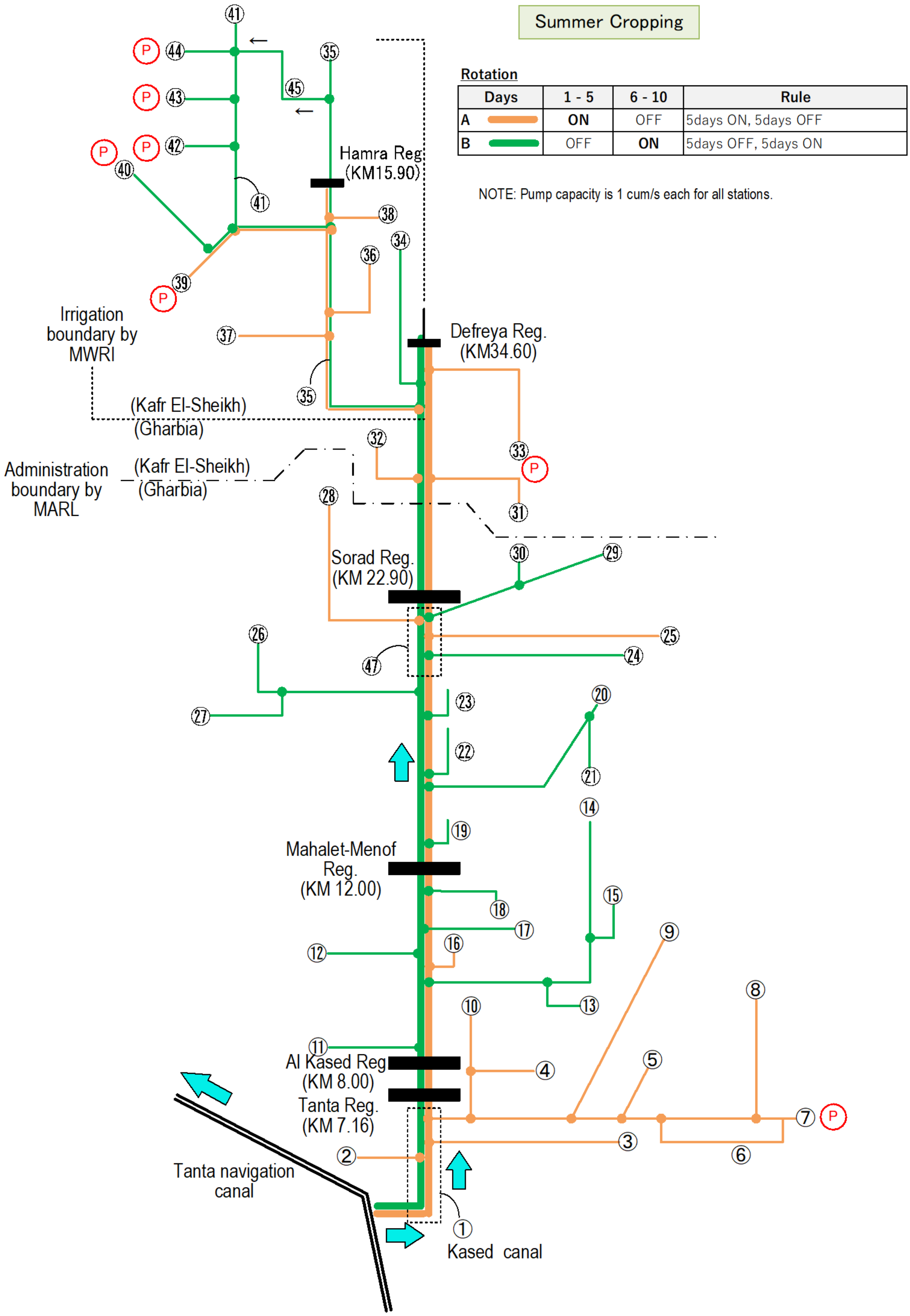
Table 4.2.24 Simulation Conditions for the Minimum Discharge in 2022 (15.0m3/s)

Case	Summer Rotation		Winter Rotation			Canal Condition		Regulator	
	A	B	A	B	C	Non-Lined	Concrete-Lined	Present Condition	Improved Condition
2022Min_WA_NL_PC			✓				✓	✓	
2022Min_WB_NL_PC				✓			✓	✓	
2022Min_WC_NL_PC					✓		✓	✓	
2022Min_WA_NL_IC			✓				✓		✓
2022Min_WB_NL_IC				✓			✓		✓
2022Min_WC_NL_IC					✓		✓		✓

Source: JICA Survey Team

The purpose of the simulation for the Tanta Navigation Canal and the Kased Main Canal is to evaluate the feasibility of adequate water distribution in the current condition and to determine the maximum water level at the intake point of the Kased Main Canal. For this simulation, it is enough to consider the section of the simulation canal until the Tanta 1 Regulator; there is no need to consider its downstream canals, canal condition, or regulator condition.

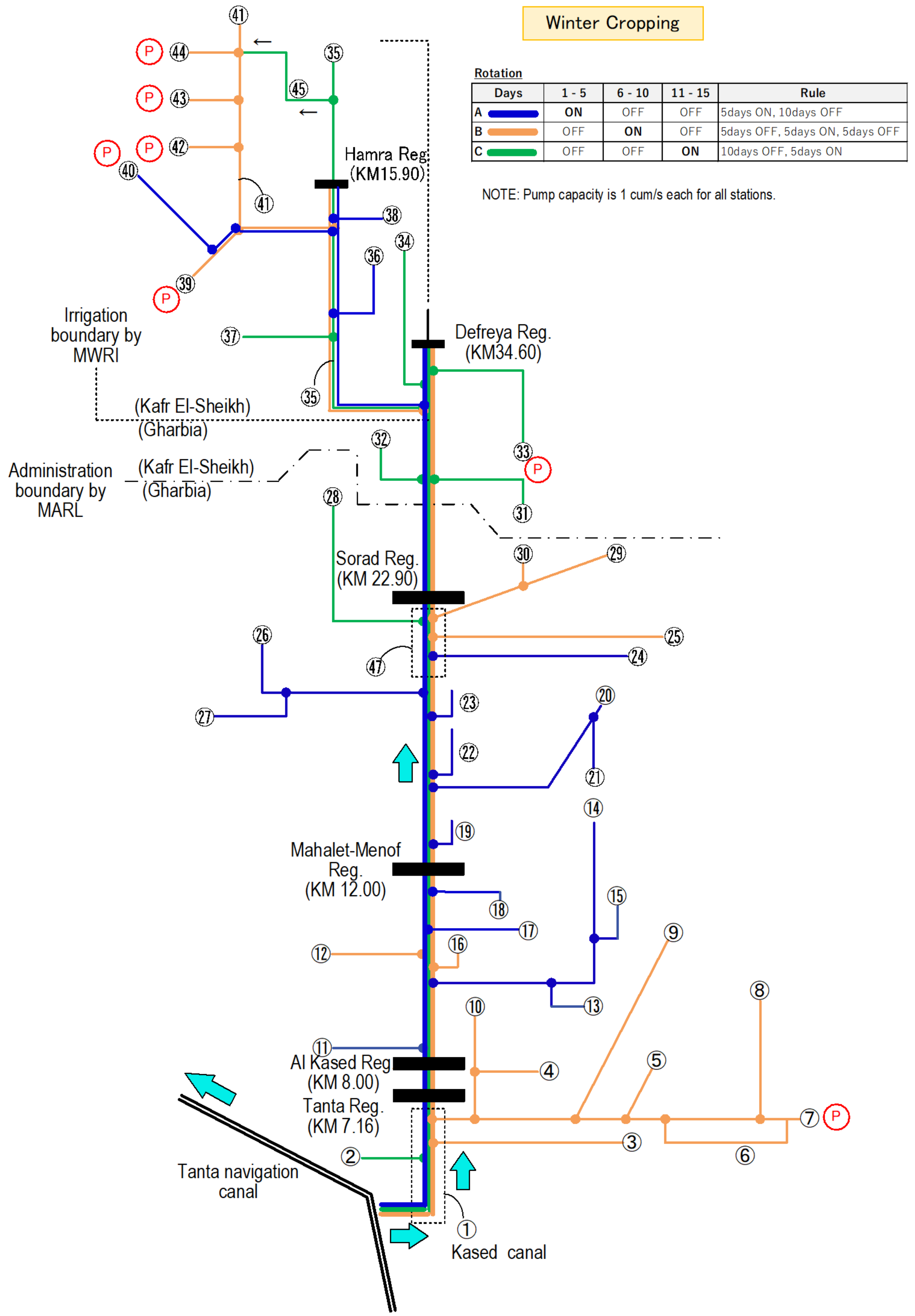
Therefore, the case is very simple: only the maximum and minimum discharge volume shall be determined. The main hydraulic conditions for the simulation are shown in Table 4.2.26 in the next section. As for the maximum discharge volume to the Tanta 1 Regulator (Kased Main Canal), the calculated maximum value based on the future cropping pattern, 45m^3/s, is considered along with the actual maximum discharge recorded in 2021.



Days		1 - 5	6 - 10	Rule
A	(orange line)	**ON**	OFF	5days ON, 5days OFF
B	(green line)	OFF	**ON**	5days OFF, 5days ON

Figure 4.2.26 Water Distribution Map of the Summer Rotation System

Source: Irrigation Directorate of Gharbia and JICA Survey Team



Days	1 - 5	6 - 10	11 - 15	Rule
A	ON	OFF	OFF	5days ON, 10days OFF
B	OFF	ON	OFF	5days OFF, 5days ON, 5days OFF
C	OFF	OFF	ON	10days OFF, 5days ON

Figure 4.2.27 Water Distribution Map of the Winter Rotation System

Source: Irrigation Directorate of Gharbia and JICA Survey Team

2) Boundary Conditions of the Simulation

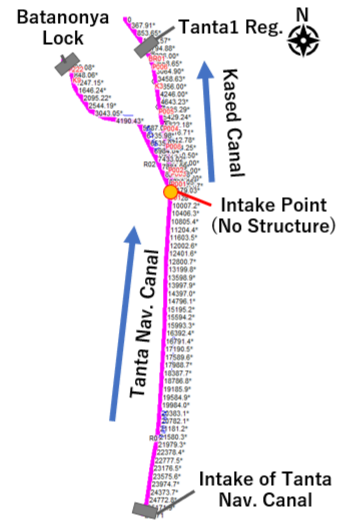
The simulation is conducted canal by canal, which means it is necessary to know the downstream boundary conditions for each canal. In this simulation, the water level at the downstream end is set based on the elevation of the tail escape. According to the survey, the water level at tail escapes is usually managed by being set 30cm lower than the elevation of the top of gates. In the case of the downstream water level for the Kased Main Canal, the end point is set as the Defreya Regulator. Table 4.2.25 shows the downstream water level condition at each canal end.

Table 4.2.25 Boundary Conditions in the Kased Area

Name	Discharge During Summer Season	Discharge During Winter Season	Slope (Normal Depth)	WL at Downstream End
Kased	52 m^3/s	15 m^3/s - 18 m^3/s	1/10,000	5.10 m
Gannabiet Shabshir	17 m^3/s	4.7m^3/s – 5.7 m^3/s	1/10,000	6.54 m
Smella	5.2 m^3/s	2.3 m^3/s – 2.8 m^3/s	1/10,000	6.32 m
Damat	5.0 m^3/s	2.2 m^3/s – 2.7 m^3/s	1/10,000	5.75 m
Samahat	7.6 m^3/s	3.8 m^3/s – 4.7 m^3/s	1/10,000	4.24 m
Rowena	20 m^3/s	4.4 m^3/s – 6.4 m^3/s	1/10,000	2.80 m

Source: JICA Survey Team

Table 4.2.26 Main Hydraulic Conditions for the Simulation

Name	Max Q	Min Q	Max WL	Min WL	Schematic Model
Intake of Tanta Navigation Canal	70 m^3/s & 60m^3/s	24 m^3/s	-	-	
To Batanonya Lock	18 m^3/s & 15 m^3/s	6 m^3/s	EL.8.90m	EL.7.95m	
To Tanta1 Reg. (Kased Main Canal)	52 m^3/s & 45 m^3/s	18 m^3/s	EL.8.40m	EL.8.00m	

Source: JICA Survey Team

3) Other Conditions Considered

Intake volumes along the canals included here are also significant for the simulation of the water level at each point. Those intakes are for branches, sub-branches, and sometimes Meskas. In the simulation, a total of 177 intake points were detected in the field survey, and required intake volume was calculated individually for each based on the actual service area delineated in satellite images. The location and the intake volume of drinking water plants within the Kased command area were also confirmed and considered in the simulation.

Furthermore, required water levels for each branch canal along the Kased Main Canal are designed by MWRI, so the opening of gates on the Tanta 1 Regulator and Sorad Regulator are adjusted to ensure sufficient water levels. Target water levels are shown in Table 4.2.28, indicating that required water levels between maximum and minimum have a range of 15cm to 30cm.

Table 4.2.27 Location and Capacity of Drinking Water Plants in the Kased Area

No.	Name	District	Location		Capacity
1	El Etwah	Kotor	Kased	KM 36.5	4,000 m^3/day
2	Aziz Kafr El Shiekh	Kotor	Kased	KM 37.8	6,912 m^3/day
3	El Galaa	Tanta	Kased	KM 5.9	20,736 m^3/day
4	El Morsheha	Tanta	Kased	KM 7.9	51,840 m^3/day
5	El Estaad Movable	Tanta	Kased	KM 11.0	2,000 m^3/day
6	Meet Sodan Movable	Tanta	Kased	KM 15.1	2,000 m^3/day
7	Abo Gondy Movable	Tanta	Kased	KM 23.0	2,200 m^3/day
8	Shobra Nabbas Movable	Tanta	Kased	KM25.8	2,000 m^3/day
9	Mahalet Mousa	Kafr El Sheikh	Rowena	KM 4.4	8,640 m^3/day
10	Meet El Deeb	Kafr El Sheikh	Rowena	KM 7.2	8,640 m^3/day
11	El Hdoud	Kafr El Sheikh	Rowena	KM 11.6	17,280 m^3/day
12	Tanta Navigation	Tanta	Tanta Nav.	KM 24.6	172,800 m^3/day

Source: JICA Survey Team

Table 4.2.28 Required Water Level at Each Location

Name of Branch/Regulator	Location		Required Water Level (Max-Min)
Gannabiet Shabshir	Kased	KM 7.3	8.00 m – 7.70 m
US of Tanta1 Regulator	Kased	KM 7.3	8.40 m – 8.00 m
Smella	Kased	KM 14.4	6.65 m – 6.40 m
Damat	Kased	KM 26.1	5.85 m – 5.60 m
Samahat	Kased	KM 30.1	5.70 m – 5.55 m
US of Sorad Regulator	Kased	KM 30.3	7.10 m – 5.80 m
Rowena	Kased	KM 37.9	4.60 m – 3.60 m
Al Gamayel Al Bahiriya	Kased	KM 42.0	4.85 m – 4.60m
Gannabeit1 of Shabshir	G. Shabshir	KM 1.1	7.55 m – 7.35 m
Sbrebay	G. Shabshir	KM 2.0	7.50 m – 7.30 m
Al Awqaf	G. Shabshir	KM 4.3	7.30 m – 7.15 m
El Melqa	G. Shabshir	KM 6.0	7.20 m – 7.00 m
El Wrety	Smella	KM 1.0	6.50 m – 6.30 m
Segen	Smella	KM 8.7	5.40 m – 5.30 m
Waslet Damat	Damat	KM 8.5	5.07 m – 4.78 m
Al Sheikh (Meska)	Samahat	KM 1.3	3.95 m
Al Saafiya (Meska)	Samahat	KM 9.4	3.70 m
Al Halah (Meska)	Samahat	KM 11.1	3.60 m
Abdel Hamid (Meska)	Samahat	KM 14.5	3.25 m
Al Muht Al Sharqi	Rowena	KM 8.4	2.80 m – 3.60 m
Mahdet El Kasab	Rowena	KM 9.0	2.80 m – 3.60 m
Sandella	Rowena	KM 12.5	2.20 m – 3.00 m
Shaboora	Rowena	KM 12.5	2.40 m – 3.00 m
US of Hamra Regulator	Rowena	KM 16.0	3.00m – 1.70 m
Al Saath Feeder	Rowena	KM 19.4	0.50 m – 1.40 m

Source: JICA Survey Team

4) Simulation Result

4.1) Kased Main Canal

Table 4.2.29 summarizes the water levels for each condition at the main intake points and regulators. First, the water level upstream of the Tanta 1 Regulator exceeds the EL8.40m in a certain rotation of Case 1 even though the gates are all fully opened (case with the maximum discharge volume: Q=52.0m^3/s). It occurs during the summer rotation B, which does not provide water to the intake of the Gannabiet Shabshir Branch Canal. This indicates that the discharge volume in summer rotation B must be less than 52m^3/s, and therefore, simulation results in the summer rotation A should be applied in considering the maximum water level along the main canal.

The aforementioned indication can be supported by confirming the longitudinal section of the water level along the Kased Main Canal (see Figure 4.2.28). In summer rotation B, water levels in many sections are higher than the bank level, indicating overflow to the outside of the canal. In summer rotation A, water levels at all cross-sections are under the bank level. Therefore, the condition in summer rotation B seems unrealistic.

In the summer rotation A (52.0m^3/s) which generates the highest water level in the season, it does not seem that any overflow occurs from the Kased Main Canal. It should be noted, however, that cross-sections in the upstream area of the Sorad Regulator tend to have lower bank heights compared to the other areas. In this geometric condition, if the water level becomes higher at the Sorad Regulator, overflow could occur in the section around 1km upstream from the Sorad Regulator.

The simulation indicates that any case can satisfy the minimum water level to distribute adequate water to each branch canal (see Table 4.2.29). However, the difference in water level upstream and downstream of the Tanta 1 Regulator becomes larger as the discharge volume becomes smaller and the roughness coefficient smaller, e.g., due to installation of concrete-lined canals.

According to the structural survey, the maximum allowable difference in water level upstream and downstream of the Tanta 1 Regulator is 1.10 m, and 1.30 m for the Sorad Regulator. In the Case 1 and Case 2, the difference in water level is still within allowable level, but when it comes to Q=15m^3/s (Case 3 and Case 4), the result indicates that the water level difference becomes larger than the allowable value.

Table 4.2.29 Simulation Results in the Kased Area (Present Regulator Condition)

Case	Case No.	1	2	3	4
	Discharge, Q	52.0 m^3/s	18.0 m^3/s	15.0m^3/s	15.0 m^3/s
	Rotation	Summer A, B	Winter A, B, C	Winter A, B, C	Winter A, B, C
	Canal	Non-Lining	Non-Lining	Non-Lining	Concrete-Lining
	Regulators	Present	Present	Present	Present
Water Level	Gannabiet Shabshir	7.98 – 8.64	7.99 – 8.00	7.97 - 8.00	7.99 - 8.00
	US of Tanta1 Regulator	7.99 – 8.65	7.99 - 8.00	7.97 - 8.00	7.99 - 8.00
	DS of Tanta1 Regulator	7.95 – 8.57	6.97 – 7.23	6.90 – 7.09	6.73 – 6.82
	Dif. WL	0.04 – 0.07	0.77 – 1.03	0.90 – 1.11	1.18 – 1.27
	Smella	7.45 – 7.93	6.64 – 6.78	6.63 – 6.65	6.6.3 – 6.65
	US of Mahlet Menouf Regulator	7.06 – 7.44	6.35 – 6.53	6.34 – 6.57	6.58 – 6.63
	DS of Mahlet Menouf Regulator	7.04 – 7.41	6.35 – 6.52	6.33 – 6.56	6.58 – 6.63
	Dif. WL	0.02 – 0.03	0.01	0.01	0.00 – 0.01
	Damat	6.43 – 6.65	6.04 – 6.42	6.02 – 6.50	6.53 – 6.61
	Samahat	5.66 – 5.99	5.69 – 6.37	5.80 – 6.47	6.51 – 6.60
	US of Sorad Regulator	5.65 – 5.97	5.69 – 6.36	5.90 – 6.47	6.51 – 6.60
	DS of Sorad Regulator	5.62 – 5.95	5.17 – 5.39	5.15 – 5.31	5.11 – 5.16
	Dif. in WL	0.02 – 0.03	0.31 – 1.14	0.59 – 1.27	1.35 – 1.48
	Rowena	5.11	5.10 – 5.11	5.10 – 5.11	5.10
	Remarks	WL becomes higher than max WL in rotation B			

Source: JICA Survey Team

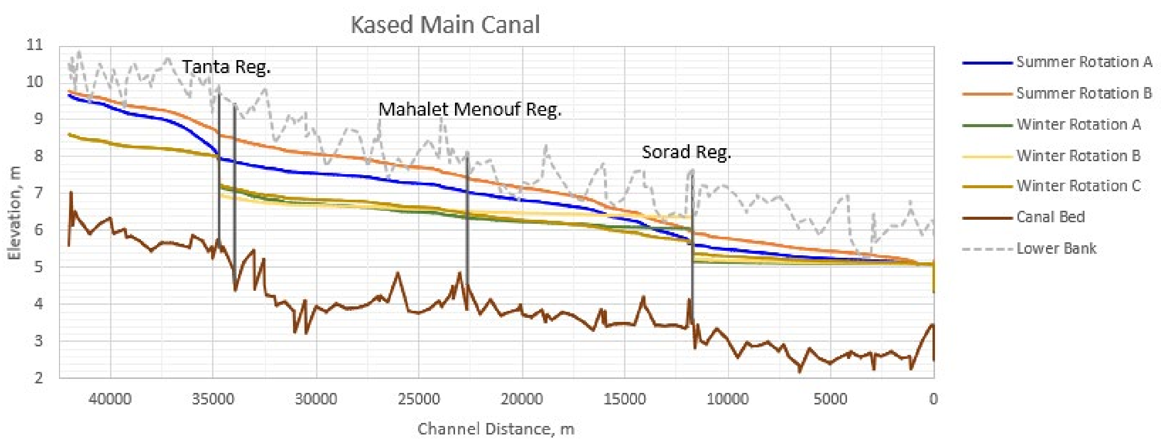


Figure 4.2.28 Water Level Along the Kased Main Canal in Summer Rotations A, B and Winter Rotations A, B, C

Source: JICA Survey Team

The Mahlet Menouf Regulator, the regulator located between Tanta 1 and Sorad, plays a key role in making the differences in water level upstream and downstream of the Tanta 1 Regulator and the Sorad Regulator smaller for their safety management. The Mahlet Menouf Regulator is currently not functioning based on the structural survey, so Case 5 and Case 6 show the condition that will exist if this regulator functions well to adjust the water level.

In those cases, both Tanta 1 and Sorad Regulators become more stable in terms of function. As shown in Table 4.2.30, the water level difference becomes 0.53m to 0.81m under the earthen canal condition and 0.58m to 0.96m under the concrete-lined canal for the Tanta 1 Regulator (0.52m to 0.87m in earthen canal and 0.85m to 0.93m in concrete-lined canal for the Sorad Regulator). This result indicates the necessity of the rehabilitation of the Mahlet Menouf Regulator.

In addition, large-scale rehabilitation for both the Tanta 1 and Sorad Regulators is recommended to stabilize them structurally in case the Mahlet Menouf Regulator is not functioning due to lack of maintenance, sudden failure, etc. Ideally, those regulators should be stable even the water level difference reaches more than 1.50 m considering the future discharge condition.

There is another non-functional regulator (Tanta 2) located at the 0.75km downstream from the Tanta 1 Regulator. The change in water level between the regulators is estimated to be only 0.07 m, so that rehabilitation of the Tanta 2 Regulator instead of the Tanta 1 is another option because the Tanta 2 Regulator was constructed more recently than Tanta 1 (1983 for Tanta 2 and 1932 for Tanta 1).

Table 4.2.30 Simulation Results in the Kased Area (Improved Regulator Condition)

Case	Case No.	Case 3	Case 4	Case 5	Case 6
	Discharge, Q	15.0m^3/s	15.0 m^3/s	15.0m^3/s	15.0 m^3/s
	Rotation	Winter A, B, C	Winter A, B, C	Winter A, B, C	Winter A, B, C
	Canal	Non-Lining	Concrete-Lining	Non-Lining	Concrete-Lining
	Regulators	Present	Present	Improved	Improved
Water Level	Gannabiet Shabshir	7.97 - 8.00	7.99 - 8.00	7.97 – 8.02	7.99 – 8.01
	US of Tanta1 Regulator	7.97 - 8.00	7.99 - 8.00	7.98 – 8.05	7.99 – 8.01
	DS of Tanta1 Regulator	6.90 – 7.09	6.73 – 6.82	7.24 – 7.44	7.04 – 7.41
	Dif. WL	0.90 – 1.11	1.18 – 1.27	0.53 – 0.81	0.58 – 0.96
	Smella	6.63 – 6.65	6.63 – 6.65	7.14 – 7.28	6.95 – 7.39
	US of Mahlet Menouf Regulator	6.34 – 6.57	6.58 – 6.63	7.10 – 7.19	6.91 – 7.38
	DS of Mahlet Menouf Regulator	6.33 – 6.56	6.58 – 6.63	6.18 – 6.34	6.09 – 6.15
	Dif. WL	0.01	0.00 – 0.01	0.85 – 0.92	0.76 – 1.29
	Damat	6.02 – 6.50	6.53 – 6.61	6.04 – 6.06	6.05
	Samahat	5.80 – 6.47	6.51 – 6.60	5.85 – 6.02	6.01 – 6.04
	US of Sorad Regulator	5.90 – 6.47	6.51 – 6.60	5.83 – 6.02	6.01 – 6.04
	DS of Sorad Regulator	5.15 – 5.31	5.11 – 5.16	5.15 – 5.31	5.11 – 5.16
	Dif. in WL	0.59 – 1.27	1.35 – 1.48	0.52 – 0.87	0.85 – 0.93
	Rowena	5.10 – 5.11	5.10	5.10 – 5.11	5.10
	Remarks			Functioning Mahlet Menouf	Functioning Mahlet Menouf

Source: JICA Survey Team

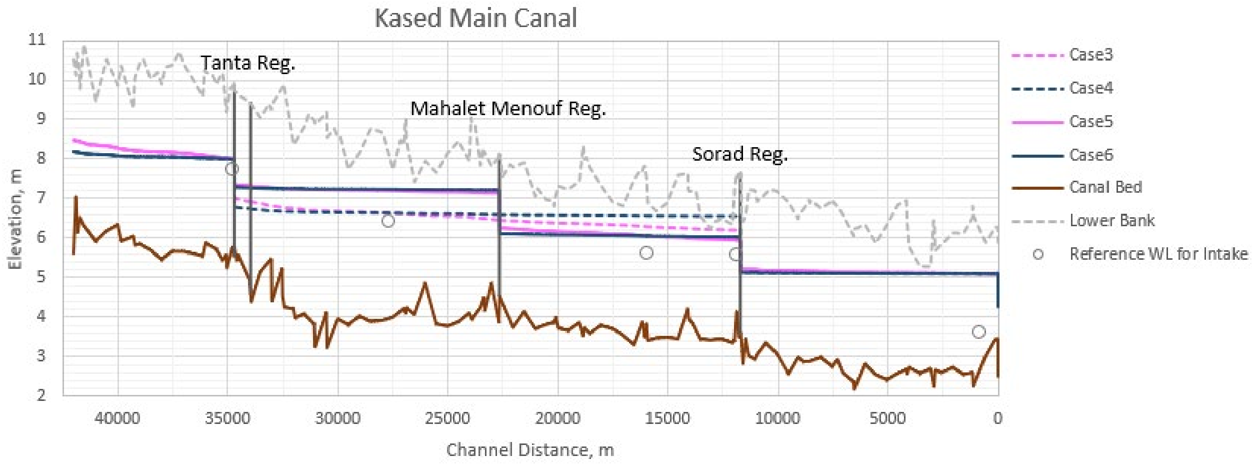


Figure 4.2.29 Water Level Along the Kased Main Canal in Case 3 to Case 6

Source: JICA Survey Team

Table 4.2.31 Comparison with the Required Water Level and Simulation Results (Kased Main Canal)

Name of Branch/Regulator	Required Water Level (Min)	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Gannabiet Shabshir	7.70 m	7.98 m	8.00 m	8.00 m	8.00 m	7.97 m	7.99 m
Smella	6.40 m	7.45 m	6.64 m	6.63 m	6.65 m	7.14 m	6.95 m
Damat	5.60 m	6.43 m	6.04 m	6.02 m	6.54 m	6.04 m	6.05 m
Samahat	5.55 m	5.66 m	5.69 m	5.80 m	6.52 m	5.83 m	6.01 m
Rowena	3.60 m	5.11 m,	5.10 m	5.10 m	5.10 m	5.10 m	5.10 m

Source: JICA Survey Team

4.2) Branch Canals under the Kased Main Canal

The impact of a change in discharge volume and canal condition (non-lining or concrete-lining) on the water level is summarized in Table 4.2.32. With the Case 2 assuming current winter condition as the regulating water level, the largest change in water level is found at the intake point of the Samahat Branch Canal, which decreases by 16 cm in Case 3 (future discharge volume, 15m^3/s) and 59 cm in Case 4 (future discharge volume with concrete-lined canals). On the Samahat branch, there is no regulator for 13 km from the intake point, and this is a longer distance than in the other branches.

For the Smella Branch Canal, the maximum decrease in water level downstream of Smella Regulator 1 is 8 cm in Case 3, and 24 cm in Case 4. In order to minimize the impact of a change in water level, it will be necessary to rehabilitate the regulators that are not functioning at present, such as the Smella Regulators 2 and 3. This will be required for efficient water distribution, as there is no active regulator for the 7.5 km reach after the Smella Regulator 1.

When water levels at the key cross-sections for each branch are analyzed, however, the results indicate they are sufficiently higher than the regulating water levels to distribute water into all the sub-branches and downstream Meska in all cases (See Table 4.2.33).

Table 4.2.32 Comparison of the Water Levels by Simulation Cases (Branch Canals in the Kased Area)

Case No.		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Discharge, Q		52.0 m^3/s	18.0 m^3/s	15.0m^3/s	15.0 m^3/s	15.0m^3/s	15.0 m^3/s
Rotation		Summer	Winter	Winter	Winter	Winter	Winter
Canal		Non-Lining	Non-Lining	Non-Lining	Concrete-Lining	Non-Lining	Concrete-Lining
Regulators		Present	Present	Present	Present	Improved	Improved
Name of Branch/Regulator	Location	Case 1	Case 2 (Standard)	Case 3	Case 4	Case 5	Case 6
Gannabiet Shabshir	Intake Point	+0.74 m	0 m	-0.13 m	-0.33 m	-	-
Smella	DS Smella Reg.1	+0.34 m	0 m	-0.08 m	-0.24 m	0.00 m	0.00 m

Case No.		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Discharge, Q		52.0 m³/s	18.0 m³/s	15.0m³/s	15.0 m³/s	15.0m³/s	15.0 m³/s
Rotation		Summer	Winter	Winter	Winter	Winter	Winter
Canal		Non-Lining	Non-Lining	Non-Lining	Concrete-Lining	Non-Lining	Concrete-Lining
Regulators		Present	Present	Present	Present	Improved	Improved
Name of Branch/Regulator	Location	Case 1	Case 2 (Standard)	Case 3	Case 4	Case 5	Case 6
Damat	Intake Point	+0.37 m	0 m	-0.09 m	-0.26 m	0.00 m	0.00 m
Samahat	Intake Point	+0.44 m	0 m	-0.16 m	-0.59 m	-	-
Rowena	Intake Point	+1.11 m	0 m	-0.13 m	-0.51 m	-	-

Source: JICA Survey Team

Table 4.2.33 Comparison with the Required Water by Simulation Cases (Branch Canals in the Kased Area)

Case	Case No.	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
	Discharge, Q	52.0 m³/s	18.0 m³/s	15.0m³/s	15.0 m³/s	15.0m³/s	15.0 m³/s
	Rotation	Summer	Winter	Winter	Winter	Winter	Winter
	Canal	Non-Lining	Non-Lining	Non-Lining	Concrete	Non-Lining	Concrete
	Regulators	Present	Present	Present	Present	Improved	Improved
Required Water Level (Min)		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
G. Shabshir	7.35 m	8.58 m	7.84 m	7.71 m	7.51 m	7.71 m	7.51 m
	7.30 m	7.90 m	7.59 m	7.48 m	7.43 m	7.47 m	7.43 m
	7.15 m	7.53 m	7.53 m	7.43 m	7.41 m	7.43 m	7.41 m
	7.00 m	7.20 m	7.20 m	7.20 m	7.20 m	7.20 m	7.20 m
Smella	6.30 m	6.69 m	6.53 m	6.50 m	6.46 m	6.50 m	6.47 m
	5.30 m	5.75 m	5.75 m	5.75 m	5.75 m	5.75 m	5.75 m
Damat	4.78 m	5.46 m	5.45 m	5.45 m	5.45 m	5.45 m	5.45 m
Samahat	3.95 m	5.77 m	5.36 m	5.22 m	4.85 m	-	-
	3.70 m	4.40 m	4.30 m	4.28 m	4.25 m	-	-
	3.60 m	4.29 m	4.26 m	4.25 m	4.25 m	-	-
	3.25 m	4.24 m	4.24 m	4.24 m	4.24 m	-	-
Rowena	2.80 m	4.04 m	3.31 m	3.23 m	3.07 m	-	-
	2.20 m	3.10 m	3.01 m	3.00 m	2.99 m	-	-
	1.50 m	2.80 m	2.80 m	2.80 m	2.80 m	-	-

Source: JICA Survey Team

Figures 4.2.30 to 4.2.34 show the hydraulic profiles of all the simulated branches. Those results indicate that there is no problem with water allocation even under the most severe condition (i.e., future discharge volume during the winter season with concrete-lined canals) if all the regulators are properly active. In addition, canals on the target branches have enough capacity for design discharge (twice the discharge volume for the summer season, and thrice that for the winter season).

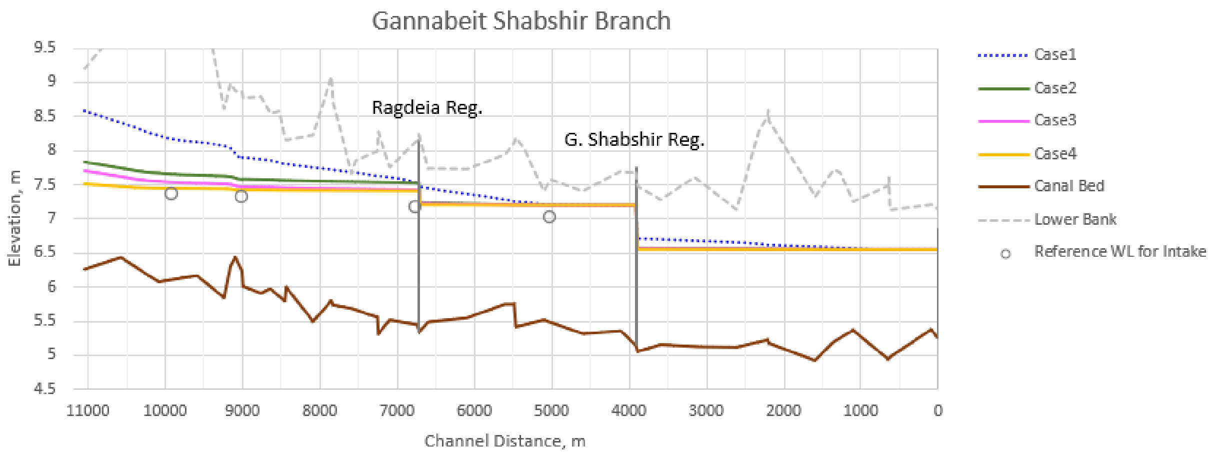


Figure 4.2.30 Water Level Along the Gannabeit Shabshir Branch Canal in Case 1 to Case 4

Source: JICA Survey Team

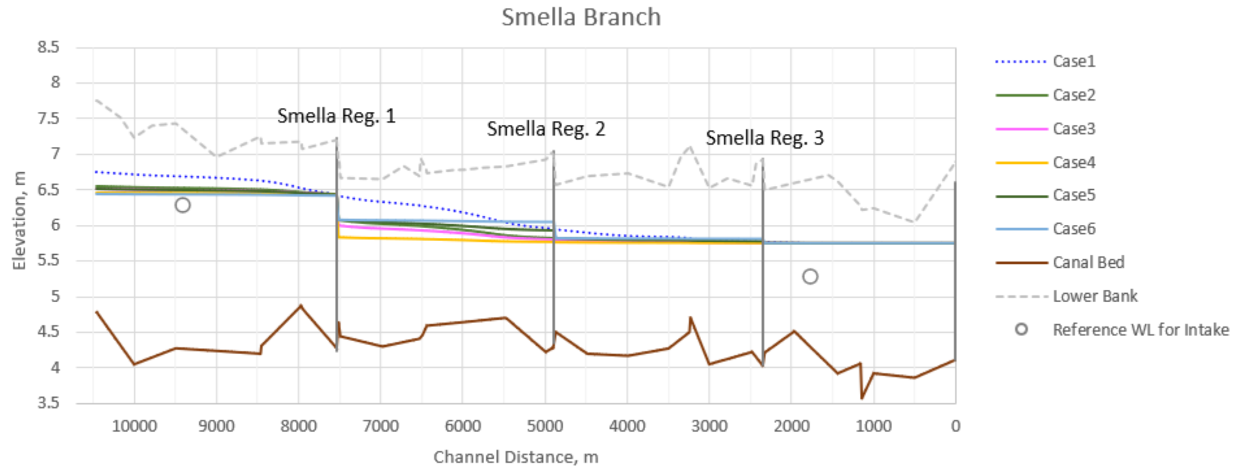


Figure 4.2.31 Water Level Along the Smella Branch Canal in Case 1 to Case 6

Source: JICA Survey Team

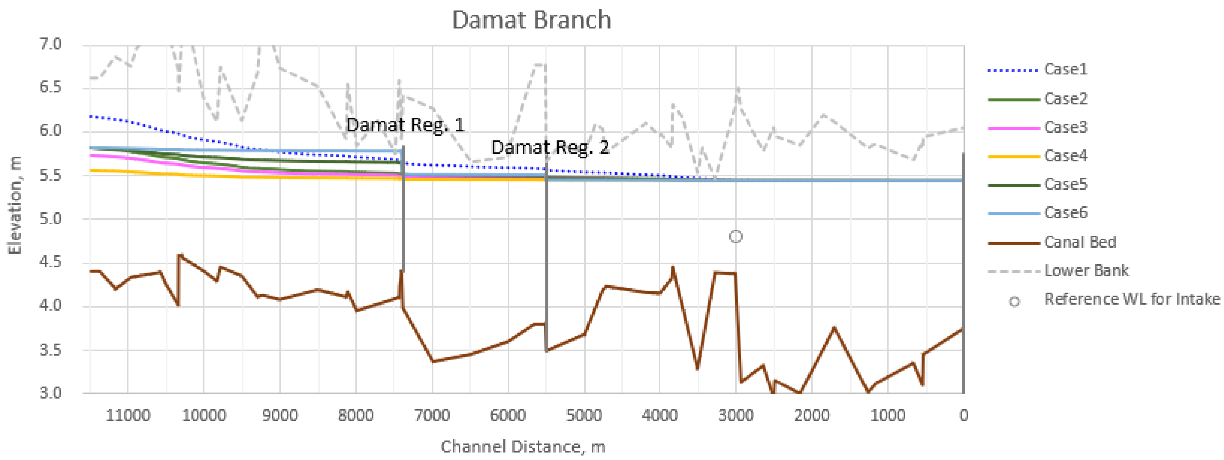


Figure 4.2.32 Water Level Along the Damat Branch Canal in Case 1 to Case 6

Source: JICA Survey Team

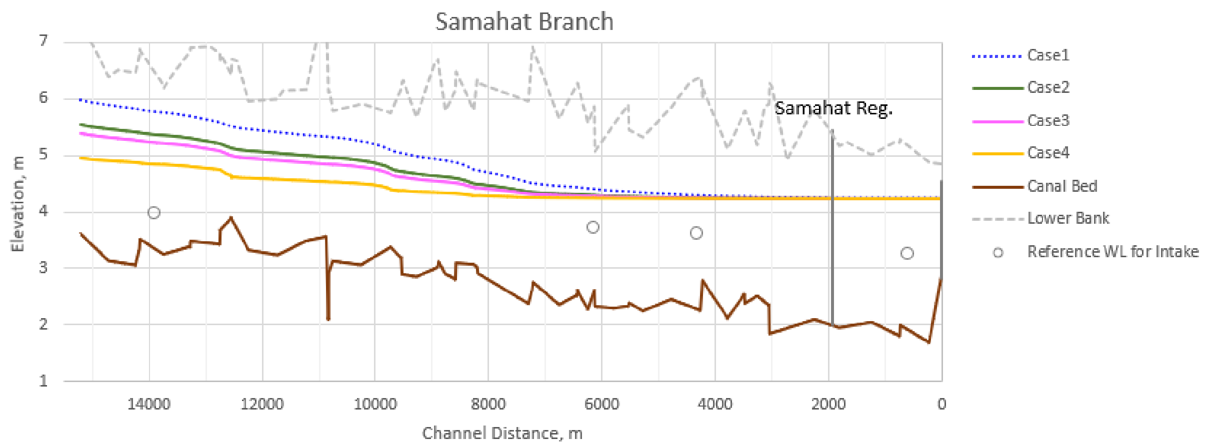


Figure 4.2.33 Water Level Along the Samahat Branch Canal in Case 1 to Case 4

Source: JICA Survey Team

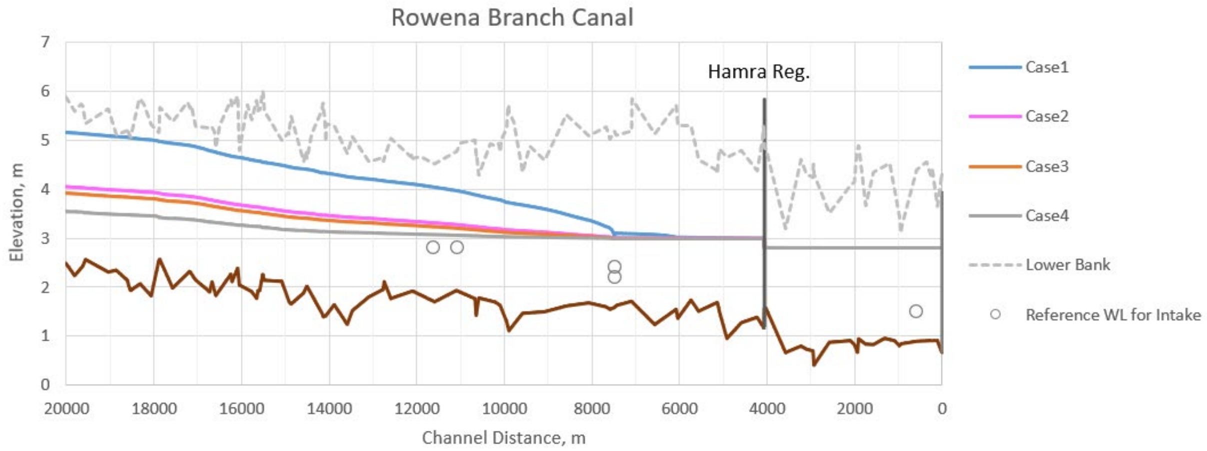


Figure 4.2.34 Water Level Along the Rowena Branch Canal in Case 1 to Case 4

Source: JICA Survey Team

4.3) Tanta Navigation Canal (Intake of Kased Main Canal)

Based on the cross-sections from the topographic survey conducted in 2021, it seems to be hydrologically unachievable to converge the simulation. Case 1 to Case 3 focus on the energy balance of flow, with the discharge volume as the variable, and Case 4 to Case 6 show the condition that applies the discharge volume as a constant value.

If the simulation focuses on energy balance to look for the more realistic value under the current geometric condition, the discharge volume to the Kased Main Canal becomes approximately half that in the maximum volume case (Q = 70m^3/s & 60m^3/s at the intake of Tanta Navigation Canal), and 30% in the minimum volume case (Q = 24m^3/s). On the other hand, if the discharge volume is fixed, the water level upstream of the confluence point becomes lower than that upstream of the Kased Main Canal.

This indicates that water level at the intake point of the Kased Main Canal needs to be approximately EL.9.7m based on the current geometric condition, which requires the Batanonya Lock to be set with a higher control water level than the current one. However, controlling the water level at the Batanonya Lock is not easy because there are two main intakes (one for the service area of 27,800 feddan, and another for a drinking water plant, the capacity of which is 2m^3/s).

Therefore, actual discharge during summer season (Q=52m^3/s for the Kased main canal) seems not to be achievable under the current hydrologic condition. Thus, it is recommended to install a new regulator at the confluence point of the Kased Main Canal and the Tanta Navigation Canal to avoid the aforementioned difficulties in controlling the intake volume for the Kased Main Canal.

Table 4.2.34 Comparison of the Water Levels by Simulation Cases (Tanta Navigation Canal)

Case		Case1	Case2	Case3	Case4	Case5	Case6
Discharge Q	1 Tanta Nav. Canal Intake	70 m^3/s	60 m^3/s	24 m^3/s	70 m^3/s	60 m^3/s	24 m^3/s
	2.US Kased Main Canal	33 m^3/s	30 m^3/s	7 m^3/s	52 m^3/s	45 m^3/s	18 m^3/s
	3.DS Tanta Nav. Canal	37 m^3/s	30 m^3/s	17 m^3/s	18 m^3/s	15 m^3/s	6 m^3/s
Energy Balance (Set Q as variable)		Yes	Yes	Yes	No	No	No
Slope	1 Tanta Nav. Canal Intake	1/10,000					
	2.US Kased Main Canal						
	3.DS Tanta Nav. Canal						
Canal	1 Tanta Nav. Canal Intake	Non-Lining					
	2.US Kased Main Canal						
	3.DS Tanta Nav. Canal						
Water Level	1.Tanta Nav. Canal US of the Confluence Point	9.17 m	9.50 m	8.13 m	8.95 m	8.94 m	7.97 m
	2.US Kased Main Canal	9.16 m	9.49 m	8.14 m	9.66 m	9.48 m	8.58 m
	3.DS Tanta Nav. Canal	9.17 m	8.95 m	8.13 m	8.97 m	8.95 m	7.98 m

Source: JICA Survey Team

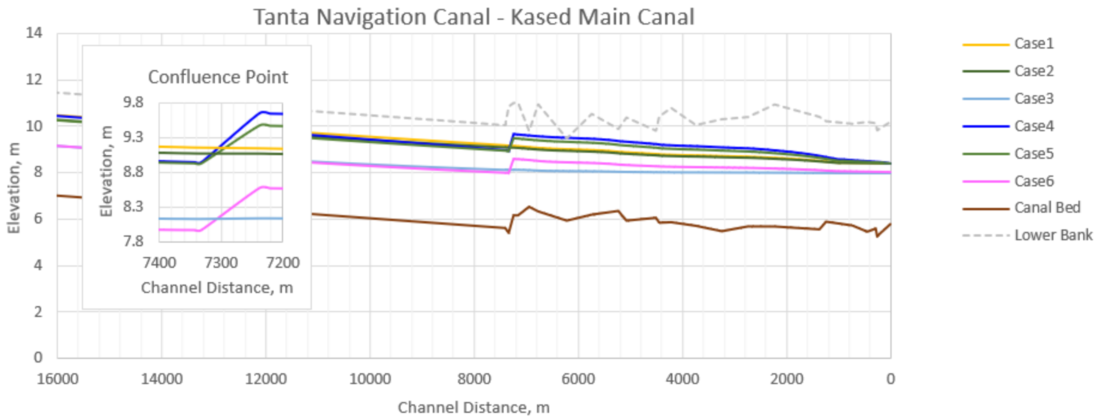


Figure 4.2.35 Water Level Along the Tanta Navigation Canal to the Kased Main Canal in Case 1 to Case 6

Source: JICA Survey Team

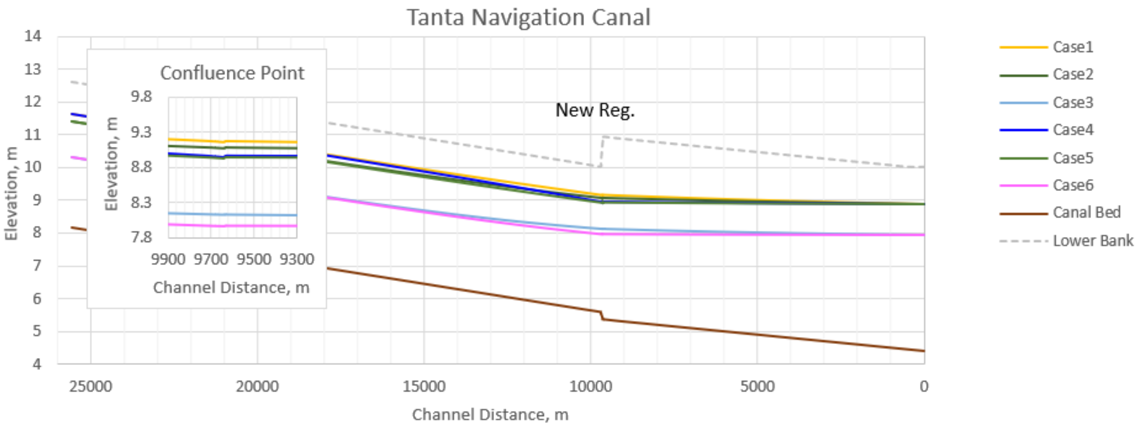


Figure 4.2.36 Water Level US of the Tanta Navigation Canal to DS of the Tanta Navigation Canal in Case 1 to Case 6

Source: JICA Survey Team

When the regulator is installed at the intake point, control of the water level is much easier than in the current situation. Table 4.2.35 shows the comparison of the simulation results with and without a regulator by each case. In all the cases including the future condition, the design discharge volume can be achieved with the control water levels at the existing 2 regulators, and the maximum water level at the new Kased Regulator should be EL 9.69 m in Case 7 (EL 8.25m for the minimum water level, as shown in Case 9).

The impact on the water level in Case 8, which is the future discharge condition considering the decrease in paddy cultivation, is calculated as 0.18 m upstream of Tanta Navigation Canal. The simulation assumes the canal is in the non-lined condition because lining on the main canal has a disadvantage in maintenance (dredging).

Table 4.2.35 Comparison of the Water Levels by Simulation Cases (Tanta Navigation Canal)

Case		Case1	Case2	Case3	Case7	Case8	Case9
Discharge Q	1 Tanta Nav. Canal Intake	70 m^3/s	60 m^3/s	24 m^3/s	70 m^3/s	60 m^3/s	24 m^3/s
	2.US Kased Main Canal	33 m^3/s	30 m^3/s	7 m^3/s	52 m^3/s	45 m^3/s	18 m^3/s
	3.DS Tanta Nav. Canal	37 m^3/s	30 m^3/s	17 m^3/s	18 m^3/s	15 m^3/s	6 m^3/s
Energy Balance (Set Q as variable)		Yes	Yes	Yes	Yes	Yes	Yes
New Regulator* for Kased Main Canal		No	No	No	Yes	Yes	Yes
Slope	1 Tanta Nav. Canal Intake	1/10,000					
	2.US Kased Main Canal						
	3.DS Tanta Nav. Canal						
Canal	1 Tanta Nav. Canal Intake	Non-Lining					
	2.US Kased Main Canal						
	3.DS Tanta Nav. Canal						

Case		Case1	Case2	Case3	Case7	Case8	Case9
Water Level	1.Tanta Nav. Canal US of the Confluence Point	9.17 m	9.50 m	8.13 m	9.69 m	9.51 m	8.25 m
	2.US Kased Main Canal	9.16m	9.49 m	8.14 m	9.66 m	9.48 m	8.25 m
	3.DS Tanta Nav. Canal	9.17 m	8.95 m	8.13 m	8.97 m	8.95 m	8.08 m

*Three gates, with 2m x 4m (width x height) assumed to be installed like at the Batanonya Lock
Source: JICA Survey Team

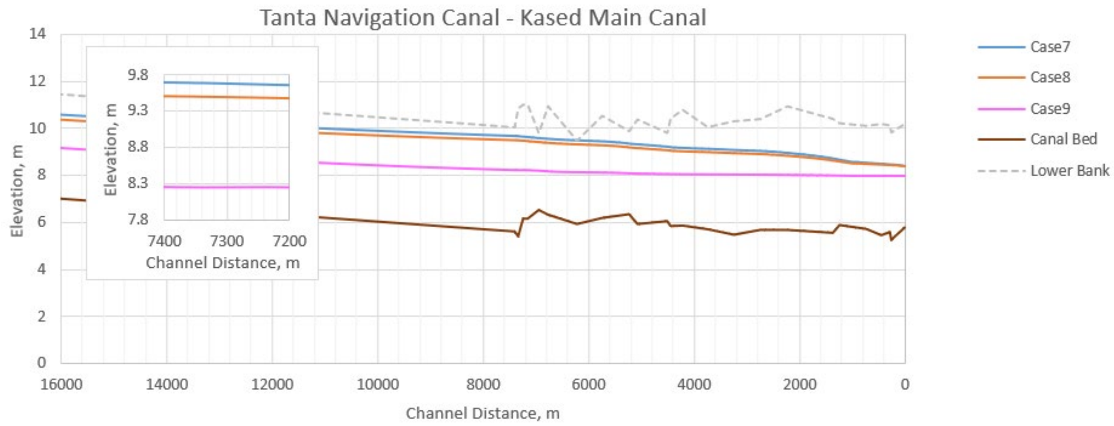


Figure 4.2.37 Water Level Along the Tanta Navigation Canal to the Kased Main Canal in Case 7 to Case 9

Source: JICA Survey Team

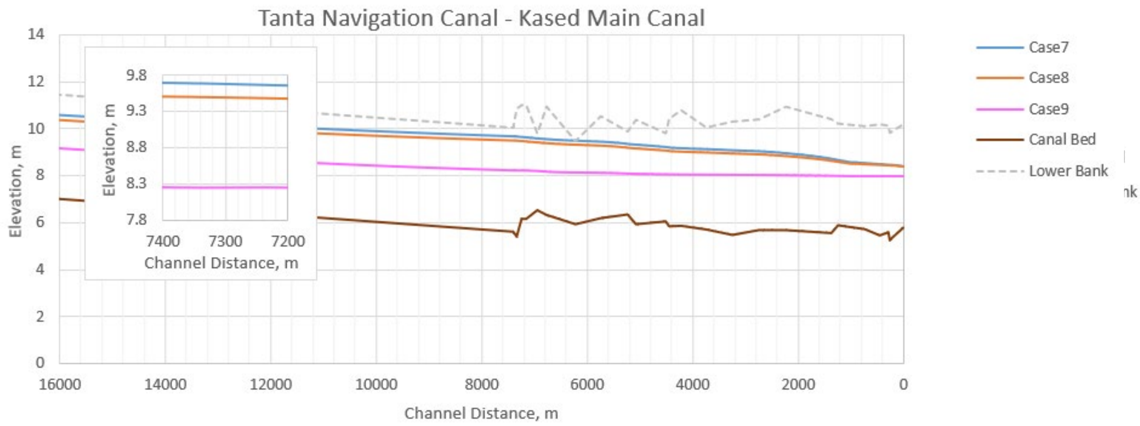


Figure 4.2.38 Water Level US in the Tanta Navigation Canal to DS in the Tanta Navigation Canal in Case 7 to Case 9

Source: JICA Survey Team

In conclusion, the simulation for the Kased main and branch canals indicates the following:

- For all the simulated canals, required water level is satisfied at all the branches even at the minimum discharge volume with the concrete-lined canal condition.
- For the Kased Main Canal, it is recommended to install functional regulators around every 10km for the adequate water distribution to the branch canals under the future minimum discharge condition. Therefore, as the first step, the Mahlet Menouf Regulator, which is currently not functioning, should be reconstructed. In the condition where the Mahlet Menouf Regulator does not function, the other regulators, Tanta and Sorad, would make larger differences in the water levels than the ones structurally allowed.
- It is also recommended to reconstruct/rehabilitate both the Tanta 1 Regulator and the Sorad Regulator at a large scale in order to stabilize them structurally in case the Mahlet Menouf Regulator is not functioning in the event of a lack of maintenance, sudden failure, etc. Instead of the Tanta 1 Regulator, rehabilitation of the Tanta 2 Regulator, which is located 0.75km downstream of the Tanta

1 Regulator, is another option to consider.

- For the branch canals simulated, the simulation found that water allocation would not be hampered even under the future low-discharge condition with a concrete-lined canal. Therefore, there is no need to establish new regulators on the branch canals in the Kased Area so long as the current regulators can function properly, so they should be maintained and/or rehabilitated as required.
- It is necessary to construct a new regulator at the confluence of the Tanta Navigation Canal and the Kased Main Canal because the simulation found that current maximum discharge designed, 52 m^3/s, is hydrologically unachievable. The design water level of the new regulator should be EL 9.69 m in the case of the current maximum discharge (52 m^3/s for the Kased area), and EL 9.51 m in the case of future maximum discharge (45m^3/s).
- Based on the topographic survey, overflow points are most likely to occur approximately 1 km upstream from the Sorad Regulator. Where erosion and unequal settlement of channel embankments are observed, necessary repairs should be made.

4.3 Large Hydraulic Structure Construction: Component 1

A series of field surveys were conducted on the existing hydraulic structures as described in the next Chapter 4.4. Through this survey, it was found that structures rated S1 need to be reconstructed, while those rated S2 need rehabilitation or repair. Of the structures rated S1, the Mahlet Menouf Regulator and the Sorad Regulator located on the Kased Main Canal are large in size.

In re-constructing these large structures, the design should be based on detailed surveys including geological and structural investigations. In addition, the lack of structure at the Kased Canal Intake presents difficulties for adequate water intake from the Tanta Navigation Canal as above-mentioned in sub-chapter 4.2. This chapter describes the results of the investigations conducted at the Kased Intake works, the Mahlet Menouf Regulator, and the Sorad Regulator, as well as the basic design of three structures based on the results of the investigations.

4.3.1 Results of Geological and Structural Investigations at the Proposed Hydraulic Structure Construction Sites

1) Results of Geological and Structural Investigations at the Kased Intake

To identify the foundation layer, the boring survey at two sites were conducted, i.e., one at the canal diversion point and the other 300 m downstream (Tanta Navigation Canal side). As a result of the survey, both the left and right banks have a thick layer of fill and clay with N-values ranging from 5 to 20, distributed at depths of 9 to 11 m. There is no clay at deeply depth, as opposed to the Sorad and Mahlet Menouf Regulator.

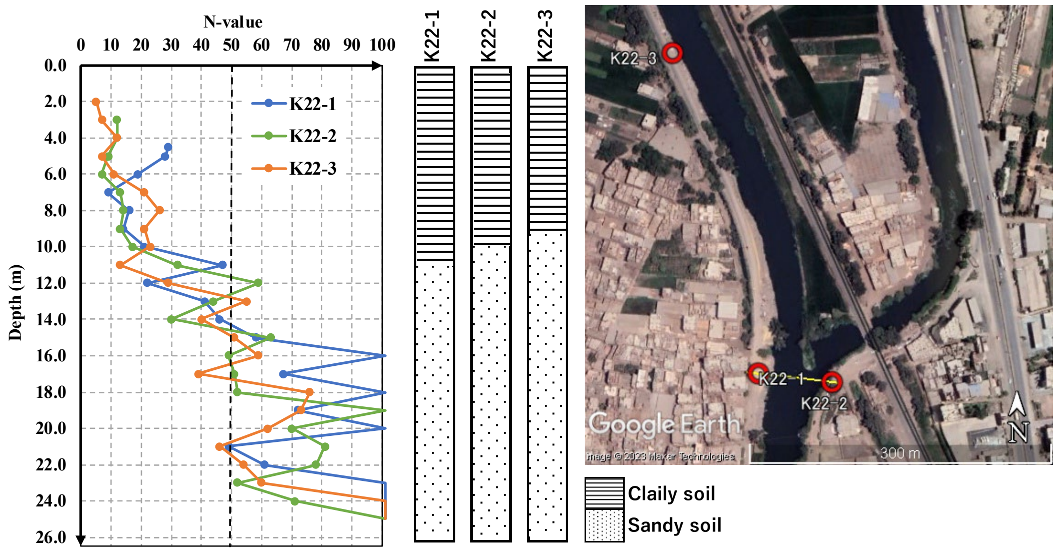


Figure 4.3.1 N-value and Borehole Log of Proposed Site for Kased Intake

Source: JICA Survey Team

2) Results of Structural Investigation of Tanta Regulator No.1

Borehole survey was conducted at each of the regulator's 2 piers. It was found that the superstructure (bridge) consisted of 10-cm-thick asphalt and 90-cm-thick concrete. Brick and mortar around 4m high and foundation concrete 1.6-1.8m thick, which constituted the regulator piers, were identified at the lower part, with 3mm-thick steel plates in between the superstructure and the pier parts.

Table 4.3.1 Result of Uniaxial Compressive Strength Test on Tanta Regulator

Regurator	Boring No.	Depth	qu (MPa)	Material
Tanta	T22-1	2.40-2.54	2.829	Brick
	T22-1	3.30-3.44	2.476	Brick
	T22-1	4.50-4.63	4.951	Brick
	T22-1	5.50-5.63	12.918	Concrete
	T22-2	1.20-1.30	9.549	Brick
	T22-2	4.60-4.72	6.013	Brick
	T22-2	5.50-5.65	20.536	Concrete

Source: JICA Survey Team

The regulator pier on the left bank side (Borehole T22-1) had few cracks except for in its upper 1m, and a good core sample was obtained, with high adhesion between the bricks and mortar. On the other hand, only 1.5m of the 4.5m-high brick structure of the pier on the right bank side (Borehole T22-2) was sampled as a column core, and the 3m section where no core was collected is likely to have deteriorated substantially. However, both regulator piers have low permeability of E-06 to E-09 (m/sec). Also, the uniaxial compressive strength shows 3 to 10 (MPa) for the regulator pier brick and 13 to 20 (MPa) for the basement concrete. These are not considered to be in need of repair under the current conditions (See Table 4.3.1).

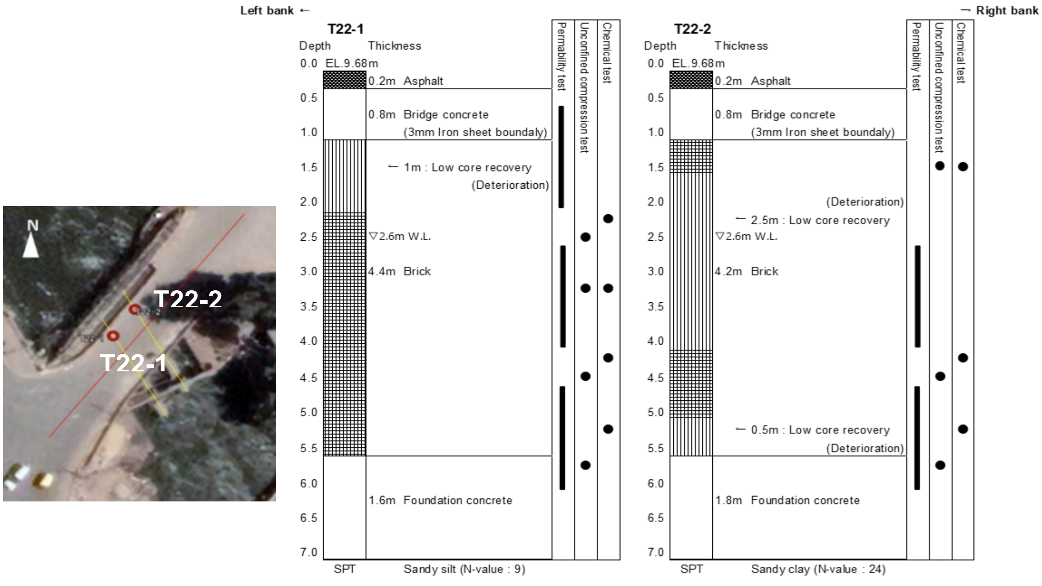


Figure 4.3.2 Borehole Log of Tanta Regulator 1 (Left: T22-1, Right: T22-2)

Source: JICA Survey Team

3) Results of Geological and Structural Investigations at the Mahlet Menouf Regulator

The boring S22-1 at the left bank side adjustment pier occurred to spout sand from the hole, when a depth was at 2 m. Hence, the drilling was stopped. The Mahlet Menouf Regulator also caused severe vibration of the bridge section during the drilling like the Sorad Regulator. Originally, there was significant damage and cracking on the concrete surface of the pier as well as the place around the gate section. To avoid further damage, therefore, the remaining boring surveys were cancelled. Accordingly, the rehabilitation of the regulator is obviously needed.

Furthermore, to identify the foundation layer, the boring survey at two sites were conducted, i.e., 30 m downstream and 65 m upstream from the existing regulator. As a result of the survey, on both the left and right banks, thick layers of fill and clay with N values ranging from 5 to 20 are distributed up to a depth of 7 m. The sandy soil layer also has a low degree of solidification in

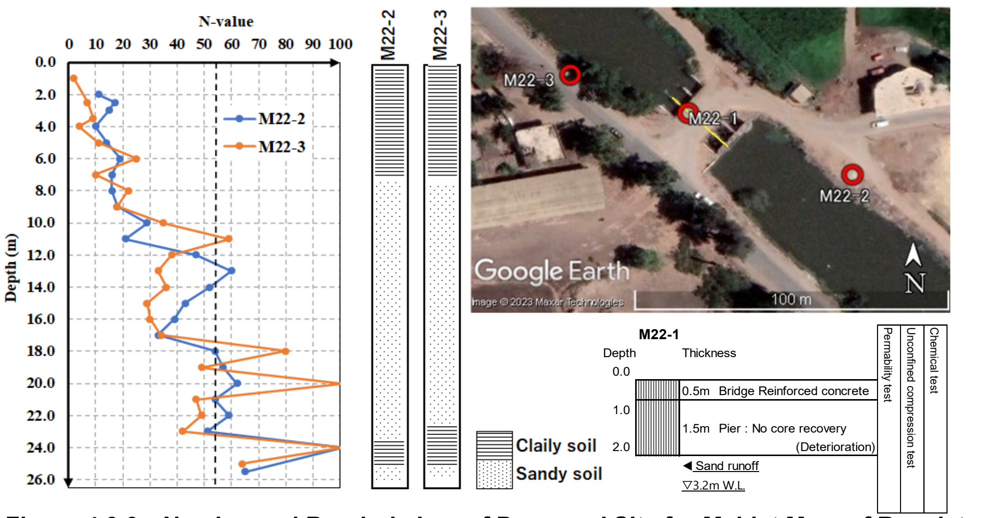


Figure 4.3.3 N-value and Borehole Log of Proposed Site for Mahlet Menouf Regulator

Source: JICA Survey Team

the shallower areas with N values ranging from 20 to 50 and there generally are N-values of 50 or higher at depths of 18 m and more.

4) Results of Geological and Structural Investigations at the Sorad Regulator

Sand and gravel came up from the borehole at depths of 2.0m and 4.2m during excavation of the borehole S22-1. The boring was terminated at a depth of 4.2m due to concerns about damage to the regulator body caused by continued boring. The few blackened brick fragments and unconsolidated sand and gravel collected suggested that the interior of the weir column had a high porosity and may have been filled with rubble, indicating the fragility of the regulator. In addition, the fact that water spurts out from the regulator columns when the water level in the canal drops also makes it imperative to replace the regulator.

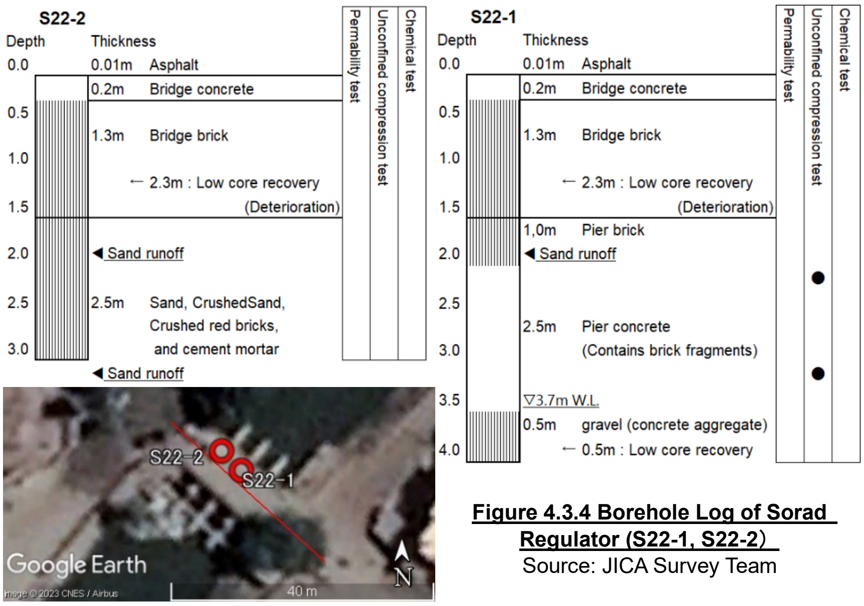


Figure 4.3.4 Borehole Log of Sorad Regulator (S22-1, S22-2)

Source: JICA Survey Team

Vibration of the superstructure (bridge section) during the excavation was also severe, and it was therefore determined that further boring could result in a loss of functionality as a bridge, so the remaining boring survey were cancelled.

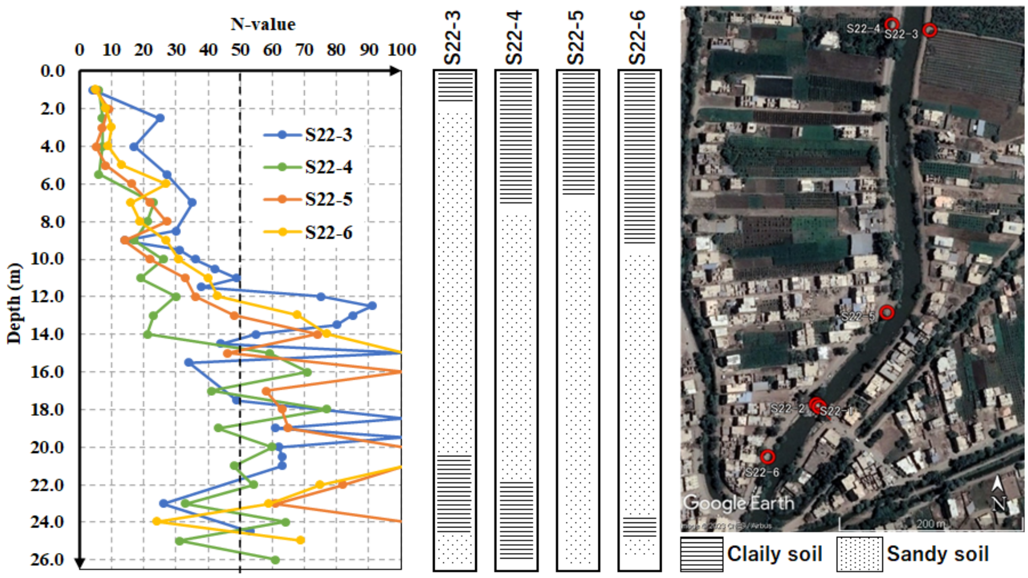


Figure 4.3.5 N-value and Borehole Log of Proposed Site for Sorad Regulator

Source: JICA Survey Team

Concrete cores were taken from the regulator column in the hole S22-1, but their uniaxial compressive strength was only 6-7 (MPa), less than half the strength of the concrete core from the Tanta 1 regulator, which was conducted simultaneously, indicating significant age-related deterioration (see Table 4.3.2).

The borings for foundation layer were conducted at three candidate sites, i.e., 405m downstream, 135m downstream, and 70m upstream from the existing regulator. On the left bank side S22-4 to S22-6, the fill and clay layer with N-values of 5 to 20 are thickly distributed to a depth of 7 to 9 m. On the right bank side S22-3, there is no fill layer, therefore, the ground surface elevation is lower than the left bank. The unconsolidated sand layer with N-values of 20 or more is distributed.

Table 4.3.2 Result of Uniaxial Compressive Strength Test on Soard Regulator

Regurator	Boring No.	Depth	qu (MPa)	Material
Sorad	S22-1	2.20-2.35	7.427	Concrete
	S22-1	3.20-3.35	6.013	Concrete

Source: JICA Survey Team

4.3.2 Basic Design of 3 Major Structures (Kased Intake, Mahlet Menouf Regulator, and Sorad Regulator)

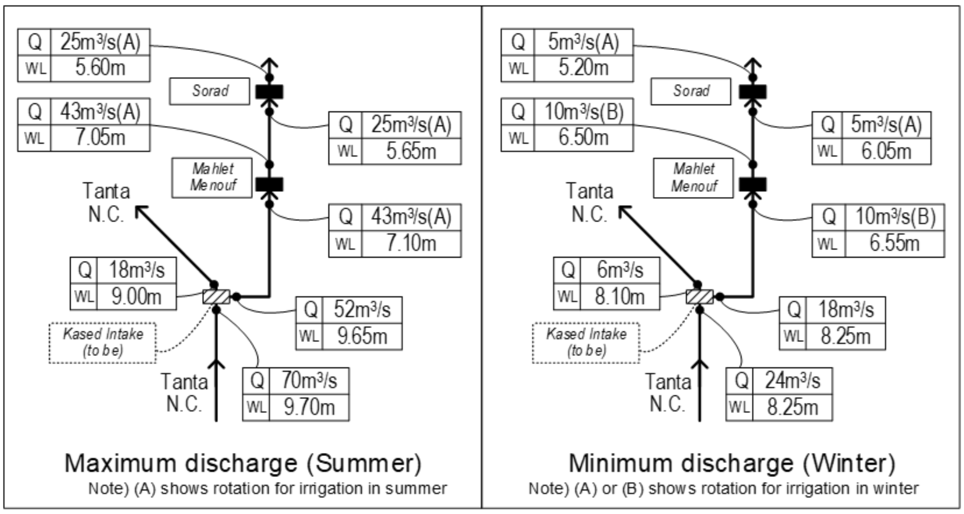
Based on the results of the field survey, structural survey and physical investigation and testing, 3 major structures, the Kased Intake, the Mahlet Menouf Regulator and the Sorad Regulator, are to be built new or replaced.

1) Hydraulic Conditions of the Existing Structures

The hydraulic conditions of the Kased Main Canal were obtained from interviews with the Water Distribution Sector of MWRI and Gharbia Governorate, which provided information on flow rates by period. Based on this flow rate, hydraulic conditions were calculated near the diversion point from the Tanta Navigation Canal to the Kased Main Canal and at each regulator in the Kased Main Canal. The hydraulic conditions at the targeted regulator construction sites are shown below.

Table 4.3.3 Hydraulic Conditions for Each Regulator on the Kased Main Canal

	Kased Intake (Kased C.)	Kased Intake (Tanta Nav. C.)	Existing Mahlet Menouf	Existing Sorad
Max. discharge (m3/s)	52	18	43	25
Max. water level at U/S (m)	9.69 →9.70		7.06 →7.10	5.65 →5.65
Max. water level at D/S (m)	9.66 →9.65	8.97 →9.00	7.04 →7.05	5.62 →5.60
Min. discharge (m3/s)	18	6	10	5
Min. water level at U/S (m)	8.25		6.53 →6.55	6.05
Min. water level at D/S (m)	8.08 →8.10	8.25	6.52 →6.50	5.17 →5.20



Source: JICA Survey Team

Installation of a new regulator in the canal would cause a new hydraulic head loss, which would affect the upstream water level. In this design study, the approach to hydraulic head loss is simplified and the hydraulic head loss generated by the new regulator is planned to be within the range of the hydraulic head loss generated at each regulator location based on the hydraulic analysis above. In other words, the hydraulic head losses of the new construction and removal will generally be offset.

2) Study of Structure Location

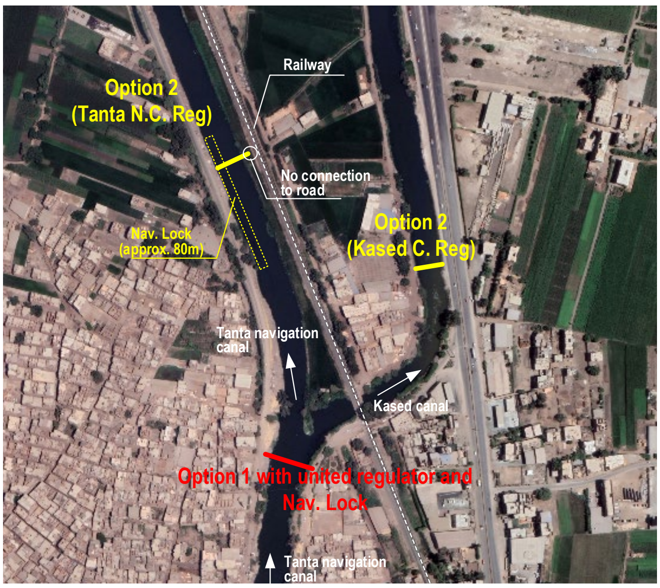
2.1) Kased Intake Works (New Construction)

In order to provide a stable diversion of the Kased Main Canal, a water intake shall be installed at the diversion point between the Kased Main Canal and the Tanta Navigation Canal. The location of the intake can be upstream of the diversion point or downstream of the Tanta Navigation Canal.

In addition, since the Tanta Navigation Canal has a role in water transportation, the new facility will need to have a ship channel. Gharbia ID has indicated that the size of the navigation lock will be comparable to that of the Batanonya Lock, which is located downstream of the Tanta Navigation Canal (Approximately 11 km downstream from the proposed construction site). The design conditions for the Navigation Lock are as follows: the width of the channel will be 11 m, and the length between the gates upstream and downstream of the channel (straight section) will be 80 m.

Under these conditions, two locations were considered. Option 1 is to construct the regulator (Intake) upstream of the diversion point, and Option 2 is to construct a regulator in each canal downstream of the diversion point. Based on the pros and cons shown in the table below, the JICA Survey Team propose to construct the regulator directly upstream of the diversion point (Option 1). The new regulator axis will be located near where the diversions to both canals begin. The regulator axis will be approximately 80 m upstream from the building on the farmland between the two canals. The location of Kased Intake was also agreed upon in consultation with Gharbia Irrigation Directorate (ID).

Table 4.3.4 Study of the Kased Intake Construction Location

1. Option of regulator axis		
	Option 1	Option 2
2. Hydraulic assessment	Flow rates on the Kased C. and Tanta N.C. sides can be adjusted directly at each gate, allowing for centralized regulation and easy gate operation and flow rate adjustment. 2pt	Same as current operation using downstream Batanonya Lock on Tanta N.C. side. Indirectly adjust flow to Kased C. side. Little improvement effect realized by installation of facilities. 0pt
3. Structural assessment	The scale of the facility is larger than Option 2. It can also have the function of a road bridge. The structure is complicated by the need for a dividing wall to divert water from the regulator point to Kased C.	The scale of the facility is smaller than in Option 1. The right bank side is a railroad, so the road bridge function is not required, and the structure is less complex. However, since the railroad is on the right bank side, it is not

	and Tanta N.C. 1pt	possible to provide a road function. 2pt
4. Construction	Good access for construction vehicles due to the presence of roads on both sides of the shore. The facility is larger and more costly than Option 2. 1pt	The construction will be done from the left bank side due to the presence of the railroad on the right bank side. The scale of the facility is smaller than that in Option 1, which presents a cost advantage. 1pt
5. Social impact	The bridge can be used as a road bridge, which will have the effect of improving traffic convenience. Although the excavation will result in excavation to the side of the road on either side of the bank, there are no land use issues because it is within MWRI's right-of-way. 2pt	A portion of the farmland on the right bank side needs to be accommodated. 0pt
6. Overall assessment	**6pt (adopt)** Although the structure of the facility is large, complex, and more costly than Option 2, it will drastically improve the efficiency of water diversion and allow for appropriate flow regulation. In addition, it can be used as a road bridge, which is expected to have benefits for non-water users.	3pt The facility structure is uncomplicated and small in scale, which gives it a cost advantage, but the way the diversion is created is not much different from the current situation, so the regulator's functions will not be fully realized. In addition, some farmland needs to be accommodated, and there are concerns about the impact on landowners.

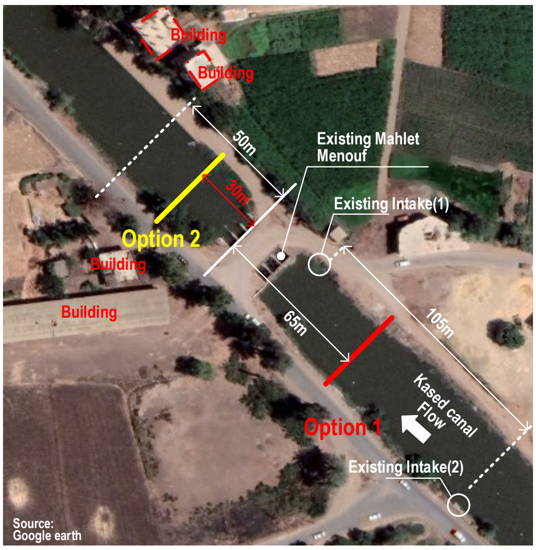
Source: JICA Survey Team

2.2) Mahlet Menouf Regulator (New Construction)

In the comparison table below, the Optional location of the regulator axis (two options) was examined at the upstream and downstream locations from the existing regulator. As shown in the consideration in the table below, the downstream proposal (Option 2) has four underground pipes on the right bank side, which may have an impact on the construction work.

On the other hand, the upstream proposal (Option 1) has one buried pipe on the right bank side, however, the construction conditions are less disturbing than those on the downstream side. Although two existing intakes were identified on the upstream side from the existing regulator, there would be no impact on the intake during the construction. Because construction would be possible within the section of both intakes. Therefore, the regulator axis should be at the upstream location (Option 2). The location was agreed with the Gharbia ID through consultations.

Table 4.3.5 Study of the New Mahlet Menouf Regulator Construction Location

<table>
<tr><td rowspan="2">1. Option of regulator axis</td><td colspan="2">
</td></tr>
<tr><td>Option 1（U/S）</td><td>Option 2（D/S）</td></tr>
</table>

2. Hydraulic assessment	Since the existing structure will be removed, the hydraulics will be only slightly superior to those in Option 2. 2pt	Since the existing structure will be removed, there is little difference in hydraulic performance between Option 1 and Option 2. The construction of the downstream side will increase the water level just upstream of the new regulator, but the level will still be kept under the design WL. Therefore, no significant groundwater rise is expected in the area. 1pt
3. Structural assessment	Although the new regulator is upstream, the water level in the canal is almost the same as in the downstream Option 2, as there is almost no water gradient and the canal width is similar, so the size of the facility is almost the same as in the downstream Option 2. However, a new water intake facility will need to be installed. 1pt	Although the new regulator is downstream, there is little difference in the size of the facility from the upstream proposal in Option 1, as the water level in the canal has almost no hydraulic gradient and the canal width is similar. 2pt
4. Construction	The right bank upstream of the existing facility is relatively vacant, so there is less interference with the construction work by other facilities. The restriction of the construction area is also superior to that of Option 2. Water level must be maintained at the current intake level during the construction period. 2pt	The construction work will be constrained due to the limited area between a house on the side of the road on the right bank downstream of the existing regulator and the existing regulator. There are four buried pipes under the road on the downstream side of the right bank, which will have a considerable impact on the revetment excavation. The Gharbia ID has requested that excavation on the downstream side of the right bank be avoided. 1pt
5. Social impact	Although the bridge will be constructed upstream of the existing intake, there will be no impact on water intake since the existing intake can be used during construction. As a road bridge, it will provide excellent access to roads on both sides of the river. 2pt	The construction will be at a place of the downstream of the existing regulator, so there will be no disruption to the current water intake. There are many buried pipes on the right bank side, so damage is a concern. 1pt
6. Overall assessment	**7pt (adopt)** The hydraulic function and structural superiority of the regulator is almost the same as Option 2, with no impact on existing intake facilities during the construction. There are fewer restrictions on the excavation at the right bank side (upstream).	6pt The hydraulic function and structural superiority of the regulator is almost the same as Option 1, also there is no impact on the existing water intake. The excavation work at the right bank side (downstream) will have a significant impact on the buried pipe.

Source: JICA Survey Team

2.3) Sorad Regulator (New Construction)

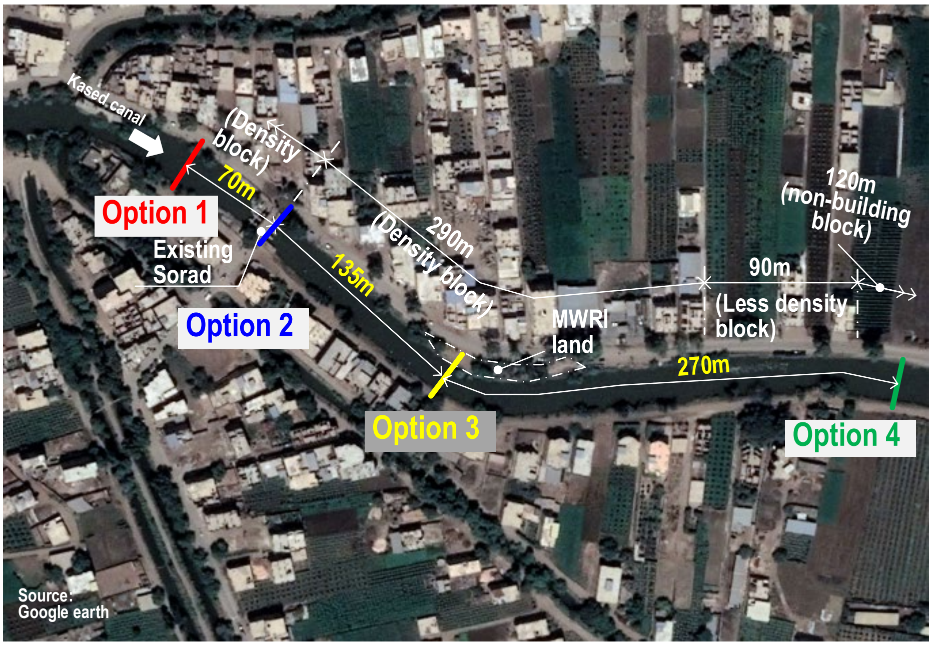
The area around the existing regulator is a major transportation hub, with a high concentration of houses and stores. Renewal near the existing regulator would have a considerable social impact, as it would be difficult to ensure safety during construction. In the study of the regulator location, four alternatives were considered.

As for the new regulator at the upstream, the candidate location is at the vicinity area where the MWRI site (right bank side) is located (Option 1) of approximately 70 m upstream of the existing regulator. However, this section is also densely populated with the houses and stores, so the same constraints of the construction as near the existing regulator (Option 2) are concerned. The approximately 290m downstream of the existing regulator is densely populated with private homes and stores, while the 90m further downstream is dotted with private homes on both sides or one side of the canal. More downstream, there is a 120 m section with no houses on either side of the canal.

Option 3 is the downstream location where the relatively large MWRI site at the left bank, and Option 4 is the place completely away from the densely populated residential area.

Based on the above local conditions, Option 1 (existing upstream), Option 2 (existing regulator location), Option 3 (MWRI site 135 m downstream of existing regulator), and Option 4 (site 405 m downstream with no houses) were considered as the regulator axis in selecting. After the result of consideration shown in the table below and discussions with Gharbia ID, the Option 3 as new regulator location was agreed upon.

Table 4.3.6 Study of the New Sorad Regulator Construction Location

1. Option of regulator axis				
	Option 1（U/S 70m）	Option 2（Exiting regulator）	Option 2(D/S 135m)	Option 3(D/S 405m)
2. Hydraulic assessment	The proximity to the upstream diversion point allows for the most timely water level adjustment. 4pt	Since it will be constructed at the same location as the existing regulator the water level control will be the same as the existing one. 3pt	The water level control is inferior to that in Option 1. 2pt	Since it is the furthest from the existing regulator, it is the least efficient of the 3 options in terms of water level control. In addition, the construction of the regulator will make the water level higher. The groundwater level will therefore be affected, resulting in an increase corresponding to the water level rise in the canal. 1pt
3. Structural assessment	Although the regulator is upstream, there is no difference in the size of the facilities in the 3 proposals because the water level in the canal has almost no hydraulic gradient and the canal width is similar. 1pt	The same as on the left. 1pt	The same as on the left. 1pt	The same as on the left. 1pt
4. Construction	The construction area is limited by the density of private residences. In addition, since the temporary road cannot be constructed, sheet pile must be used to reduce the impact of the excavation and to secure the width of the	The construction area is restricted due to the densely populated section. In addition, during construction, about half of the existing regulator will be demolished, and the other half will be used. The existing regulator	The MWRI's land is located on the left bank and can be used for a construction yard.	Agricultural land extends along both banks, but there are few obstructions to construction of other facilities. The least restrictive of the three proposals.

	road. This increases the cost of temporary construction. 1pt	are quite old and need to be rehabilitated. The two gates of the existing regulator will not be able to discharge the necessary water to the canal during the construction. 1pt	3pt	4pt
5. Social impact	The construction will take place in a densely populated residential area, which will have a significant impact on the lives and traffic of nearby residents. The waterlogged area will be slightly smaller than in the current situation, and will hardly be affected by groundwater. 1pt	Since the construction will take place in a dense area, it will have a significant impact on the lives and traffic of nearby residents. 1pt	The construction will take place in a densely populated residential area, which will have an impact on the lives and traffic of nearby residents. However, it will be less impact than with Option 1 as the construction crew can use MWRI's land. In addition, the groundwater section will be slightly wider than the existing one and is in a densely populated residential section, so there is a slight concern about groundwater impacts. 2pt	The construction will have the least impact on the neighborhood. However, groundwater impacts on dense residential neighborhoods upstream are a concern because the groundwater section will be considerably wider than the existing section. 2pt
6. Overall assessment	6pt This option allows for the most rapid adjustment of the water level at the regulator, but the construction work will have a significant impact on nearby residents. The option also creates the least impact on groundwater due to the change in waterlogged areas.	6pt The control of the water level at the regulator can be done most quickly, but the construction work will have a large impact on the neighborhood. Rehabilitation to the existing regulator is necessary, because the partially demolished existing structure must be used during the construction.	**8pt (adopt)** The rapidity of water level control at the regulator is slightly less than in Option 1 and 2. Although there is an Impact on neighboring residents due to the construction, it is less than that of Option 1 and 2. (Note) The proposal was evaluated as a tie with Option 4, but after discussion with Gharbia ID, Option 3 (this proposal) was recommended to adopt due to the superiority of the water level control function and the access to the surrounding roads.	**8pt** Although the speed of the water level control of the regulator is the least rapid of the 4 proposals, the impact of the construction on the neighborhood is the least. There is concern about the impact on groundwater due to the change in waterlogged areas.

Source: JICA Survey Team

3) Gate Type and Gate Width

The gate type will be planned with reference to the gates of the existing regulators constructed in the Kased Main Canal and the Tanta Navigation Canal. Each regulator will have the same gate width for efficient gate maintenance and economical facility maintenance.

The radial type of gate was adopted in the existing Mahlet Menouf Regulator, but as the lifting and lowering of the gate operates around a rotating shaft, the load on the shaft is heavy, causing significant damage to the frame. No repair work has been conducted, indicating that this type of regulator is difficult to maintain and manage. Therefore, the radial type of gate is judged to be difficult to use in this area, and the F.H. (Fahmy Henen) type gate, which can be moved up and down, is to be adopted. The width of the F.H. gate should be 3 m, based on the width of the F.H. gates on Batanonya Lock and the main

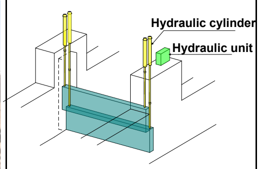
Kased Main Canal (see Table 4.3.6 and Table 4.3.7).

Table 4.3.7 Gate Span Lengths and Water Passage Width for Existing Structures

Regulator's name	Existing vents width and nos.	Total opening range	Gate type	Per width
Kased Intake	Non existing facility	—	—	—
Mahlet Menouf	4.0m and 3 vents	12m	Radial type	t=0.8m
Sorad	2.5m and 4 vents	10m	F.H. type	t=1.25m
Batanonya Lock	3.0m and 3 vents +1 Nav. Lock	9m without Nav. Lock	F.H. type	t=xxm

Source: JICA Survey Team

Table 4.3.8 Comparison of Gate Types

Items	**Option 1** Double-leaf overflow type gates (by JICA grant aid project)	**Option 2** Sluice gate type by of hoist of hydraulic pressure (single or double leaf)	**Option 3** Sluice gate type by hoist of chain or wire (single or double leaf)	**Option 4** F.H.(Fahmy Henen) gate type
1. Gate picture or sketch				
2. Water control /Operation	This gate was introduced in the Japanese project. Even though the gate size is large, it is capable of overflow discharge, which allows for highly accurate water level control. When the lower door is opened, the accumulated sand can flow out. 4pt	It was introduced in the Ibrahimia Intake and New Dirout Group Regulators. Depending on the type, the structure can be either overflow or underflow, so the water level regulation function is comparable to that in Option 1. 4pt	This gate type is widely used in Egypt. Since it is an underflow (orifice flow) discharge, the regulation system is inferior to that of over-flow. However, if the gates are small, a certain degree of appropriate adjustment is possible. 3pt	The same as on the left. 3pt
3. Structural feature	Hoisting machines are required for each of the upper and lower gate bodies, making them heavy. The regulator structure itself is also large and expensive. 1pt	Hydraulic pressure would need to be piped and a hydraulic cylinder equal to the height of the regulator body would be required. For smaller gates, the regulator structure would be lighter than in Option 1 because it would be a lightweight structure. 2pt	Hosting machines are either movable equipment on regulators or installed at each gate. Many facilities are operated by human power. 3pt	Hoisting machines are located at each vent and can be operated electrically by attaching a motor. Since the hoisting machines are small, the regulator structure is the lightest of the 4 options. 4pt
4. Maintenance	Because the switch gear is located in a high position, replacing the wire and servicing the switch gear is complicated. 2pt	This option requires more hydraulic expertise for maintenance than Option 3 and 4, and requires specialized factory maintenance. Maintenance costs are higher than with Option 3 and 4. Also, there are few examples of installation in small- and medium-scale facilities. 1pt	The factory is located in a city near Kased C and is easy to procure and maintain. The structure is simple and easy to repair, but the facility is larger than in Option 4, so maintenance costs will increase. 3pt	The factory is located in a city near Kased C and is easy to procure and maintain. The structure is simple and easy to repair. 4pt
5. Initial cost gate facility only (reference)	26M LE/vents (BxH=3m x 5m)	18~22M LE/vents (BxH=3m x 5m)	75,000~100,000 LE/vents (BxH=3m x 5m)	50,000 LE/vents (BxH=3m x 5m)

6. Overall assessment	7pt Excellent coordinating function, but high equipment cost for small and medium-sized facilities.	7pt Excellent coordinating function, but high equipment cost for small and medium-sized facilities. Also, expertise is required for maintenance and management.	9pt Although the adjustment function is inferior to those in Options 1 and 2, it is not a problem for small- and medium-scale facilities. Maintenance and management are also easy since they are distributed domestically.	**11pt（adopt）** Although the adjustment function is inferior to those in Option 1 and 2, it is not a problem for small- and medium-scale facilities. It is the least expensive of the four options.

Source: JICA Survey Team

4) Number of Gates and Heading Up

The number of gates and gate widths are determined by considering the maximum allowable flow velocity per gate when a gate is fully open and the allowable range of raising by the regulator, as shown in the Egyptian code (Chapter 5 Regulators and Gates: Design Standards of Egypt).

4.1) Study Conditions

The Kased Main Canal is classified as a main canal, which is smaller than the Nile River and the principal canal, and has a design maximum flow of approximately 50m^3/s. Therefore, the "small regulator" classification in the table below is applied. The maximum allowable flow velocity is 1.0 m3/s. In other words, the maximum allowable flow velocity is 1 to 1.5 m/s.

・Maximum allowable flow velocity

Table 4.3.9 Allowable Flow Velocity Values by Regulator Size

Category	Allowable max. velocity (m/s)	Remarks
Small regulators	**1 – 1.5 m/s**	**Applied**
Big regulators (barrages)	1.25 – 1.5 m/s	
Barrages on Rivers	2.5 – 3.5 m/s	

Source: Egyptian code, Chapter Five Regulators and Gates (Sec. 5-4-2-1 in 5-4-2 Hydraulic Design)

・Heading up

The Egyptian code (Chap. 5, Regulators and Gates) indicates that the difference in water level at heading up should be within 10 cm when the regulator is fully opened, using the following formula for the degree of cross-sectional obstruction for regulator construction. However, as described in "1) Hydraulic Conditions," the existing regulator is to be removed and the hydraulic loss due to the new regulator is to be kept within the range of the hydraulic loss of the existing regulator. Therefore, based on the results of the current overall hydraulic calculations, the hydraulic loss of the existing regulator when fully opened will be approximately 5cm, and the number of gates will be planned to keep it within this range.

「The regulator heading up is measured when it is completely open to allow the max discharge through it, provided that the **heading up does not increase more than 10cm※.**」

*For the purposes of this study, 5cm will be used to keep within the hydraulic loss at full opening of the existing regulator. Source: Egyptian code, Chapter Five Regulators and Gats (Sec. 5-4-2-4 in 5-4-2 Hydraulic Design)

Table 4.3.10 Heading Up Calculation Formula

Formula	Symbol	Description	Unit
$h=\frac{Vc^2}{2g}\frac{1}{C^2}[(\frac{Ac}{Av})^2-1]$	H	Heading up	m
	Vc	Flow velocity in water canal without construction a regulator	m/s
	Ac	Cross-sectional area of water flow without construction a regulator	m^2
	Av	Regulator vents area	m^2
	C	Factor depends on the vent span, its value comes from; 0.72: vent with width less than 2 meters 0.82: vent with width ranges from 2–4 meters 0.92: vent with width more than 4 meters	
	g	9.81	m/s^2

Source: Egyptian code, Chapter Five Regulators and Gats (Sec. 5-4-2-4 in 5-4-2 Hydraulic Design)

4.2) Results of the Study

The results of the study for each of the three regulators are shown in the table below, with the exception of the regulator on the Tanta Navigation Canal side of the Kased Intake, where the number of vents for all of the regulators is four. The number of vents on the Tanta Navigation Canal side is less than the three vents at the Batanonya Lock, which is located at the downstream of the Tanta Navigation Canal, while the calculation by the Egyptian conde shows that two vents satisfy with the necessary hydraulic conditions. However, a navigation lock will be designed on the Tanta Navigation Canal side, therefore, this enables the extra discharge to pass through if necessary.

Table 4.3.11 Results of Hydraulic Study for Each Structure

Regulator's name		Design vents width and nos.	Water depth	Max. velocity at regulator	Heading up	Judge
Kased Intake	Kased C.	4 vents x 3m	4.00m (sill: 0.5m)	1.0≦1.24m/s<1.5	0.045m≦0.05m	OK
	Tanta N. C	3 vents x 3m (one vent for spare)	4.00m (sill: 1.0m)	1.0≦1.00m/s<1.5 (for 2 vents)	0.036m≦0.05m (for 2 vents)	OK
New Mahlet Menouf		4 vents x 3m	3.10m (sill: 0.5m)	1.0≦1.38m/s<1.5	0.050m≦0.05m	OK
New Sorad		4 vents x 3m	2.50m (sill: 0.5m)	1.0≦1.05m/s<1.5	0.027m≦0.05m	OK

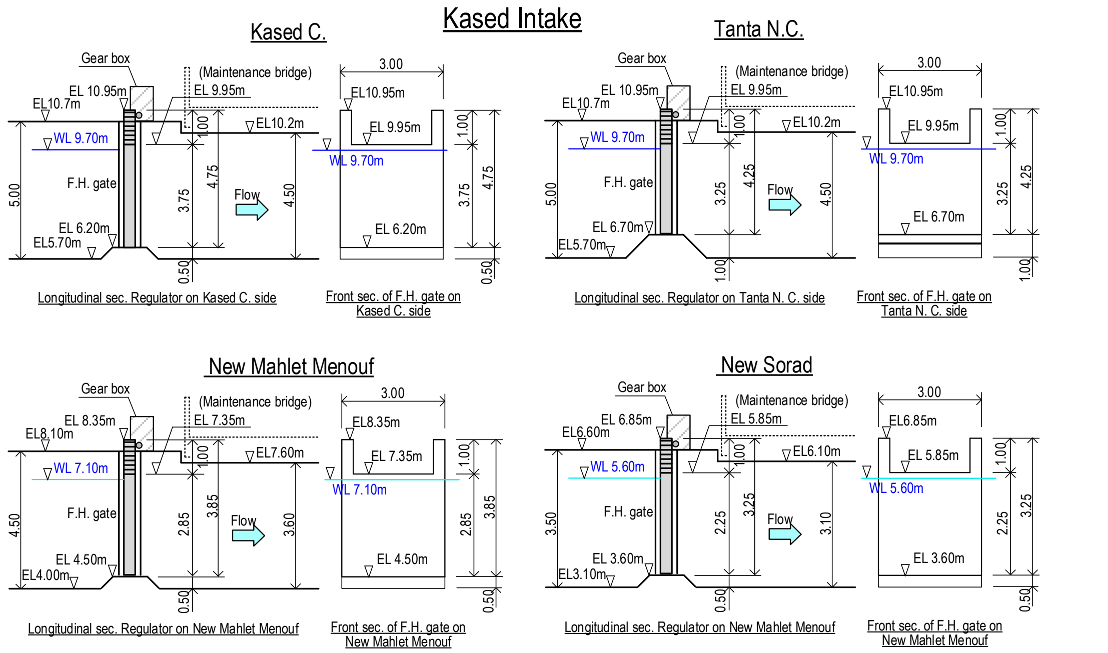
Source: JICA Survey Team

5) Elevation of Main Parts

The elevations of the regulator body, gate equipment, regulator piers, and operation and maintenance bridge, which are the main parts of the facility, will be studied. The following table shows the elevation and height of each of the main parts of the facility.

Table 4.3.12 List of Main Section Apron Heights for Each Structure

Regulator's name		Surface of regulator basement	Sill level at gate (Height)	Gate head level (Height)	Head level of pier
Kased Intake	Kased C.	EL 5.70m	EL 6.20m (0.5m)	EL. 9.95 (3.75m)	EL 10.7m (5.0m)
	Tanta N. C	EL 5.70m	EL 6.70m (1.0m)	EL. 9.95 (3.25m)	EL 10.7m (5.0m)
New Mahlet Menouf		EL 4.00m	EL 4.50m (0.5m)	EL. 7.35 (2.85m)	
New Sorad		EL 3.10m	EL 3.60m (0.5m)	EL. 5.85 (2.25m)	



Source: JICA Survey Team

5.1) Elevation of Regulator

The elevation of the regulator body shall be determined by considering the connection with the canal elevation at the proposed regulator site and the effect of sedimentation. The surface elevation of the apron should be about the average elevation of the upstream and downstream canals, referring to the elevation of the upstream and downstream canal bottoms at the proposed construction location of each regulator.

5.2) Gate Facilities

The gate height is determined by considering the gate sill given in "3) Gate Type and Width" above. For the elevation of the center of the gate, the design water level (WL. 9.70m) and the gate sill height of 0.25m, as specified in the Egyptian code, should be taken into account. In addition, the groove contacts on both sides of the gate shall protrude 1.0m above the required gate height in order to overlap with the moving parts of the switchgear. The gate size for each regulator is shown in the table below.

Table 4.3.13 Gate Elevations and Heights of Piers for Each Structure

Regulator’s name		Gate sill level	Design water level	Gate clearance	Gate head level (Gate side level)	Gate height (Gate side height)
Kased Intake	Kased C.	EL 6.20m	EL 9.70m	0.25m	EL 9.95m (EL10.95m)	3.75m (4.75m)
	Tanta N. C	EL 6.70m	EL 9.70m		EL 9.95m (EL10.95m)	3.25m (4.25m)
New Mahlet Menouf		EL 4.50m	EL 7.10m		EL 7.35m (EL8.35m)	2.85m (3.85m)
New Sorad		EL 3.60m	EL 5.60m		EL 5.85m (EL6.85m)	2.25m (3.25m)

Source: JICA Survey Team

5.3) Regulator Pier Top Elevation

The elevation of the top of the regulator pier shall be determined in accordance with the Egyptian code (Chapter 5, Regulators and Gates), with a margin of 0.5m above the design water level. In addition, since the F.H. gate has a structure that protrudes from the groove when it is fully opened, an overlap of 0.5m between the gate and the groove at that point is given to prevent the gate from tipping over. Therefore, the elevation of the top of the regulator pier should be "design water level + 0.5m (required margin height) + 0.5m (groove length)." However, since the regulator pier downstream of the gate does not need to have the hanging length at the gate, the height of the hanging length at the gate is not taken into account.

Table 4.3.14 Pier Top Elevation and Height for Each Structure

Regulator’s name		Regulator basement	Design water level	Pier clearance	Extra height for F.H. gate	Pier head level U/S (Height)	Pier head level D/S (Height)
Kased Intake	Kased C.	EL 5.70m	EL 9.70m	0.50m	0.50m	EL 10.70m (5.00m)	EL 10.20m (4.50m)
	Tanta N. C	EL 5.70m	EL 9.70m			EL 10.70m (5.00m)	EL 10.20m (4.50m)
New Mahlet Menouf		EL 4.00m	EL 7.10m			EL 8.10m (4.10m)	EL 7.60m (3.60m)
New Sorad		EL 3.10m	EL 5.60m			EL 6.60m (3.50m)	EL 6.10m (3.10m)

Source: JICA Survey Team

6) Seepage Length and Apron Thickness

The difference in the water level is the maximum water level upstream and the difference in the water level downstream, which is the same as the apron elevation. The apron thickness should satisfy "t=(0.80 to 1.00$\sqrt{H}$)" or "t=Vents width/4 + 0.5$\sqrt{H}$" as described in the code, and should be thick enough to withstand the lifting pressure. The apron structures of the Kased and Tanta Navigation Canals shall be the same. The results of the study are shown below.

Table 4.3.15 Results of Apron Length and Thickness for Each Structure

Regulator's name		Design length of Apron	Required length of Apron	Judge	Design thickness of Apron	Required thickness of Apron	Judge
Kased Intake	Kased C.	16.25m※	≧4.88m	OK	2.00m	≧2.00m	OK
	Tanta N. C	16.25m※	≧4.30m	OK	2.00m	≧2.00m	OK
New Mahlet Menouf		16.00m※	≧3.86m	OK	1.80m	≧1.76m	OK
New Sorad		16.00m※	≧4.88m	OK	1.60m	≧1.58m	OK

*The apron length will be the length that is more than the required length due to the width of the control bridge, the location of gate facilities, and the installation of the walkway.
Source: JICA Survey Team

7) Length of the Bed Protection Works

Empirically, the length of the bed protection should be 3 to 5 times the design depth. Therefore, the length of the bed protection should be 4 times the average design depth. However, based on the experience of Gharbia ID, the minimum length of revetment is 15m. In addition, since the area downstream of the Kased Intake (Kased C. side) and the New Sorad Regulator are at a curved section, the bed protection should be installed in the area over the curved section. The results of the study are shown below.

Table 4.3.16 Results of Length of Bed Protection for Each Structure

Regulator's name		Design water level	Bed protection length
Kased Intake	Kased C.	4.00m	approximately 55m
	Tanta N. C	4.00m	16m
New Mahlet Menouf		3.10m	12.4m→15m
New Sorad		2.50m	approximately 26m

Source: JICA Survey Team

8) Maintenance Bridge

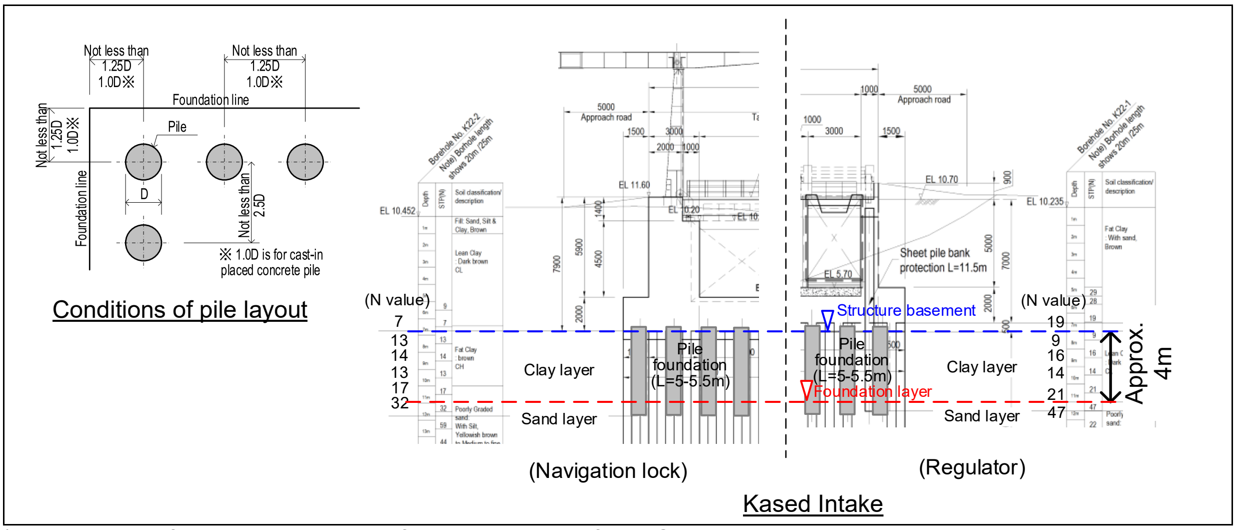
The maintenance bridge should be planned downstream of the gate, with reference to the structure of nearby regulators. The width of the maintenance bridge is indicated as 6m - 12m in the Egyptian code (Chapter 5, Regulators and Gates). Since the road width on both sides of each regulator is generally 6 - 8m, the width of the bridge should be 8.5m with a vehicle width of 6m, a sidewalk width of 1m on both sides (in total 2m), and a guardrail section of 0.25m (in total 0.5m).

9) Foundation Treatment

The Kased Intake identified a clay layer with weak N-values (9, 13) below the regulator bottom and also a weak clay layer with N-values 13, 14 at a depth range of about 5m. Therefore, the reliable layer is assumed to be a clay-mixed sand and gravel layer with N-values of 20-30 where it is appeared at the depth of 5 m below the bottom of the basement. The pile foundations should be applied. The piles are planned to be the type of cast-in-place piles (Pile Diameter: 800mm, Pile length: 5.0-5.5 m), which are commonly applied in Egypt. The pile layout should be designed with the maximum numbers taking into account the conditions shown in the table below.

Table 4.3.17 Pile Layout of Kased Intake

Kased Intake	Piles number
Regulator (Basement :26.5m x 16.25m)	B x L = 13 x 6 = 78 piles (Pile diameter: 800mm, Pile length: 5m)
Navigation lock (Basement: 10.0m x 96.5m)	Bridge section: B x L = 10 x 6 = 60 piles (Pile length: 5m) Navigation wall section: B x L = 10 x 38 = 380 piles (Pile length: 5.5m) (Pile diameter: 800mm)



*The conditions of pile layout should be referred to the Project for NDGR.
Source: JICA Survey Team

The N-value of the bottom of the New Mahlet Menouf Regulator is 25, which is a relatively strong clay-mixed sand layer, however, there is an N-value 10 layer (clay layer) within 2 m of the bottom below the regulator. Since the depth to the reliable layer is relatively shallow, the ground improvement method is planned.

The N-value under the bottom of the New Sorad Regulator is relatively strong clay-mixed sand layer (N-value 22), however, there is a N-value 14 layer (sand and gravel layer) within 3 m from the regulator bottom, so the reliable layer should be 3 m below the regulator with an N-value of around 22. Since the depth to this layer is relatively shallow, the ground improvement method is planned.

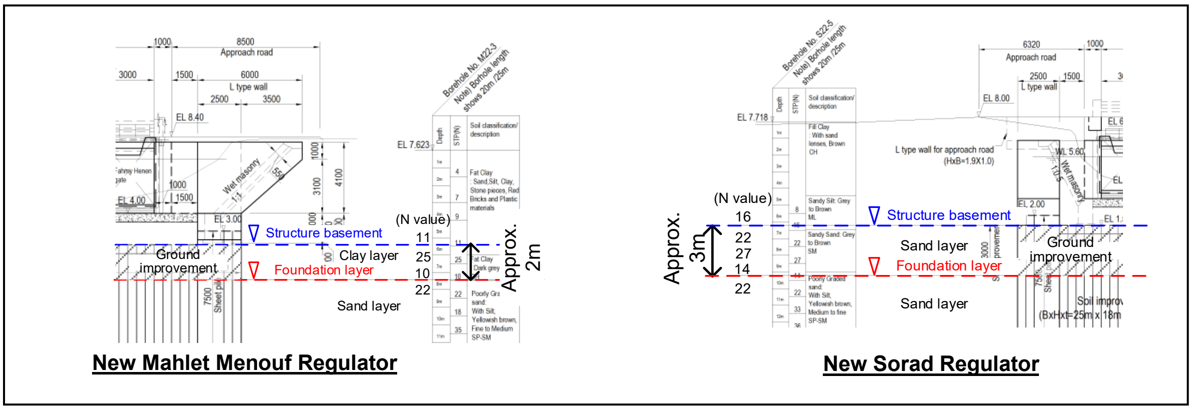


Figure 4.3.6 Foundation of New Mahlet Menouf and New Sorad Regulator

Source: JICA Survey Team

10) Control House

Control house will be planned at each regulator to secure the remote-control equipment for the gates and maintenance equipment. The Kased Intake is more important than the other two regulators, because it is the beginning point of Kased Main Canal and is located at the diversion point of the Navigation Canal. The size of the house is planned to be twice as large as the other two regulators, because it will also require a storage room for the stop-logs that will be used for the other two regulators. In addition, the house will be two-story in consideration of Gharbia ID's request.

Table 4.3.18 Size of Control House for Each Regulator

Regulator's name	Size of control house	Number of stories
Kased Intake	10m x 5m	2 stories
New Mahlet Menouf	5m x 5m	single story
New Sorad	5m x 5m	single story

Source: JICA Survey Team

11) Preliminary Construction Plan

Since the irrigation to the command area is required during construction, the canal must be kept in a water-conveying. Therefore, the construction with the half-by-half of canal will be planned, and steel sheet piles will be used to secure the construction yard and at the same time, the necessary water passage of cross section is secured as well. The construction work will be divided into halves.

Depending on the water depth, the double sheet piles coffer dam or the single sheet piles coffer dam shall be used. As for the necessary discharge during the construction, it was confirmed to the Gharbia ID that the amount of discharge can be reduced by 10% of the maximum discharge. The table below shows the assumed discharge during the construction for each regulator.

Table 4.3.19 Assumed Discharge During Construction and Type of Coffer Dam

Regulator's name	Discharge		Expected coffer dam type
Kased Intake	63 m^3/s	Kased C. : 46.8m^3/s Tanta N. C. :16.2m^3/s	Double Sheet piles
New Mahlet Menouf	38.7 m^3/s		Single Sheet pile
New Sorad	22.5 m^3/s		Single Sheet pile

Source: JICA Survey Team

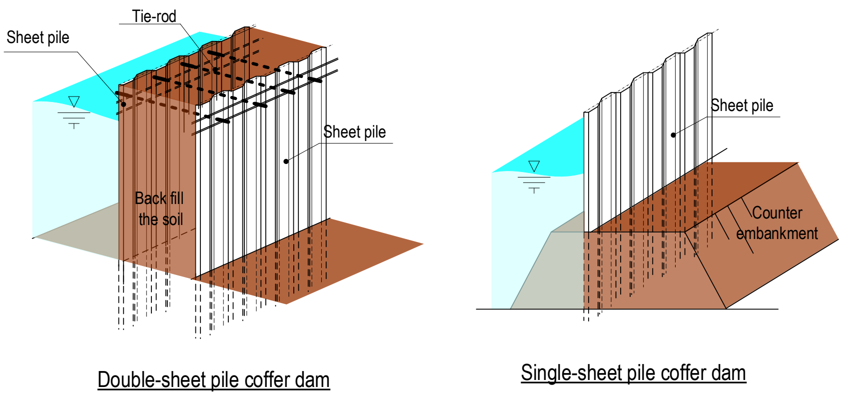


Figure 4.3.7 Diversion Works

Source: JICA Survey Team

12) Plan of the Structures

・Kased Intake (New Construction)

Figure 4.3.8 Plan of Kased Intake Structure (New Construction)
Source: JICA Survey Team

・Mahlet Menouf Regulator (Replacement to a New Regulator)

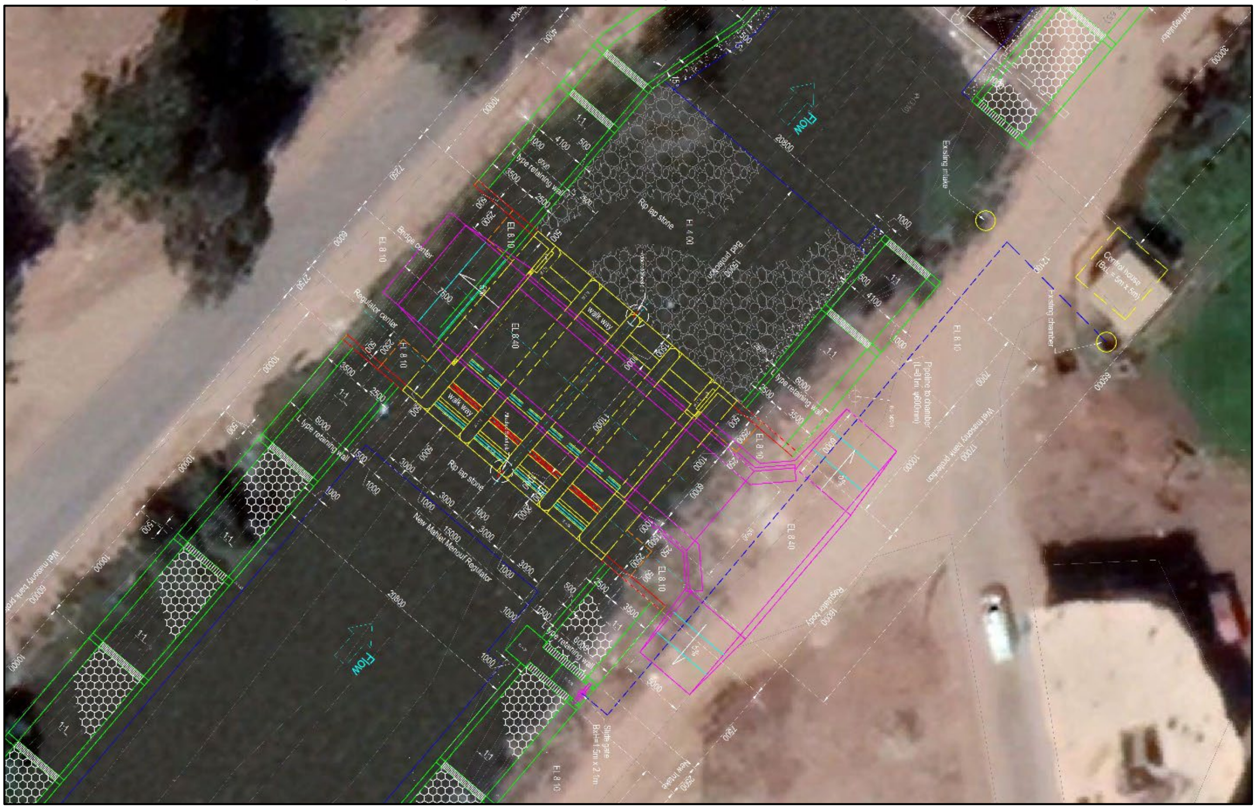


Figure 3.4.9 Plan of New Mahlet Menouf Regulator (New Construction)
Source: JICA Survey Team

・Sorad Regulator (Replacement to a New Regulator)

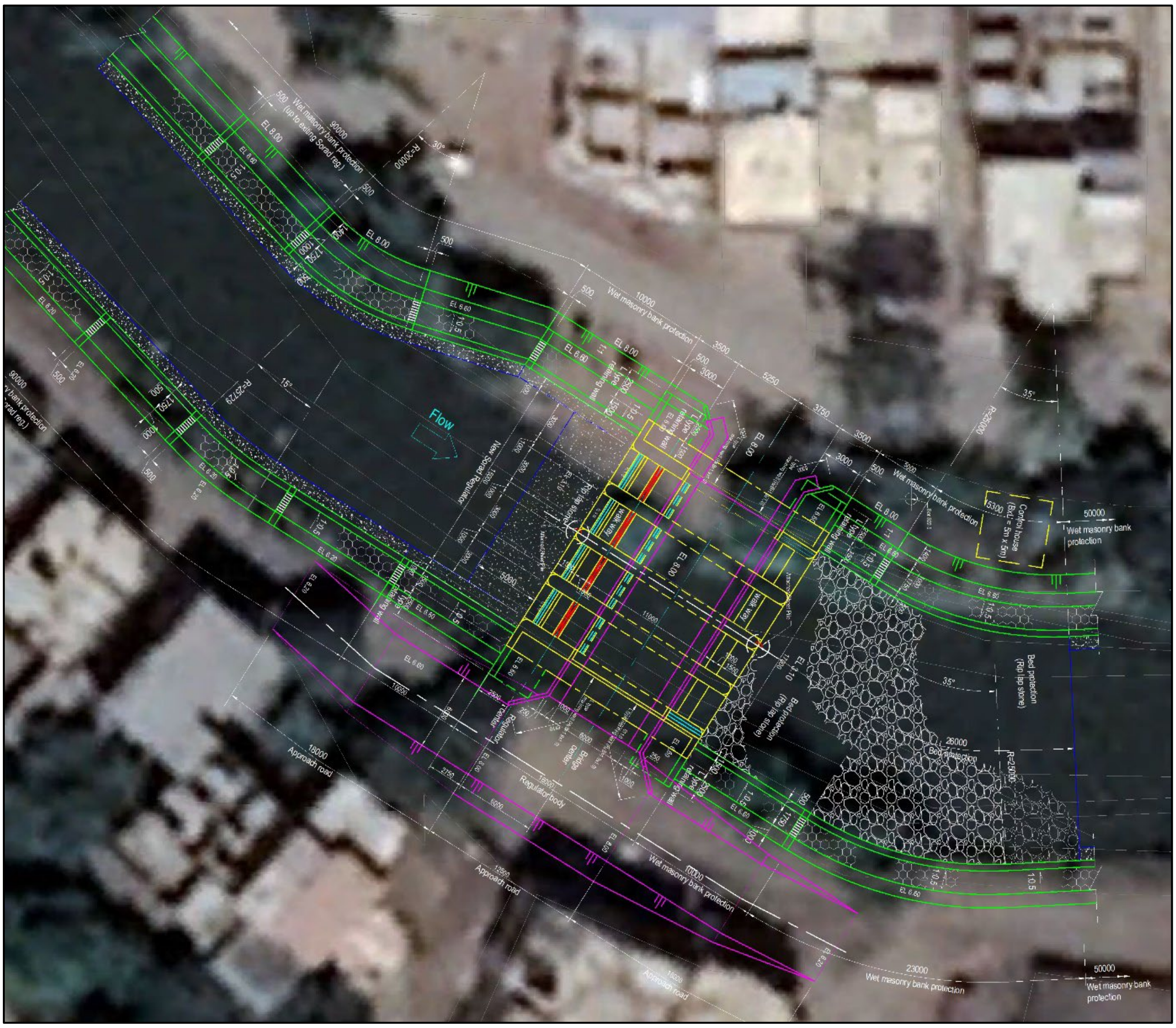


Figure 4.3.10 Plan of New Sorad Regulator (New Construction)
Source: JICA Survey Team

4.4 Construction of Small Hydraulic Structures, and Rehabilitation of Hydraulic Structures: Components 2 and 3

This section presents the results of the assessment of the existing hydraulic structures. Based on the results, the JICA Survey Team proposes reconstruction and/or rehabilitation of the hydraulic structures in the target areas. The surveyed structures are those constructed or installed on the Bahr Yusef and Ibrahimia Principal Canals and in the 3 priority sub-regions, i.e., Abo Shosha, Aros & Abo Seer, and Kased.

It is noted that though this section deals with all the hydraulic structures in the survey areas above-mentioned, the replacement of the Mahlet Menouf Regulator and the Sorad Regulator identified in the Kased Area is described separately in Section 4.3 Construction of Large Hydraulic Structures: Component 1, as it will be a new construction of large structures requiring basic design. That is, the plans described in this section are for the construction of new small hydraulic structures (Component 2) and also the rehabilitation of hydraulic structures (Component 3).

4.4.1 Approach and Methodologies

Many hydraulic structures can be found in the target area. They have various functional statuses, i.e., in good operation, in narrowly functional condition, no longer in functional condition or in use even with improvised components. To complete a survey covering such a large number of structures in the field, a structural survey should be systematically conducted. Thus, a 2-stage approach is applied here.

The 1st stage survey focuses mainly on the functionality of the whole structures, and the 2nd stage survey focuses on their physical status together with the level of required rehabilitation and/or reconstruction needed on those structures that are severely damaged. Details of the 2-stage survey are as follows (see also Figure 4.4.1):

- ✓ The objective of the 1st stage structural survey stage is to determine structures' primary functional statuses and classify them into 5 ranks for the purpose of preliminarily identifying such measures as rehabilitation, reconstruction, and minor repairs, as well as conducting regular monitoring of each structure. The 1st stage survey categorizes all the structures in the target area into 5 ranks—S1, S2, S3, S4, and S5—according to their level of functionality. Those at S1 are the least functional, while those at S5 are almost free of malfunctions. In other words, the 1st stage survey aims to identify the soundness of whole hydraulic structures based on their functional status.

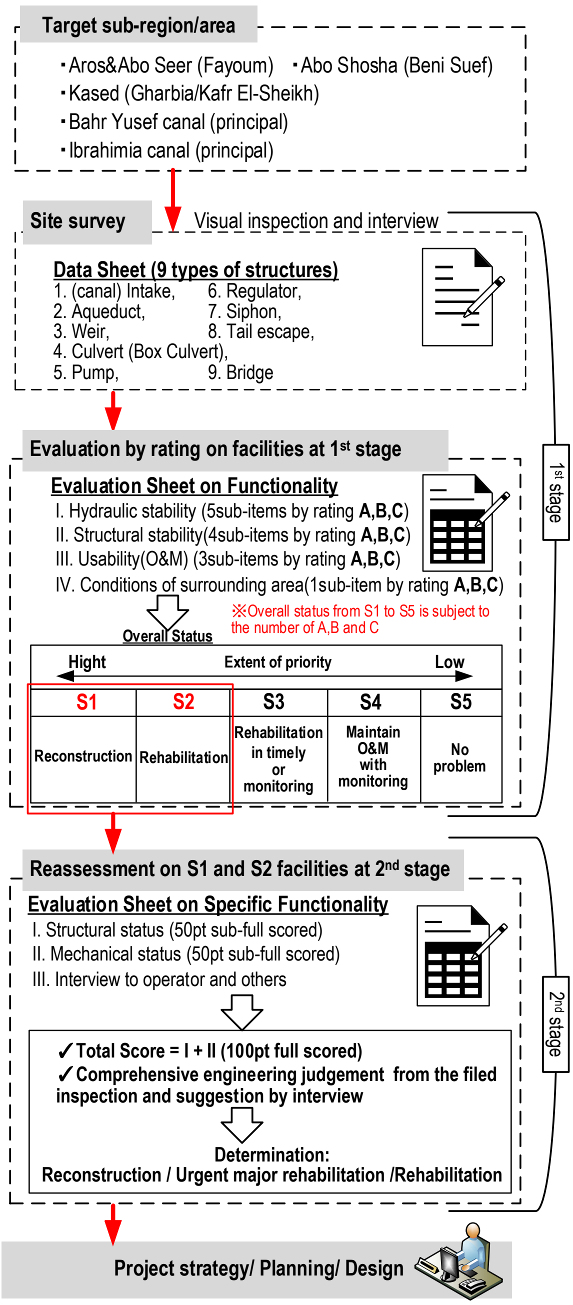


Figure 4.4.1 Flow of Structure Survey

Source：JICA Survey Team

- ✓ The 2nd stage survey covers only those structures ranked at S1 and S2 in the 1st stage. Structures ranked at S1 basically need reconstruction or new construction, and structures ranked at S2 should be given major and urgent rehabilitation. This second-stage survey is conducted to clarify such major interventions on the sites in collaboration with the relevant directorate and district engineer. The 2nd stage survey assesses the physical status of facilities in depth in order to identify the scale of the rehabilitation or reconstruction needed. As part of this process, the ranks of S1 and S2 may be reassessed.

4.4.2 1st Stage Structure Survey (All-out Survey)

The first-stage survey uses 2 sets of pre-formatted spreadsheets, namely a **data sheet** for the purpose of collecting inventory data on a facility's dimensions/condition and an **evaluation sheet** for assessing the facility's functional status. To enable systematic and fair assessments of different kinds of facilities, the evaluation sheet should be always prepared in a similar manner, regardless of the structure type and considering the facilities' structural function and status. The recommended categories are I. Hydraulic Stability, II. Structural Stability, III. Usability (O&M), and then IV. Social Conditions. The intent is to know the extent of impacts in the nearby areas when rehabilitations are to be implemented. These are basically assessed by a visual inspection.

1) Data and Evaluation Sheet for 1st Stage Survey

1.1) Data Sheet

The 1st stage survey uses the data sheet, as indicated in Table 4.4.1. The surveyors take measurements of major dimensions and photos of the facilities. The latter are sorted into 9 types: Intake, Regulator, Aqueduct (fly-over canal), Siphon (under beneath canal-bed), Weir (drop), Tail-escape, Culvert (box culvert), and Pump station. The items listed on the data sheet are the facilities' names, locations, age, primary structural dimensions/mechanical specifications, O&M status, and pictures.

1.2) Evaluation Sheet

Based on the information from the data sheet and visual inspections, including interviews with the structure operators in charge, the facilities are assessed on a rating scale and using the evaluation sheet (refer to Table 4.4.2). The sheet lists the primary assessment factors as I. Hydraulic Stability, II. Structural Stability, III. Usability (O&M), and IV. Social Conditions. This information is useful in determining the possible extent of impact in nearby areas during the construction/rehabilitation stage.

The evaluation partly relies on the criteria of Japanese stock management approach authorized by the Ministry of Agriculture, Forest and Fisheries (MAFF) of Japan, which include the **S1** to **S5** scale noted above. These are defined in Table 4.4.3, which is based on an engineering judgment referring to the results of the sub-evaluation items on the evaluation sheet.

The sub-evaluations of the 4 primary factors noted above are composed of a total of 13 items, which depend on these factors. These 13 items are assessed with the rates of **A**, **B,** and **C**, with **A** being the worst and **C** the best status. The ratings of S1 to S5 are methodically decided depending on the total scores for these items (Refer to Table 4.4.2, in which the 13 sub-evaluation items are indicated by the blue dotted line).

※ For example, in Table 4.4.2, the result of ratings of A, B, and C for the 13 sub-evaluations and overall status are assessed as follows:

Excerpt of Table 4.4.2 (Evaluation Sheet on 1st Stage)

I. Hydraulic Stability,	A/0	B/3	C/2
II. Structural Stability,	A/2	B/1	C/1
III. Usability (O&M),	A/0	B/1	C/2
IV. Social Conditions,	A/0	B/1	C/0
Total	A/2	B/6	C/5

Function	Extent of priority (rating) High ← → Low S1 Reconstruction	S2 Rehabilitation	S3 Rehabilitation in timely or monitoring	S4 Maintain O&M with monitoring	S5 No problem
I. Hydraulic stability II. Structural stability	both of I and II each A nos. ≧ 2	either of I or II 1 ≦ A nos. ≦ 2	both of I and II each B nos. ≧ 1	either of I or II B nos. ≧ 1	All of C
III. Usability (O&M)	either of A or B nos. ≧ 1	either of A or B nos. ≧ 1	either of B or C nos. ≧ 1	either of B or C nos. ≧ 1	
IV. Social conditions	B or C	B or C	B or C	B or C	

Source：JICA Survey Team

Overall status: S2

Table 4.4.1 Data Sheet (example for regulator)

Data Sheet	Regulator		No-XX
1. Name	XXXregulator	2. Construction Year	2010
3. Type --Select from as follow item-- (Intake, Regulator, Tail escape)			Regulater
4. Canal's name	Bahr Youssef	5. Structure Location from intake (km)	77.600
6. Coordinate	E: 30°41`25`	N: 27°59`44`	※Google map
7. Service Area (feddan)		8. Max discharge (m^3/day) or (m^3/s)	
9. Material of the structure / Wood, Brick, Stone, Steal, Other			concrete
10. Question and Dimension the structure (If no information at any, please write "N")			
1) Gate Height (m)			N
2) Gate Width (m)			4.00
3) Number of Vent			4.00
4) Up stream water depth(m)			N
5) Down stream water depth(m)			N
6) Water gauge nearby structure/ yes or no			yes
7) Gate type / Wood, Steal, Others, Nothing			Steel
8) Structure maintenace by who?			Irrigation directorate
9) Please write remarks, if any			
15. Picture	Front	Top	Side or Behind

Source：JICA Survey Team

Table 4.4.2 Evaluation Sheet on 1st Stage (example for regulator)

Evaluation Sheet

Reference Number of the structure or facility	M1	Location of the structure or facility	XXX canal
Type of Structure or facility	Regulator	Name of the structure or facility	XXXX Regulator

ITEMS	Rank : A	Rank : B	Rank : C	Selection of Rank
I. Hydraulic stability				
1 Secure of water level	so hard to keep water level	difficult to keep water level	not difficult or keep water properly	B
2 Fair discharge volume/ Water deliverability	so hard to be fair water	difficult to be fair water	not difficult or discharge fair water properly	B
3 Water leakage	too much vol.	much vol.	not so much	B
4 Sedimentation around the structure	---------	much vol.	not so much	C
5 Condition around the structure	---------	obstruction much vol.	obstruction not so much	C
II. Structural stability				
6 Extent of structural aging	old age (more than 50years)	medium age (20~50years)	new (within 20years)	B
7 Crack or scouring of part on structure	many	not so many	few or no	A
8 Deformation of the structure or mechanical facility or steel material	much deformation	medium deformation	little or no	C
9 Damage of the mechanical facility or steel material	much damage or nonfunctional	medium damage or still functional	little or functional	A
III. Usability: O&M				
10 Problem of Operation	Fatal problem (not working all etc.)	some problem (not working some etc.)	few or no problem	C
11 Ease of maintenance works	---------	difficult	easy	B
12 Cost for maintenance at present	---------	high	reasonable	C
IV. Social conditions				
13 Condition of the surround area	---------	density area or main road	not so density area	B
Remarks, if any				

Evaluation

Items	Number of "A"	Number of "B"	Number of "C"
I. Hydraulic stability	0	3	2
II. Structural stability	2	1	1
III. Usability: O&M	0	1	2
IV. Social conditions	0	1	0
Sub-total	2	6	5
Comprehensive evaluation	S2		

Table 4.4.3 Criteria for the Comprehensive Rating of S1 to S5

Function	Extent of priority (rating) High ← → Low S1 Reconstruction	S2 Rehabilitation	S3 Rehabilitation in short-term future or monitoring	S4 Maintain O&M with monitoring	S5 No problem
I. Hydraulic stability II. Structural stability	both of I and II each A nos. ≧ 2	either of I or II 1 ≦ A nos. ≦ 2	both of I and II each B nos. ≧ 1	either of I or II B nos. ≧ 1	All of C
III. Usability (O&M)	either of A or B nos. ≧ 1	either of A or B nos. ≧ 1	either of B or C nos. ≧ 1	either of B or C nos. ≧ 1	
IV. Social conditions	B or C	B or C	B or C	B or C	

Source：JICA Survey Team

2) Inventory of Structures in the Surveyed Area

The 1st stage survey has basically covered all the structures in the 3 priority sub-regions and those installed along the 2 principal canals of Bahr Yusef and Ibrahimia. The survey area has been subdivided into 8 areas: Aros and Abo Seer (2 areas), Abo Shosha (1 area), Kased (3 areas, i.e., from intake to Mahlet Menouf as the U/S, from Mahlet Menouf to end of Kased Main Canal as the M/D, and to Rowena Branch Canal as the D/S), and Bahr Yusef and Ibrahimia. As a result of the field survey, a total of 560 irrigation facilities have been identified and evaluated (see Table 4.4.4).

Table 4.4.4 Inventory of Irrigation Structures

	Fayoum		BeniSuef	Kased (Ghalbi/Kafr El-Sheikh)			Bahr Yusef	Ibrahimia	sum
	AboSeer	Aros	AboShosha	Kased_US	Kased_MD	Kased_DS			
(canal) Intake	14	36	43	36	2	12	36	122	301
Regulator	0	0	15	18	4	6	5	10	58
Aqueduct	4	0	1	3	0	7	0	0	15
Siphon	0	0	1	0	0	1	0	0	2
Weir	3	31	1	0	0	0	0	0	35
Tail escape	0	0	6	17	0	5	0	3	31
Culvert	0	8	48	24	0	6	0	1	87
Box Culvert	0	0	1	0	0	0	0	0	1
Pump	2	2	3	2	0	0	21	0	30
sum	23	77	119	100	6	37	62	136	560

Source : JICA Survey Team

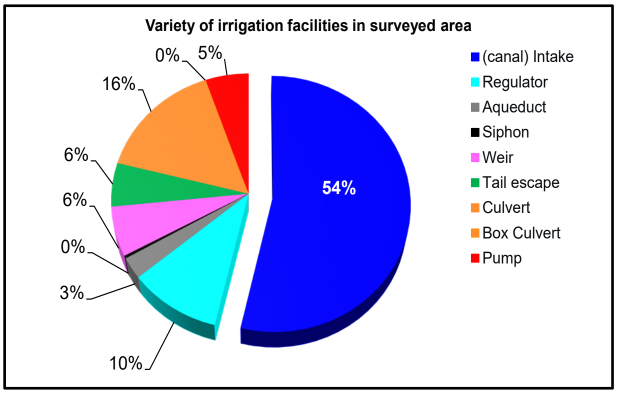


Figure 4.4.2 Pie Chart of Structure Inventory
Source: JICA Survey Team

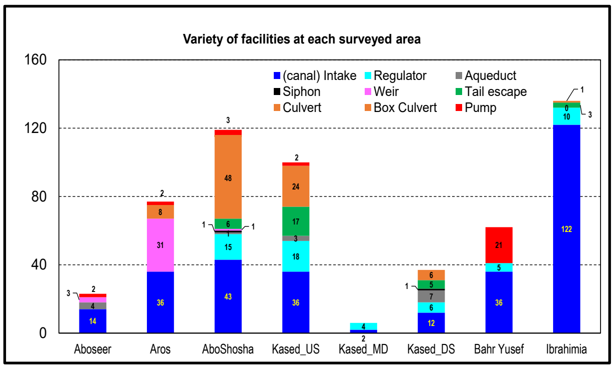


Figure 4.4.3 Graph Chart of Inventory in Each Area
Source: JICA Survey Team

In Figure 4.4.2, intake facilities are the majority of the irrigation facilities in the surveyed area (54%), followed by culverts (box culverts) at 16% and regulators with a 10% share. The following features are captured in Figure 4.4.3:

- ✓ In the Aros & Abo Seer sub-region in Fayoum (13,330 feddan), weirs (drop structures) are found where the topography descends by approximately 30 m from the Lahoun Regulator to Lake Qarun. The weirs work to reduce water energy for the purpose of gentle water distribution, dissipating the water energy effectively.
- ✓ In the Abo Shosha sub-region, there are a significant number of intake structures despite the scheme scale, which is only 17,881 feddan, implying well-organized irrigation networks. Many varieties of irrigation facilities are found within the sub-region, as well as in the Kased Command Area.
- ✓ In the command area of Kased Main Canal (95,976 feddan), which is the largest scheme among the 3 priority sub-regions, the number of facilities is about 1.6 times larger than that in Abo Shosha, in spite of the fact that the command area of Kased is 5 times larger than that of Abo Shosha. Accordingly, it may be said that fewer facilities exist in the Kased sub-region. They are not appropriately stationed where they are needed, which may be creating difficulties with irrigation water distribution.
- ✓ There seems to be an obvious gap between facility numbers in the Bahr Yusef and Ibrahimia Command Areas. There are about twice as many irrigation facilities along the Ibrahimia Principal Canal as along the Bahr Yusef Principal Canal. It could be said that more development and investment have been made in Ibrahimia than in the Bahr Yusef. In the Bhar Yusef Command Area, there are substantial numbers of pumps, implying there is a difficulty in irrigating the whole command area only by gravity. In fact, there are higher command areas toward the western side of Bahr Yusef Command Area, which may require pumps to irrigate.

3) Evaluation of Structures 1st Stage Survey

3.1) Overview of the Rating Evaluation

Based on the rating method of evaluation with S1 to S5, which represents the facility's functionality with "S1" being the highest priority for reconstruction to "S5" being the lowest for its need, the overall trend of evaluation, The result of the prioritization process is summarized in Figure 4.4.4, which uses the S1 to S5 evaluation scale outlined above. In the surveyed areas, structures rated at S1 (7%) and S2 (41%) account for approximately half of all structures. That is, half the facilities in these areas should be rehabilitated and/or reconstructed, or otherwise repaired to some extent.

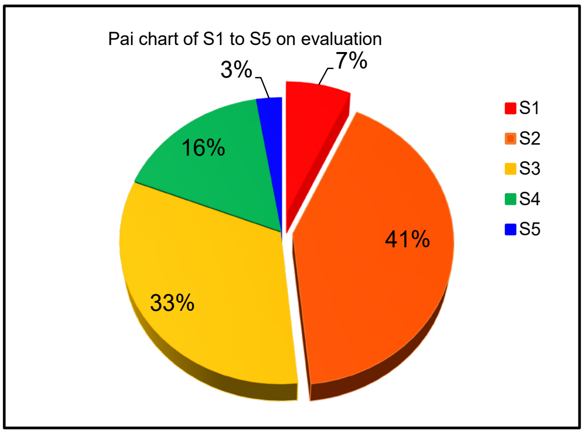


Figure 4.4.4 Pie Chart of Structure Evaluation
Source: JICA Survey Team

The other facilities, i.e., those rated at S3 to S5, are given less priority for rehabilitation. However, S3-rated facilities, which account for 33% of the total, may have to be given proper rehabilitation/repairs in a timely manner. Therefore, periodic monitoring should be conducted.

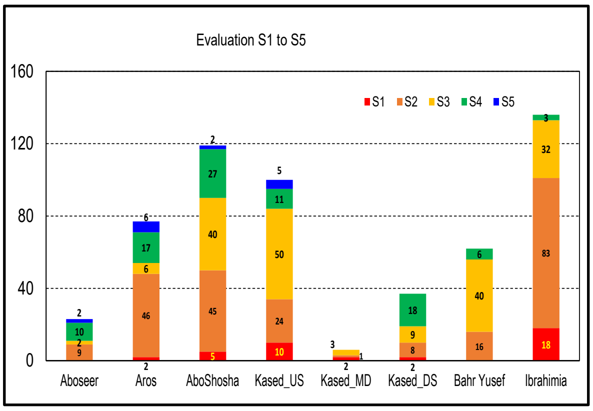
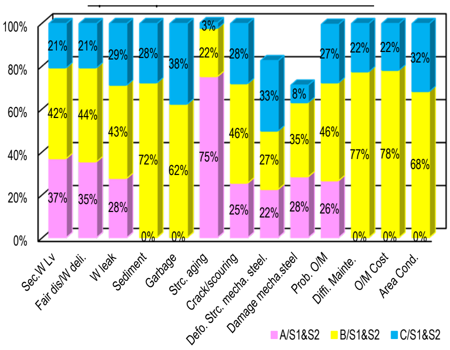


Figure 4.4.5 Graph Chart of Evaluation at Each Area
Source: JICA Survey Team

Figure 4.4.5 shows the trend in evaluation results from S1 to S5 by the surveyed area. There are a total of 39 structures rated at S1, located in Aros (2), Abo Shosha (5), Kased_US (10), Kased_MD (2), Kased_DS (2) and Ibrahimia (18). In those areas, intake is the most common type of structure rated at S1. There are 24 intakes among the 39 S1-rated structures. Along the Ibrahimia Principal Canal, there are 14 intakes evaluated at S1, meaning that almost half of the S1 structures are found along the Ibrahimia Principal Canal. The structures rated at S2 include a variety of facilities, namely Intake, Regulator, Aqueduct, Siphon, Weir, Tail-escape, Culvert (Box culvert) and Pump, but the majority—136—are intakes.

3. 2) Specific Evaluation in Each Facility

The specific statuses of the facilities are determined according to the sub-evaluation comprised of the 13 items on the evaluation sheet. This enables assessments of which problems are serious. A ranking of A, B, and C is used.



Sub-evaluation in Evaluation sheet	Short-description in graph
1. Secure of water level	Sec.W Lv
2. Fair discharge volume/ Water deliverability	Fair dis/W deli.
3. Water leakage	W leak
4. Sedimentation around the structure	Sediment
5. Condition around the structure	Strc arou. Cond.
6. Extent of structural aging	Strc. aging
7. Crack or scouring of part on structure	Crack/scouring
8. Deformation of the structure or mechanical facility or steel material	Defo. Strc. mecha. steel.
9. Damage of the mechanical facility or steel material	Damage mecha.steel
10. Problem of Operation	Prob. Oepe.
11. Ease of maintenance works	Diffi. Mainte.
12. Cost for maintenance at present	O/M Cost
13. Condition of the surround area	Area Cond.

Figure 4.4.6 Specified Problem of All Areas in S1 and S2
Source：JICA Survey Team

The tendencies in specific problems are summarized in Figure 4.4.6, which focuses only on S1- and S2-rated facilities. A table on the right side presents guidance for understanding the figure. The most critical functionality issue in A-rated facilities (identified by a pink color in Figure 4.4.6) is "structure aging." Others highlighted are "security of water level," "fair discharge volume/water deliverability," and "water leakage."

3.3) Result of 1st Stage Survey and the Way Forward to the 2nd Stage Survey

Due to the approximate and subjective assessment used, the 1st stage structure survey may not be able to indicate a specific decision on what design should be applied for reconstruction and/or rehabilitation. However, based on the results of the survey evaluation and rating, the following suggestions should be considered:

- ✓ S1-rated facilities should be given the highest priority for reconstruction in order to restore their hydraulic function. They account for 7% of the irrigation facilities, or 39 facilities out of 560 irrigation structures surveyed.
- ✓ S2-rated facilities should be given the second-highest priority for rehabilitation in most cases, as they account for 41% of the irrigation facilities, or 232 facilities out of 560.
- ✓ To clarify practical measures for reconstruction and/or rehabilitation of the S1- and S2-rated facilities, specific reassessments should be conducted, with reference to the results of the first-stage survey. S1 and S2 facilities should therefore be surveyed again in the field with reference to the items checked on the spreadsheet prepared for the second-stage survey.

4.4.3 2nd Stage Structure Survey (Selective Survey for the S1 and S2 Structures)

In the 1st stage structure survey, 560 hydraulic structures were physically observed and separated into 5 categories: S1, S2, S3, S4, and S5. The ranking was made mostly from the viewpoint of how well or poorly a structure was functioning, with S1 being the worst and S5 the best. With this functionality-focused survey completed, the JICA Survey Team has proceeded to the 2nd stage survey.

The 2nd stage survey now focuses on the level of physical deterioration of each part of the structures ranked at S1 and S2. As aforementioned, S1 indicates the lowest functionality, probably due to severe deterioration, which will most likely require reconstruction. S2 structures show low functionality as well, though not to the level of S1 structures; thus, they may need major rehabilitation. Structures ranked at S3, S4, and S5 are not covered in this stage of the survey, as those structures need only minor repairs and/or rehabilitation, or none at all.

1) Methodology for the 2nd Stage Survey

Prior to the commencement of the 2nd stage survey, the JICA Survey Team compiled a summary table, which shows the results of evaluations of all those hydraulic structures ranked at S1 and S2 in the 1st stage survey. The JICA Survey Team presented the table to the relevant directorate officers, including the undersecretary in most cases and the General Director of Irrigation Directorate, and made a series of confirmations and inquiries. It investigated:

- ✓ the validity of the team's ranking for the S1 and S2 structures, keeping in mind the probable future measures that S1 structures would need for reconstruction and S2 structures would require for major rehabilitation; and
- ✓ other structures needed, which are not in place at present, but which would need to be newly constructed from a viewpoint of, e.g., better water management. An example of this could be a regulator in a long canal where there is currently difficulty in controlling the water level.

Through the confirmations by the relevant officers, some of the S1 structures were suggested to be S2. For example, it was suggested that in structures in which gates would all be replaced but the structure bodies were still solid and only partly damaged, it would not be necessary to replace all the bodies. Additional structures were also proposed to realize and maintain sound water delivery and distribution.

For this 2nd structure survey, the JICA Survey Team has prepared a specific survey sheet, different from the ones employed in the 1st stage survey, with reference to a structural survey format used by MWRI. The new sheet has 2 parts: 1) evaluation of structure status, and 2) evaluation of metal part status. Each of the 2 parts is further sub-divided into 5 items focusing on specific points of observation.

As in the following table, a structure body is scored on each of the 5 parts and given an overall rating, and the metal parts like gates are scored on each of the 5 items and given an overall rating as well. All the surveyed structures are scored according to the checkpoints and rated on a 100-point scale, the same as in the survey format used by MWRI.

Table 4.4.5 Evaluation Sheet for the 2nd Stage (Example for Regulator)

Evaluation Sheet (1/2)

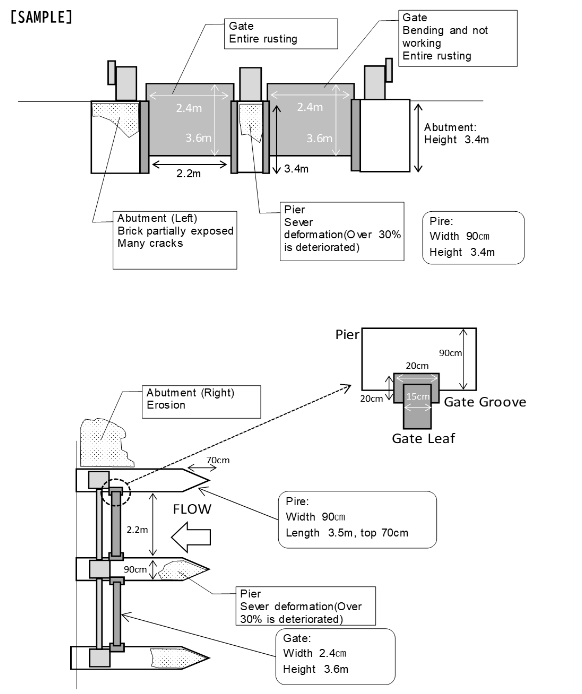
Reference Number of the structure or facility	M1	Location of the structure or facility	XXX canal
Type of structure or facility	Regulator	Name of the structure or facility	XXXX Regulator
Constructed year	19XX	Directorate/ Governorate	XXXX xxxx

ITEMS	Check point	Mark evaluation				Rating
I. Structural status						
1 Pier	Extent of deformation or harmful cracks. Particularly bottom or joint block of pier should be carefully inspected	1: 10	2: -	3: -	4: -	
1 Abutment	Extent of deformation or harmful cracks. Particularly bottom or joint block of pier should be careful inspected	Left: 10		Right: 10		30/30
2 Foundation/Apron	Extent of scouring or erosion on the surface as well as canal bed nearby	5				5/5
3 Entire body	Extent of settlement	5				5/5
4 Retaining wall (on the canal slope protection)	Extent of deformation, harmful cracks or damage at joint section	5				5/5
5 Maintenance or road bridge on regulator	Extent of deformation or harmful cracks. Particularly center of vents or joint block should be carefully inspected	5				5/5
Comments	There are many collapses. Bricks are exposed. Severely deteriorated.					50/50
II. Mechanical status		1	2	3	4	
6 Gate leaf	Extent of deformation or corrosion/ Extent of structural damages	10	10	-	-	10/10
7 Lifting device/Gear box	Extent of deformation or corrosion	10	10	-	-	10/10
8 Chain/Wire rope/ spindle	Extent of deformation or corrosion	10	10	-	-	10/10
9 Gate groove	Extent of deformation or corrosion	10	10	-	-	10/10
10 Entire soundness of gate operation	Extent of difficulty in operational performance	10	10	-	-	10/10
Comments	All gates are bending and not working. Severely deteriorated.					50/50
					Total	100/100
III. Interview to operator and others						
11 Regular maintenance	Once a year.					
12 Condition of the surround area						
13 Remarks if any						
IV. Entire Assessment / Optimal measure for facility						
Gates and the body should be all replaced.						

Evaluation Sheet (2/2)

Reference Number of the structure or facility	M1	Location of the structure or facility	XXX canal
Type of Structure or facility	Regulator/Intake	Name of the structure or facility	XXXX Regulator
Constructed year	19XX	Directorate/ Governorate	XXXX xxxx

Sketch (Main structures)



Source: JICA Survey Team, with modifications of MWRI's survey form

With the survey sheet above prepared, a group of engineers composed of JICA Survey Team members and engineers from relevant directorate and district offices have visited the sites where there are S1 and S2 structures and the places where the irrigation directorate has proposed new structures. The group has observed and visually examined the level of deterioration and damage, and has also asked the site staff about the current status, including vibrations, etc. This information has been used to determine scores according to the parts/items specified on the sheet.

In addition, the group has conducted brief dimension measurements of the structures and for the parts heavily damaged/ deteriorated, and also made sketching for the structures and those parts. The measurement and sketching are meant to serve the purpose of planning the reconstruction and/or major rehabilitation of those structures, namely, to be forwarded to the next step of the basic design. Further, based on the experiences of the relevant officers who were together with the JICA Survey Team at the sites, first hand rough cost estimation for the total replacement and/or major rehabilitation were asked as reference information for the coming cost estimation work.

2) Reassessment of the Structures

Through the 2nd stage survey, those structures that had been ranked as S1 and S2 in the first stage have been reassessed based on the results of scoring on the structural parts and metal parts and considering, the facility's age. Structures that need reconstruction are now classified as S1, and those that need major rehabilitation works are classified as S2.

As a standard, structures with scores over 70 are classified as S1, and those with scores of 50-69 are classified as S2. The following are examples of S1- and S2-ranked structures:

- ✓ Example of an S1 structure: A major part of the facility is collapsed and already not functioning, or the function seems likely to be lost in the near future due to aging even if it is currently in use (e.g., a regulator in which piers and abutments are collapsed).
- ✓ Example of an S2 structure: Partial replacement is required due, for example, to partial collapse or heavy deterioration on a part of the structure (e.g., gates are lost or difficult to operate due to deterioration and/or aging).

With this ranking method of S1 and S2 measures required the deterioration and damage are planned by considering the structure body and mechanical parts separately. For example, in the case of a structure body score of 20/50 and the mechanical part score of 40/50, the total score is 60, which means the structure is classified as S2. In this case, in fact, the deterioration of the body is not so severe, although gates are heavily damaged, so the only measures should be the replacement of the gates and probably minor rehabilitation of the body.

Based on the above-mentioned method of ranking the structures and the interviews with directorate/district engineers, some structures that were evaluated as S1 or S2 in the 1st stage survey have been reassessed as not having any need of certain rehabilitation measures, and thus excluded from the group of S1 or S2 structures. On the other hand, some structures that were evaluated as S2 in the 1st stage survey have been classified as S1 through the discussions and site observations with the directorate engineers, taking into account the levels of deterioration and damage.

Table 4.4.6 and Figures 4.4.7 and 4.4.8 summarize the S1 and S2 structures reassessed through the 2nd stage survey by type of the structure and by canal command area. Tables 4.4.7 and 4.4.8 show the detailed list of the S1 and S2 structures, respectively. From those tables and figures, the following can be found:

- ✓ The number of S1 structures is 41, while that of S2 structures is 144, for a total of 185. Among the principal canals, the Ibrahimia Principal Canal has been found to have a large number of structures that need reconstruction or major rehabilitation, while the Bahr Yusef Principal Canal only has 9 structures ranked at S2 and none at S1. Among the 3 priority sub-regions, the Kased Area has the biggest combined number of S1 and S2 structures.
- ✓ Many intakes have been assessed as S1 and S2 (54% and 77%, respectively). Regulators and tail escapes each make up 15% of S1 structures, followed by weirs, at 10%. Regulators make up 13% of structures ranked at S2, and tail escapes a further 6%.

Table 4.4.6 Reassessed Structures Ranked at S1 and S2 by Canal Area and by Structure Category

Area	Rank	Regulator	Intake	Weir	Culvert	Aqueduct	Pump	Siphon	Tail escape	Total
Abo Shosha	S1	0	1	0	0	0	0	0	0	**1**
	S2	3	16	0	0	0	0	0	5	**24**
Aros & Abo Seer	S1	0	7	3	0	0	0	0	0	**10**
	S2	0	0	2	0	0	0	0	0	**3**
Kased	S1	3	5	0	1	2	0	0	4	**15**
	S2	12	8	0	0	0	0	0	2	**22**
Bahr Yusef	S1	0	0	0	0	0	0	0	0	**0**
	S2	0	5	0	0	0	4	0	0	**9**
Ibrahimia	S1	3	9	1	0	0	0	0	2	**15**

Area	Rank	Regulator	Intake	Weir	Culvert	Aqueduct	Pump	Siphon	Tail escape	Total
	S2	3	82	0	0	0	0	0	1	**86**
Total	**S1**	**6**	**22**	**4**	**1**	**2**	**0**	**0**	**6**	**41**
	S2	**18**	**111**	**3**	**0**	**0**	**4**	**0**	**8**	**144**

Source: JICA Survey Team through site observation with the relevant irrigation directorate/district officers.

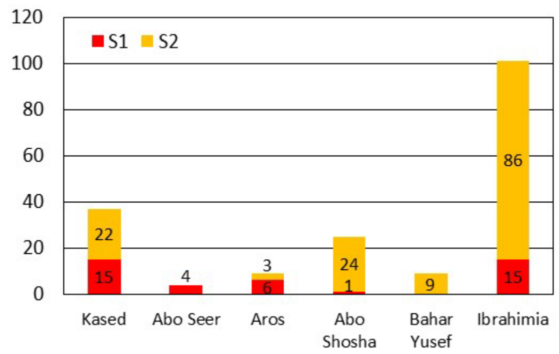


Figure 4.4.7 Number of Structures of S1 and S2

Source: JICA Survey Team

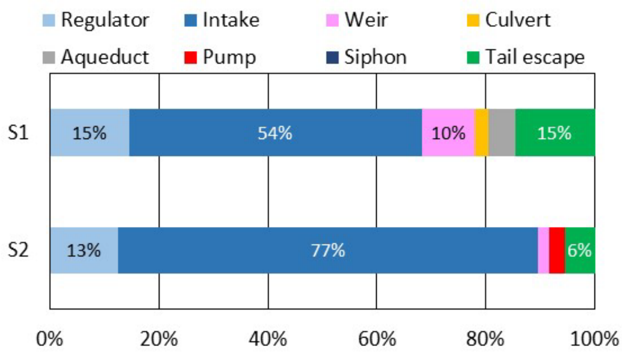


Figure 4.4.8 The Ratio of Structure of S1 and S2

Source: JICA Survey Team

3) Final S1 and S2 Structures by ID Decision

The Irrigation Department (ID) further reviewed the S1 and S2 structures based on the results of the above survey by the JICA Survey Team and field office staff. The ID determined that it would be desirable for the MWRI budget to include funds for some structures, especially smaller ones, and that additional structures would be needed where none existed at this time (e.g., the Kased Intake structure). Table 4.4.7 compares the number of structures identified by the JICA Survey Team and that identified by field officers with the ID, while Tables 4.4.8 and 4.4.9 show the S1 and S2 structures, respectively, by governorate and district.

Referring to Tables 4.4.7 and 4.4.8, three S1 structures have been identified in the Kased area: the Kased Intake Works (new), the Mahlet Menouf Regulator (renewal) and the Sorad Regulator (renewal). Since these are all new large hydraulic structures, the basic design for these structures was described in the above-mentioned 'Section 4.4 Construction of Large Hydraulic Structures: Component 1'.

Table 4.4.7 Number of S1 and S2 Structures Identified in the Field and Final Quantities Identified by ID

Category	From Field		ID HQs Finalization		Difference		Remarks
Evaluation (S1/S2)	S1	S2	S1	S2	S1	S2	
Aros	4	3	4	3	0	0	
Abo Seer	6	0	7	0	1	0	
Abo Shosha	1	24	1	24	0	0	
Kased	15	22	3 (0)*	1	-12	-21	
Bahr Yusef	0	9	0	5	0	-4	
Ibrahimia	15	86	7	80	-8	-6	
Total	41	144	22 (19)*	113	-19	-31	

*/ Shows Kased Intake Works (new), Mahlet Menouf Regulator (renewal) and Sorad Regulator (renewal), which are new large hydraulic structures. The numbers in parentheses are the quantities excluding the three large structures.

Source: JICA Survey Team through site observation with the relevant irrigation directorate/district officers, and ID headquarters

Table 4.4.8 Structures Ranked at S1 by Canal Command Area Base

No.	Ref. No.	Structure Type	Location	Structure Name	Survey Score Body	Survey Score Gate	Survey Score Total	Measures
Abo Seer (Fayoum)								
1	S1-AA-1	Intake	km 0.00	Abo Seer Intake	50	35	85	All replacement (including the road)
2	S1-AA-2	Intake	km 1.754	Omar Bek Intake	35	35	70	All replacement.
3	S1-AA-3	Intake	km 1.755	Bahr El Kashef Intake	35	-	70	All replacement.
4	S1-AA-4	Weir	km.1756	Bahr El Kashef Weir	35	35	70	All replacement.
Aros (Fayoum)								
1	S1-AA-5	Intake	km 5.666	El Maasra Intake	35	-	70	All replacement.

No.	Ref. No.	Structure Type	Location	Structure Name	Survey Score			Measures
					Body	Gate	Total	
2	S1-AA-6	Weir	km 5.674	Defno Weir	35	-	70	All replacement.
3	S1-AA-7	Intake	km 5.671	El Swafna Intake	35	-	70	All replacement.
4	S1-AA-8	Weir	km 5.674	El Barq Weir	35	-	70	All replacement.
5	S1-AA-9	Intake	km 1.277	Khamas sawaki (5 wheels)	50	50	100	All replacement (reinstall water wheels)
6	S1-AA-10	Intake	km 1.745	Talat Sawaki (2 wheels)	50	50	100	All replacement (reinstall water wheels)
7	S1-AA-11	Screen		Bahr Yusef Trash Screen	Added by ID			New construction with electrical system, at the upstream of Lahoun Regulator.
Abo Shosha (Beni Suef)								
1	S1-AS-1	Intake	km 215.00 IB canal LHS	Abo Shosha Intake	45	40	85	Replace the upstream part.
Kased (Gharbia)								
1*	S1-KA-1	Regulator	km 22.000	Sorad cross Regulator *	47	25	72	All replacement (to be studied with structural test)
2*	S1-KA-2	Regulator	km 12.000	Mahlet Menouf Regulator *	44	50	94	All replacement (with electric system).
3*	S1-KA-3	Intake	-	Kased Intake *				New construction at the intake point
Ibrahimia (Beni Suef)								
1	S1-IB-1	Intake	229.700 RHS	Intake of Ahmed Pashe El Bahria	30	50	80	Replace the body & gate (incl. edge & upper layers of the conduit).
2	S1-IB-2	Tail Escape	249.175	Tail escape of El Saida	38.5	33	71.5	Replace the upstream part (with electrical system).
3	S1-IB-3	Weir	273.237	Bani Hader Weir	38.5	50	88.5	All replacement.
4	S1-IB-4	Tail Escape	279.16	El Zawia Tail Escape	35	35	70	Replace the upstream part.
5	S1-IB-5	Tail escape	-	El Fent Canal Tail Escape	added by ID			New construction.
Ibrahimia (Minya)								
1	S1-IB-6	Intake	113.35	Intake of Kom El Zoheir (Right)	40	46	86	Replace the upstream part.
2	S1-IB-7	Intake	114.325 LHS	Intake of Kom El Zoheir (Left)	40	46	86	Replace the upstream part.

*/ Since these are new large hydraulic structures, a basic design was conducted as Component 1 (see 4.3 Construction of Large Hydraulic Structures: Component 1).
Source: JICA Survey Team through site observation with the relevant irrigation directorate/district officers, and ID headquarters

Table 4.4.9 Structures Ranked at S2 by Canal Command Area

No.	Ref. No.	Structure Type	Location	Structure Name	Survey Score			Measures
					Body	Gate	Total	
Aros (Fayoum)								
1	S2-AA-1	Weir	km 0.00	Abo El Meer Weir	25	-	50	Rehabilitate the surface of the body.
2	S2-AA-2	Weir	km 9.612	Weir of Bahr Elo Ghaba Intake	25	-	50	Rehabilitate the surface of the body.
3	S2-AA-3	Weir	km 9.612	Weir of Bahr Itsa El Qebly	25	-	50	Rehabilitate the surface of the body.
Abo Shosha (Fayoum)								
1	S2-AS-1	Intake	km 6.480	Intake of branch - 3 of Abo Shosha	20	30	50	Replace the gate component.
2	S2-AS-2	Intake	8.812=RHS	Branch Talt Intake	25	42	67	Replace the gate component.
3	S2-AS-3	Intake	km 8.850 LHS	Intake of Shawky Branch	20	30	50	Replace the gate component.
4	S2-AS-4	Intake	9.32	Intake of Hanna Branch	20	30	50	Replace the gate component.
5	S2-AS-5	Intake	km 10.800	Intake of Tawfik Branch	20	30	50	Replace the gate component.
6	S2-AS-6	Regulator	km 12.440	El Qoliaa Regulator	20	30	50	Replace the gate component.
7	S2-AS-7	Intake	km 15.435	MAZORA INTAKE	20	30	50	Replace the gate component.
8	S2-AS-8	Intake	km 17.230	Intake of Nosir Branch	20	30	50	Replace the gate component.
9	S2-AS-9	Intake	km 18.500	Intake of Belany Branch	25	40	65	Replace the gate component.
10	S2-AS-10	Regulator	km 18.510	El Sheikh Abed Regulator	20	30	50	Replace the gate component.
11	S2-AS-11	Intake	km 22.590 RHS	El Sheikh Abed Intake	20	30	50	Replace the gate component.
12	S2-AS-12	Tail Escape	km 23.300	El Beweb Tail Escape	25	40	65	Replace the gate component.
13	S2-AS-13	Intake	km 25.610	Intake of Branch - 1 of Abo Shosha	25	40	65	Replace the gate component.
14	S2-AS-14	Regulator	km 27.400	Dashtout cross Regulator	20	30	50	Replace the gate component.
15	S2-AS-15	Tail Escape	km 27.460	DASHTOOT TAIL ESCAPE	25	40	65	Replace the gate component.
16	S2-AS-16	Intake	km 28.820	Intake of Dashtout	20	30	50	Replace the gate component.
17	S2-AS-17	Intake	0	Intake of branch 1 Sheikh Abed	20	30	50	Replace the gate component.
18	S2-AS-18	Intake	0	Intake of Branch 1 of Talt	25	40	65	Replace the gate component.
19	S2-AS-19	Intake	0.00 Branch 2 Talt	Intake of Branch 2 Talt	25	40	65	Replace the gate component.
20	S2-AS-20	Intake	0.00 Selim El Mostagadda	Selim El Mostagadda Intake	25	40	65	Replace the gate component.
21	S2-AS-21	Intake	0.00 Selim	Selim Intake	20	30	50	Replace the gate component.
22	S2-AS-22	Tail Escape	3.032 Selim	Selim Tail Escape	25	40	65	Replace the gate component.
23	S2-AS-23	Tail Escape	2.9	Aref Mesqa Tail Escape	30	38	68	Replace the gate component.
24	S2-AS-24	Tail Escape	2.7	Saft El Arfa Tail Escape	25	40	65	Replace the gate component.

No.	Ref. No.	Structure Type	Location	Structure Name	Survey Score			Measures
					Body	Gate	Total	
Kased (Gharbia)								
1	S2-KA-1	Regulator	km 7.160	Tanta Cross Regulator	34.25	25	59	Replace the gate component (with electrical system).
Bahr Yusef (Beni Suef)								
1	S2-BY-1	Intake	229	Qoftan Intake	0	0	0	Replace the gate component.
2	S2-BY-2	Intake	264	Al Osra Intake	0	0	0	Replace the gate component.
3	S2-BY-3	Intake	265.5	Meiana Intake	0	0	0	Replace the gate component.
Bahr Yusef (Minya)								
1	S2-BY-4	Intake	177	Bahnsa El Qebly Intake	20	30	50	Replace the gate component.
2	S2-BY-5	Intake	-	Manshet Dahab, Saba, Hareka	added by ID			Replace the gate component
Ibrahimia (Beni Suef)								
1	S2-IB-1	Intake	195.200 LHS	Intake besie Bahri bridge	25	40	65	Replace the gate component.
2	S2-IB-2	Intake	200.100 LHS	El Fahnia Intake	25	40	65	Replace the gate component.
3	S2-IB-3	Intake	203.760 LHS	El Fashnia El Qeblia Intake	25	40	65	Replace the gate component.
4	S2-IB-4	Intake	208.700 LHS	Middle Fashnia Intake	25	40	65	Replace the gate component.
5	S2-IB-5	Intake	212.00 LHS	El Fashnia El Bahria Intake	25	40	65	Replace the gate component.
6	S2-IB-6	Intake	213.000 RHS	Al Abaadia Intake	25	40	65	Replace the gate component.
7	S2-IB-7	Intake	215.460 LHS	Intake of gannabeit Abo Shosha -Yosna	25	40	65	Replace the gate component.
8	S2-IB-8	Intake	215.480 LHS	Intake of gannabeit Abo Shosha - Yomna	25	40	65	Replace the gate component.
9	S2-IB-9	Intake	216.400 RHS	El Shrahna Intake	25	40	65	Replace the gate component.
10	S2-IB-10	Intake	217.732 LHS	Absoog El Qeblia Intake	25	40	65	Replace the gate component.
11	S2-IB-11	Intake	217.750 LHS	El Soultany Intake	25	40	65	Replace the gate component (with electrical system).
12	S2-IB-12	Intake	217.794	Intake of El Shrahna and El Qeblia	25	42	67	Replace the gate component.
13	S2-IB-13	Intake	217.776 LHS	Ahmed Pash El Qeblia Intake	25	36	61	Replace the gate component.
14	S2-IB-14	Tail Escape	217.800 LHS	Shrahna Tail escape	15	40	55	Replace the gate component (with electrical system).
15	S2-IB-15	Regulator	217.95	El Shrahna Regulator	25	40	65	Replace the gate component.
16	S2-IB-16	Intake	223.500 LHS	Gannabeit El Shrahna Intake	25	40	65	Replace the gate component.
17	S2-IB-17	Intake	225.010 LHS	Middle Ahmed Pasha Intake	25	40	65	Replace the gate component.
18	S2-IB-18	Intake	229.530 RHS	El Shrahna El Bahria Intake	25	40	65	Replace the gate component.
19	S2-IB-19	Intake	237	Abo Romh Intake	25	44	69	Replace the gate component.
20	S2-IB-20	Intake	238.800 RHS	El Magroofa El Gharbia Intake	25	40	65	Replace the gate component.
21	S2-IB-21	Intake	238.850 LHS	Intake of Gannabeit Tensa - left	25	40	65	Replace the gate component.
22	S2-IB-22	Intake	238.853 LHS	Intake of Tensa connection	25	40	65	Replace the gate component (with electrical system).
23	S2-IB-23	Intake	238.858 LHS	Intake of gannabeit Tensa - right	25	40	65	Replace the gate component.
24	S2-IB-24	Intake	238.860 LHS	Intake of right branch of Tensa	25	40	65	Replace the gate component.
25	S2-IB-25	Intake	244.850 RHS	Intake of Tazmant - right	25	40	65	Replace the gate component.
26	S2-IB-26	Intake	244.850 LHS	Intake of Sheikh Haroun	25	40	65	Replace the gate component.
27	S2-IB-27	Intake	245.550 RHS	Nasrt Qebly Intake	25	40	65	Replace the gate component.
28	S2-IB-28	Intake	247.800 LHS	Intake of El Sahhara Ahnasia	25	40	65	Replace the gate component.
29	S2-IB-29	Intake	247.800 RHS	Intake of new Beni Suef	25	40	65	Replace the gate component.
30	S2-IB-30	Intake	248.100 LHS	Aseer Intake	25	40	65	Replace the gate component.
31	S2-IB-31	Intake	249.100 LHS	Intake of Al Azhary water	15	45	60	Replace the gate component.
32	S2-IB-32	Intake	251 RHS	El Sahhara Intake	25	43	68	Replace the gate component.
33	S2-IB-33	Regulator	252.4	El Geneidy Regulator	17	40	57	Replace the gate component (with electrical system).
34	S2-IB-34	Intake	258.000 LHS	Boosh Intake	25	40	65	Replace the gate component.
35	S2-IB-35	Intake	262.800 LHS	El Zeitoon Intake	25	40	65	Replace the gate component.
36	S2-IB-36	Intake	263.800 RHS	Intake of Ashmant El Qeblia	25	40	65	Replace the gate component.
37	S2-IB-37	Intake	263.985 LHS	Intake of Gannabeit El Mansour	25	40	65	Replace the gate component.
38	S2-IB-38	Intake	264.000 LHS	Intake of Mansour	25	40	65	Replace the gate component.
39	S2-IB-39	Intake	264.015 LHS	Intake of the right Gannabit El Mansour	25	40	65	Replace the gate component.
40	S2-IB-40	Regulator	264.045	Ashmant Regulator	16	44	60	Replace the gate component (with electric system).
41	S2-IB-41	Intake	264.650 LHS	Intake of Gannabeit bny Odai	20	30	50	Replace the gate component.
42	S2-IB-42	Intake	267.400 LHS	Intake of new Gannabeit Qashasha	20	30	50	Replace the gate component.
43	S2-IB-43	Intake	270.060 LHS	Intake of west Gannabeit El Maimoon	25	40	65	Replace the gate component.
44	S2-IB-44	Intake	274.000 RHS	Ashmant El Baharia Intake	25	40	65	Replace the gate component.
45	S2-IB-45	Intake	275.000 LHS	Middle Qashisha Intake	25	40	65	Replace the gate component.
46	S2-IB-46	Intake	278	El Zawia & Abo Zeid Intake	25	40	65	Replace the gate component.
47	S2-IB-47	Intake	279.080 LHS	El Masloub branch Intake	25	40	65	Replace the gate component.
48	S2-IB-48	Intake	280.145 LHS	El Hooma Intake	25	40	65	Replace the gate component.
49	S2-IB-49	Intake	280.160 LHS	Maidoom Intake	25	40	65	Replace the gate component.
50	S2-IB-50	Intake	280.170 LHS	Afoo Intake	25	40	65	Replace the gate component.
51	S2-IB-51	Intake	280.200 LHS	Intake of gannabia - 1 of Ibrahimia	25	40	65	Replace the gate component.
52	S2-IB-52	Intake	283.1	Atwab Intake	25	40	65	Replace the gate component.

No.	Ref. No.	Structure Type	Location	Structure Name	Survey Score			Measures
					Body	Gate	Total	
53	S2-IB-53	Intake	284.700 LHS	Intake of Gann 1 of Ib	25	40	65	Replace the gate component.
54	S2-IB-54	Intake	285.000 LHS	Intake of Gannabia -1 of Ibrahimia	25	40	65	Replace the gate component.
55	S2-IB-55	Intake	288.8	Intake - 2 of Gannabeit Ibrahimia	25	40	65	Replace the gate component.
Ibrahimia (Minya)								
1	S2-IB-56	Intake	85.1	El Sabein Intake	25	40	65	Replace the gate component.
2	S2-IB-57	Intake	92.685	Serry Pasha Intake	20	35	55	Replace the gate component (with electrical system).
3	S2-IB-58	Intake	119.100 RHS	Intake of Abo Mahdy	35	30	65	Replace the gate component.
4	S2-IB-59	Intake	122.340 RHS	Maqosa Intake	25	40	65	Replace the gate component.
5	S2-IB-60	Regulator	132.15	New El Minia Regulator	25	40	65	Replace the gate component (with electrical system).
6	S2-IB-61	Intake	135.225 LHS	El Bergaia Intake	25	40	65	Replace the gate component.
7	S2-IB-62	Intake	138.200 LHS	Morqos Intake- Sefsafa - 2	25	40	65	Replace the gate component.
8	S2-IB-63	Intake	140.000 LHS	El Magrfa Intake	25	40	65	Replace the gate component.
9	S2-IB-64	Intake	143.650 LHS	Al Hatata Intake	25	40	65	Replace the gate component.
10	S2-IB-65	Intake	180.285 RHS	Abo Aseer El Qeblia Intake	25	40	65	Replace the gate component.
11	S2-IB-66	Intake	186.000 LHS	El Gharabawy Intake	25	40	65	Replace the gate component.
12	S2-IB-67	Intake	186.200 LHS	Aba El Sharqia Intake	30	35	65	Replace the gate component.
13	S2-IB-68	Intake	187.310 LHS	Aba El Gharbia Intake	25	40	65	Replace the gate component.
14	S2-IB-69	Intake	187.900 LHS	Dahrout El Qeblia Intake	25	40	65	Replace the gate component.
15	S2-IB-70	Intake	189.300 RHS	Aly Fahmy Intake	30	35	65	Replace the gate component.
16	S2-IB-71	Intake	189.5	Dahrout El Baharia Intake	25	40	65	Replace the gate component.
17	S2-IB-72	Intake	191.160 LHS	Attalah Intake	25	40	65	Replace the gate component.
18	S2-IB-73	Intake	192.300 LHS	El Gendia Intake	25	40	65	Replace the gate component.
19	S2-IB-74	Intake	193.100 LHS	El Fashnia Intake	25	40	65	Replace the gate component.
20	S2-IB-75	Intake	193.900 LHS	Ganbia Fashnia Intake	25	40	65	Replace the gate component.
21	S2-IB-76	Regulator	-	New Hafez, Matay, Maghagha				Electrify the gate system.
22	S2-IB-77	Intake	92.695 RHS	Hafez El Sharqia Intake	48	35	83	Replace the gate component.
23	S2-IB-78	Intake	93.400 LHS	Hafez El Gharbia Intake	45	40	85	Replace the gate component.
24	S2-IB-79	Intake	125.750 RHS	El Doost Intake	48	35	83	Replace the gate component.
25	S2-IB-80	Intake	151.100 LHS	Samalout Intake	50	25	75	Replace the gate component.

Source: JICA Survey Team through site observation with the relevant irrigation directorate/district officers, and ID headquarters

3.1) Example of an S1 Structure: Abo Seer Intake

The structure was once evaluated as S2 during the 1st stage survey because the gate was in operation and there were moderate deteriorations found. However, as this is an important facility for the area and there is high concern about the loss of functionality due to its aging, the directorate office proposed an entire replacement.

With the detailed visual inspections under the 2nd stage survey, the brick structure was found to be deteriorating significantly, with many cracks and damaged parts already starting to collapse. Likewise, the gate was found to have been largely damaged and difficult to operate. As a result, this intake was reassessed as S1, and the body and the gate system will be reconstructed.

Body: There are collapses already started in the lower parts of the brick structure.

Gate: Badly damaged, partly deformed, and very much difficult to operate.

Figure 4.4.9 An Example of a Status S1 Structure, Reassessed from the 1st Stage Survey Result

Source: JICA Survey Team

3.2) Example of an S2 Structure: Eknaway Intake

This is the intake of Eknaway Branch Canal installed on the Kased Main Canal, which was evaluated as S2 in the 1st stage survey. In the 2nd stage survey, deterioration/damage has been observed on the surface of the intake body, and the gate has been out of order due to the loss of lifting devices. With these current conditions, it is concluded that the gate should be replaced, and deteriorated/damaged parts of the body should be rehabilitated, but there is no need to reconstruct the intake body. Therefore, the Eknaway Intake has again been ranked at S2.

	
Gate: The lifting device is lost and out of operation.	Body: Deterioration/damage is apparent.

Figure 4.4.10 An Example of a Status S2 Structure (Eknaway Intake on the Kased Main Canal)
Source: JICA Survey Team

4.5 Large Canal Rehabilitation (Bahr Yusef, Ibrahimia, Kased Canals): Component 4

The plans for new construction and rehabilitation of hydraulic structures in the target area, such as regulating weirs and water intake works at the entrance of branch canals, were described in the previous chapters. This section describes the rehabilitation plan for large scale canals not covered above. The large canals covered in this section are the Bahr Yusef Principal Canal and Ibrahimia Principal Canal in the Upper Egypt, and also the Kased Main Canal located in the central delta in Gharbia and Kafr El Sheik Governorates. All of these canals are operated under continuous flow.

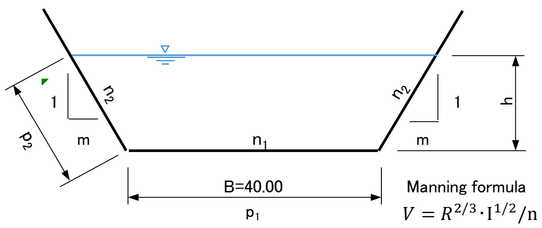
4.5.1 Rehabilitation of Bahr Yusef and Ibrahimia Principal Canals

As afore-mentioned in the hydrologic assessment evaluation, the flow capacity of both principal canals is insufficient. Against this problem, the flow capacity must be increased by, e.g., putting back the cross section to the designed one by widening and/or deepening the cross-sections, and also it can be done by the introduction of concrete lining for the purpose of improving the roughness. However, improvement of roughness by the introduction of concrete lining may not be a realistic solution due to the following reasons, and therefore putting back to the designed sections by dredging, or otherwise, measures to prevent overflow from the canals could be a realistic solution:

- ✓ The JICA Survey team believes that there is no choice but to allow sedimentation in the canals due to transported soil/sand from upstream and flying sand from desert areas nearby. Therefore, dredging and other maintenance works against sedimentation is periodically needed to secure the flow capacity, and thus a maintenance plan should be well designed. Lining the canal bed would make maintenance difficult because the lining itself may be damaged by those works,
- ✓ Due to the flat shape of the canal cross section, effective roughness improvement cannot be achieved by installing lining only on the canal slope sections. As shown in the table below, when lining is applied only to the canal slope sections, only about 40 cm of water level reduction can be obtained in the case of concrete lining, and only about 10 cm in the case of masonry and gabion, and
- ✓ Lining work along the entire canal is very difficult because towns and villages are located along the principal canals and there are many crossing structures such as bridges.

Table 4.5.1 Comparative Study of Revetment Types and Combined Roughness

levee protection type	Flow rate Q(m3 /s)	Bottom width B(m)	Gradient m	coefficient of roughness n1	n2	ni	average flow velocity V(m/s)	Uniform depth h(m)	Depth difference Δh(m)
Embankment canal	200.00	40.00	1.5	0.030	0.030	0.030	0.85	4.963	0.000
Concrete lining	200.00	40.00	1.5	0.030	0.015	0.026	0.93	4.567	-0.396
Masonry/ Gabion	200.00	40.00	1.5	0.030	0.025	0.029	0.87	4.866	-0.097



n_i : composite roughness coefficient

$$ni = \{\frac{1}{\Sigma pi}(p1 \cdot n1^{\frac{3}{2}} + p2 \cdot n2^{\frac{3}{2}} \cdots\cdots\}^{2/3}$$

p_i : wetted perimeter (m)

Source: JICA Survey Team

1) Improvement by Re-shaping the Cross Section

The cross section of the principal canals is determined by overlaying the existing cross section with the planned standard cross sections and, when required and possible, expanded canal cross sections (see Figure 4.5.1). The planned cross section is determined by estimating the canal bed width, expressed as “B”, to keep the flow capacity and prevent from overflow along the entire canals. The canal bed width should be designed by make cross sections smaller from upstream to downstream. The determined cross sections of the improvement plan are shown in Table 4.5.2 and Table 4.5.3.

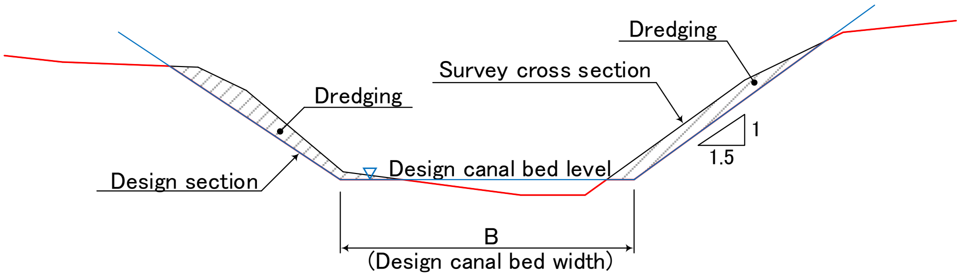


Figure 4.5.1 Typical Cross Section of Improvement

Source: JICA Survey Team

Table 4.5.2 Improvement Plan of the Cross Section (Bahr Yusef Principal Canal)

Interval			Distance (km)	Planned bottom width B (m)			Remarks
				Max.Q	14% up	32%up	
NDGRs	-	Dahab Reg.	76.560	50.0	45.0	40.0	
Dahab Reg.	-	Sakoula Reg.	101.700	45.0	40.0	35.0	
Sakoula Reg.	-	Mazoura Reg.	53.950	45.0	40.0	35.0	
Mazoura Reg.	-	Lahoun Reg	60.430	45.0	40.0	35.0	

Source: JICA Survey Team

Table 4.5.3 Improvement Plan of the Cross Section (Ibrahimia Principal Canal)

Interval			Distance (km)	Planned bottom width B (m)			Remarks
				Max.Q	14% up	32%up	
NDGRs	-	New Hafez Reg.	33.040	40.0	40.0	35.0	
New Hafez Reg.	-	New Minia Reg.	38.808	40.0	35.0	30.0	
New Minia Reg.	-	Matay Reg.	34.632	35.0	35.0	30.0	
Matay Reg.	-	Maghagha Reg.	27.460	35.0	30.0	25.0	
Maghagha Reg.	-	Shrahna Reg.	23.990	30.0	25.0	25.0	
Shrahna Reg.	-	Geneidy Reg.	34.630	25.0	25.0	20.0	
Geneidy Reg.	-	Ashmant Reg.	12.060	25.0	20.0	20.0	
Ashmant Reg.	-	Buy Hedira Reg.	9.400	15.0	15.0	10.0	
Buy Hedira Reg.	-	Bahary Reg.	9.390	10.0	7.0	7.0	

Source: JICA Survey Team

2) Hydraulic Verification after the Improvement

The results of the hydraulic verification after the improvement of cross sections are shown in Table 4.5.4 and Table 4.5.5, and Figures 4.5.2 to 4.5.7 for hydraulic profile.

Table 4.5.4 Result of Hydraulic Examination Along the Bahr Yusef Principal Canal

		Discharge conditions				Remarks
		Max.Q	14%up	32%up	Min.Q (winter season)	
NDGRs	WL. at U/S(m)	N/A	N/A	N/A	N/A	
	WL. at D/S(m)	44.539	44.414	44.164	42.857	
Dahab Reg.	WL. at U/S(m)	40.400	40.400	40.400	40.400	B.P of examination
	WL. at D/S(m)	39.613	39.527	39.270	37.826	
Sakoula Reg.	WL. at U/S(m)	33.700	33.700	33.700	33.700	B.P of examination
	WL. at D/S(m)	32.381	32.317	32.132	31.070	
Mazoura Reg.	WL. at U/S(m)	29.700	29.700	29.700	29.700	B.P of examination
	WL. at D/S(m)	28.887	28.821	28.647	27.635	
Lahoun Reg.	WL. at U/S(m)	26.600	26.600	26.600	26.600	B.P of examination
	WL. at D/S(m)	N/A	N/A	N/A	N/A	

Source: JICA Survey Team

Table 4.5.5 Result of Hydraulic Examination in Ibrahimia Principal Canal

		Discharge conditions				Remarks
		Max.Q	14%up	32%up	Min.Q (winter season)	
NDGRs	WL. at U/S(m)	N/A	N/A	N/A	N/A	
	WL. at D/S(m)	45.017	44.814	44.724	43.852	
New Hafez Reg.	WL. at U/S(m)	43.000	43.000	43.000	43.000	B.P of examination
	WL. at D/S(m)	42.649	42.693	42.630	41.628	
New El Minia Reg.	WL. at U/S(m)	39.900	39.900	39.900	39.900	B.P of examination
	WL. at D/S(m)	39.518	39.325	39.281	38.381	
Matay Reg.	WL. at U/S(m)	36.500	36.500	36.500	36.500	B.P of examination
	WL. at D/S(m)	36.178	36.264	36.230	35.386	
Maghagha Reg.	WL. at U/S(m)	34.300	34.300	34.300	34.300	B.P of examination
	WL. at D/S(m)	33.928	34.028	33.554	32.872	
El Shrahna Reg.	WL. at U/S(m)	32.100	32.100	32.100	32.100	B.P of examination
	WL. at D/S(m)	31.834	31.678	31.779	30.997	
El Geneidy Reg.	WL. at U/S(m)	29.000	29.000	29.000	29.000	B.P of examination
	WL. at D/S(m)	28.650	28.754	28.481	28.212	
Ashmant Reg.	WL. at U/S(m)	28.000	28.000	28.000	28.000	B.P of examination
	WL. at D/S(m)	27.715	27.643	27.816	27.445	
Bny Hedira Reg.	WL. at U/S(m)	27.100	27.100	27.100	27.100	B.P of examination
	WL. at D/S(m)	26.637	26.725	26.436	26.053	
El Wasta Reg.	WL. at U/S(m)	25.500	25.500	25.500	25.500	B.P of examination
	WL. at D/S(m)	N/A	N/A	N/A	N/A	

Source: JICA Survey Team

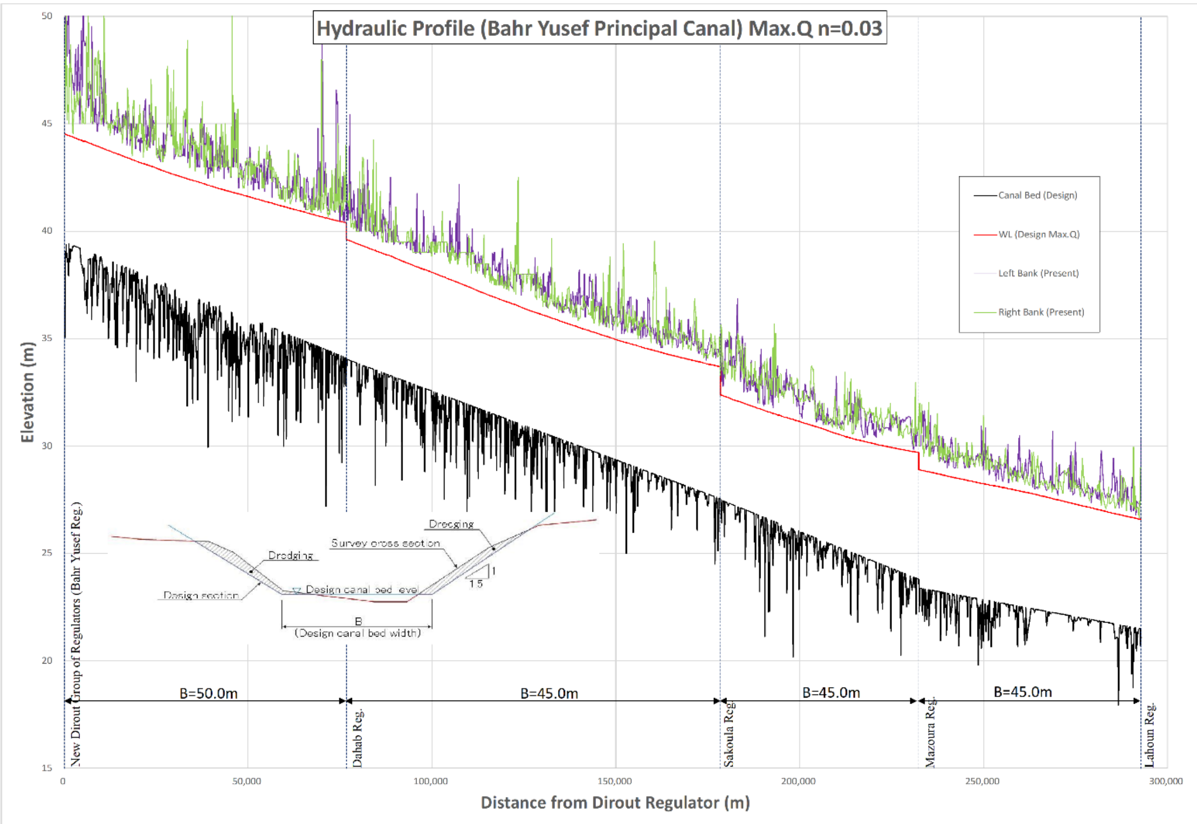


Figure 4.5.2 Hydraulic Longitudinal Section of Bahr Yusef Principal Canal (Maintenance Plan: Max.Q)

Source: JICA Survey Team

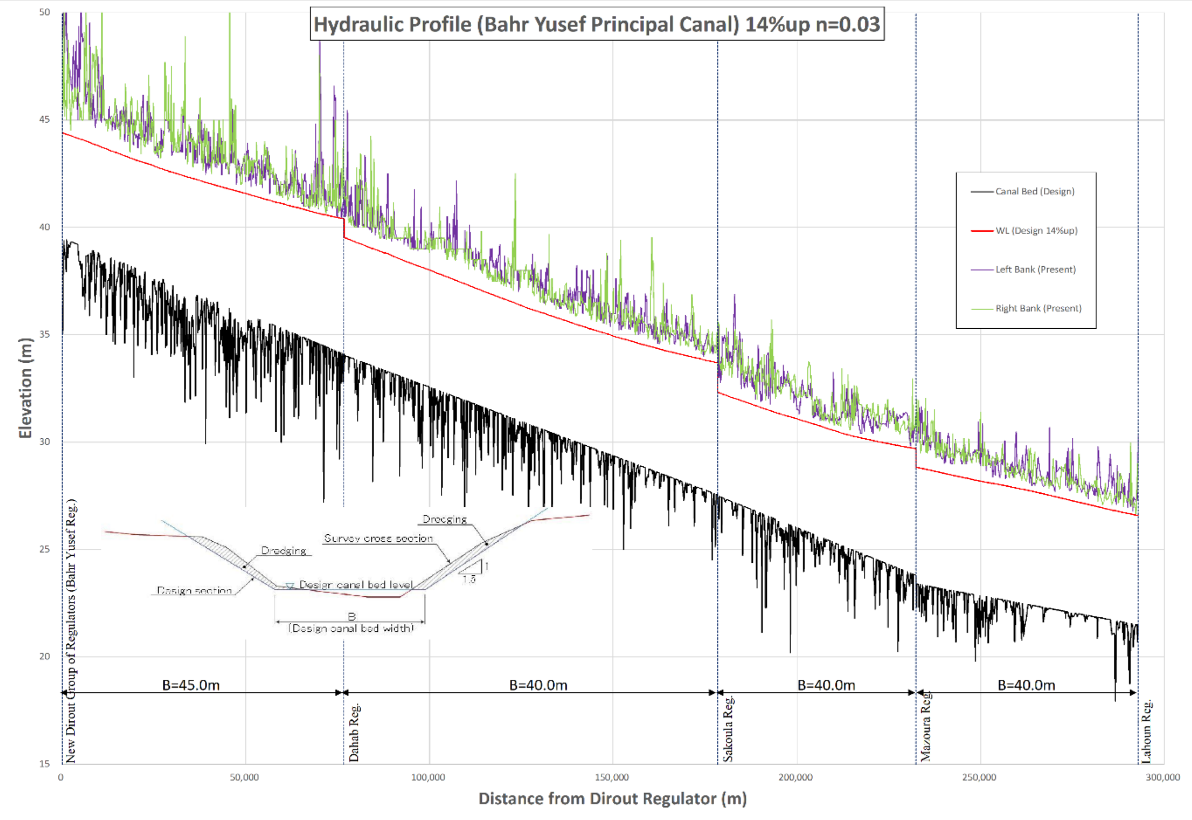


Figure 4.5.3 Hydraulic Longitudinal Profile of Bahr Yusef Principal Canal (Maintenance Plan: 14% up)

Source: JICA Survey Team

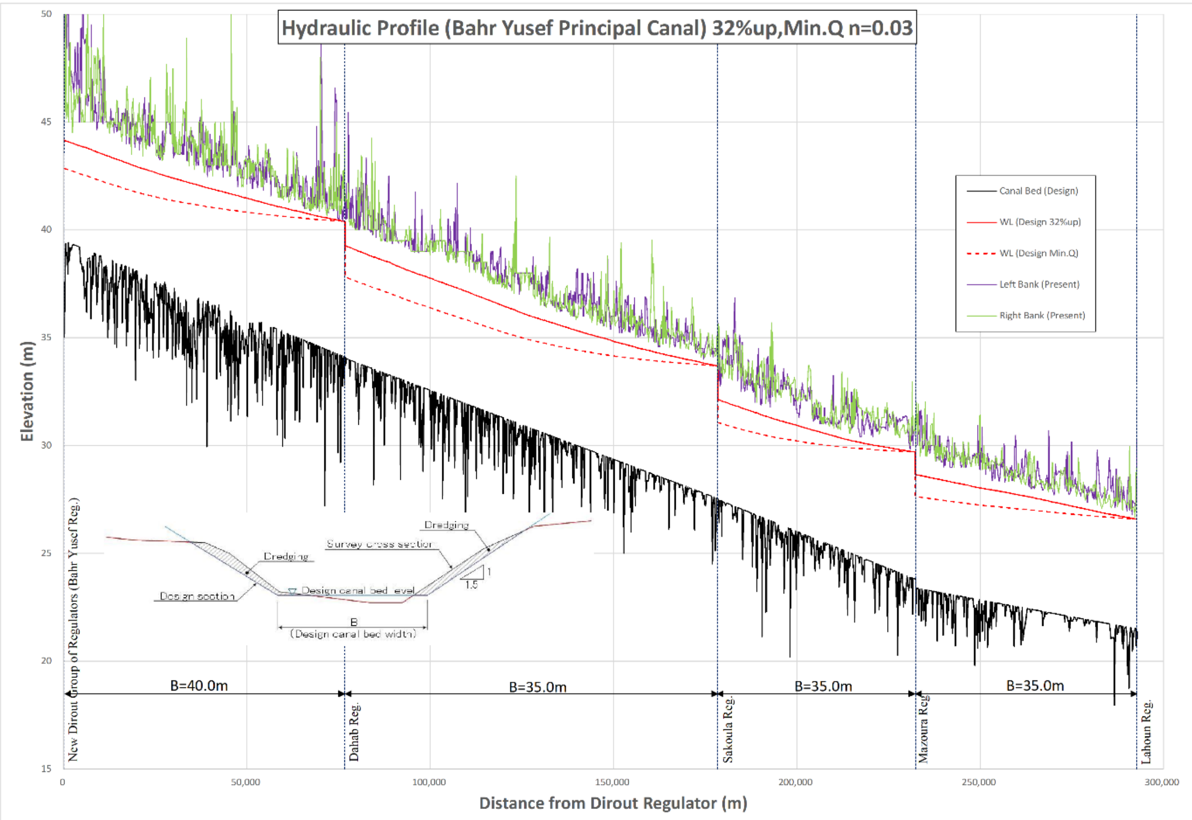


Figure 4.5.4 Hydraulic Longitudinal Profile of Bahr Yusef Principal Canal (Maintenance Plan: 32% up & Min.Q)

Source: JICA Survey Team

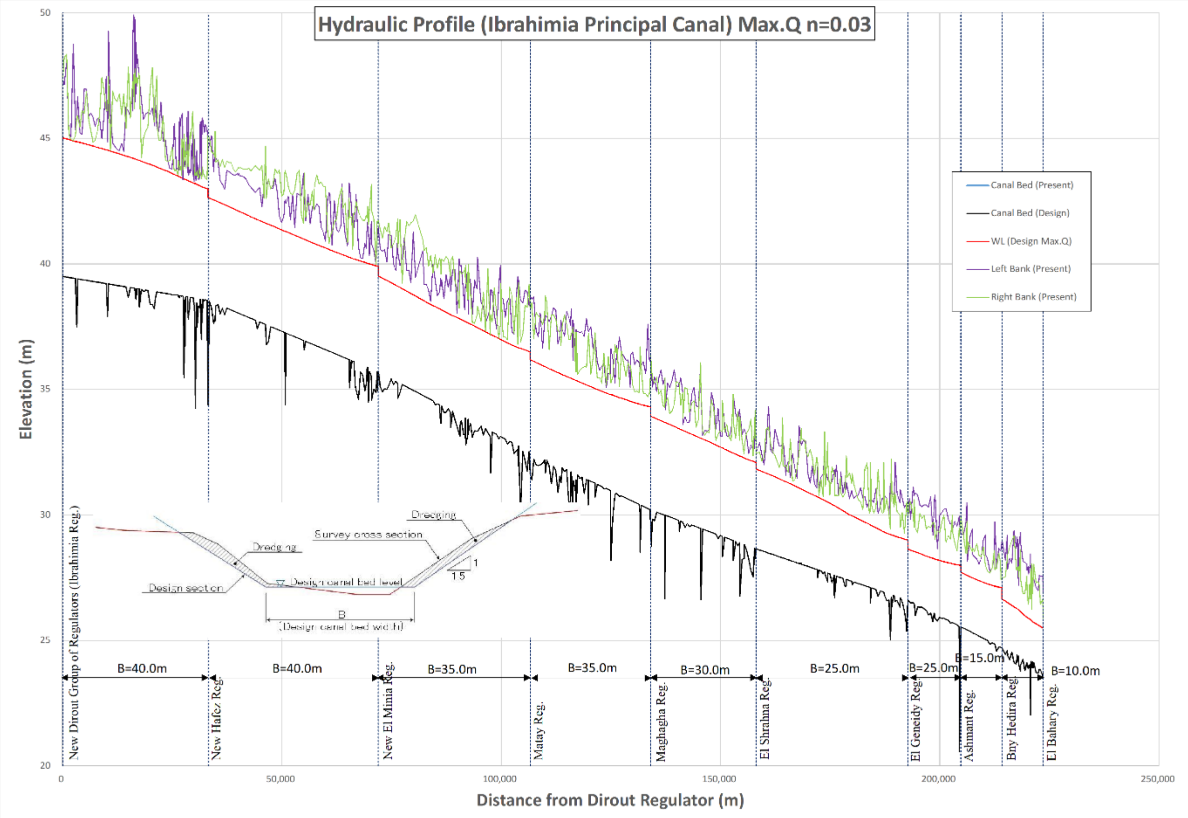


Figure 4.5.5 Hydraulic Longitudinal Section of Ibrahimia Principal Canal (Maintenance Plan: Max.Q)

Source: JICA Survey Team

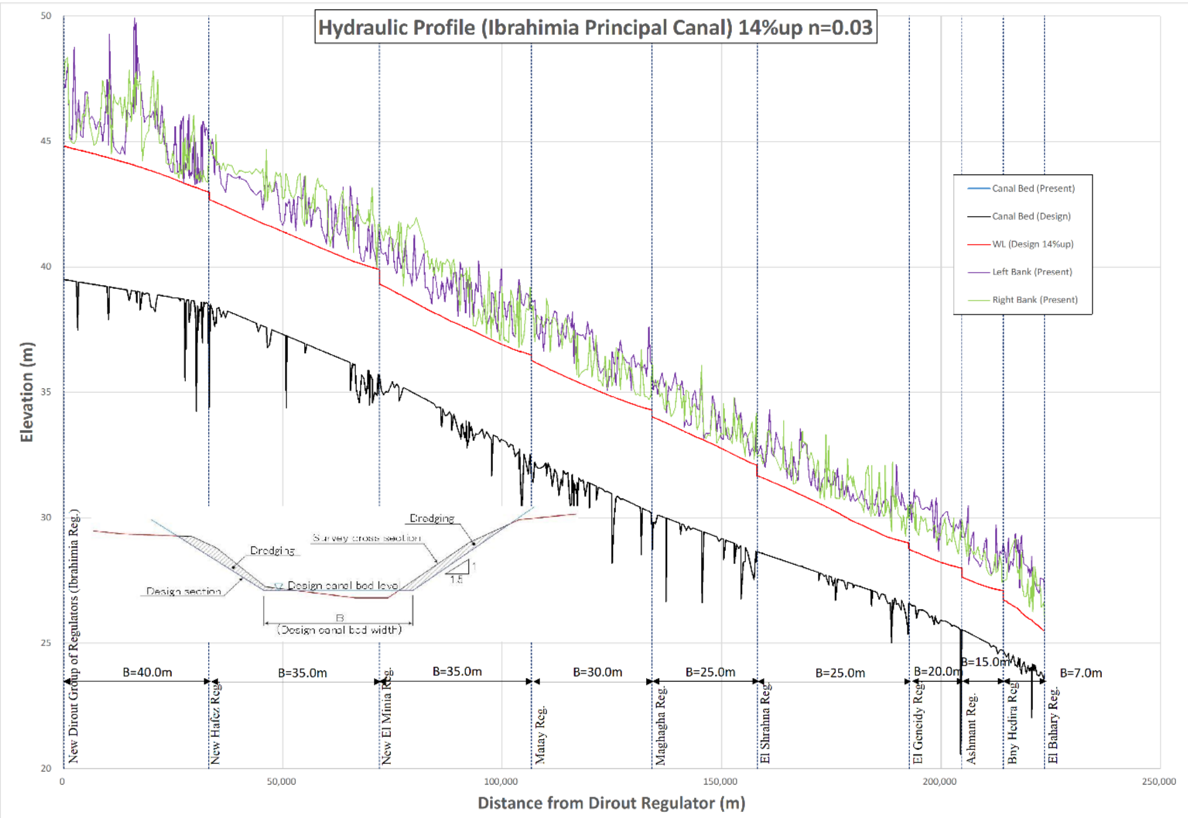


Figure 4.5.6 Hydraulic Longitudinal Profile of Ibrahimia Principal Canal (Maintenance Plan: 14% up)

Source: JICA Survey Team

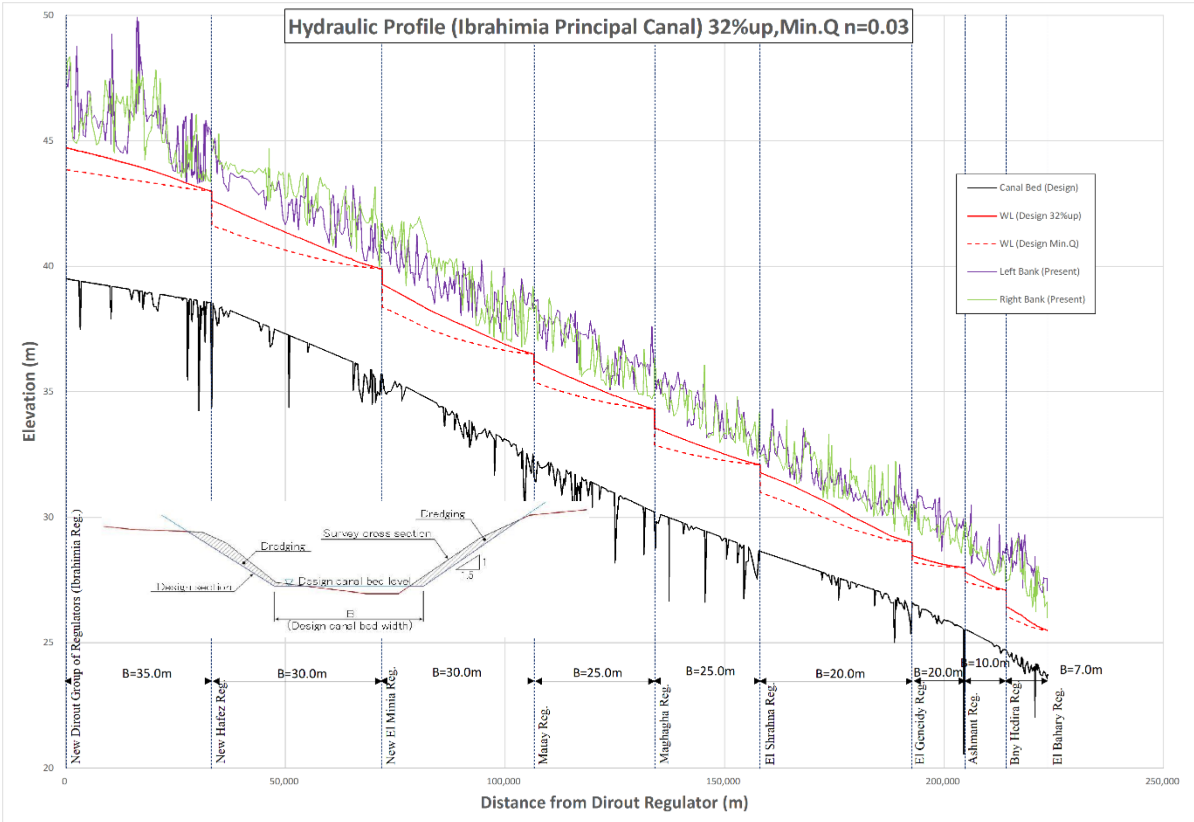


Figure 4.5.7 Hydraulic Longitudinal Profile of Ibrahimia Principal Canal (Maintenance Plan: 32% up & Min.Q)

Source: JICA Survey Team

3) Quantity for the Improvement

The aforementioned hydraulic analysis of both canals considered the current cross-sections and the cases of improved irrigation efficiencies (two cases: irrigation efficiency increased by 14% and 32%). The simulation indicated that dredging of 11 million to 21 million cum for the Bahr Yusef Principal Canal and 6 million to 11 million cum for the Ibrahimia Principal Canal would be required to solve the cross-sections shortage. It is not feasible to dredge these large amounts of sediments within a single period of the project plan.

Table 4.5.6 Quantities on Bahr Yusef Principal Canal Dredge Soils

Interval			Distance (km)	Amount of dredged soils					
				Max.Q		14%up		32%up	
				B(m)	Vol(m^3)	B(m)	Vol(m^3)	B(m)	Vol.(m^3)
NDGRs	-	Dahab Reg.	76.560	50.0	5,417,000	45.0	3,842,000	40.0	2,600,000
Dahab Reg.	-	Sakoula Reg.	101.700	45.0	7,504,000	40.0	5,544,000	35.0	4,007,000
Sakoula Reg.	-	Mazoura Reg.	53.950	45.0	3,650,000	40.0	2,642,000	35.0	1,858,000
Mazoura Reg.	-	Lahoon Reg	60.430	45.0	3,952,000	40.0	2,903,000	35.0	2,098,000
Sum			292.640		20,523,000		14,931,000		10,563,000

Source: JICA Survey team

Table 4.5.7 Quantities on Ibrahimia Principal Canal Dredge Soils

Interval			Distance (km)	Amount of dredged soils					
				Max.Q		14%up		32%up	
				B(m)	Vol(m^3)	B(m)	Vol(m^3)	B(m)	Vol.(m^3)
NDGRs	-	New Hafez Reg.	33.040	40.0	2,027,000	40.0	2,027,000	35.0	1,482,000
New Hafez Reg.	-	New Minia Reg.	38.808	40.0	2,542,000	35.0	1,785,000	30.0	1,229,000
New Minia Reg.	-	Matay Reg.	34.632	35.0	1,085,000	35.0	1,085,000	30.0	618,000
Matay Reg.	-	Maghagha Reg.	27.460	35.0	1,483,000	30.0	870,000	25.0	458,000
Maghagha Reg.	-	Shrahna Reg.	23.990	30.0	984,000	25.0	590,000	25.0	590,000
Shrahna Reg.	-	Geneidy Reg.	34.630	25.0	1,289,000	25.0	1,289,000	20.0	747,000
Geneidy Reg.	-	Ashmant Reg.	12.060	25.0	659,000	20.0	443,000	20.0	443,000
Ashmant Reg.	-	Buy Hedira Reg.	9.400	15.0	271,000	15.0	271,000	10.0	136,000
Buy Hedira Reg.	-	Bahary Reg.	9.390	10.0	119,000	7.0	66,000	7.0	66,000
Sum			223.410		10,459,000		8,426,000		5,769,000

Source: JICA Survey team

4) Measures against the Lack of Cross-sections (Measure against Overflowing)

Since the dredging work is conducted as part of MWRI's annual maintenance work, the Team proposes that the cross-sectional profile should be shaped during the dredging (see Figure 4.5.1 and Tables 4.5.2 and 4.6.3 afore-mentioned) and the required section (see Tables 4.5.6 and 4.5.7 above) be included in the maintenance plan and implemented over a long term. Therefore, cross-sectional reshaping by dredging works will not be addressed as a project component for this Project.

On the other hand, in a canal with insufficient cross-sectional area, it is possible to compensate for the lack of cross-sectional area by raising the embankment, in addition to measures by dredging. According to the hydraulic simulation results at the existing cross-sections, the maximum overflow height at the present maximum flow and at the flow with improved irrigation efficiencies of 14% and 32% would be 87 - 4 cm for the Bahr Yusef Principal Canal and 87 - 38 cm for the Ibrahimia Principal Canal, respectively.

Based on the scale of the overflow depths, it is assumed that an increase of approximately 1 m of the canal embankment would be sufficient. Embankments are generally raised by an additional soil-material top-up, but concrete retaining walls can be installed for smaller overflow depths. In particular, it is judged that it would be difficult to adopt embankment works that require a certain degree of base width in both target canals, due to the parallel-running of railroads and trunk roads, and also site constraints in the vicinity of urban areas. In addition, in general in Egypt, it is difficult to procure good quality soil material with a good grain size distribution.

Therefore, a small concrete retaining wall (1 m height) is planned to be placed at the top of the canal bank (see Figure 4.5.8). Regarding the problem of insufficient cross section of Bahr Yusef and Ibrahimia Principal Canals, it is expected that a certain overflow prevention effect can be quickly obtained by raising the top of the canal bank with this concrete wall. As the irrigation efficiency will be improved in future, the preventive measure takes up the maximum 32% increase in irrigation efficiency, under which the plan to install concrete retaining walls in the overflow sections is made. As some of the to-be-raised areas have sections where the existing bank height is higher than the overflow water depth, the raised areas where the concrete retaining wall is to be installed should be determined by excluding those sections (see Table 4.5.8 and Table 4.5.9). Note that since the right bank of the Ibrahimia Principal Canal (adjacent to the railroad) is not damaged by overflow, only the overflow section of the left bank is targeted for raising.

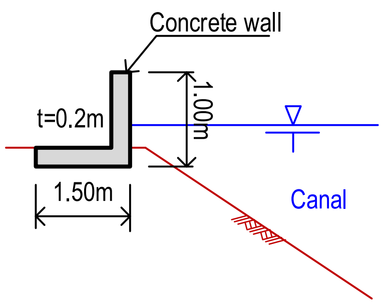


Figure 4.5.8 Raised Concrete Retaining Wall
Source: JICA Survey Team

Table 4.5.8 Raised Sections of Bahr Yousef Principal Canal

Bahr Yousef canal			
Left bank		Right bank	
Distance from DGR	Length(km) *	Distance from DGR	Length(km) *
61.202 - 70.772km	9.570 (1.431)	66.746 - 68.983km	2.237 (1.059)
79.241 - 80.249km	1.008 (0.754)	77.929 - 79.895km	1.966 (1.449)
216.623 - 219.626km	3.003 (0.932)	94.638 - 97.705km	3.067 (2.093)
Subtotal	13.581km (3.117km)	Subtotal	7.270km (5.411km)
		Grand total	20.851km (8.528km)

Note: The total distance (Length) is from the Dirout Regulator Group (DGR) to the target area scattered within the section.
* ( ) shows the section where the concrete retaining wall shall be installed.
Source: JICA Survey Team

Table 4.5.9 Raised Sections of Ibrahimia Principal Canal

Ibrahimia Principal Canal			
Left bank			
Distance from DGR	Length(km) *	Distance from DGR	Length(km) *
1.459 - 10.957km	9.498 (2.903)	117.068 - 120.442km	3.374 (0.000)
11.935 - 17.977km	6.042 (2.272)	121.929 - 131.434km	9.505 (1.165)
24.476 - 31.016km	6.540 (3.657)	131.434 - 138.429km	6.995 (0.277)
31.016 - 36.966km	5.950 (1.703)	141.453 - 149.93km	8.477 (4.420)
45.455 - 49.961km	4.506 (0.999)	155.398 - 159.927km	4.529 (2.937)
52.963 - 59.957km	6.994 (1.493)	163.418 - 170.418km	7.000(3.258)
60.780 - 61.456km	0.676 (0.246)	171.418 - 179.42km	8.002 (4.507)
83.949 - 89.948km	5.999 (0.496)	182.421 - 188.732km	6.311 (2.622)
93.448 - 100.443km	6.995 (1.264)	191.006 - 206.236km	15.230 (0.891)
101.445 - 103.814km	2.369 (0.000)		
Subtotal	55.569km (15.033km)	Subtotal	69.423km (20.077km)
		Grand total	124.992km (35.110km)

Note: The total distance (Length) is from the Dirout Regulator Group (DGR) to the target area scattered within the section.
* ( ) shows the section where the concrete retaining wall shall be installed.
Source: JICA Survey Team

4.5.2 Countermeasures against the Curved Sections of Bahr Yusef Principal Canal

2) Improvement Plan: Curved Sections of the Bahr Yusef Principal Canal

As the Bahr Yusef Principal Canal is used to be a natural river, it has numerous curves where scouring and sedimentation can easily occur at the outer and inner sides of the curves respectively. These curved sections can be one of the main factors to decrease the flow capacity, so it is necessary to take measures to mitigate the further sedimentation and erosion to the existing farmlands and houses found just behind the curved sections. According to existing materials and field surveys, total 45 curves have been found (see the list of Table 4.5.10).

Table 4.5.10 List of Locations where There are Curved Sections along Bahr Yusef Principal Canal

No.	Jurisdiction GD	From the Dairy Route Distance (km)	Curve length (m) *	No.	Jurisdiction of directorate	Distance from DGRs (km)	Curve length (m) *
1	East Minya	6.10	350 (350)	26	West Minya	105.00	300 (0)
2		6.80	400 (0)	27		108.00	350 (350)
3		7.30	400 (400)	28		136.70	200 (200)
4		8.90	400 (400)	29		163.70	250 (0)
5		10.10	300 (300)	30		164.50	250 (0)
6		12.20	350 (0)	31	Beni Suef	210.00	100 (100)
7		14.10	400 (400)	32		211.50	200 (200)
8		14.85	250 (0)	33		213.00	200 (200)
9		16.50	350 (350)	34		214.50	400 (0)
10		18.10	250 (250)	35		215.50	160 (160)
11		22.80	400 (400)	36		216.50	200 (0)
12		23.50	350 (350)	37		217.00	400 (0)
13		48.90	300 (0)	38		218.20	300 (300)
14		50.70	300 (0)	39		219.00	200 (0)
15		60.80	400 (400)	40		219.50	300 (0)
16	West Minya	61.60	500 (0)	41		221.00	300 (0)
17		64.50	250 (0)	42		222.00	50 (0)
18		71.05	500 (500)	43		224.00	200 (200)
19		72.75	300 (0)	44		225.00	400 (400)
20		75.40	300 (300)	45		231.00	250 (250)
21		76.10	400 (400)				
22		79.05	300 (300)				
23		85.50	450 (450)				
24		87.40	350 (350)				
25		89.79	350 (350)	Total			13,910 (8,610)

* ( ) shows the section where the gabions shall be installed.
Source: Cooperation Planning Survey on the Irrigation Sector (upper Egypt and Middle Delta) in Egypt (JICA, 2018)

As measures on the curved sections, protection on the canal slope is planned to mitigate the erosion. The sedimentation on the inner side of curved sections should be cared through maintenance works such as dredging. As a result of a comparative study between wet-masonry type protection and gabion type protection, the latter measure is recommended (see Figure 4.5.9), since the former needs de-watering during the construction periods keeping the site dry while the latter, gabion works, can be done even in water. The sections to be covered by the gabions are to be a total of 8.61 km, by selecting only big curve sections.

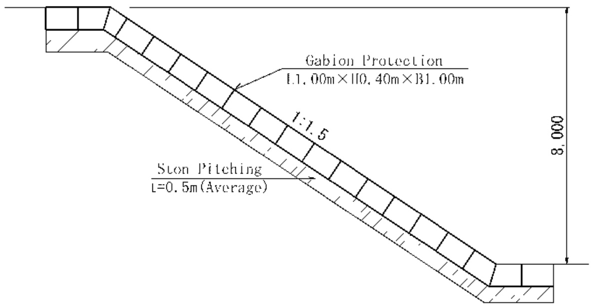


Figure 4.5.9 Slope Protection against Souring Portions

Source: JICA Survey Team

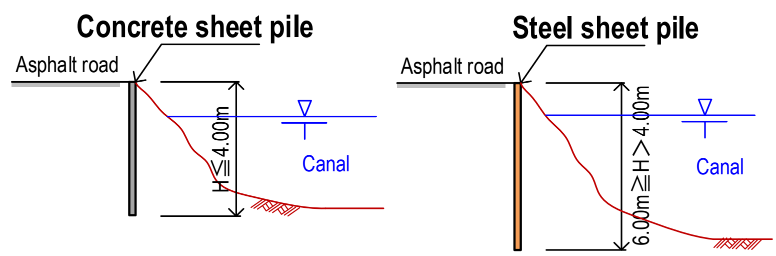
4.5.3 Kased Main Canal

Based on the hydraulic analysis for the Kased Main Canal, no overflow from the channel is currently occurring. However, it is known that Black Cotton Soil, which expands under wet condition, is present in the delta area. This soil can also be seen along the Kased Main Canal, resulting in a partial expansion of the canal slope towards canal inside, especially along the main road, possibly due to vehicle travel loads. Based on interviews with the officers in Gharbia irrigation directorate, it was revealed that the following 2 sections (No.1 and 6), which have particularly high priority for rehabilitation, need to be addressed, and a measure should be included in the project plan.

Countermeasures against canal slope expansion require durability against external forces. Since most of the target area is along a main road, the extent of canal excavation associated with the installation of a structure is subject to construction restrictions. Therefore, the sheet pile method is adopted with priority, which does not require channel excavation/embankment during construction.

The sheet pile material can be either concrete sheet piles, which are used locally, or steel sheet piles (self-supporting type), which have higher strength. Depending on the height of the canal bank to be applied, the plan is to use both methods according to the local condition. Concrete sheet piles should be applied when the applied height is less than 4 m, and steel sheet piles be applied when the applied height exceeds 4 m (see Table 4.5.11). However, since the sheet piles are self-supporting steel sheet piles, the maximum applicable height shall not be over 6 m in total.

Table 4.5.11 Typical Protection Section of Kased Main Canal

No.	Distance from Kased .C B.P.	Length (km)	Retaining wall for deformation on bank nearby road
1	**11.56 - 14.46km**	**2.90**	
2	15.16 - 17.60km	2.50	
3	19.56 - 21.26km	1.70	
4	28.00 - 29.30km	1.30	
5	29.30 - 31.00km	1.70	
6	**33.00 - 33.12km**	**0.12**	
	Total length	10.22	
	Target section length	**3.02**	

Source: JICA Survey Team

4.6 Branch Canal Rehabilitation and Lining: Component 5

In Egypt, concrete lining works are underway starting in 2020 for existing branch canals that are operated ON and OFF basis (rotational operation). 20,000 km of branch canals are to be lined with concrete over a four-year period starting in 2020. Most of the lining is being done with plain concrete with a thickness of 10 cm, but some (about 10%) are being lined with reinforced concrete. This section discusses the ongoing lining work and present improvement for the branch canals as project component 5.

4.6.1 Canal Lining Method in General

The primary objective of the ongoing concrete lining is to reduce seepage loss from the canal. A method that reduces seepage loss from the existing earthen canal and can be constructed in a short period of time must be easy to install while providing a non-permeable lining to the canal. Existing lining methods available based on these criteria are as follows:

- ✓ Thin concrete lining method (5 cm to max. 15 cm),
- ✓ Precast concrete panel lining method,
- ✓ Concrete block lining method (or brick lining), and
- ✓ Masonry lining method.

Other lining materials and methods include asphalt and synthetic rubber membrane lining, but the above four methods are generally adopted in consideration of cost, durability, and maintenance. The empirical maximum allowable flow velocity is 3.00 m/s for thick concrete (about 18 cm) and 1.50 m/s for thin concrete (about 10 cm), yet since irrigation canals in Egypt have very gentle slopes, thin concrete linings are considered applicable.

1) Thin Concrete Lining Method

Currently in Egypt, branch canals are being rehabilitated with thin concrete linings with a trapezoidal cross-section profile, as shown in the figure on the right. In general, the requirements for stable canal lining with thin concrete are as follows;

- ✓ Since the lining is expected to function as a pavement and does not use formwork for concrete placement in most cases, the side slope of the canal should be about 1:1.2 to 1:1.50.
- ✓ In the case of new construction, the canal cross-section is determined by considering the most hydraulically advantageous cross-section, construction method, and maintenance. In the case of rehabilitation of an existing canal, in addition to the above, conditions such as the current cross-sectional shape of the canal, site condition, and construction method should also be taken into account in determining the cross section.
- ✓ The lining thickness should be as thin as economically feasible to resist water pressure, prevent cracking, and prevent water seepage and erosion of the slope. According to actually implemented past cases, the thickness has ranged from 5 to 12 cm.
- ✓ The base of the lining should be compacted and shaped with suitable material at a minimum depth of 0.15 m for replacement if needed. The maximum dimension of stones in the material should generally be less than 10 cm. In the case of cut foundations, clay or other materials that expand and contract significantly should be replaced with appropriate materials and adequately compacted.

- ✓ Drainage culverts or drainage holes are necessary when groundwater is high and groundwater pressure is exerted on the concrete backside. Further, side drains may be installed at the slope and underdrains at the bottom, and flap valves might be installed at the bottom of the canals.
- ✓ According to ACI 224.3 (American Concrete Institute), the maximum spacing between concrete joints should be 24 - 36 times the thickness of the concrete. Thus, for example, for a lining thickness of 100 mm, the joint spacing would be approximately 3 m. Usually, the joints are sealed with a non-permeable bituminous material.
- ✓ Reinforced concrete lining is recommended when 1) the underlying soil material consists of highly permeable sand and gravel, etc., and the groundwater table fluctuates significantly, 2) the soil is soft or passes through expansive clay areas that are difficult to replace, or 3) the water table in the canal changes rapidly or the bed materials is easily eroded.

If the existing canal before the lining is an earthen canal, the velocity in the canal after the canal lining will increase and the water level will decrease significantly compared to the existing condition because the roughness of the canal will be significantly changed. According to estimates, the water depth in the concrete-lined canal after lining will be reduced to about 2/3 of the depth of the existing earthen canal.

This will affect water diversion to the lower canals, e.g., sub-secondary canals, and Meska, as well as in-canal storage capacity of irrigation water. Possible countermeasures include the construction of new water control structures (water level control weirs, etc.) or adjusting the width of the to-be-lined canal to maintain the water level, meaning that the width of the canal should be reduced.

2) Precast Concrete Panel Lining Method

The application of the panel lining method is similar to the requirements of the thin concrete lining, but since the method involves placing of panels in a continuous line, it has the following characteristics:

- ✓ The roughness coefficient of Manning for flowing water is n = 0.012 - 0.016 for thin concrete linings, while n = 0.014 - 0.017 applies to concrete panel linings. In other words, the roughness coefficient is slightly higher than that for concrete lining.
- ✓ This method can be used for embankment sections with poor foundations that may cause unequal settlement, and it is easy to reduce damage caused by partial settlement and to repair partial damage. In the panel lining method shown in the photo on the right, steel bars are crossed through the panel, and the bars are tightened at the joints. The joints should be filled with mortar, but the panels are flexible as a whole. At the back of the panels, fabric materials are usually placed to prevent the back soil material from being eroded.
- ✓ Since the joints between panels are permeable, attention must be given to water leakage and back soil suction-out. In other words, measures such as filling the joints with joint material and filters to prevent soil suction-out are necessary. In the case shown in the photo at right, 3-inch-thick (approx. 8 cm) precast concrete panels are placed with 3-inch joint spacing, and the joints are filled with concrete and compacted. The gaps between the joints are


Example of panel lining method


Example of panel lining method

thus filled and smoothed to increase the strength of the lining and reduce the leakage from the joints.

- ✓ Panels are produced by precast. This means that the panels can be manufactured throughout the year, regardless of the conditions at the construction site. In Egypt, irrigation is often conducted for 5 days on and 5 days off in the summer and for 5 days on and 10 days off in the winter. Therefore, it is possible to carry out a large amount of work in the winter season when the water supply is cut off for longer periods.

3) Concrete Block and Brick lining methods

Lining with concrete blocks or bricks has been a widely used lining method for a long time. The application requirements are almost the same as those for concrete panel lining afore-mentioned. In this method, concrete blocks or bricks are placed one by one by hand and mortar is placed between them to form the lining (see the photo below left). Because of the slow construction speed of this method, the brick lining method is not widely used today due to soaring labor costs and other factors.

4) Masonry Lining Method

In this method, rough stones are joined with concrete or cement mortar and piled up one after another to form a lining, replacing bricks in the aforementioned brick lining method (see right photo below). This method can be considered when stones are available in the vicinity of the construction site, ensuring low production cost for the stones.

Manning's roughness coefficient is estimated to be n = 0.017 to 0.030. The depth of the rehabilitated masonry-lined canal can be reduced to approximately 90% of the existing depth if the bottom slope and width are not changed from the existing canal, thus having relatively little impact on the change of hydraulic conditions. The construction speed of this method is comparable to that of concrete block and brick lining methods.


Example of Brick Lining Method

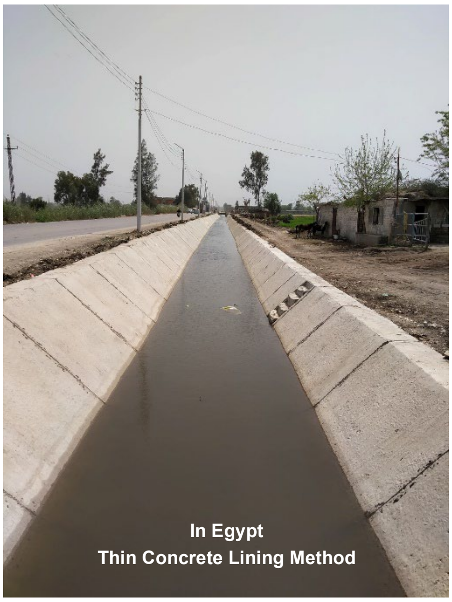

Example of masonry lining method

4.6.2 Review of Current Lining Methods in Egypt

As mentioned above, in Egypt, a total of 20,000 km of existing branch canals operated under rotational irrigation is to be lined with thin concrete over a period of 4 years to reduce seepage loss of irrigation water from the canals (see the photo on the right as an example of on-going canal lining in Egypt). The following is a review of the irrigation canal lining method on-going in Egypt.

1) Construction Speed

The construction speed of canal lining varies depending on the type of lining, the size of the waterway, the conditions and treatment method of the foundation, and the method of placing concrete, etc. According to the results in a loan project implemented in an Asian country from 2015 to 2019, as shown below, the concrete lining entails the fastest construction speed. In the precast concrete panel lining method, the joints should be filled with concrete, so the installation speed cannot be as fast as in the thin concrete lining method.



- ✓ Thin concrete lining 148,500 sq.ft/Month (2.48)
- ✓ Precast Concrete Panel Lining 92,800 sq.ft/Month (1.55)
- ✓ Brick Lining 59,800 sq.ft/Month (1.00)

Placing the thin concrete lining is usually expected to have the fastest construction speed and the shortest construction time compared to other lining methods.

2) Lining Concrete

The 28-day strength of concrete used for the lining of trapezoidal canals is usually 200 to 210 km/cm^2, including the practice in Japan. Slumps of 5 to 12 cm are applied, although 7 cm ± 1 cm[1] is often used for the sides of the canal when slope forms are used, and 3 cm[2] for the bottom. Coarse aggregate is generally 20 to 40 mm, but larger coarse aggregate is considered appropriate to increase workability, especially in Egypt due to the high temperature and dry weather. The thickness of the concrete lining is 10 cm with plain concrete, which is considered appropriate according to the generally applied range of 5 to 12 cm.

3) Lining Concrete Joints

The concrete joints (joints) in the lined canals in Egypt are installed at 3 m intervals, and bituminous material is injected into the joints. According to ACI 224.3R (American Concrete Institute), the maximum spacing is 24 to 36 times the length of the concrete thickness, so a recommended joint spacing for a 100 mm lining thickness is approximately 3 m. It is also suggested that the joints be sealed with a bituminous material that is impermeable to water, which is the method used in Egypt for on-going concrete lining works.

4) Base of Lined Concrete Canal

The majority of concrete linings currently in implementation in Egypt are constructed by placing a 10 cm plain concrete lining on a rough masonry base with approximately 30 cm thick, to a maximum of 50 cm, as shown in the photo at right. Generally, the base of a concrete-lined canal should be 10 cm to 15 cm thick, compacted and shaped with appropriate materials with good particle sizes mixed. From this point of view, the 30 cm thick rough masonry used in Egypt may be considered somewhat excessive as the base for concrete placement, and is likely to cause the project cost to rise.

When a concrete lining is installed on a very coarse masonry base, it provides a very strong foundation, and therefore, structural stability to the lining could be very high. However,

[1] If surface smoothing and compaction are to be performed without the use of slope forms, a slump of 3 to 5 cm is considered acceptable, after test construction.

[2] Since this is a flat surface construction work, it is preferable to use a low slump concrete, which is more resistant to shrinkage and cracking, so the slump should be as small as possible in the construction.

once water leakage from concrete joints or cracks occurs, the possibility cannot be denied that it may lead to a slope failure due to soil erosion, since coarse masonry has very high permeability.

The reason for introducing a coarse masonry base with such a thickness of 30 cm may be to reduce the width of the canal to be lined in consideration of keeping the water level same as the original one as much as possible. Concrete lining entails water level drop due the change in the roughness coefficient, unless otherwise the width of the canal be reduced (see next section). However, it is suggested that the filling of the spacing of the masonry stones with good quality soil should be at least considered.

4.6.3 Reduction in Water Level with the Concrete Lining, and Required Reduction in Canal Width to Maintain the Water Level

The existing canal is an earthen canal and the roughness coefficient of the canal is large, usually around 0.03. If the canal were to be lined with a material with a small roughness coefficient, such as concrete with a smooth surface assuming a roughness coefficient of 0.015, the velocity of flow in the canal would increase and the depth of water would decrease. This condition may interfere with water management such as diversion to the branch canals and Meska.

Assuming a trapezoidal earthen canal with a water depth of 2.5 m, bottom width of 6.0 m, and slope of 1:1.5 as a typical existing canal cross-section, water depths were estimated by changing the bottom width after concrete lining to 6.0 m, 5.0 m, 4.0 m and 3.0 m as shown in the table below:

Table 4.6.1 Water Depth Changes due to Canal Rehabilitation

Lining Type	Concrete Lining	Wet Masonry	Earth w/certain grass
Coefficient of roughness: n	0.015	0.025	0.030

Source: Japanese Canal Design Standard

Case	Side Wall	Base	Water Depth H (m, % for Original 2.5m)			
			B=6.0m	B=5.0m	B=4.0m	B=3.0m
Original	Earth w/certain grasses (n=0.03)	Earth w/certain grasses (n=0.03)	2.50	2.92	3.57	4.61
			100%	117%	143%	184%
Improvement	Concrete Lining (n=0.015)	Concrete Lining (n=0.015)	**1.47**	1.69	2.00	**2.50**
			59%	67%	80%	**100%**

Source: JICA Survey Team

When the water depth of the existing canal (earthen canal) is set at 100%, it is found that if the entire surface is concrete lined, the water depth will decrease to about 60% of the original depth. Here, if the same water depth is to be maintained, the following two methods are considered:

- ✓ Reduce the width of the canal: Referring to the table above, the canal width would need to be reduced from the original 6m to 3m. In other words, if the water level is to be maintained by reducing the canal width, as much as half of the canal width reduction would be required. Reducing the canal width by half may result in a considerable increase in construction costs, such as additional earthwork.
- ✓ Raise the water level upstream of the weir point in question by a water level control structure: If an existing water control weir is not effective enough to raise the water - for example, if there is no water level control regulator over a long section - a new control structure, regulator or a weir, should be constructed (see figure on the right).

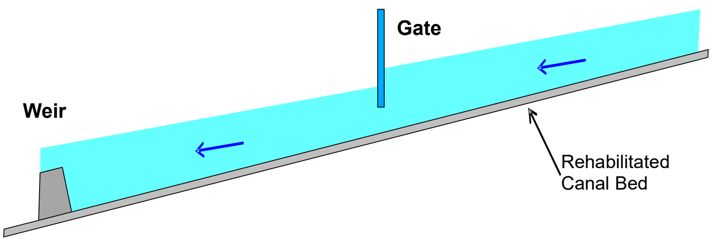


Figure 4.6.1 Water Level Maintenance by a Regulating Weir
Source: JICA survey team

Canal longitudinal gradients in Egypt are very gentle (typically 1/10,000 to 1/15,000). In such a case, it is highly likely that the effect of raising the upstream water level with a water level control weir can be expected over a long section of the canal. In addition, many branch canals in Egypt are irrigated with 5 days ON and 5 days OFF during the summer season when the maximum flow is discharged.

This means that the amount of water required for 10 days is delivered to the branch canals in 5 days. The fact that intermittent irrigation is used during this period means that the existing branch canals (and their subordinate sub-branch canals and Meska) have twice the capacity of the canal cross section required under continuous irrigation.

The fact that the Egyptian branch canals have twice the cross-sectional area required under continuous flow is synonymous with the fact that the canal itself has a large storage effect. In the lining of the branch canals, the canal width should not be reduced so as to reduce the storage effect of the canal itself, but should be lined in such a way as to maintain the current cross-sectional area. Construction of new water level control structures should be undertaken as needed.

4.6.4 Alternatives (Proposed Improvements from the Current Concrete Lining)

The current concrete lining method (10 cm thick) is a reasonable lining method from the view of preventing water leakage from the canals and the required construction speed. However, the current base thickness of 30 cm (to a maximum of 50 cm) should be less effective in preventing the reduction of the water level in the canal.

In addition, due to the significantly high permeability of the coarse stone piled base, small-scale collapse may occur on the back of the slope due to seepage water through the joints of the lining or in the event of cracks on the concrete. Based on these considerations, the JICA team proposes the following 4 alternative plans for the concrete lining as in the table below:

Table 4.6.2 Alternatives of Concrete Lining for Secondary Canals

Alternatives	Measures	Remarks
Alternative 1	Base 15cm by particle adjusted materials including clay and silt, plus T10cm plain concrete	Forming the base by particle adjusted materials without organic matters
Alternative 2	Base 20cm by cobbles & sand mixed materials, plus T10cm plain concrete	In case, clay & silt without organic matters not available
Alternative 3	Base 30cm by cobbles & sand mixed materials, plus T10cm plain concrete	In case, clay & silt without organic matters not available
Alternative 4	Pre-cast concrete panel lining	Seepage and/or uneven settlement is foreseen

Source: JICA Survey Team

Of the 4 alternative proposals, the first three differ in the structure of the base to be placed under the concrete lining. The most desirable is to form the base with a good quality mixed materials that have been adjusted for particle size, including clay and silt without organic content. However, since clay and silt without organic content may be difficult to obtain in Egypt, in such a case, a mixture of sand and cobbles should be placed at 20-30 cm, depending on the foundation conditions.

Reinforced concrete lining as an alternative is not proposed here. Though reinforced concrete is used in about 10% of the sections of lining work currently in progress, considering that reinforced concrete is about four times more expensive than unreinforced concrete and that the lining targets are relatively small to medium-sized secondary canals, it is not recommended to introduce reinforced concrete lining. Even if the ground is of expansive clay materials, the lining function can be fulfilled by placing a thick base, minimum 30 cm or more, of mainly cobbles with sand in between, and by placing unreinforced concrete on top of it.

1) Alternative 1: Construction of a Particle-size Adjusted Base and Concrete Lining

The existing canal may contain soft ground in some sections due to the uneven soil characteristics of the slope and foundation. It may also be possible that the canal has been reshaped by materials containing organic matters and debris due to many years of use and maintenance. Therefore, it is recommended that a minimum 15 cm thick foundation of coarse-grained stone mix, adjusted for particle size, be provided with a maximum grain size of 12 cm. Then, a 10 cm plain lining on top of the foundation should be made, assuming sufficient shaping of the slope and bottom prior to placing the lining concrete.

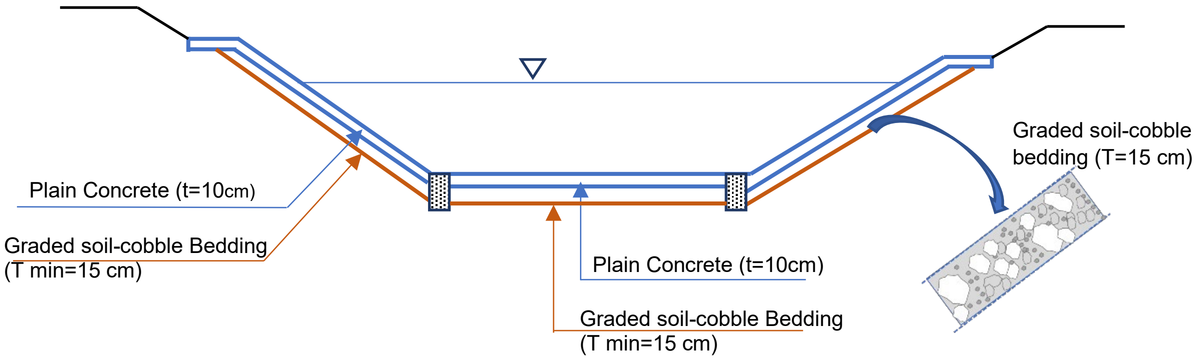


Figure 4.6.2 Standard Cross-section of Concrete Lining (15 cm thick, Particle-size-adjusted Base)

Source: JICA survey team

Due to the thin base and concrete lining thickness, it is desirable to introduce a floor-stop at the contact between the base and the slope to ensure higher stability (hatched square area in the figure above). It should be made of plain concrete or coarse stone mortar piles, and dimensions of about 30 cm high and 25 cm wide should be sufficient.

2) Alternative 2 & 3: Construction of Base with Sand and Coarse Stones and Concrete Lining (Recommended Alternative)

Instead of clay and silt, which may be difficult to obtain in Egypt, sand is available in large quantities. Therefore, instead of the grain-size-adjusted foundation described above, a mixture of only sand and stones with a minimum thickness of 20 cm could be used as the foundation. The top layer would then be the 10 cm of plain lining. This is recommended as an alternative when clay or silt with no organic matter is not readily available. The maximum grain size of the gravel material should be 15 cm.

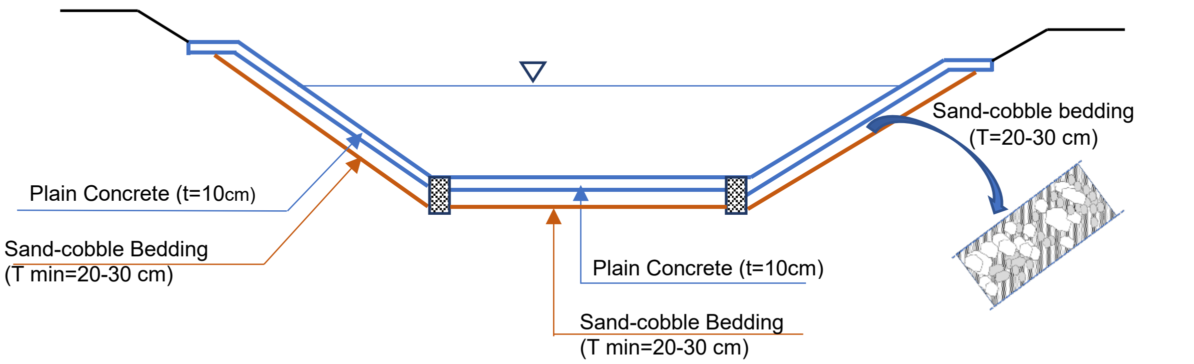


Figure 4.6.3 Standard Section of Concrete Lining (20-30 cm Thick Sand and Cobbles Base)

Source: JICA survey team

3) Alternative 4: Sections where Uneven Settlement or Groundwater is Expected

In cases where uneven settlement is a particular concern, such as in soft ground, or where in-situ concrete lining is not feasible due to high groundwater appearance, the precast concrete panel lining method is suggested. However, the panel lining requires prevention of water leakage from joints by putting bituminous material or concrete. In locations where the groundwater table is high or there is a spring water, a sand bed (5 to 8 cm) should be placed first, then a geotextile could be placed, and precast concrete panels be placed on top of the sand bed and geotextile. In this case, joint sealing should not be made allowing the groundwater coming out (see Figure 4.6.5).

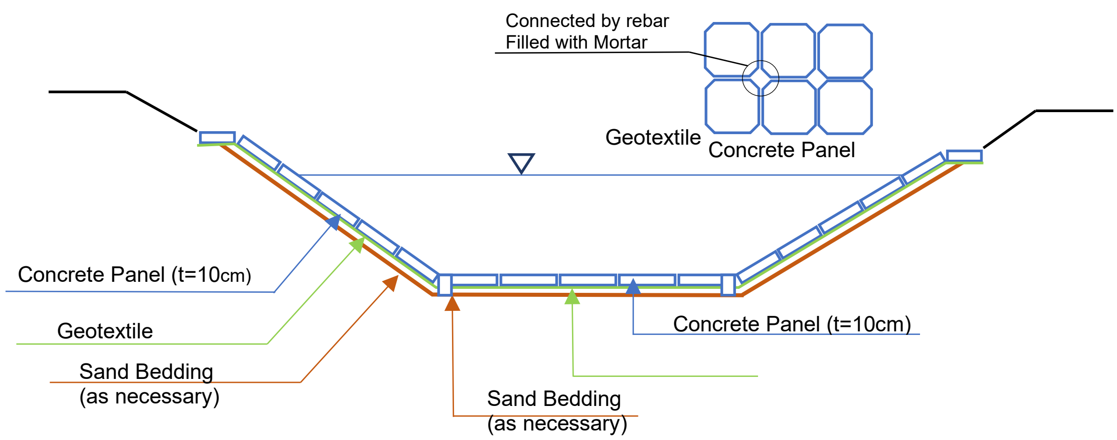


Figure 4.6.4 Standard Cross Section and Precast Concrete Panel Lining

Source: JICA survey team

In canals constructed under cut-and-fill conditions, if the groundwater level behind the lining becomes high, back-pressure can act on the back of the lining, leading to lifting of the lining or even localized collapse. To avoid this, drains are often installed only where the groundwater level behind the lining is high. However, in Egypt, the soil is likely to be soft in areas where the groundwater table is high or where there is groundwater seepage. Therefore, in such cases, lining with precast concrete panels, instead of installing drains, is recommended.

In Egypt, it is assumed that the groundwater level behind the lining is unsaturated or not very high, since field under-drains are installed almost throughout the nationwide farmlands. Also, during peak irrigation periods, the groundwater table may rise temporarily, but at that time, there is an abundant irrigation water in the canal. Thus, the possibility of damage to the lining due to the pressure from the back of the lining is low. Therefore, the use of precast concrete panels for lining may be limited to areas where groundwater seepage is expected, such as low elevation areas where groundwater gathers.

4) Restoration of Localized Eroded Sections

In shaping and compacting the base which supports the lining, it is necessary to make a strong base by a localized cut and fill, and compacting to maintain a regular cross-section by means of backhoe or human power. If there are large erosion or depressions, filling should be made using coarse stones, gravels, organic-free soil or sand with a maximum particle size of about 1/2 the backfill thickness, and compacted, and lined on top (see Figure 4.6.6).

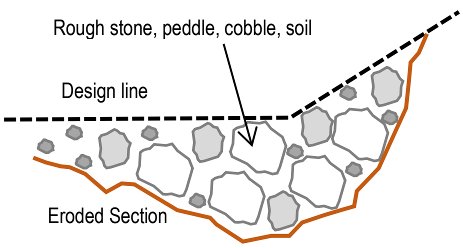


Figure 4.6.5 Treatment of Eroded Areas

Source: JICA survey team

4.6.5 Concrete Lining Introduction in the 3 Priority Areas

Concrete lining is introduced for branch canals operated under ON-OFF irrigation. Although some of the larger branch canals are operated under continuous irrigation, MWRI is introducing concrete lining for canals with a bottom width of 6 m or less mainly for the purpose of easy construction. Therefore, this Project also plans to introduce concrete lining in branch canals with a bottom width of less than 6 m and operated under ON-OFF rotational irrigation.

In principle, MWRI plans to introduce concrete lining in all the branch canals as of 2022. However, if we refer to the target water saving ratio estimated by referring to the National Water Resources Plan 2037, which is the overarching plan for the water sector, it is not necessary to introduce the concrete lining in all over the branch canals for the target year of 2037.

According to the future target irrigation efficiency shown in Chapter 4.1, if the distribution efficiency of the branch canal is increased from the current 0.88 to 0.92, the necessary overall irrigation efficiency can be attained, i.e., water can be saved as per meeting the target (see Case B in Table 4.1.15). In other words, assuming a maximum water distribution efficiency of 0.95 when all branch canals are lined, the required water savings can be achieved by lining approximately 60% of the total length of the branch canals as below:

(0.92 – 0.88) / (0.95 – 0.88) = 0.57 say 60%

Where:
0.92: required distribution efficiency in 2037
0.88: current distribution efficiency
0.95: distribution efficient at the full concrete lining canal (assumed)

The tables below show the branch canals in each priority area selected for the concrete lining based on the above discussions. Basically, 60% of the total canal length was selected with a canal bottom width of less than 6 m, assuming that lining is to be done from the upstream section. In the Abo Shosha and Aros and Abo Seer Areas, the concrete lining has not been implemented to date (as of March 2023), while in the Kased Area, the lining has already been implemented by MWRI to some extent. The target under this branch canal lining is to achieve 60% coverage, including this previously lined canal length.

Table 4.6.3 Branch Canal List in Abo Shosha Area

Canal Name	Length	Canal Bed Width	Canal Depth	Canal Name	Length	Canal Bed Width	Canal Depth
1. Target Branch Canal for Concrete Lining				**2. Non-target Branch Canal for Concrete Lining**			
Abo Shousha Branch 1	4.560Km	2.00m	2.50m	**(1) Sub-branch canal of Talt canal**			
Mesqa Aref	2.100Km	2.00m	2.00m	Branch Beshry	1.120Km	2.00m	2.00m
Abo Shosha Branch 2	2.840Km	1.50m	2.50m	Branch Sliem Bek	3.020Km	2.00m	2.00m
Abo Shosha Branch 3	2.000Km	2.00m	2.00m	Branch Sliem Al Mostagad	0.950Km	2.00m	2.00m
Talt canal	8.600Km	5.00m	3.00m	Branch Shafik	2.260Km	2.00m	2.00m
Talt branch	2.300Km	2.00m	2.00m	Branch Al Kordy	0.500Km	2.00m	2.00m
Shawky	2.050Km	2.00m	2.00m	Branch Moa'wad	0.900Km	2.00m	2.00m
Henna	2.740Km	2.00m	2.00m	Branch Tela	2.700Km	2.00m	2.00m
Tawfik	1.650Km	2.00m	2.00m	Branch Al berawy	0.590Km	2.00m	2.00m
Branch 1 Abo Shousha	1.760Km	2.00m	2.00m	Branch 1Talat	1.840Km	2.00m	2.00m
Kamoun	0.560Km	2.00m	2.00m	Branch 2Talat	0.680Km	2.00m	2.00m
Mazoura	2.625Km	2.00m	2.00m	Branch 3Talat	3.000Km	2.00m	2.00m
Nousir	0.770Km	2.00m	2.00m	**(2) Sub-branch canal of El Sheikh Abid**			
Belani	1.760km	2.00m	2.00m	Branch 3 Al Shiekh Abid	2.590Km	2.00m	2.00m
El Sheikh Abid	2.680Km	3.00m	3.00m	Branch Al Shantoutor	2.480Km	2.00m	2.00m
Walida	2.750Km	2.00m	2.00m	Branch Saburu	1.470Km	2.00m	2.00m
Al Kassaba	1.330Km	2.00m	2.50m	Branch 2 Al Shiekh Abid	1.370Km	2.00m	2.00m
Branch (1) Abo Shousha	4.690Km	2.00m	3.00m	Branch 1 Al Shiekh Abid	0.530Km	2.00m	2.00m
Branch (2) Abo Shousha	1.000Km	2.00m	2.00m	**(3) Sub-branch canal of Branch (1) Abo Shousha**			
Dashtout	2.600Km	3.00m	3.00m	Infront Al Salibiyah Regulator	3.330Km	2.00m	2.00m
End of Abo Shosha Main Canal	1.905Km	2.50m	2.50m	Branch Khalil	1.360Km	2.00m	2.00m
Total (a)	**53.270Km**	**(61%)**		**(4) Sub-branch canal of Dashtout**			
				Branch 1 Dashtout	1.550Km	2.00m	2.00m
				Branch Kom Al nour	0.980Km	2.00m	2.00m

Canal Name	Length	Canal Bed Width	Canal Depth	Canal Name	Length	Canal Bed Width	Canal Depth
				Branch 2 Dashtout	0.900Km	2.00m	2.00m
				Total (b)	**34.120Km**	**(39%)**	
				Grand Total (a)+(b)	**87.390Km**	**(100%)**	

Source: JICA Survey Team

Table 4.6.4 Branch Canal List in Aros & Abo Seer Area

Canal Name	Length	Canal Bed Width	Canal Depth	Canal Name	Length	Canal Bed Width	Canal Depth
Target Branch Canal for Concrete Lining				**Non-target Branch Canal for Concrete Lining**			
(1) Aros				**(1) Aros**			
Bahr Aros (main)	9.610km	5.00m	2.00m	Bahr AL Ghaba	9.920km	3.00m	1.50m
Bahr Defno Al oumomy	9.550km	3.00m	1.50m	Bahr Itsa al kebly	3.700km	3.00m	1.50m
Bahr Abo Al meir	7.590km	3.00m	1.50m	**Sub-total**	**13.620km**	**(29%)**	
Sub-total	**26.750km**	**(57%)**		**(2) Abo Seer**			
(2) Abo Seer				Bahr Omar Bek	0.910km	1.00m	1.50m
Bahr Abo Sir (main)	3.770km	2.00m	1.50m	**Sub-total**	**0.910km**	**(2%)**	
Al Kashif	0.990km	2.00m	1.50m	**Total (b)**	**14.530km**	**(31%)**	
Extension Bahr AboSeer	0.740km	2.00m	1.50m	**Grand Total (a)+(b)**	**46.780km**	**(100%)**	
Sub-total	**5.500km**	**(12%)**					
Total (a)	**32.250km**	**(69%)**					

Source: JICA Survey Team

Table 4.6.5 Branch Canal List in Kased Area

Canal Name	Length	Canal Bed Width	Canal Depth	Canal Name	Length	Canal Bed Width	Canal Depth
Target Branch Canal for Concrete Lining				Waslet Damat	2.10km	2.00m	2.00m
Ekhnway	4.40km	3.00m	3.00m	Ganbia5 of Kased	1.80km	2.00m	2.00m
Sbrebay	14.10km	5.00m	3.00m	Ganbia6 of Kased	1.70km	2.00m	2.00m
Ganbia1 of Shabsher	7.20km	5.00m	3.00m	Shoubra Baloola	6.70km	3.00m	2.50m
Smella	10.30km	5.00m	3.00m	Sourad	7.90km	2.50m	2.00m
Damat	11.50km	5.00m	3.00m	Negreeg	1.20km	3.00m	3.00m
Qotor	7.50km	5.00m	3.00m	El Fahimia	2.30km	3.00m	3.00m
Al Samahat	15.20km	5.00m	3.50m	Al Gamayel Al Qebliya	3.00km	7.50m	2.00m
El Taaleb	10.10km	5.00m	3.50m	Shenno	5.60km	2.00m	2.00m
Mehdet el kasab	4.10km	5.00m	2.00m	Al Gamayel Al Bahiriya	4.20km	3.00m	2.50m
EL Ghamria	6.00km	5.00m	3.00m	El Shakria	14.00km	3.00m	3.00m
Total	**90.40km**	**(34%)**		Rewina	20.20km	15.00m	3.50m
Non-target Branch Canal for Concrete Lining (including previously lined canal: 70.37km)				Al Muit Al Sharkqi	4.30km	3.00m	2.00m
Al kased	7.20km	10.00m	4.00m	Shaboora	1.90km	7.50m	3.00m
Qaem Tanta	1.40km	2.00m	2.00m	Dalil El Ghamia	2.30km	2.00m	2.00m
Qohafa El Gedida	2.60km	2.00m	2.00m	Sandella	9.10km	10.00m	3.50m
Al Awqaf	2.90km	2.00m	2.00m	El Khraba	5.00km	2.00m	2.00m
El Melqa	5.10km	3.00m	2.50m	Om Dokhan	3.00km	3.00m	3.00m
Gann. Shabashir	11.20km	3.00m	3.00m	Al Saath	2.70km	2.00m	2.00m
Abo Kharouf	2.80km	2.00m	2.00m	Al Saath Feeder	1.00km	2.00m	2.00m
Qahafa new	1.70km	2.00m	2.00m	Direct absorption btw G6 and Sorad Regulator	14.10km	5.00m	3.00m
Om Rabee	3.70km	2.00m	2.00m	**Total**	**173.00km**	**(66%)**	
El Wrety	2.00km	2.00m	2.00m	**Grand Total**	**263.40km**	**(100%)**	
Segen	3.60km	2.00m	2.00m	Total length of previously lined canal (a) =			70.37Km
Ganbia2 of Kased	3.50km	2.00m	2.00m	Total length of target branch canal for concrete lining (b) =			90.40Km

Canal Name	Length	Canal Bed Width	Canal Depth	Canal Name	Length	Canal Bed Width	Canal Depth
El Nashw	4.20km	2.00m	2.00m	(a) + (b) =			160.77Km
Boreg	3.60km	3.00m	3.00m	Total length of branch canal (c) =			263.40Km
Ganbia4 of Kased	3.40km	2.00m	2.00m	**Percentage of lined canal (previously lined canal and target branch canal) =**			**(a+b) / c =61%**

Source: JICA Survey Team

4.6.6 Seepage Reduction with Concrete Lining

The review of the current lining works and improvements were discussed in the previous sections. In this section, trial examination is conducted to know how much seepage could be reduced with the introduction of concrete lining to the branch canals as follows:

- ✓ Seepage reduction based on distribution efficiency improvement, and
- ✓ Seepage reduction taking into account evaporation and seepage separately.

1) Seepage Reduction based on Distribution Efficiency Improvement

In this Preparatory Survey, at first, overall actual irrigation efficiency was estimated based on the actually discharged irrigation water and actually cropped area detected by Sentinel-2 satellite image analysis. Then, the overall irrigation efficiency was discomposed into the 3 efficiencies of; 1) conveyance, 2) distribution, and 3) field application as discussed in '4.1.2 Target Irrigation Efficiencies and Project Direction'.

Table 4.6.6 shows the irrigation efficiencies estimated in Section 4.1.2. Note that the efficiency in this section considers the utilization of drainage reuse, and not the efficiency against only freshwater simply because water provided to the farmland includes drainage reuse. As shown below, the current distribution efficiency has been estimated to be 0.88, and with the introduction of concrete lining, the efficiency is expected to be 0.93 with an assumption of 5% plus and also to 0.95 which is usually set as the maximum distribution efficiency according to FOA and ILRI. Therefore, the overall efficiency of the current 0.55 is expected to increase to 0.59, or 0.60 as the maximum.

Table 4.6.6 Irrigation Efficiency Change with the Introduction of Concrete Lining to Branch Canals

Condition	Overall Irrigation Efficiency	Conveyance Efficiency	Distribution Efficiency	On-farm Efficiency
Current	0.55	0.90	0.88	0.70
With Lining works (+5% up)	**0.59**	0.90	**0.93**	0.70
With Lining works (max 0.95)	**0.60**	0.90	**0.95**	0.70

Source: JICA Survey Team

Table 4.6.7 presents how much additional available water can be expected with the increase of irrigation efficiency to be realized by the introduction of concrete lining to the branch canals. The estimation is made on the Bahr Yusef and Ibrahimia command areas with the future design discharge (maximum discharge). As indicated in the table, the efficiency increase will newly bring about approximately 16 to 20 cum/s water, equivalent to 7 to 9 % increase of the water available for crops. With an assumption that the increased water available for crops came from the reduction of loss due to the concrete lining, it can be said that concrete lining to the branch canals would reduce the loss by 7 to 9 %.

Table 4.6.7 Reduction of Loss with the Introduction of Concrete Lining to Branch Canals

Condition	Overall Irrigation Efficiency	Bahr Yusef	Ibrahimia	Available Water	Balance cum/s	Increment %
		232 m3/s	166 m3/s	398 m3/s		
Current	0.55	127.60	91.30	218.90	-	-
With Lining works (+5% up)	0.59	136.88	97.94	234.82	15.92	7.3%
With Lining works (max 0.95)	0.60	139.20	99.60	238.80	19.90	9.1%

Source: JICA Survey Team

2) Seepage Reduction taking into account Evaporation and Seepage Separately

This section tries to estimate evaporation loss from the water surface in the canals, and then make an assumption that the concrete lining could fully prevent seepage loss while leaving the evaporation loss as it is. Simply to do this trial, a static canal section is assumed as in the following table, in which there are typical branch canals whose depth and width area 2 – 3 meter and 5 to 20 meters, daily evaporation from the water surface is assumed at 7 mm/day, equivalent to the evaporation from Lake Qarun in July, and the current distribution efficiency is set at 0.88.

With the assumption that the current distribution efficiency is 0.88, the overall loss composed of seepage and evaporation can be 12%, and according to the table below, the evaporation loss could be around 2 to 3 % only against whole water volume. Therefore, with the 100% water-proof canal lining, it is assumed that only 2 to 3 % could be the loss from the branch canals, presenting as high as 97% to 98% distribution efficiency.

Table 4.6.8 Evaporation Loss Estimation from Typical Branch Canals

Particulars	Unit	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Canal Depth	m	3	2	3	2	3	2
Canal Width	m	20	20	10	10	5	5
Canal Length	m	10,000	10,000	10,000	10,000	10,000	10,000
Unit Evaporation 1/	mm/d	7	7	7	7	7	7
Distribution Efficiency	-	0.88	0.88	0.88	0.88	0.88	0.88
Volume	m3	600,000	400,000	300,000	200,000	150,000	100,000
Water Surface Area	m2	200,000	200,000	100,000	100,000	50,000	50,000
Evaporation	m3/day	1,400	1,400	700	700	350	350
Canal Loss	m3/day	72,000	48,000	36,000	24,000	18,000	12,000
Ratio of Evaporation	%	2%	3%	2%	3%	2%	3%

1/: According to 2006, ESTIMATION OF EVAPORATION FROM LAKE QARUN USING STANDARD METEOROLOGICAL MEASUREMENTS, the maximum evaporation from Quan Lake takes place in June with an amount of 7.099 mm/day.
Source: JICA Survey Team

With the 97% to 98% of the distribution efficiency, the overall efficiency comes to 0.61 to 0.62 considering the conveyance efficiency of 0.90 and on-farm efficiency of 0.70 (see Table 4.6.9 for the Current). By applying the overall efficiency, the water newly available for crops could be increased by around 11 to maximum 13 % (see Table 4.6.10), which is considered to have come from the seepage prevention with the concrete lining.

In fact, there are expansion joints every 3 meters on the concrete lining and also there could be some cracks which may happen in future, so that around 10% reduction may be a reasonable estimation. With the afore-mentioned estimations, 7.3% to 9.1% reduction, this trial concludes there could be around 10% loss reduction with the introduction of concrete lining to branch canals.

Table 4.6.9 Irrigation Efficiency Change with the Introduction of Concrete Lining to Branch Canals

Condition	Overall Irrigation Efficiency	Conveyance Efficiency	Distribution Efficiency	On-farm Efficiency
Current	0.55	0.90	0.88	0.70
With Lining works	**0.611**	0.90	**0.97**	0.70
With Lining works	**0.617**	0.90	**0.98**	0.70

Source: JICA Survey Team

Table 4.6.10 Reduction of Loss with the Introduction of Concrete Lining to Branch Canals

Condition	Overall Irrigation Efficiency	Bahr Yusef	Ibrahimia	Available Water	Balance cum/s	Increment %
		232 m3/s	166 m3/s	398 m3/s		
Current	0.55	127.6	91.3	218.9	-	-
With Lining works	0.61	141.52	101.26	242.78	23.88	10.9%
With Lining works	0.62	143.84	102.92	246.76	27.86	12.7%

Source: JICA Survey Team

4.7 Water Management Improvement: Component 6

Water management of irrigation canals is undertaken by MWRI from the principal canal to the intake of the terminal facility, Meska, while water users and WUAs manage water after the Meska. For the principal/main canals and the rest of the intra-regional canal system, water management is based on the downstream water levels at regulators that MWRI has accumulated through experiences. This section plans to improve the water management system in line with the construction and rehabilitation of irrigation facilities under the Project. Since water management in the Upper Egypt area is included in the new Dirout Group Regulators under construction as of 2023, this section plans for water management in the Kased Area.

4.7.1 Current Practice of Water Distribution among Canals

1) Water Management of a Wide Area at the Principal Canal Level

MWRI implements water management by dividing the canal system from the principal canals to several zones of branch canals. Water management of the irrigation system is carried out by the Water Distribution Division under the Irrigation Sector (IS) from the intake points along the Nile River to the main facilities along the principal canal level. Water management is then carried out regionally by the Upper Egypt (Assuit) and Lower Egypt (Tanta) Water Distribution Sectors under the IS.

Large-scale facilities such as the intake along the Nile River, the Dirout Regulators, and facilities located on the borders of the governorates are managed directly by the Water Distribution Division. Other major facilities along the main canals and those located on the borders of Irrigation Districts (IDs) are managed by the General Directorate (GD), which controls water allocation in its administrative areas.

2) Water Management at the Regional Level

At the regional level, MWRI has been managing water discharge by water levels based on its experiences since the completion of the Aswan High Dam. The GD is responsible for water management along the canals within the region. This water management is carried out by IDs who operate the gates daily under instruction from the GDs. Each ID has an operator, called a Bahari, who operates the gates and observes the water levels.

Water level information for major facilities is reported by the gate operators to the GD and then to the CD of the Water Distribution Section in Cairo via the Upper or Lower CD of Water Distribution. In contrast, the operators of regulators and intake gates send reports in the opposite direction of the flow of water level information. These reports and instructions are made by mobile phone, and water level adjustments are usually made twice a day, early in the morning and in the evening. The reginal canal network consists of a system of canals distributed from the principal canal. These are then managed by each regional GD and ID. However, reporting instructions for operation and water level information by mobile phone has problems such as risk of miscommunication and misidentification of information.

3) Water Management at the On-farm Level

MWRI provides irrigation water according to a planned allocation in most areas through a rotational irrigation method. The rotational irrigation water supply is implemented in a two-shift rotation (5 days water supply on and 5 days water off) or a three-shift rotation (5 days water supply on and 10 days water off), depending on the region and the cropping season. However, due to the greater topographical gradient in Fayoum compared to other governorates, the gravity irrigation system provides continuous water flow to Meska.

MWRI is responsible for water management until the canal where the Meska intake is located, and then water users and WUAs are responsible for water management after Meska. At the Meska level, water is allocated according to the demand for irrigation use within the amount of water supplied from the branch canal. At each Meska site, water is distributed simultaneously with the start of the water supply for the rotation at the branch canal level. Therefore, when the operating times of several pumps located along Meska overlap, the water level in the branch canal drops.

Thereafter, during the night, water withdrawals decrease significantly and the water level in the branch canal begins to rise again. However, due to the distance to Meska, which is downstream of the tributary canal, it will take time until all farmers are able to withdraw their water. Therefore, farmers in the downstream area generally have fewer days to withdraw water for irrigation than farmers in the upstream area. Upstream farmers have an advantage in water use, and downstream farmers are affected by the water withdrawal status of upstream farmers.

4) Expectations for Equal Water Management

As mentioned above, water management by MWRI has been practiced for many years and is a method that has been developed through experience in water management at the ground level. However, flexible and equitable water management is required to meet changing needs, such as responding to changes in water demand due to crop diversification, real-time water distribution based on water supply, demand for effective use of water resources, and water-saving agriculture with the introduction of modern irrigation systems.

The high level of interest among farmers in wide-area water allocation and the ongoing development of scalable and inexpensive telemetry facilities by MWRI has led to a strong need for a way to visually monitor the status of water allocation and distribute water in a fair way in real time.

4.7.2 Improvement of Water Management at Macro and Meso Levels

1) Water Management System for the New Dirout Group of Regulators

In the Project for Construction of the New Dirout Group of Regulators, water management monitoring devices are to be installed at major intakes and regulators, which are the main facilities in the principal canal, with the main purpose of acquiring and communicating information. An improved water management system has been proposed to improve the fairness and reliability of water management through the accumulation and processing of acquired information in a central monitoring house.

The integrated water management system will improve the monitoring and information transfer/processing process by centrally managing the information and will allow for the regulation and verification of the amount of water flowing through the facilities in the principal canals. The integrated water management system is also expected to realize equitable water distribution.

In selecting the facilities to be covered by the water management system, the following facilities are targeted for management: facilities that serve as the base water distribution of the principal canal, facilities along the principal canal that are important for water management purposes, and those that have intake with a large distribution discharge from the principal canal to the main canal.

- ✓ Major diversion and water level control facilities:
  Ibrahimia Intake, New Dirout Group of Regulators, regulators along Bahr Yusef Principal Canal, regulators along Ibrahimia Principal Canal
- ✓ Intakes for main canals along the principal canals

2) Water Management Improvement

In this study, the locations of important regulators and intakes to be monitored will be selected using the facility selection concept employed in the Project for Construction of the New Dirout Group of

Regulators. Through interviews with each GD (Gharbia, Beni Suef, and Fayoum) and the Lower Egypt (Tanta) and Cairo Water Distribution Division, each organization requested that the monitoring targets include regulators, intakes, weirs, and facilities located on the borders of the governorates.

Of the three priority areas, the Kased Canal is the one that flows from Gharbia to Kafr El Sheik. Therefore, compared to the Abo Shosha Canal (Beni Suef) and the Aros & Abo Seer Canal (Fayoum), which flow among the same governorate, the Kased Canal requires monitoring of water management conditions and the water distribution situation in the Kafr El Sheik Governorate.

In addition, when modern irrigation facilities are introduced, the existing irrigation rotation days may be newly modified. For this purpose, it is proposed to monitor water levels at midstream and downstream locations in long branch canals in order to check the flowing status of irrigation water.

For the purpose of monitoring the Kased and long branch canals, monitoring facilities along the Kased Canal will be installed at the regulators along the Kased Canal, the major branch canal intake in Gharbia GD and Kafr El-Sheikh GD, and the midstream and upstream locations along the branch canal that diverts irrigation water upstream of the Tanta 1 Regulator. Table 4.7.1 shows the requested facilities for monitoring.

Table 4.7.1 Requested Facilities and Monitoring Equipment

GD	Canal	Name	Facility	Proposed Facility	Responsible Project
Gharbia	Kased	Kased Intake	Regulator	WL, CCTV, Gate Status, Discharge	This Project
		Tanta 1	Regulator	WL, CCTV, Gate Status	
		Tanta 2	Regulator	WL, CCTV, Gate Status	
		Mahlet Menouf	Regulator	WL, CCTV, Gate Status	
		Site-1	Intake	WL, CCTV, Gate Status, Discharge	
		Site-2	Intake	WL, CCTV, Gate Status	
		Site-3	Intake	WL, CCTV, Gate Status	
		Site-4	Intake	WL, CCTV, Gate Status	
		Site-5	Intake	WL, CCTV, Gate Status	
		Site-6	Intake	WL, CCTV, Gate Status, Discharge	
		Site-7	Cana	WL	
		Site-8	Canal	WL	
		Sorad	Regulator	WL, CCTV, Gate Status, Discharge	
		-	Monitoring Room	Monitoring System	
Beni Suef	Abo Shosha	Abo Shosha	Intake	WL	New Dirout Project
		Hadir	Weir	WL	Telemetry Section
Fayoum	Aros	Aros	Weir	WL	Telemetry Section
		Nasba End	Tail End	WL	
	Abo Seer	Abo Seer	Intake	WL	Telemetry Section
		Canal End	Tail End	WL	
	-	Rayan No.2	Lake	WL	
	-	Rayan	Drainage Canal	Discharge	

Note: WL (Water Level: water level observation), CCTV (Closed-Circuit Television Camera: monitoring camera), Gate Status (gate positioning status), Discharge (flow measurement by Acoustic Doppler Current Profiler [ADCP])
Source: JICA Survey Team

Generally, when capturing water management status over a wide area, it is considered appropriate to monitor the intakes that cover approximately 80% of the total irrigation area in order of the area that each intake distributes water. Therefore, the branch canal intakes to be monitored along the Kased Canal are selected to correspond to the irrigation area (75,781 feddan) from the top 80% of the total area (95,976 feddan) (Table 4.7.2). Figure 4.7.1 shows the facilities to be monitored in the Kased Canal.

Table 4.7.2 Name of Target Facilities and Areas to be Monitored

Name	Facility	Name of Covered Area			Area	
					(feddan)	(%)
Site-1	Intake	・Qohafa El Gedida ・Al Awqaf ・El Melqa	・Gann. Shabashir ・Abo Kharouf ・Sbrebay	・Ganbia1 of Shabsher	14,115	15.0
Site-2	Intake	・El Wrety	・Smella	・Segen	5,506	6.0
Site-3	Intake	・Damat	・Waslet Damat		5,306	6.0
Site-4	Intake	・Sourad	・Negreeg		5,505	5.0
Site-5	Intake	・Al Samahat			6,307	7.0
Sorad	Regulator	・Al Gamayel Al Qebliya ・Shenno ・Al Gamayel Al Bahiriya ・El Shakria ・Rewina ・Mehdet el kasab	・Al Muit Al Sharkqi ・Shaboora ・Dalil El Ghamia ・EL Ghamria ・Sandella ・El Khraba	・Om Dokhan ・Al Saath ・Al Saath Feeder ・G1 Elyosra for Elkased ・Direct btw G6 and Sorad Regulator	39,542	41.0
					75,781	80%

Source: JICA Survey Team

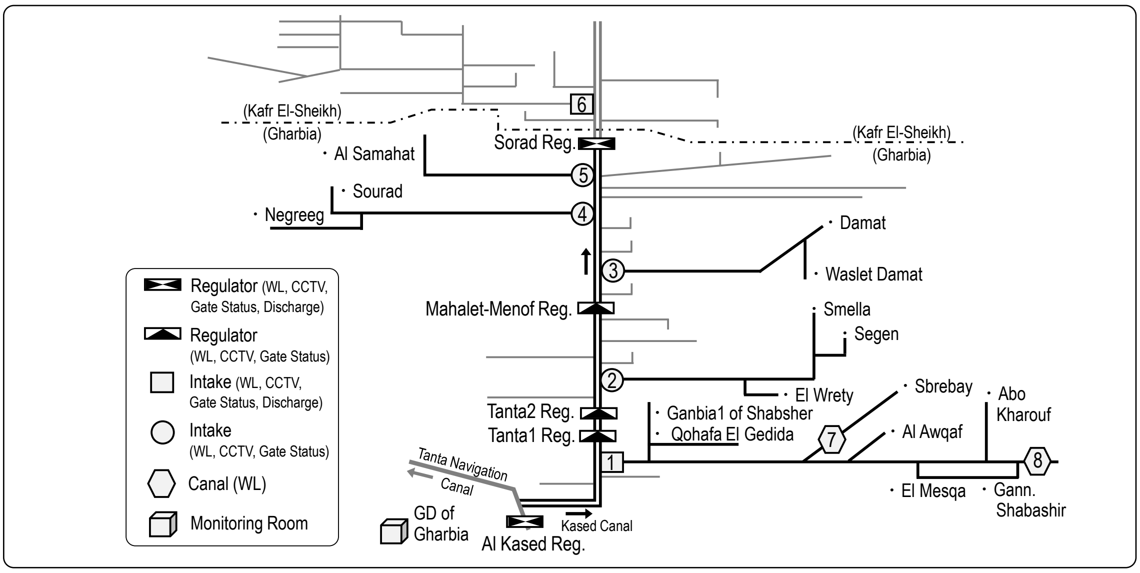


Figure 4.7.1 Data Flow Diagram of Water Management System

Source: JICA Survey Team

In the Abo Shosha and Aros & Abo Seer Canals, the facilities that are already monitored by the Project for Construction of the New Dirout Group of Regulators will be excluded from this study. The telemetry section of MWRI has installed water level gauges and other instruments at major facilities in Beni Suef and Fayoum and is operating a system to distribute the collected data hourly via e-mail. The Team proposes that the facilities requested by GD in the Abo Shosha and Aros & Abo Seer Canals be covered by a system already in operation by the telemetry section.

3) Water Management Improvement Concept in Kased Canal

The water management level of the Kased Canal will not have a remote gate control function for the regulators but only remote water level monitoring and CCTV video monitoring. The reason for not controlling the gate remotely is that control from a remote office would lose the opportunity to inspect for safety when opening and closing the gate and for early detection of malfunctions due to unusual noises during operation. From the perspectives of safe operation and daily inspection and management of the facility, the Team proposes not to remote control the opening and closing of the gate at this time. Water level data and CCTV video at the regulators and water level data at the intake will be remotely monitored in a new monitoring room in the Gharbia GD Office.

In the future, a calculation function will be added to the monitoring system, taking into consideration the possibility of studying the water balance by comparing supply and demand. Figure 4.7.2 shows a data flow diagram example of the water management system improvement. This is the system proposed for the Project for Construction of the New Dirout Group of Regulators. The details of the system will be worked out by the MWRI telemetry section, which has expertise in various types of equipment.

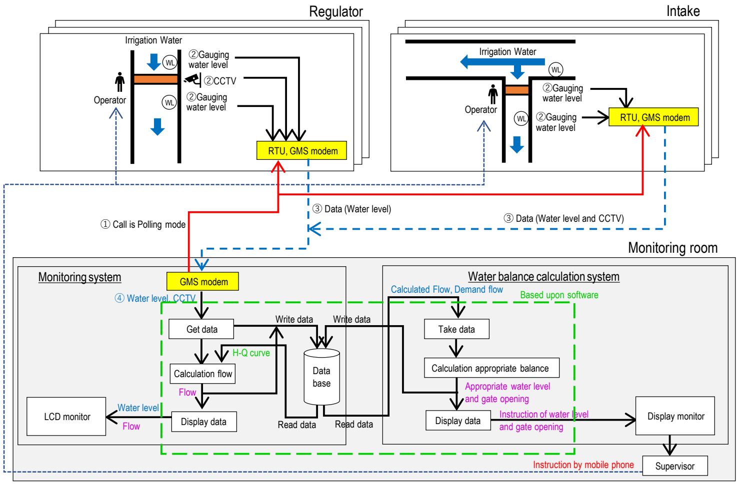


Figure 4.7.2 Data Flow Diagram of Water Management System (example)

Source: JICA Survey Team

Undisclosed Information

Undisclosed Information

4.7.3 Introduction of Visual Water Management System to Follow the Cultivated Area

The Team would like to propose the introduction of satellite image analysis to follow the cropped area as an advanced water management method. This method allows MWRI to obtain information on the planting status and the area where harvesting has taken place, which can then be reflected in the water management system. At present, it is possible to monitor the latest status of cropped areas by analyzing published satellite images (SAR or optical images). The Team proposes to use the data from these satellite images to manage irrigation water supply to reflect changes in cropping coverage and crop growth stages. Satellite image analysis can also be used to identify areas with poor growth that require more water supply.

Table 4.7.4 summarizes satellite imagery systems that are free and available to the public. In most cases, satellite imagery is available in approximately one day. As illustrated in Figure 4.7.3, GD and ID operating irrigation systems can quickly identify cropping conditions. In addition, by referring to the satellite images, it is possible to manage water management according to the field conditions, i.e., to identify areas of water shortage and to increase the amount of water distributed to these areas.

Table 4.7.4 Publicly Available Satellite Imaging System

Operation	Name	Method	Type	Resolution	Interval	Data release	Remarks
USGS	Landsat-8	Optical	Level1	30m	16days	Within 24 hours	TOA
USGS	Landsat-8	Optical	Level2	30m	16days	14-16 days later	SR
ESA	Sentinel-2	Optical	Level-1C	10m	5days	Within 6 hours	TOA
ESA	Sentinel-2	Optical	Level-2A	10m	5days	Within 8 hours	BOA
ESA	Sentinel-1	SAR	SLC	5m×20m	12days	Within 24 hours	Northbound orbit (Or Southbound orbit)
ESA	Sentinel-1	SAR	GRD	10m	12days	Within 24 hours	Northbound orbit (Or Southbound orbit)

TOA: Top of Atmosphere BOA: Bottom of Atmosphere SR: Surface Reflectance
Source: JICA Survey Team

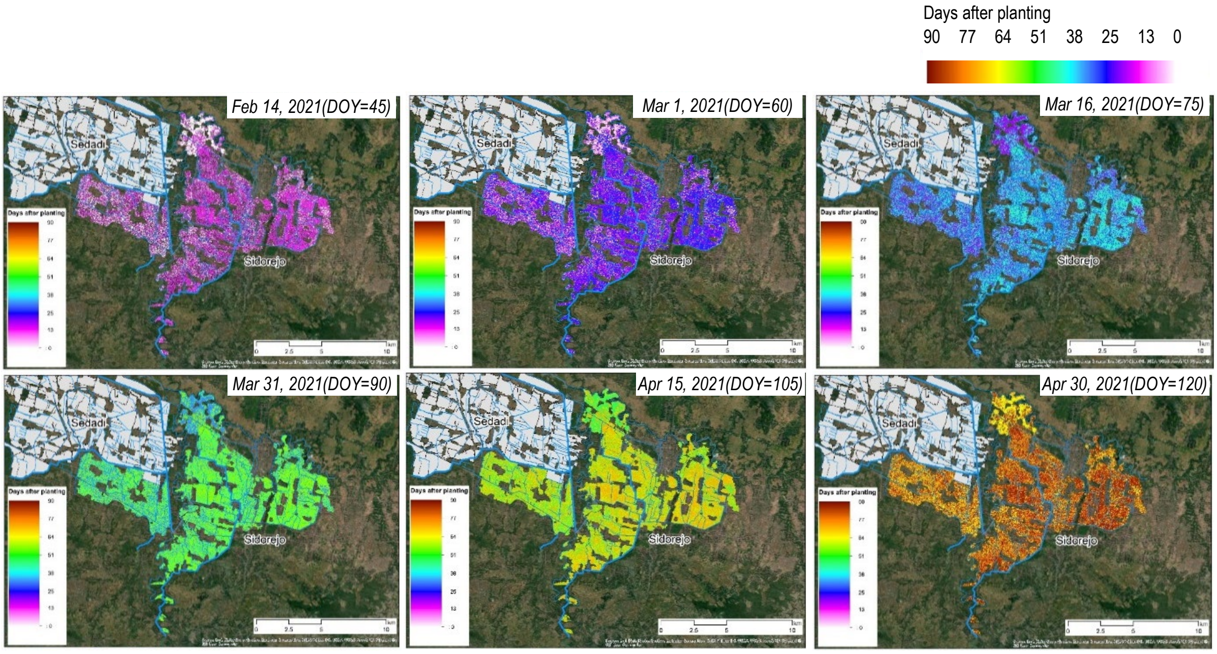


Figure 4.7.3 Example of a Satellite Image Showing Cultivation Conditions in an Area
Note: DOY indicates the number of days elapsed since the beginning of the year (2/14 would be DOY 45)
Source: JICA Survey Team

By referring to the satellite data and observation data, appropriate water management is possible. Furthermore, after these data are accumulated, they can be used to formulate irrigation plans for the following year and to accurately determine the amount of water supplied. As shown in Figure 4.7.4, the integration of satellite image analysis and monitoring and management systems will realize advanced irrigation management through efficient use of irrigation water and reduction of non-use water. To sustain such appropriate irrigation management, it is also necessary to develop operational manuals and guidelines and to train human resources.

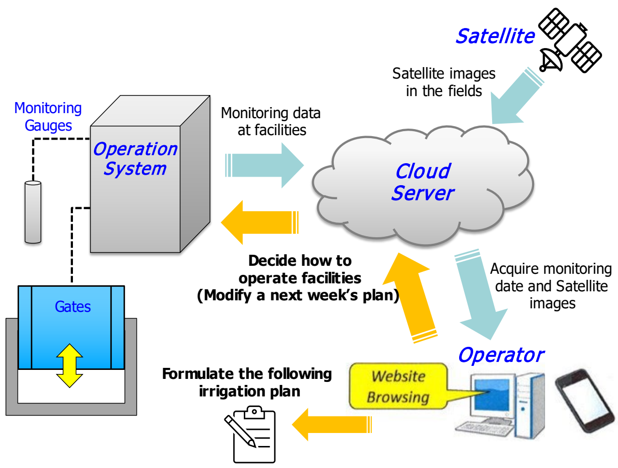


Figure 4.7.4 Conceptual Diagram of Modernized Water Management System
Source: JICA Survey Team

4.8 Procurement of Maintenance Machineries: Component 7

Maintenance of irrigation facilities (e.g., periodic dredging of canals) is undertaken by the Central Directorate for Canal Maintenance. Gharbia and Minya Offices under the Central Directorate are located in the Project area, but the maintenance equipment owned by these offices is generally aging, and maintenance and repairs are time-consuming (see Section 3.7 Maintenance of Irrigation Facilities). Also, the equipment in the workshops, some of which were provided by USAID in 1984 and some of which were procured by MWRI around the 1980s and 1990s, is quite outdated.

Interviews were conducted with the Gharbia and Minya Offices regarding maintenance and workshop equipment, and it was confirmed from the interviews that there is a need to replace existing equipment and introduce new equipment (see 3.7 Maintenance of Irrigation Facilities). Therefore, the procurement of equipment for maintenance and workshop equipment is planned in this sub-chapter. In addition to the previous maintenance, the maintenance of the concrete lined canals that MWRI is currently working on will be a new task as the previous maintenance was only for earthen canals.

4.8.1 Maintenance Methods for Concrete Lined Canals

Since 2020, MWRI has been implementing concrete lining works on the branch canals operated under rotational irrigation as part of its water conservation measures. The concrete lining is targeted at branch canals with a bed width of 6 m or less, and most are lined with plain concrete. As the General Directorate of Canal Maintenance has no experience in maintaining such concrete-lined canals, it is necessary to procure the necessary equipment and train the staff on how to maintain concrete-lined canals.

In general, removal of accumulated sediment, waterweeds, and debris in irrigation canals is carried out using a long-arm backhoe or similar equipment. However, when working in concrete-lined canals, the bucket of the backhoe engaged in the removal work may damage the concrete. Therefore, removal of sediments and floating debris within the concrete-lined canals should be performed by the following method:

- ✓ When the width of the canal is about 5 to 6 m, a small tractor equipped with a blade can be used to collect sediment accumulated on the canal bed, and a backhoe should be used to remove the sediment outside of the canals. To prevent damage to the concrete, the tractor should be a crawler type and equipped with rubber caterpillars.
- ✓ In maintaining small irrigation canals with a bed width of 1-2 m, removal work should be carried out by manual labor as necessary.

In order to avoid damage to the lining of the canal slope when tractors enter the canal, concrete slabs or step blocks that can be installed and removed should be placed on the canal slope (see Figure 4.8.1 as an example).

Figure 4.8.1 Concrete Slab and Step Blocks for Tractor Entry into Canals
Source: Hokukon, a Japanese manufacture

4.8.2 Renewal and Procurement of Canal Maintenance Machinery

The following should be considered as a guide for selecting the necessary machinery and equipment to be used for the purpose of maintenance and management of irrigation and drainage canals.

- ✓ Since almost all the machinery/equipment is obsolete, in many cases beyond its depreciation period, replacement or renewal of those needed for required canal maintenance works should be considered. Necessary machinery includes a long armed hydraulic excavator, a hydraulic excavator (standard type), a wheel loader, a backhoe loader, and a dump truck.
- ✓ It is necessary to improve the efficiency of irrigation canal maintenance work, such as removal of accumulated sediment, waterweeds, garbage, etc. For this purpose, new models that contribute to the improvement of work efficiency should be introduced, even if the canal maintenance office has no or little experiences in owning such machinery. Applicable models include a floating (amphibious) hydraulic excavator, a small mowing boat, and a mowing machine for submerged-grasses.
- ✓ Machinery and equipment will be introduced to maintain the concrete lined canals (branch lined canals). The applicable machinery and equipment are a tractor (rubber crawler type) and a plastic bucket (attachment of hydraulic excavator).
- ✓ Currently, machinery and equipment that have broken down in the field during the work must be transported to the workshop for repair, hindering the progress of canal maintenance work. For this reason, equipment that can rush to the site to perform maintenance and repair of the equipment should be introduced. The necessary equipment includes a work truck (mobile workshop), a forklift truck, a truck loader crane, a rough terrain crane, and a low bed semi-trailer.

Based on the above discussion, and as a result of discussions with MWRI, the JICA Survey Team plans to procure the maintenance machinery and equipment shown in Table 4.8.1. The purposes of procuring the machinery and equipment are shown in Table 4.8.2.

Table 4.8.1 Proposed List of Maintenance Machinery and Equipment

No.	Name of Machinery	Specification	Required Number		Purpose of use *1
			Gharbia Office	Minya Office	
1	Long Armed Hydraulic Excavator	14ton class, Bucket capacity: 0.28m3	1	1	(a), (b), (c)
2		30ton class, Bucket capacity: 0.69m3	1	1	
3	Hydraulic Excavator (Standard Type)	7ton class, Bucket capacity: 0.30~0.37m3	1	1	(a), (b), (c), (d)
4		20ton class, Bucket capacity: 0.50~1.20m3	1	1	
5	Floating (Amphibious) Hydraulic Excavator	20~25ton class, Bucket capacity: about 1m3	1	1	(a), (b)
6	Wheel Loader	16ton class, Bucket capacity: 2.7~4.0m3	1	1	
7		22ton class, Bucket capacity: 3.6~5.2m3	1	1	
8	Backhoe Loader	6~7ton class, Loader bucket capacity: 0.8m3	1	1	(a), (b), (c), (d)
9		7~8ton class, Loader bucket capacity: 1.0m3	1	1	
10	Dump Truck	Loading capacity: 12ton (7m3)	1	1	(e), (f)
11		Loading capacity: 25ton (14~16m3)	1	1	
12	Truck Loader Crane	Maximum loading capacity: 12ton	1	1	(f), (g), (h), (i)
13	Rough Terrain Crane	Maximum loading capacity: 30ton	1	1	(h), (j)
14	Low Bed Semi-Trailer	Width of platform: more than 3.0m	1	1	(i)
15	Tractor (Crawler Type)	3ton class with rubber crawler	1	1	(k)
16	Small Mowing Boat	less than 2ton class, weed harvester	1	1	(l)
17	Mowing Machine for Submerged grasses	2~3ton class, weed harvester	1	1	(l)
18	Work Truck (Mobile Workshop)	Air compressor, welding machine, generator, and mechanic tool set etc.	1	1	(m)
19	Forklift Truck	Diesel engine type, Loading capacity: 7~8ton	1	1	(o)

No.	Name of Machinery	Specification	Required Number		Purpose of use *1
			Gharbia Office	Minya Office	
		Total	19	19	
		Grand Total	38		

*1: The (a) - (o) in this column correspond to Table 4.8.2
Source: JICA Survey Team

Table 4.8.2 Purpose of Procuring the Maintenance Machinery and Equipment

No.	Purpose of Use for Maintenance Machinery
(a)	Removal of sediment soil, garbage, and grasses from the canals etc.
(b)	Loading the removed sediment, soil, garbage, and grasses on the truck, etc.
(c)	Repair of canal embankment and canal slope, etc.
(d)	Various kinds of repair work for irrigation facilities
(e)	Transportation of sediment, soil, garbage, and grasses to the disposal area
(f)	Transportation of construction material to the work site
(g)	Transportation of steel structures (gate, aqueduct, steel syphon, and screen) to the work site
(h)	Installation of steel structures, etc. at work site
(i)	Transportation of maintenance machinery and workshop equipment to the work site
(j)	Loading and unloading of machinery, WS equipment, and steel structures (gate, aqueduct, syphon, screen, etc.)
(k)	Gather the sediment, soil, garbage, and grasses in the concrete lined canal
(l)	Mow and gather the grasses and garbage in the canal
(m)	Repair of maintenance machinery at work site
(n)	Supplying the fuel, engine oil, and lubricating oil, etc. at work site
(o)	Transportation of workshop equipment and steel structures (gate, aqueduct, steel syphon, and screen etc.)

Source: JICA Survey Team

In addition to the machinery and equipment above, there will be a need to procure backhoe attachments, spare parts, and consumables for each of them. Backhoe attachments should include a skeleton bucket, a slope bucket, and a breaker (Hummer), etc.

4.8.3 Renewal and Procurement of Workshop Equipment

Currently, several pieces of equipment installed in the workshop have been confirmed to be in good working condition, and accordingly there is no request for renewal of that equipment, including an engine lathe and a bench electric grinder. Except for those, the Team proposes that equipment should be renewed or newly procured if the workshop equipment is in the following conditions and for the following reasons:

- ✓ Not in operation due to a malfunction and repair is not possible,
- ✓ Low performance, i.e., equipment specifications are not up to the required standards and higher performance equipment is needed,
- ✓ The operability or performance of the current equipment has progressed dramatically from that at procurement,
- ✓ New equipment is needed to improve the fabrication quality of steel structures and the efficiency of operations, and
- ✓ New procurement for the purpose of repairing hydraulically operated maintenance and workshop machinery and equipment.

Based on the above and through the discussions with MWRI, the Team proposes the procurement of the workshop equipment as shown in Table 4.8.3:

Table 4.8.3 Proposed List of Workshop Equipment

No.	Name of Workshop Equipment	Required Number		Reasons for Procurement
		Gharbia Office	Minya Office	
1	Hydraulic Press Machine	1	1	Renewal due to low performance
2	Welding Machine, Diesel Engine	1	1	Renewal due to dysfunction
3	Welding Machine, Electric	1	1	Renewal due to outdated
4	Electric Cutter (for steel cutting)	1	1	Renewal due to outdated
5	Portable Crane	1	1	Renewal due to dysfunction and low performance
6	Hydraulic Hose Fitting Press Machine	1	1	New procurement - repair of hydraulic system

Source: JICA Survey Team

4.9 Modern On-farm Irrigation Development: Component 8

The Government of Egypt has officially decided to introduce modern on-farm irrigation facilities in September 2021 to cope with water shortages in the coming near future. The target is to install sprinklers and drips on a large area of about 4 million feddans of agricultural land. In fact, in the Old Lands, some farmers, especially those at the end of canals, where water scarcity and deterioration of water quality are severe, are installing modern irrigation facilities on their own. In this section, a plan for the introduction of modern field irrigation facilities is described against this background.

4.9.1 Modern On-farm Irrigation Method

Modern irrigation facilities include sprinklers and drip tubes for small field sizes and various other methods such as center pivot irrigation for large fields. However, the target area of this Project is the Old Lands, where the average farmer's field size is smaller than one feddan. Therefore, modern irrigation facilities used in large fields, such as those used by private companies in New Lands, should be excluded. In general, in terms of equipment characteristics, sprinkler irrigation is suitable for field crops such as alfalfa, berseem, and wheat, while drip irrigation is suitable for vegetables, fruit trees, and other crops which are planted in rows.

Table 4.9.1 shows the modern irrigation facilities so far installed by the farmers in the Old Lands. Each farmer's field area ranges from 1 to 2 feddan, and drip irrigation is used to cultivate vegetables and fruit trees. The reasons for introducing drip irrigation include the use of groundwater due to water shortages and deterioration of water quality in the canals. These farmers are located at the ends of existing canals. In addition to increased crop yields, a variety of positive effects have been observed since the introduction of the facility, including reduced irrigation water, reduced fertilizer application and labor, and crop diversification.

The cost invested by farmers at the individual level in installing facilities has ranged from EGP 5,000/feddan to EGP 19,000/feddan for shallow well construction and small diesel pumps, EGP 17,000/feddan to EGP 20,000/feddan for drip irrigation, and the overall amount comes to EGP 28,000/feddan to EGP 39,000/feddan (see Table 4.9.1). As shown in Figure 4.9.1, the facilities installed at the individual level are the minimum required equipment, such as a small diesel pump and drip tube.

Table 4.9.1 Old Land Farmers' Adoption of Modern Irrigation Facilities

On-farm size	Installation Year	Crop	Reason of Installation	Change after Installation	Major equipment and Cost (EGP/feddan)	
1.0 feddan (Beni Suef)	2021	Fruit trees, cabbage	Water Shortage	•Yield increase •Crop diversification	Pump from well	19,000
					Drip line	20,000
1.0 feddan (Biba, Beni Suef)	2020	Tomatoes	Far from Meska	•Yield increase •Water and fertilizer saving •Labor cost saving	Pump from well	5,000
					Drip line	17,000
1.0 feddan (Gharbia)	2013	Garlic	Bad quality of canal water	•Yield increase •Water and fertilizer saving •Labor cost saving •Stable production	Pump from well	N/A
					Drip line	34,000
2.0 feddan (Fayoum)	2020	Tomatoes	Water shortage	•Yield increase •Stable irrigation water •Reduction in irrigation time	Pump from well	28,000
					Drip line	
				Pump & Well	EGP 5,000 - 19,000/feddan	
				Drip line	EGP 17,000 - 20,000/feddan	
				Total Cost	EGP 28,000 - 39,000/feddan	

Source: Interview by JICA Survey Team (Converted from the cost in the year of introduction to the cost in 2022 by taking into account the rate of inflation)

As indicated above, while there are positive effects from the introduction of facilities, modern irrigation facilities are precision products, so it is essential to introduce high-quality products and maintain them regularly. Especially in drip irrigation, if there is no filter to prevent it, clogging will prevent uniform irrigation to the crops. In the case of low-quality products, there are also examples of farmers who had to replace their products after about one year of their service life. Therefore, when introducing modern irrigation facilities, it is essential to emphasize the importance of maintenance and to introduce high-quality products. Table 4.9.2 presents suggestions for the introduction of modern irrigation based on interviews with farmers.

Table 4.9.2 Proposal to Introduce Modern Irrigation

Topic	Subject
Proposals for equipment installation	・Purchasing quality products, even at higher prices, is ultimately advantageous from a life-cycle cost perspective. ・Drip tube installation adapted to the crop to be grown
Proposals for operation and maintenance	・Filters are installed early in the installation process due to the precision of the equipment. ・Periodic replacement of filters ・Periodic hydraulic cleaning of the drip tube to eliminate clogging
Proposal for area size of the installation	・Establish a reasonable investment amount for equipment based on the assumption of increased yield and reduced input.

Source: JICA Survey Team

Figure 4.9.1 Example of Modern On-farm Irrigation Facilities Installed at the Individual Level

Source: JICA Survey Team

4.9.2 Options for Modern On-farm Irrigation

In some cases, in addition to the construction of collective pumps and the pipelining of Meska improvements, the IIIMP has also introduced pipelined Marwa, which are farm ditch canals. The WUAs that pipelined the Marwa have raised requests to the IAS to improve the Marwa because they said that the Meska improvements alone do not provide enough water to reach all the fields.

The modern irrigation development plan is to provide drip irrigation and sprinkler irrigation in each farmer's plot to promote increased yields, reduced cost of cultivation, and cultivation of diversified crops under appropriate water use. The WUA's trend of requesting the pipelining of Marwa for farm ditch canals is to prepare irrigation facilities to achieve more equitable water allocation and crop diversification, which is consistent with the direction of modern irrigation development.

Based on recent trends, the modern irrigation improvement plan will follow the existing Meska improvement process and plan a series of modern irrigation systems by constructing a collective pump, pipelines to be installed with the Meska improvement, pipelines to distribute water in the direction of the fields, and modern irrigation facilities (sprinklers and drip tubes) in the fields. Table 4.9.3 shows the options and characteristics of modern irrigation facilities to be considered.

Table 4.9.3 Options of Modern Irrigation Development

Particulars	Option-1 Drip irrigation system	Option-2 Sprinkler system	Option-3 Lateral-move sprinkler system	Option-4 Movable sprinkler
Description	Water pressure is coming from the pumping station	Water pressure is coming from the pumping station	Water pressure is coming from the pumping station	Water pressure is coming from the movable pump
Required Facilities at Meska	Pumping station (Pump, Filter), Meska improvement	Pumping station (Pump, Filter), Meska improvement	Pumping station (Pump, Filter), Meska improvement	Movable pump
Required Facilities after Meska	Pipe (Marwa main and sub), Valve, Fertilizer, Control valve, Drip tube	Pipe (Marwa main, sub and connection), Valve, Fertilizer, Sprinkler	Pipe (Marwa main and sub), Valve, Fertilizer, Lateral-move sprinkler	Valve, Fertilizer, Movable sprinkler
Water Pressure	0.1 - 0.35 (MPa)	0.2 - 0.5 (MPa)	0.2 - 0.8 (MPa)	0.2 - 0.5 (MPa)
Amount of water supply	1.0 - 4.0 (liter/hour)	5.0 - (liter/min)	120 - (liter/min)	5.0 - (liter/min)
Features	・ Most economical of the options ・ Head loss increases along with the drip tube ・ Some already exist in Egypt	・ More economical without drip irrigation ・ There are some examples in Egypt	・ Effective for a wide and rectangular shaped area ・ Maintenance of the driving parts is required ・ Power source is required depending on the type	・ Versatile and can be used for personal use ・ Maintenance of the pump is required ・ Suitable for small-scale farmers
Irrigation Efficiency	◎	◎	○	○
Economy	◎	◎	△	△

Source: JICA Survey Team

For Options 1-3, the existing Meska will be pipelined and buried underground. Collective pumps will be installed along the Meska, with each collective pumping area covering an area of approximately 10 to 30 feddan. Option 1 is a drip irrigation system via a pipeline from the collective pump to each field, and Option 2 is a sprinkler system.

Option 3 is to irrigate by installing sprinklers that move laterally in the long rectangular fields that are being pumped from the collective pump. This method is suitable for Egyptian farmlands, which are mostly a long rectangular shape. In addition to installation at the individual farm level, this system could be undertaken as a business by a private service provider specializing in irrigation for small farmers, or otherwise by a village cooperative established under MALR.

Option 4 is to irrigate with equipment that combines a mobile pump with a small sprinkler system. The advantage of this irrigation method is that since a mobile pump is used to draw water from the canal, there is no need to consider the collective pump's operating time in coordination with other farmers. The ability to irrigate individually allows farmers to have flexibility in irrigated agriculture. However, this system is only applicable in nearby Meskas and branch canals with easy access to irrigation water, so installation sites are limited.

In Options 1-3, the collective pump will be designed with pressures that can operate both drip and sprinkler systems in the field. By integrating the Meska improvement with modern irrigation facilities, the existing Meska improvement design procedures that have been implemented by MWRI will be utilized as much as possible.

Options 1 and 2 have high irrigation efficiency. In recent years, more individual farmers are beginning to adopt drip irrigation and sprinkler irrigation. Therefore, the Team proposes a design layout that allows farmers to choose either drip irrigation (Option 1) or sprinkler irrigation (Option 2) as a modern on-farm irrigation development. In addition, the pipelines to be installed in the field should be equipped with valves at regular intervals for leaching to flush out the salt that may accumulate in the soil.

4.9.3 Operation Based on TRAM for Modern On-farm Irrigation

The advantage of introducing modern irrigation is that it saves more water than traditional irrigation methods. Water-saving irrigation is a method of irrigating mainly around the roots of crops with smaller amounts of water than traditional irrigation. When considering water-saving irrigation, irrigation interval days should be established based on soil property and crop type. The irrigation interval days are calculated using TRAM. TRAM is calculated by the formula "TRAM (mm) = (FC-WP) × D × (1/SMEP)," which simply indicates the total amount of water that can be consumed by the crop in millimeters.

Where: FC: Field Capacity (weight %)
WP: Wilting Point (weight %)
D: Thickness of the Rooting Depth (mm), (assumed 125 mm)

SMEP: Soil Moisture Extraction Pattern

The irrigation interval is determined by dividing the TRAM by the maximum water requirement of the crop. This is the number of days that irrigation should be applied every other day; TRAM is strongly influenced by the soil type, and the maximum water requirement is determined by the crop type. Table 4.9.4 shows the typical soil properties presented by FAO, and Table 4.9.5 summarizes the estimated irrigation intervals using the typical soil properties. In this examination, the soil type is assumed to be intermediate in nature, and the number of days between irrigation intervals is set at 5 days under the conditions of irrigating maize of Nile Crop requiring high water consumption.

Table 4.9.4 Typical Soil Properties according to FAO

Type of Soil	Light (coarse) texture	Medium texture	Heavy (fine) texture
Saturation capacity (SC) % weight	25-35%	35-45%	55-65%
Field capacity (FC) % weight	8-10%	18-26%	32-42%
Wilting point (WP) % weight	4-5%	10-14%	20-24%
SC/FC	2/1	2/1	2/1
FC/WP	2/1	1.85/1	1.75/1
Bulk density (volume weight)	1.4-1.6 g/cm3	1.2-1.4 g/cm3	1.0-1.2 g/cm3
Soil available water (moisture) by volume (FC-WP x bulk density)	0.06	0.12	16-20%
Available moisture (Sa) in mm per meter soil 60 mm	60 mm	120 mm	160-200 mm
Soil water tension in bars:			
at field capacity	0.1	0.2	0.3
at wilting point	15.0	15.0	15.0
Time required from saturation to field capacity	18-24 h	24-36 h	36-89 h
Infiltration rate	25-75 mm/h	8 -16 mm/h	2-6 mm/h

Source: http://www.fao.org/3/a1336e/a1336e06.pdf

Table 4.9.5 Irrigation Intervals by Soil Type and Assumed Crop

Particular	Unit	Nile Crop: Maize (due to the highest water requirement)				
TRAM: Total Readily Available Moisture	mm	15.625	25	37.5	37.5	56.25
Cumax: Max Water Requirement	mm	7.5	7.5	7.5	7.5	7.5
Irrigation Interval	**days**	**2.1**	**3.3**	**5.0**	**5.0**	**7.5**
Soil Type		Light		Medium		Fine
FC: Field Capacity % Weight	%	10	18	26	32	42
WP: Wilting Point % Weight	%	5	10	14	20	24
FC – WP	%	5	8	12	12	18
De: Effective Soil Depth	mm	500	500	500	500	500
D: Depth of Controlling Soil =De/(4 layers)	mm	125	125	125	125	125
SMEP: Soil Moisture Extraction Pattern	%	40	40	40	40	40
Ef: Field Application Efficiency	%	80.0	80.0	80.0	80.0	80.0
Crop Targeted		Nile Crop : Maize				
Days in the Month	days	30	30	30	30	30
WC: Water Consumption (MWRI)	cum/fed	752	752	752	752	752
WC: Water Consumption	mm/day	6.0	6.0	6.0	6.0	6.0

Source: JICA Survey Team

In designing the modern irrigation system for this Project, the design conditions are set as shown in Table 4.9.6. The crop is set to be maize of Nile Crop season, which is widely grown with high water consumption, and a water consumption of 752 cum/feddan/month in September is used for design. The field application efficiency is 80% for sprinkler irrigation and 90% for drip irrigation, but 80% is used in the design to accommodate higher water consumption in future operations. The daily irrigation time with a modern irrigation system is set to be 12 hours during the daytime.

Table 4.9.6 Design Conditions for Modern Irrigation Systems

Item	Unit	Design Condition
Type of Crop	-	Maize (Nile Crop)
Water Requirement	m^3/feddan/month	752
	m^3/feddan/day	25.1
	mm/day	6.0
Field Application Efficiency	%	80
Gross Irrigation Depth per Day	mm/day	7.5
TRAM	mm	37.5
Irrigation Interval	Day	5
Irrigation hours	hour	12

Source: JICA Survey Team

4.9.4 Basic Design of Recommended Modern On-farm Irrigation

The size of the Meska improvement area implemented by IIP and IIIMP is around 30 to 70 feddan. Assuming that the area owned per farmer in Old Lands is about 0.6 feddan, there are approximately 50 to as many as 120 farmers of the WUA in the Meska improvement area. In this area, WUA members use collective pumps for irrigation. Therefore, the number of WUAs should not be too big to be able to manage close communication and collective actions in view of proper water allocation.

IIIMP has implemented Meska improvement in the Delta region, where the main crop is rice. In the case of rice, IIIMP set the design area for Meska improvement at 50 to 100 feddan. IIIMP's Meska improvement covers the installation of a collective pump and pumping water from the collective pump to open canals and hydrants in the fields. This irrigation facility is different from the full-pressure water distribution system used to operate drips and sprinklers in the field in the modern irrigation development.

For an on-farm irrigation system that will be a pressure pumping system to the end of the field, it is necessary to reduce the size of the area to be irrigated to below the size of the area where rice cultivation is conducted in the IIIMP to ensure proper collective operation. This will lead to proper management of water allocation by reducing the number of WUA farmer members handling one collective pump.

Sakia used for pumping water from Meska to the fields covers an irrigated area of approximately 20 to 100 feddan. Based on the current situation around the target area, there are many cases where in the past Sakia was covering an area of approximately 30 feddan of agricultural land. Therefore, in this Project, 30 feddan covered by a single Sakia is used as a guideline for the maximum area where a collective pump can be installed for modern on-farm irrigation development. In addition, depending on the shape of the field, the installation of collective pumps will be planned to be a minimum of 10 to 20 feddan. In this case, the number of WUAs will be approximately 17 to 50 people with an assumption of 10 feddan / 0.6 feddan/farmer to 30 feddan / 0.6 feddan/farmer.

The modern irrigation facilities recommended by this Survey for Options 1 and 2 consist of a pipelined Meska, a collective pump to pump water from the Meska to the field, a sand filter, liquid fertilizer mixer, pipelines, drip tubes or sprinklers, and an outlet valve for salt leaching.

4.9.5 Typical Specifications and Cost for Modern On-farm Irrigation System

1) Study of Standard Specifications for Modern Irrigation

Table 4.9.7 shows the standard field size to be established for modern on-farm irrigation, and Figure

4.9.2 shows an image of the field layout. The existing Meska is to be pipelined and buried under the road. The pipe diameter for the Meska should be so selected to have a large enough cross-section area for the designed discharge and also for the debris in the pipeline to be able to be removed by manual laborers. So, the maximum flow rate for pipelining Meska needs to cover 100 feddan for the largest area. However, the standard pump size will be designed to irrigate an area of approximately 30 feddan.

Table 4.9.7 Standard Layout for Modern Irrigation

Item	Unit	Design Condition
Maximum Area of Existing Meska	feddan	100
Shape of the Field for the Entire Target Area	m	560×750
Length of Existing Meska (planned pipelining)	m	750
Number of Pumps to be Installed	Site	3
Area Covered by Pump	feddan	33.3 (≒30)
Shape of the Field for the Area to be Covered by the Pump	m	560×250
Required Water Head at the End of the Main Pipeline	MPa (bar)	0.5 (5.0)
Length of Existing Marwa	m	250
Shape of a Field Plot	m	28×125
Size of One Plot	feddan	0.8
Required Water Head at the End of Sub Main Pipeline	MPa (bar)	0.4 (4.0)

Source: JICA Survey Team

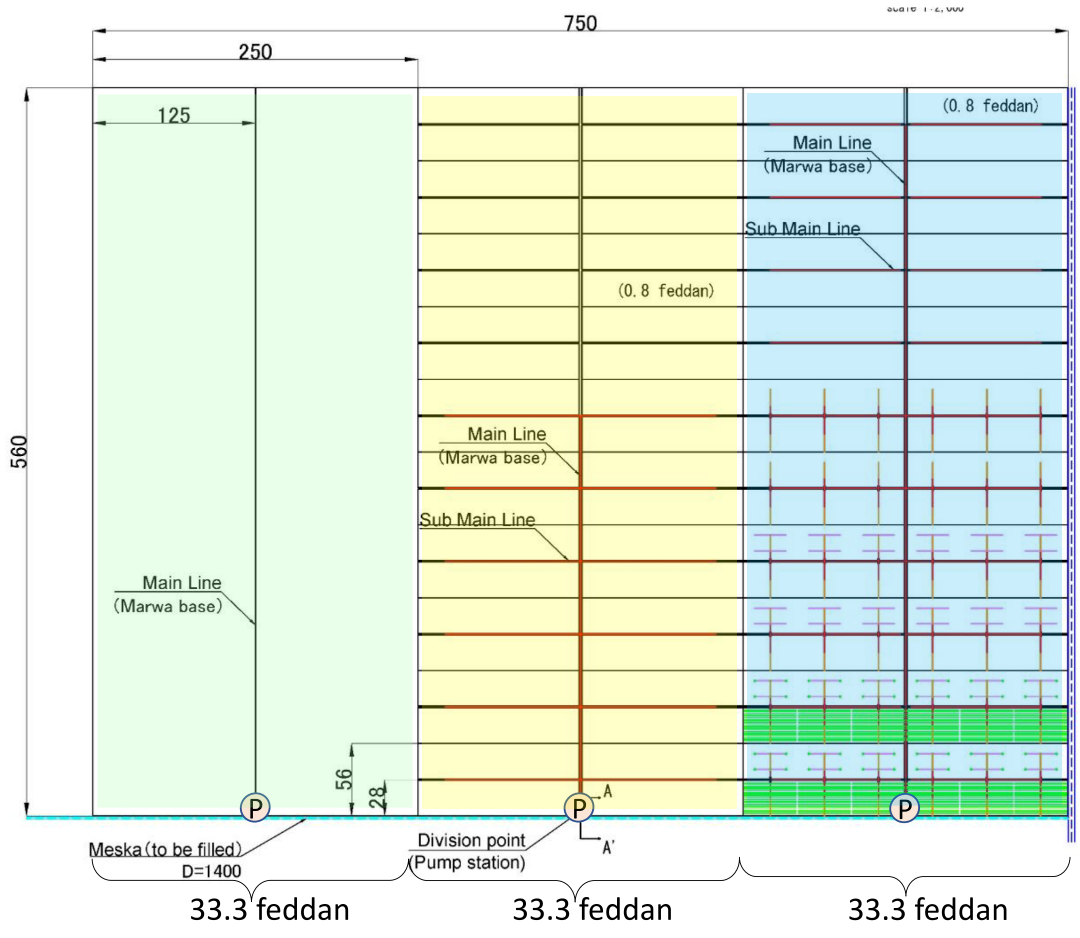


Figure 4.9.2 Standard Layout for Modern Irrigation (Case of 100 feddan Divided into 3 parts)

Source: JICA Survey Team

Based on the hydraulic calculations under the above conditions, the specifications for Meska pipeline, pump, sprinkler irrigation, and drip irrigation are shown in Tables 4.9.8, 4.9.9, and 4.9.10, respectively.

Table 4.9.8 Specification of Meska Pipeline

Item	Unit	Specification
Design Discharge	m3/s	0.336
Length of Meska Pipeline	m	750

Item	Unit	Specification
Diameter of Meska Pipeline	mm	Φ1,200 - Φ1,400*)
Material of Meska Pipeline	-	Concrete Hume Pipe

*) Select a pipe size that can pass the design discharge rate and allow manual debris removal.
Source: JICA Survey Team

Table 4.9.9 Specifications of Collective Pump and Main Pipeline

Item		Unit	Specification
Pump	Design Discharge	m3/min	1.958
	Actual Pump Head	m	50
	Total Pump Head	m	56
	Type of Pump	-	Horizontal Single Suction Volute Pump (Φ150mm)
	Main Output of Power	kW	22
Main Pipeline	Length	m	560
	Diameter	mm	Φ250（Φ200*)）
	Material	-	PVC

*) The pipe size is determined from hydraulic calculations. The specification is selected as one level bigger to allow for a larger size.
Source: JICA Survey Team

Table 4.9.10 Specifications of Sprinkler and Drip Irrigation (per 0.8 feddan)

Item			Unit	Specification
Sub Main Pipe		Design Discharge	m3/s	0.004078
		Length	m/number	104.0
		Number of Pipes	Number	1
		Pipe Diameter	Mm	Φ100（Φ75*)）
		Material	-	PVC
Main Pipe for Sprinkler or Drip		Design Discharge	m3/s	0.001360
		Length	m/number	21.0
		Number of Pipes	Number	3
		Pipe Diameter	Mm	Φ63（Φ50*)）
		Material	-	PVC
Sprinkler	Sub Pipe for Sprinkler	Length	m/number	28.0
		Number of Pipes	Number	6
		Pipe Diameter	Mm	Φ50（Φ30*)）
		Material	-	PVC
	Sprinkler	Specification	-	5022SD
		Water Head	MPa (bar)	0.25 (2.5)
		Wetted Radius	M	10.5
		Wetter Amount	Liter/min	13.6
		Installation Interval	m×m	14×14
		Number of Sprinkler	Number	18
Drip	Drip tube	Length	m/number	20.8
		Number of Pipes	Number	280
		Installation Interval	m	0.6
		Drop Tube Interval	m	0.5
	Drip emitter	Specification	-	MN-PC
		Water Head	MPa (bar)	0.10 - 0.30 (1.0 - 3.0)
		Pipe Diameter	Mm	16
		Dropping Ratio	Liter/hour	1.6

*) The pipe size is determined from hydraulic calculations. The specification is selected as one level bigger to allow for a larger size.
Source: JICA Survey Team

Figure 4.9.3 shows a standard layout for sprinkler and drip irrigation. The existing Meska will be buried underground and replaced by concrete pipes (Φ1,200 to Φ1,400 mm), from which irrigation water will be pumped to the main pipeline (Φ250 mm). The main pipeline will be buried along the location of the existing Marwa. From the main pipeline, a sub-pipeline (Φ100 mm) will be placed in the direction of the fields. After going through the main pipe (Φ63 mm) to this sub-pipeline, irrigation will be carried out by sprinklers and drip irrigation installed in each field.

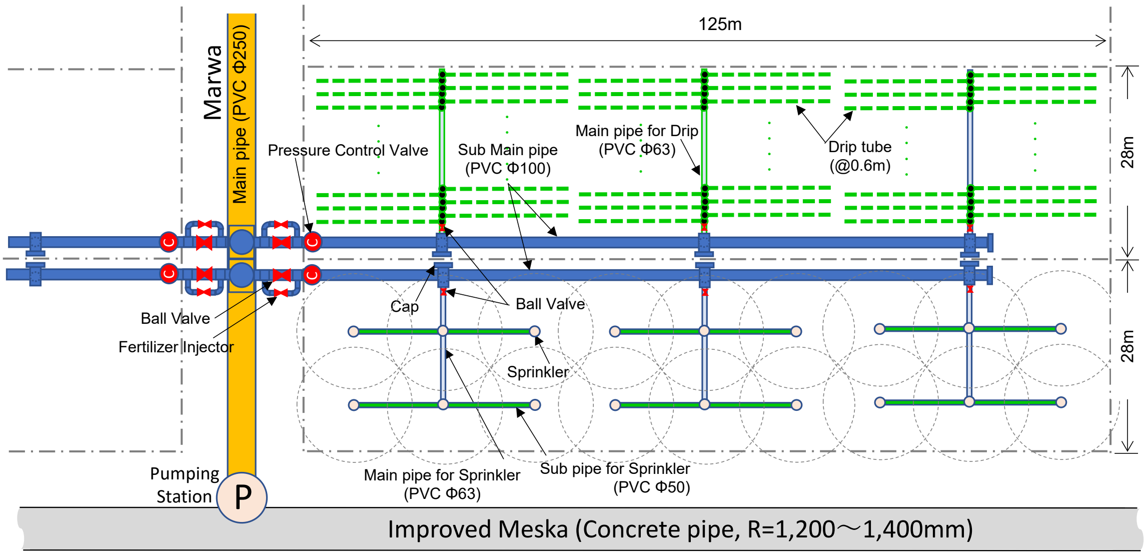


Figure 4.9.3 Example of Modern Irrigation System Layout

Source: JICA Survey Team

Table 4.9.11 shows an example of an irrigation rotational block with an area of 33 feddan and an irrigation interval of 5 days, based on standard calculation results for modern on-farm irrigation. The size of one rotation block is 6.7 feddan and consists of 8 farmers. The rotation block consisting of 8 farmers is considered one group, and each group irrigates daily under a 5-day irrigation interval. Figure 4.9.4 shows an example of the rotation of the irrigation blocks when the interval irrigation is set at 5 days.

Table 4.9.11 Irrigation Area and Block

Item		Unit	Spec.
Area Covered by Pumps	Area	feddan	33
	Size of One Plot	feddan	0.8
Rotation Block	Irrigation Interval	day	5
	Irrigation Hours	hr	12
	Size of Area	feddan	6.7
	Number of Plots	Plot	8
	Number of Farmers	Person	8

Source: JICA Survey Team

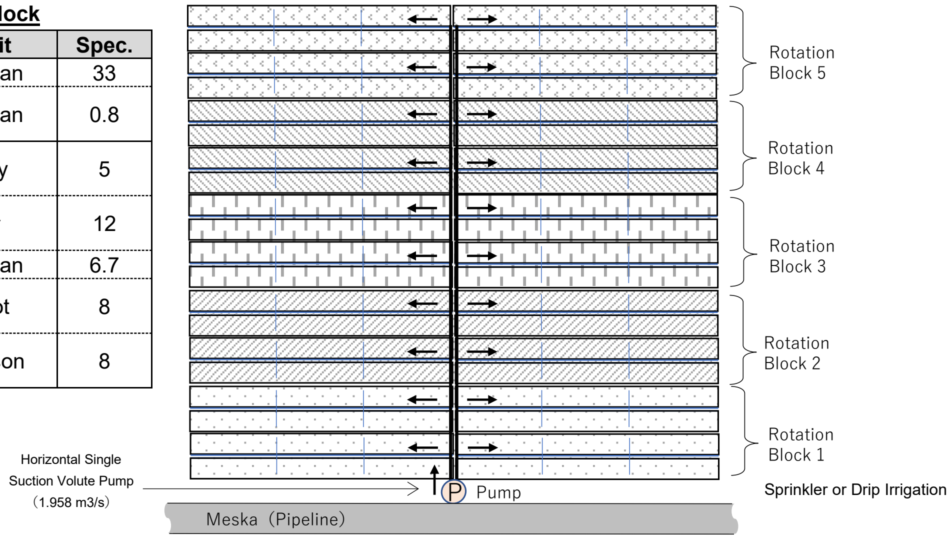


Figure 4.9.4 Image of Rotational Irrigation

2) Study of Number and Specifications of Pumps in Model Sites

The number and specifications of pumps will depend on the size of the target irrigated area and the layout of the modern irrigation system. One model site is selected from each of the three priority areas in this examination to design the layout of pumps and modern on-farm irrigation systems. In selecting the model sites, one with an approximate area of 100 feddan of Meska is chosen. Figure 4.9.5 shows satellite images of each model site.

Abo Shosha Lower **Aros & Abo Seer Upper** **Kased Upper**

Figure 4.9.5 Selected Model Sites

Source: JICA Survey Team

Within the model area, pumps will be located along the Meska, followed by a main pipeline from the pumps, and sprinkler pipelines for sprinkler irrigation and drip irrigation. The irrigation size of each pump should be minimum 10 to 30 feddan. However, since the main pipeline from the pump to the field will be arranged with reference to the existing Marwa and the coverage size of the Meska, there are cases where the maximum irrigation coverage area may exceed 30 feddan, reaching to about 40 feddan. Table 4.9.12 shows the number of pump stations by each model site designed considering the alignment of relevant Meska, Marwa, etc.

Table 4.9.12 Model Sites Selected from Three Priority Areas

Priority Area	Name of Model Site	Target Area (feddan)	Surrounded Irrigation Canal	Site Number for Pump Installation (sites)
Abo Shosha	Abo Shosha Lower	105	Noor	3
Aros Abo Seer	Aros Abo Seer Upper	89	Kasheef, OmarBik	4
Kased	Kased Upper	103	Shabser Gnabia	5

Source: JICA Survey Team

Table 4.9.13 shows the number of pump locations planned for each model site and the area covered by each pump. As shown in the table, the area covered by each pump ranges from 13 to 41 feddan, with an average area of 24.7 feddan. Figures 4.9.6 and 4.9.7 show the pump locations, the area covered by each pump in each model site, and the proposed layout of the modern irrigation system in the field.

Table 4.9.13 Number of Pumps for Model Sites

Priority Name	Model Site	Site Num. of Pump	Pump No	Covering Area (feddan)
Abo Shosha	Abo Shosha Lower	3	1 2 3	41 20 43
Aros & Abo Seer	Aros & Abo Seer Upper	4	1 2 3 4	29 14 16 30
Kased	Kased Upper	5	1 2 3 4 5	31 13 25 16 18
Average Area per Pump				24.7 feddan

Source: JICA Survey Team

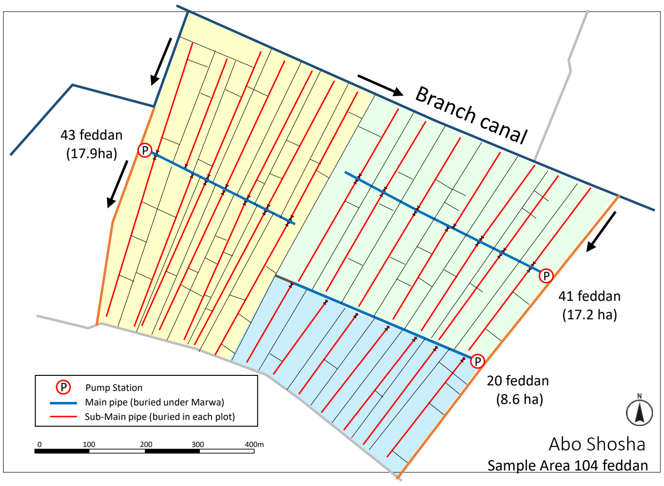


Figure 4.9.6 Model Site (Abo Shosha)

Source: JICA Survey Team

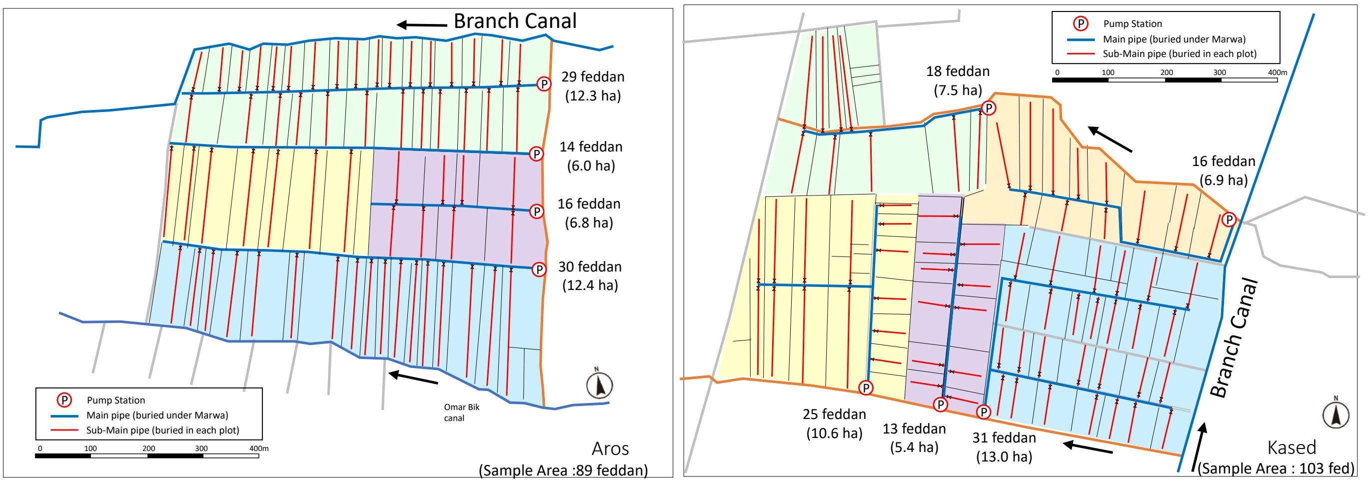


Figure 4.9.7 Model Sites (Aros and Kased)

Source: JICA Survey Team

To calculate the pump size and main pipeline for the target irrigation area, an examination is conducted for an average area of 25 feddan (≈24.7 feddan) and a minimum area size of 10 feddan (≈13 feddan) based on the assumed areas of the model sites shown in Table 4.9.15. Table 4.9.14 also includes specifications for a standard modern irrigation layout calculated as described above (33 feddan area). Figure 4.9.8 shows a standard layout pump station and sump. There are two possible plans for pump specifications: a diesel type and an electric type. However, since the electricity supply is not stable in rural areas, all pump specifications should be diesel type (adopting ◎ in the table below).

Table 4.9.14 Specifications of Pumps and Main Pipelines for Each Model Site

Item		Unit	Specification		
			33 feddan	25 feddan	10 feddan
Pump	Design Discharge	m3/min	1.958	1.469	0.734
	Number of Divided Pumps	Unit	◎ 3 (Diesel type) - 2 (Electric type) 1 Back Up (Diesel type)	◎ 3 (Diesel type) - 2 (Electric type) 1 Back Up (Diesel type)	2 (Diesel type)
	Actual Pump Head	m	50	50	50
	Total Pump Head	m	56	54	54
	Type of Pump	-	Horizontal Single Suction Volute Pump (Φ100mm)	Horizontal Single Suction Volute Pump (Φ100mm)	Horizontal Single Suction Volute Pump (Φ65mm)
	Main Output of Power	kW	22	15	7.5
Main Pipeline	Length	m	560	420	168
	Diameter	mm	Φ250 (Φ200 *))	Φ250 (Φ200 *))	Φ200 (Φ150 *))
	Material	-	PVC	PVC	PVC
Rotation Block	Irrigation Interval	day	5	5	5
	Irrigation Hours	hr	12	12	12
	Size of Area	feddan	6.7	5.0	2.5
	Number of Plots	field	8	6	3
	Number of Farmers	`person	8	6	3

*) The pipe size is determined from hydraulic calculations. The specification is selected as one level bigger to allow for a larger size.

Source: JICA Survey Team

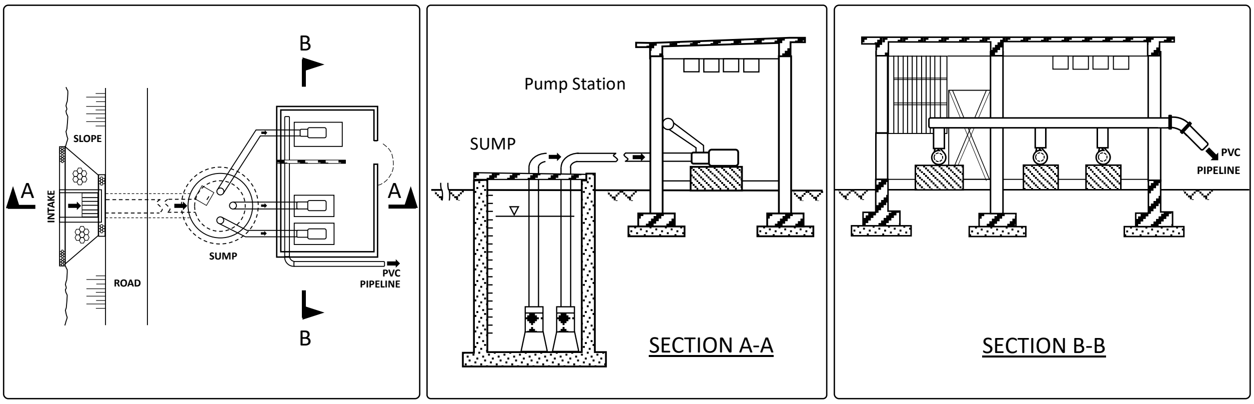


Figure 4.9.8 Standard Layout of Pump Station and Sump

Source: JICA Survey Team

3) Estimated Construction Cost Based on Standard Specifications

Undisclosed Information

Undisclosed Information

4) Examples of Estimated Construction Costs for Different Modern On-Farm Layouts

Undisclosed Information

4.9.6 Examination of Solar Powered Motor Driven System

As mentioned above, the pump is to be driven by a diesel engine. Here, we will consider the case in which the pump is operated by driving a motor using electricity from solar panels. The following points should be considered when using solar power:

- ✓ Solar power is direct current. Therefore, it is necessary to use DC motors or to use AC motors, for which the current should be converted from DC to AC by an inverter. Egypt does not manufacture DC motors. In other words, the DC motor would have to be imported, which would be costly, and spare parts could be difficult to obtain. Therefore, an inverter and AC motor should be used for this purpose.
- ✓ Solar typically operates for about 6 hours during peak hours and 7-8 hours at most. Therefore, the basic principle should be to use the diesel engine pump as the standard system as discussed above, with the AC motor and pump from the solar system added as a backup. This will greatly increase the initial cost since the power source will require a separate motor installation in addition to the diesel engine.
- ✓ The starting power of the pumps depends on the starting system, but requires about three times the power of the pumps in normal operation. In other words, the size (area) of the solar panel needs to be about three times that for a single pump in normal operation. If multiple motors are installed, they can be started one at a time, so the area of the panel can be reduced. However, since it is necessary to start the next motor while maintaining the motor in operation, an area of at least twice as large may be required.

Undisclosed Information

Undisclosed Information

4.9.7 Training Program for Modern On-farm Irrigation

Drip and sprinkler irrigation makes it possible for the farmers to maximize the effect of water and fertilizers with adequate amount of supply, hence contributing to the increase of unit yield of crops, i.e., increase of profitability as well as saving water and fertilizers. The JICA Survey Team made interviews to the farmers who have already applied modern on-farm irrigation system (2 farmers in Beni Suef and 1 group of farmers in Fayoum), and they are well aware of these effects and they are using the system in a way of realizing its benefit.

According to them, they have achieved the unit yield increase from the first year of application of the modern on-farm irrigation system because those in Beni Suef have already practiced the modern irrigation in the New Lands, one for 15 years and another for 6 years. As for the farmer group in Fayoum, they also had an experience of applying modern irrigation system before they established the large-scale modern irrigation system in 2018. Therefore, all the interviewed farmers have already had experiences of the system, which has made them possible to realize the yield increase from the first year of the system installation.

But, for those who are to newly introduce the modern on-farm irrigation, operating the devices properly may need time to get accustomed to realizing full-scale increase of the crop yields. The interviewed farmers have learned the use of modern irrigation system with a help of documents, from drip/sprinkler suppliers, neighbor farmers in the New Lands, etc., and also some of them had experiences already in his/her farmland in New Lands. In this sense, it is necessary to provide technical trainings to the farmers who will apply the modern on-farm irrigation system for their first time.

Taking the above points into consideration, the JICA Survey Team proposes a 3-layered training program as the institutional development and capacity building mechanism (see Figure 4.9.9). At Stage 1, Training of Trainers (TOT) is provided for MWRI staff, especially for the Central Department for

Irrigation Advisory Service (CDIAS)[1] by external experts and experts within MWRI. Stage 2 also includes TOT, but it is carried out as an institutional development for extensive dissemination.

Trainees at Stage 1 would play the role of trainers at Stage 2, in which the targets are the General Directorate of Irrigation Advisory Service (GDIAS)[2] as well as newly recruited contracted IAS staff. Then, at Stage 3, GDIAS and contracted IAS staff train farmers for their capacity building in each target area. The organizing process and transfer of water management are implemented through actual establishment of WUAs, and instructions for Operation & Maintenance of facilities and how to use the system are provided in this 3rd Stage.

Stages	Trainers	Trainees	Contents
Stage 1	Loan Consultants External Experts Experts from MWRI	MWRI Staff CDIAS	TOT for Parmanent MWRI Staff
Stage 2	MWRI Staff CDIAS	GDIAS Contracted IAS Staff	TOT (Institutional Development) for GDIAS & Contracted IAS Staff
Stage 3	GDIAS Contracted IAS Staff	Farmers	Actual WUA Establishment & Capacity Building for O&M (Facility & System) Practical Training at Demonstration Farm

Figure 4.9.9 3-layered Training Mechanism for Organizing Farmers

Source: JICA Survey Team

Demonstration farms should be established for the effective trainings and a showcase for farmer beneficiaries in the target sub-regions. As for the trainings for farmers, the trained CGIAS staff will be divided into groups, each of which will be responsible for one demonstration farm, and they provide a classroom training and practical training on the demonstration farm to the farmer beneficiaries. Table 4.9.20 shows an example of training contents:

Table 4.9.20 Proposed Trainings for Introducing to Modern On-farm Irrigation System

Stage	Module	Content	Inputs
TOT	(1) Introduction	About the modern irrigation: its effect and benefit compared to conventional farming	**(TOT session per Sub-region)** ・ 2 days for a classroom at any center or hall in the District/ Governorate ・ 2 days for practical session at demonstration farm. **(Establishment of Demonstration Farm)** ・ A system of 30 feddan x 3 sites in Abo Shosha and Aros & Abo Seer, and 5 sites in Kased. **(Preparation of Training manuals)** 1) Irrigation method by drip & sprinkler 2) Cultivation method by crop
	(2) Mechanical system of Drip / Sprinkler	Learn the mechanics of drip / sprinkler	
	(3) Water requirement and cultivation method including liquid fertilizer application by crop	Learn water requirement by drip / sprinkler to each crop and how to apply liquid fertilizer by drip / sprinkler	
	(4) Operation & maintenance practice	Field practice on operation and maintenance of devices	
Trainings for farmers	Classroom training: (1) to (3)		・ 2 days for a classroom at any center or hall in the District/ Governorate
	Field practice (4)		・ Average 1 day per week per site during one crop season x 2 seasons with different crops

Source: JICA Survey Team

[1] CDIAS (Central Directorate of Irrigation Advisory Services) is the department which promotes the establishment of WUA under MWRI.

[2] GDIAS (General Directorate of Irrigation Advisory Services) is the local-level agency under CDIAS.

4.10 Irrigation Development in Fayoum with the Introduction of Modern On-farm Irrigation

Water balance in the Fayoum Governorate is very complicated and can be said balanced narrowly in between the supplied fresh water, irrigation use, domestic and industry use, drainage re-use, and then the drainage discharge into the 2 lakes of Qarun and Rayan. When the modern on-farm irrigation is to be introduced over Fayoum farmland area, there will be very reduction in the drainage among, which is the source of maintaining the 2 lakes as they are now.

Qarun and Rayan Lakes are important lakes for environmental conservation, and both are designated as the national protectorates, as well as internationally registered as the Ramsar wetlands and the IBAs (Important Bird Areas). This section discusses the effect of the modern on-farm irrigation to the lakes with the analysis of future change of water balance, and present possible measures for irrigation development in Fayoum:

4.10.1 Overall Water Balance Regime in the Fayoum Area

The water source for the Fayoum area is the Bahr Yusef Principal Canal only with two major supply canals; 1) Hassan Wassef Canal commanding western part of Fayoum and 2) Bahr Yusef Principal Canal itself covering eastern part of Fayoum. From these 2 canals, an annual allocated amount of water, 2.6 billion CUM, is delivered to the whole Fayoum area. The water is used for irrigation, which is the biggest consumer, domestic and industrial purpose. When the water has been applied to the farmlands, percolation takes place by nature, and the percolation comes first in the sub-surface drainage pipes, and then, shows up in tertiary drain, secondary drain, main drain, and finally to the 2 lakes of Qarun and Rayan. No water goes out anywhere from the Fayoum.

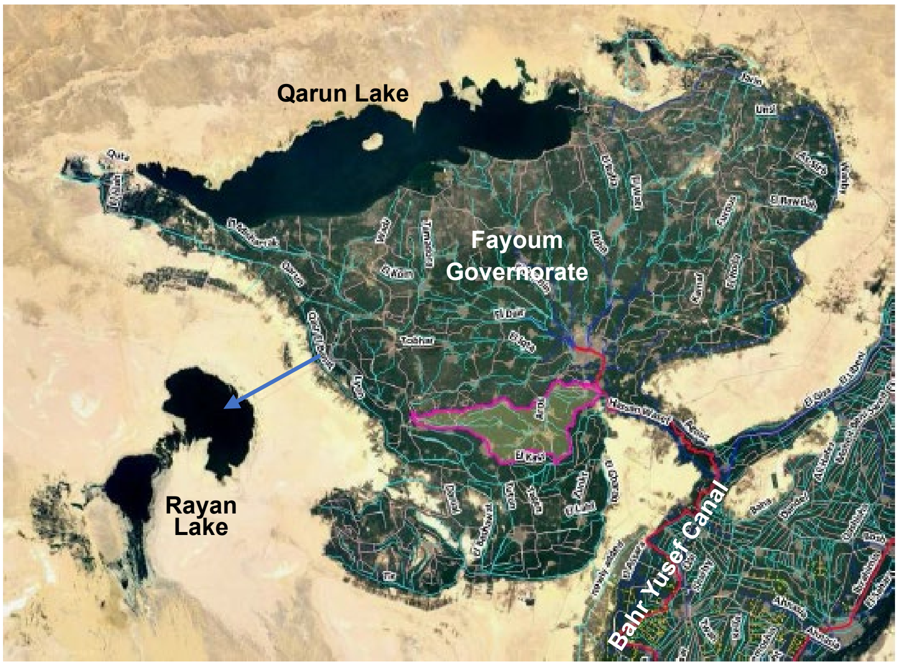


Figure 4.10.1 Map of Fayoum with Lake Qarun and Rayan
Source: JICA Survey Team with the base map of Google

1) Water Allocated and Available for Fayoum

Discharges are measured and available at the intake/regulator points of Hassen Wassef and Lahoun, both of which together consist of the whole available water provided to the Fayoum area.

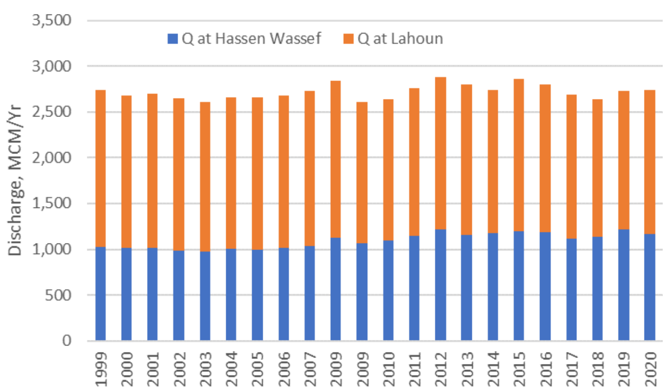


Figure 4.10.2 Actual Annual Discharge to Fayoum
Source: Water Distribution Sector, MWRI

Figure 4.10.2 shows the annual discharges provided to the Fayoum area, and also Table 4.10.1 summarizes the latest 3 years monthly basis discharges from 2018 to 2020. The officially allocated water for the Fayoum area is 2.6 billion cum per annum, and the actually provided water is almost the same as the allocation or a little more than that. According to the table, the discharges of years 2018 to 2020 were around 2%, 5%, and 5% more than the allocated 2.6 billion cum, which is still within an allowable range from the viewpoint of regulator operation.

Table 4.10.1 Monthly Basis Discharges for Fayoum Area, MCM (Allocation: 2,600 MCM)

Year	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hassan Wassef													MCM
2018	44	79	91	80	109	120	113	118	106	110	88	76	1,133
2019	54	86	98	89	109	114	119	122	106	118	106	92	1,214
2020	77	93	87	106	130	121	118	81	100	97	80	73	1,162
Lahoun													MCM
2018	38	110	133	110	160	153	159	152	147	145	107	91	1,506
2019	31	96	121	110	143	151	158	153	138	151	139	127	1,517
2020	92	118	109	113	146	161	162	156	133	142	121	121	1,574
Both Hassen Wassef and Lahoun (allocation: 2,600 MCM)													MCM
2018	83	189	224	190	269	273	271	270	253	254	195	168	2,639
2019	85	183	218	199	252	265	278	275	244	269	245	219	2,731
2020	168	211	196	219	276	282	280	237	233	239	201	194	2,736
Average	112	194	213	202	266	274	276	261	243	254	214	193	2,702

Source: Water Distribution Sector, MWRI

2) Drainage Amount to the Qarun and Rayan Lakes

Egyptian Public Authority for Drainage Projects has conducted discharge measurements periodically on the drainage water into the Qarun and Rayan Lakes. Figure 4.10.3 shows the drainage discharges into Qarun Lake in years 2019 and 2020. As is clearly seen, drainage amount becomes less during summer season while it does more during winter season. This is corresponding to the water requirement by the corps; namely, summer crops need more irrigation water so that drainage reuse should be made more to supplement the irrigation, leading to less drainage discharges to the lake.

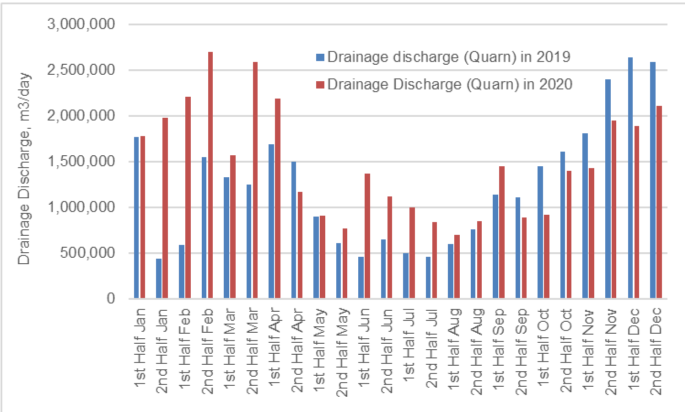


Figure 4.10.3 Drainage Discharges into Qarun Lake

Source: EPADP, MWRI

Table 4.10.2 summarizes the drainage discharge data available; 2 years of 2018 and 2019 for Rayan and 3 years of 2018-2020 for Qarun. There are periods when data are not available, e.g., January to mid-March of 2018 and 2019 for Rayan and 2018 for Qarun, and mid-October to end December of 2018 and 2019 for Rayan. For those periods where data are not available, the drainage discharge was estimated by applying proportional ratio of Qarun discharge in 2019 and 2020 between the data available period being 100% and other periods.

From the table below, it is found that the annual drainage discharges into Rayan Lake were 173 MCM and 212 MCM for the years of 2018 and 2019, and the discharges into Qarun were 400 MCM, 452 MCM, and 542 MCM for the years of 2018, 2019, and 2020, respectively. There are specified drainage discharge amount to these lakes that the MWRI has decided in order to maintain the lake water level not much changed. The specified annual amounts are 100 MCM/year and 400 MCM/year for Rayan and

Qarun respectively, totaling to 500 MCM per annum. Actual discharged drainage amount has been more than that specified one, especially in case of Rayan. The specified 500 MCM is corresponding to as much as 19.2 % of 2,600 MCM, which is allocated to Fayoum whole area.

Table 4.10.2 Drainage Discharges to Rayan and Qarun Lakes

Period	Rayan				Qarun						Ratio	
	2018, K. m3/day	2018, '000 cum	2019, K.m3/day	2019, '000 cum	2018, K.m3/day	2018, '000 m3	2019, K.m3/day	2019, '000 m3	2020, K.m3/day	2020, '000 m3	2019 Qarun	2020 Qarun
1st Half Jan	532	39,343	652	48,231	1,216	90,009	1,764	26,453	1,777	26,648	41%	58%
2nd Half Jan							439	7,023	1,980	31,676		
1st Half Feb							589	8,838	2,208	33,117		
2nd Half Feb							1,547	20,108	2,693	35,008		
1st Half Mar							1,323	19,850	1,572	23,576		
2nd Half Mar	149	2,386	610	9,767	1,266	20,263	1,249	19,984	2,585	41,367	100	100
1st Half Apr	468	7,015	799	11,992	1,038	15,570	1,685	25,271	2,188	32,816		
2nd Half Apr	202	3,025	582	8,725	882	13,232	1,501	22,515	1,167	17,512		
1st Half May	430	6,455	406	6,087	573	8,594	896	13,443	912	13,684		
2nd Half May	468	7,480	396	6,333	413	6,602	611	9,768	764	12,229		
1st Half Jun	490	7,354	291	4,358	855	12,832	454	6,816	1,366	20,487		
2nd Half Jun	137	2,195	459	7,352	382	6,120	651	10,415	1,117	17,868		
1st Half Jul	210	3,153	217	3,261	508	7,614	502	7,532	995	14,920		
2nd Half Jul	137	2,195	291	4,649	532	8,514	454	7,270	839	13,426		
1st Half Aug	481	7,214	141	2,112	684	10,253	602	9,033	701	10,512		
2nd Half Aug	576	9,221	518	8,292	1,075	17,204	761	12,183	845	13,517		
1st Half Sep	541	8,113	618	9,270	1,319	19,786	1,136	17,045	1,449	21,730		
2nd Half Sep	365	5,468	425	6,370	1,287	19,300	1,112	16,687	885	13,276		
1st Half Oct	517	7,759	555	8,320	995	14,929	1,447	21,705	916	13,738		
2nd Half Oct	707	54,405	866	66,696	1,737	26,050	1,610	25,753	1,403	22,440	85%	53%
1st Half Nov					1,203	18,047	1,807	27,106	1,430	21,455		
2nd Half Nov					1,702	25,534	2,401	36,012	1,952	29,282		
1st Half Dec					2,037	30,551	2,639	39,582	1,892	28,376		
2nd Half Dec					1,904	28,557	2,584	41,350	2,110	33,760		
Total, MCM/Yr		**173**		**212**		**400**		**452**		**542**		
Allocation, MCM/Yr	**100 MCM per annum**				**400 MCM per annum**							

Source: Egyptian Public Authority for Drainage Projects - EPADP

3) Annual Evaporation from the Lakes

With the desert climate characterized with high temperature and very low humidity, there must be a large amount of evaporation from the lakes. With reference to available data for evaporation, and also the lake surface areas detected by satellite image analysis, the JICA Survey Team estimates the monthly basis evaporation and then annual evaporation amount from the lakes, that are supposed to be replenished by drainage water in order to keep the lake water levels not much changed.

Tables 4.10.3 and 4.10.4 shows the evaporation volume from the surfaces of Rayan Lake and Qarun Lake respectively. The Lake area was estimated by analyzing Sentinel-2 optical images by month, and multiplying the evaporation in depth into the lake area presents the evaporation volume. It is now found that annual evaporations of around 160 MCM and 400 MCM take place from Rayan Lake and Qarun Lake every year. On the other hand, the actually discharged amounts estimated into the lakes were 173 MCM (2018) and 212 MCM (2019) for Rayan and 400 MCM (2018), 452 MCM (2019) and 542 MCM (2020) for Qarun, which are in most cases more than the specified amounts by MWRI.

With the MWRI's specified drainage discharge amounts to the lakes of 100 MCM and 400 MCM, one may say that the specified among for Rayan should be increased to 160 MCM, or the lake starts becoming smaller, while the specified amount for Qarun, 400 MCM, should be kept as the actual annual evaporation is almost the same as the MWRI's specified amount. In sum, the JICA Survey Team recommends that the regulating drainage amount to Rayan should be increased to 160 MCM per annum while the regulating amount to Qarun should be the same as 400 MCM.

Table 4.10.3 Evaporation from the Rayan Lake

Month	Evaporation, mm/d	Evaporation, mm/month	Lake Area, m2	Evaporation Volume, m3
Jan	3.2	96	71,584,843	6,872,145
Feb	3	90	73,225,882	6,590,329
Mar	4.5	135	73,436,941	9,913,987
Apr	6	180	73,248,368	13,184,706
May	7	210	71,938,260	15,107,035
Jun	8.2	246	73,516,479	18,085,054
Jul	9.25	277.5	71,928,757	19,960,230
Aug	9.25	277.5	71,982,117	19,975,037
Sep	8.75	262.5	71,827,858	18,854,813
Oct	7.5	225	69,510,334	15,639,825
Nov	5.5	165	69,796,711	11,516,457
Dec	3.8	114	66,900,686	7,626,678
Total		2278.5		163,326,297

Source: Evaporation by Fahmy 2013, Managing water and salt balance of Wadi El-Rayan Lakes, El-Fayoum, Egypt, and Open water area was detected by analysis of Sentinel-2 (optical) images for the year 2020.

Table 4.10.4 Evaporation from the Qarun Lake

Month	Evaporation, mm/d	Evaporation, mm/month	Lake Area, m2	Evaporation Volume, m3
Jan	3.0245	90.735	231,581,376	21,012,536
Feb	3.4155	102.465	235,666,491	24,147,567
Mar	4.0235	120.705	239,397,450	28,896,469
Apr	5.262	157.86	241,874,346	38,182,284
May	4.741	142.23	218,954,017	31,141,830
Jun	7.099	212.97	228,238,910	48,608,041
Jul	6.21	186.3	236,549,397	44,069,153
Aug	6.2485	187.455	234,381,884	43,936,056
Sep	5.7445	172.335	233,656,744	40,267,235
Oct	5.0565	151.695	231,082,317	35,054,032
Nov	3.978	119.34	230,017,923	27,450,339
Dec	3.107	93.21	230,533,327	21,488,011
Total		1737.3		404,253,553

Source: Evaporation by Maged 2006, Estimation of Evaporation from Qarun Lake using Standard, and Open water area was detected by analysis of Sentinel-2 (optical) images for the year 2020.

4) Crop Water Consumption (Net Crop Water Requirement)

MWRI's crop water table gives net crop water consumption, and EU Water STARS[1] conducted a water accounting study, which provided net crop water consumption based on Wapor_v2 model. The JICA Survey Team and also EU Water STARS conducted satellite image analysis with the Sentinel-2 data in order to detect the actual cropped area. Thus, the net crop water consumptions for the Fayoum Area estimated by multiplying the net crop water consumptions into the cropped areas are summarized in the following table. There is not much difference on the net crop water consumptions for Fayoum Area between the 2 methods.

Table 4.10.5 Net Crop Water Consumption Amount for Fayoum Area in MCM

Method	J	F	M	A	M	J	J	A	S	O	N	D	Annual
ET (MWRI Table), MCM	83	109	152	146	73	176	187	194	101	55	54	85	1,415
ET (Wapor_V2), MCM	104	116	152	154	100	121	184	170	116	122	79	80	**1,498**

Source: MWRI crop water table, and EU Water STARS

5) Domestic and Industry Water Use in Fayoum Area

There are a large number of pumping stations for domestic and industry water use in Fayoum. The

[1] EU Water Sector Technical Assistance and Reforms Support (EU Water STARS) Publication Reference: Europeaid/138797/DH/SER/EG, Contract Number: ENI/2017/393-295, Water Accounting Plus in Fayoum, Egypt (October, 2020)

summated consumption use for the domestic and industry in Fayoum Area is estimated at 692,000 cum per day according to the data provided by MWRI, equivalent to about 21 million cum per month, and 253 million cum per annum. The annual domestic and industrial use of 253 MCM shares 9.7% of the allocated amount of 2.6 billion cum.

6) Overall Water Balance in Fayoum Area

For the years of 2018 and 2019 when drainage data are available, overall water balance between the provided water to Fayoum and the water drained to the lakes is estimated. As in Table 4.10.6, 2.639 BCM and 2.731 BCM were provided to Fayoum Area in years of 2018 and 2019, which are almost equal to the allocated amount of 2.6 billion cum, while the amounts discharged to the lakes were 572 MCM and 664 MCM for the years respectively. The ratios for the drained amount of water into the lakes arrive at 22% and 24 % for the years respectively, implying that 78% and 76% of what were provided were consumed by crops as evapotranspiration, domestic & industry use, etc. which may include percolation deep into the sub-surface.

With newly estimated drainage amount of 560 MCM per annum, composed of 160 MCM for Rayan and 400 MCM for Qarun, required to keep the water level not much changed, the annual water volume to be provided from the Bahr Yusef Principal Canal into Fayoum Area is estimated at 2.6 BCM and 2.3 BCM for the years of 2018 and 2019 respectively on condition that the same drainage ratios (22% and 24%) are backward-applied against the 560 MCM drainage amount. This implies that the currently allocated amount for Fayoum, that is 2.6 billion cum, should be kept the same under the condition of current irrigation and current domestic and industry water use, otherwise the lakes would be affected.

Table 4.10.6 Overall Water Balance in Fayoum Area

Year	Water Provided, MCM	Water Drained to the Lakes, MCM		Balance, MCM	Drainage Ratio	Req. for Drain, MCM	Back calculated Req., MCM
2018	2,639	Rayan	173	2,067	22%	560	2,582 (2.6 BCM)
		Qarun	400				
		Total	**572**				
2019	2,731	Rayan	212	2,067	24%	560	2,305 (2.3 BCM)
		Qarun	452				
		Total	**664**				

Source: JICA Survey Team

7) Overall Irrigation Water Balance in Fayoum Area

Above-mentioned overall water balance is the one between the overall water provided from the Bahr Yusef Principal Canal and the water drained to the lakes, not considering domestic use, crop consumptive water, etc. Figures 4.10.4 and 4.10.5 show schematic water balance in years of 2018 and 2019 considering the domestic & industry use given by MWRI WDS as 2019 amount and crop water consumptive use, which was estimated by Wapor_V2 model (refer to the above 4) Crop Water Consumption);

- ✓ The fresh water from Bahr Yusef is provided to Hassen Wassef Intake covering most of the West Fayoum Directorate and to Lahoun Regulator covering most East Fayoum Directorate, and the total provided water to the Fayoum Area was 2,639 MCM and 2,731 MCM for the years of 2018 and 2019 respectively, which are very close to the allocated volume of 2,600 MCM (2.6 BCM),
- ✓ By subtracting domestic and industrial use from the whole provided water to the Fayoum Area, water available for irrigation purpose is estimated at 2,386 MCM and 2,487 MCM for the years of 2018 and 2019 respectively,
- ✓ There are 34,066 feddans of newly developed area and 342,838 feddans of Old Lands within the Fayoum area, where were identified by Sentinel-2 satellite images analysis, total of which comes

to 376,904 feddans,

- ✓ To irrigate whole 376,904 feddans, a net water amount of 1,498 MCM (63% of irrigation water available in 2018) should be required according to the Wapor_V2 model or 1,415 MCM based on MWRI Crop Consumption Table (refer to the following 4.10.2 section), which are the net crop consumptive use,
- ✓ Applying the bigger crop consumptive use estimated by the Wapor_V2 model, balance between the water available for irrigation and the net crop consumptive use is estimated at 888 MCM and 980 MCM for the 2 years respectively, equivalent to 37% and 39% against the irrigation water available,
- ✓ The above balance should be composed of 2 elements; 1) drained water to the 2 lakes, and 2) others, e.g., deep percolation and evaporation, not consumed by crops, and the former shares 24% and 27% against the irrigation water available and accordingly the latter shares 13% and 12% against the irrigation water available, and
- ✓ Simply summarizing, in each year of 2018 and 2019 respectively, 63% and 61% of the fresh water available for irrigation was consumed by crops, and then, 24% and 27% of the fresh water available for irrigation went to the 2 lakes while the last remaining ones of 13% and 12% went to total losses such as deep percolation and evaporation which was not consumed by crops.

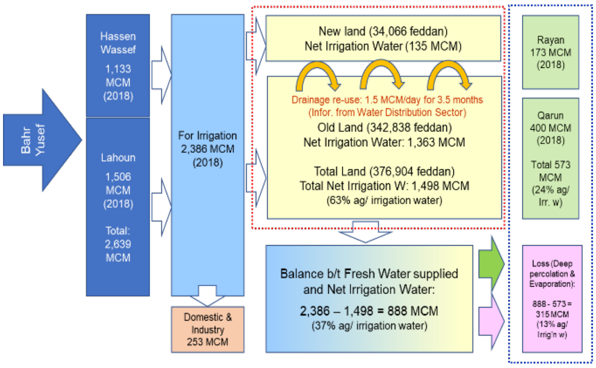


Figure 4.10.4 Overall Fayoum Water Balance (2018)

Source: JICA Survey Team based on WDS data

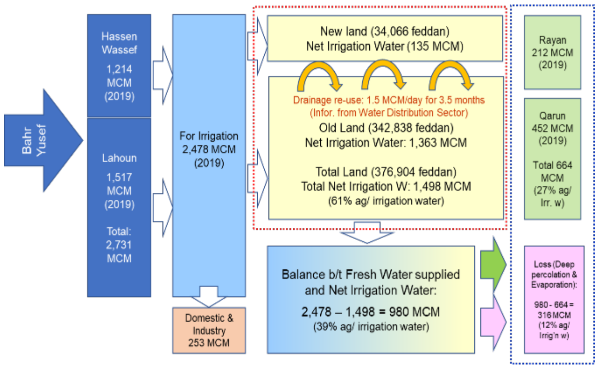


Figure 4.10.5 Overall Fayoum Water Balance (2019)

Source: JICA Survey Team based on WDS data

Further, Table 4.10.7 calculates irrigation efficiencies together with above-mentioned water balance results. The irrigation efficiencies on the fresh water, which is the water provided only by Bahr Yusef Principal Canal, are 63% and 61% for the years of 2018 and 2019 respectively, and with the addition of drainage re-use amount as a part of irrigation water, the efficiencies come to 59% and 57%, approximately 4% lower than those efficiencies on the fresh water. Re-use ratios are only 6.7% and 6.5% against the fresh water provided, which are in fact lower use as compared to nationwide re-use ratio of about 18%.

Table 4.10.7 Irrigation Efficiencies for Fayoum Area

Particulars	Year 2018	Year 2019
Overall irrigation efficiency on the fresh water	1,498/2,386=63%	1,498/2,478=61%
Overall irrigation efficiency on whole water	1,498/(2,386+1.5x107days)=59%	1,498/(2,478+1.5x107days)=57%
Re-use ratio ag/ fresh water (3.5 mnt)	(1.5x107days)/2,386=6.7%	(1.5x107days)/2,478=6.5%
Total Water Provided	2,639 MCM	2,731 MCM
Domestic & Industry	253 MCM	253 MCM
Irrigation Water Available	2,386 MCM (100%)	2,478 MCM (100%)
Crop Water Consumption	1,498 MCM (63%)	1,498 MCM (61%)
Drains to Lakes	573 MCM (24%)	664 MCM (27%)
Losses (deep percolation, evaporation)	315 MCM (13%)	316 MCM (12%)

Source: JICA Survey Team based on data provided by Water Distribution Sector of MWRI

4.10.2 Change in Future Water Regime for Fayoum Area

At present, the farmers in the Fayoum Area practice flood irrigation except for New Lands which have been developed in the peripheral areas from the Old Lands of Fayoum. According to a satellite image analysis with Sentinel-2, the New Lands have been estimated at 34,066 feddans, while the Old Lands extend over an area of 342,838 feddans totaling to 376,904 feddans[2]. In the New Lands, farmers usually apply drip irrigation cultivating olive trees in many places, but due to water quality containing salt and its shortage, the irrigation has hardly been fully developed.

Modern on-farm irrigation is to be introduced to Fayoum Area too according to the Government decision as a part of 4 million feddan modern on-farm development. With the introduction of modern on-farm irrigation to Fayoum Area, percolation from the on-farm irrigation and then seepage out to the drainages will be changed, and accordingly drainage into the Qarun and Rayan would be changed. These changes and also measures to keep the water levels of the lakes unchanged are examined with reference to the irrigation efficacy change by the method of on-farm irrigation.

1) Conditions in Estimating Future Water Regime Change

Following conditions are set in order to estimate future water regime change to be caused by the introduction of modern on-farm irrigation to the Old Lands of Fayoum Area:

- ✓ Efficiencies of the 3 types on-farm irrigation are set to be; 0.95, 0.80, and 0.70 for drip irrigation, sprinkler irrigation, and current flood irrigation with reference to available guidelines, e.g., FAO Training Manual. Note that on-farm irrigation efficiency for drip is usually set at 0.90 in many cases, yet the current drip irrigation in the New Lands of Fayoum is narrowly practiced facing water shortage, thus higher efficiency could be expected.
- ✓ As the design concept of drip irrigation is to provide right amount of water that is due required by the crop roots, there should be not any loss going into the subsurface, implying that there will not be any drainage water which is showing up in the drainage canals.
- ✓ Sprinkler provides irrigation water to the crops while wetting the soils not only around the crops but also the soils between the crops, thus there could be irrigation water not effectively consumed by the crops. As the efficiency of sprinkler is set at 0.80, percolation and then drainage is assumed to be the commensurate amount calculated by applying the difference of efficiencies between the sprinkler and drip, that is 0.15 (0.95 – 0.80).
- ✓ Likewise, the current percolation and then drainage is assumed to be the commensurate amount calculated by applying the difference of efficiencies between the flood irrigation and drip irrigation, that is 0.25 (0.95 – 0.70).

2) Net and Gross On-farm Irrigation Water (Crop Consumption Water)

Net on-farm irrigation water, or net crop consumption water, refers to those estimated by Wapor_V2 model. Table 4.10.8 summarizes the net on-farm irrigation water divided into New Lands and Old Lands by its area size, and further by applying above on-farm irrigation efficiencies of drip for the New Lands and flood for the Old Lands, gross on-farm irrigation water which are currently provided to the crops are also listed in the same table.

[2] Satellite image analysis was conducted covering 3 seasons of 2017/18 – 2019/20 with Sentinel-2 optical data. The season starts with the winter cropping from October 2017 and ends in May 2020.

Table 4.10.8 Net and Gross On-farm Irrigation Water Divided into New and Old Lands of Fayoum

Land	Area, feddan (1/)	On-farm Irrigation Efficiency	Net Crop Consumption Water (CCW), MCM	Gross CCW, MCM
New Lands	34,066	0.95	135	143
Old Lands	342,838	0.70	1,363	1,947
Total	376,904	0.72 (2/)	1,498	2,089

Note: 1/ the areas were estimated by satellite image analysis covering 3 seasons of 2017/18 – 2019/20 with Sentinel-2 optical data. 2/ the overall on-farm irrigation efficiency was estimated by weighting the size of New Lands area and Old Lands area to each of the on-farm irrigation efficiencies. Source: JICA Survey Team

3) Current Drainage Status; Sources of Drainage Water

On the assumption that commensurate amount to the difference of on-farm irrigation efficiencies between the drip and flood, following table estimates the current drainage status by source of the drainage water. From the table, it is found that an amount of 487 MCM was discharged into drains from the flood on-farm irrigation in years 2018 and 2019, which falls short to the drained amount to the 2 lakes. In those years of 2018 and 2019, total drainage amounts of 573 MCM and 664 MCM went into the lakes respectively, implying that drainage water to the lakes came not only from on-farm but also from irrigation canals as a form of seepage from the irrigation canals to drainage canals (see Table 4.10.9).

Table 4.10.9 Estimation of Current Drainage Status by Source

Particulars	2018	2019	Remarks
Drainage to Lakes, MCM	573	664	Drainage to Rayan & Qarun
Old Lands Gross CCW	1,947		Based on Wapor_V2 model, and IE0.7
On-farm Irrigation Efficiency (Drip)	0.95		
On-farm Irrigation Efficiency (Flood)	0.70		
Difference of above 2 Efficiencies	0.25		Commensurate amount to the drains
Drainage from On-farm, MCM	487 (85%)	487 (73%)	
Drainage from Canals, MCM	86 (15%)	171 (27%)	Supplemented to meet the total of drains

Source: JICA Survey Team, Note: CCW stands for Crop Consumption Water.

4) Drainage Regime Change with Modern On-farm Irrigation Introduction

In this section, drainage regime change is examined with the introduction of modern on-farm irrigation to the Old Lands of Fayoum and also the introduction of concrete lining to the main and branch canals in Fayoum Area. As the first step, irrigation efficiencies at the farm level and then the system level should be estimated as follows:

Table 4.10.10 summarizes the on-farm level irrigation efficiencies as; 0.95 in case of New Lands drip irrigation, 0.70 for current flood irrigation in the Old Lands, and 0.80, 0.85 and 0.90 for the cease of whole sprinkler, 50% sprinkler & 50% drip, and 100% drip irrigation respectively in the Old Lands. By applying the area size of New Lands and Old Lands to those corresponding irrigation efficiencies, the weighted on-farm irrigation efficiency (IE) can also be calculated ranging from 0.72 under current condition to 0.90 with full introduction of drip irrigation.

Table 4.10.10 On-farm Irrigation Efficiencies with Different On-farm Irrigation Methods

Particulars	Current	Sprinkler (SP) 100%	SP 50% +DR 50%	Drip (DR) 100%	Area, feddan
Drip Irrigation in New Lands	0.95	0.95	0.95	0.95	34,066
On-farm Irrigation Efficiency in Old Lands	0.70	0.80	0.85	0.90	342,838
Weighted On-farm IE by Area Size	0.72	0.81	0.86	0.90	376,904

Source: JICA Survey Team, based on FAO Irrigation Technical Manuals.

The next step is to estimate the system irrigation efficiency composed of the above on-farm irrigation efficiency and distribution efficiency which takes place along the main and branch/Meska canals. In this Fayoum Area, conveyance is not taken as one of the components for the system efficiency as the Bahr

Yusef up to the Hassen Wassef Intake and Lahoun Regulation should take the responsibility of conveyance.

Table 4.10.11 shows the weighted on-farm irrigation efficiencies already calculated above, distribution efficiencies and then overall (system) irrigation efficiency. In this table, first, the current system efficiency was already calculated at 0.63 as in Table 4.10.7 while weighted on-farm irrigation efficiency under the current condition is 0.72 as in Table 4.10.10, thus dividing the former by latter efficiency gives the current distribution efficiency, that is 0.87.

With this current distribution efficiency of 0.87 applied to the current earthen canals, the concrete lined canal distribution efficiencies are set to be 0.90 and 0.95 for the cases of around half lined and full-lined. Then, overall irrigation efficiency is thus calculated by multiplying the distribution efficiencies into the weighted on-farm irrigation efficiencies.

Table 4.10.11 System Irrigation Efficiencies Composed of On-farm and Distribution Efficiencies

Particulars	Current	Sprinkler 100%	SP50% +DR50%	Drip 100%	Current	Sprinkler 100%	SP50% +DR50%	Drip 100%	Current	Sprinkler 100%	SP50% +DR50%	Drip 100%
System Efficiency	0.63	0.71	0.75	0.79	0.65	0.73	0.77	0.81	0.69	0.77	0.82	0.86
Weighted On-farm IE	0.72	0.81	0.86	0.90	0.72	0.81	0.86	0.90	0.72	0.81	0.86	0.90
Distribution Efficiency	**0.87**	**0.87**	**0.87**	**0.87**	0.90	0.90	0.90	0.90	0.95	0.95	0.95	0.95
Canal Condition	Earthen (current)				Around Half of Concrete Lined				Full Concrete Lined			

Source: JICA Survey Team

With the above preparatory works, Table 4.10.12 presents the change of water regime in Fayoum Area and Table 4.10.13 summarizes the change against the allocated volume of 2.6 BCM for Fayoum Area according to the introduction of modern on-farm irrigation and also the introduction of canal lining. The conditions behind the calculation are as follows:

- ✓ The calculation is made by referring to the discharge data of 2018 as the actual discharge into Fayoum area was 2.639 BCM which is almost equal to the allocated among of 2.6 BCM, and in this year, an amount of 573 MCM drainage water went into the 2 lakes. Note that 560 MCM drainage water is required to keep the water levels not changed.
- ✓ Drainage from on-farm is estimated by referring to the difference between the irrigation efficiency for New Lands (0.95) and the weighted on-farm irrigation efficiency, which is the same as previously assumed (see Table 4.10.10).
- ✓ Drainage from irrigation canals to drainage canals should be changed proportionally in line with the difference between the current distribution efficiency (87%) and the ones of concreted lined canals, i.e., 95% at the maximum.

Table 4.10.12 shows series of decrease in drainage amount both from on-farm and from irrigation canals with the introduction of water saving on-farm irrigation methods and also water-tight lining works to the canals. The decrease will no doubt lead to the reduction of drainage water into the lakes. On condition that the current water levels of the Rayan and Qarun Lakes be kept, an additional water should be released for this purpose ranging from 182 MCM per annum in case of sprinkler introduced fully to as much as 430 MCM per annum in case of drip introduced fully with full concrete lining for canals (see Table 4.10.13). The additional water could be from fresh water, and thus salinity level of the lakes would dramatically change.

Further, Table 4.10.14 indicates that if the drainage water should not be needed for the 2 lakes, whole required water for Fayoum will be 2,202 MCM, 2,102 MCM, and 2,013 MCM per annum in case of sprinkler introduced fully, 50% sprinkler and 50% drip introduced, and drip introduced over whole

Fayoum area with the main, branch and Meska canals all concrete lined. These newly required water amounts constitute of 85%, 81% and 77% of the allocated amount of 2.6 BCM.

Yet, from the environmental point of view, the water levels of 2 lakes should be maintained, or many stakeholders engaged in, e.g., tourism, salt production, and fisheries sectors, will be affected. To keep the water levels of the 2 lakes, there should be additional releases as indicated in Table 4.10.12. With the additional releases to the lakes, the total required amounts will be around 2,437 MCM with sprinkler (see the 2nd last row of Table 4.10.13), which constitutes about 94% of the allocated 2.6 BCM, resulting in only 6% of overall water saving. With this, the JICA Survey Team recommends that modern on-farm irrigation should not be introduced to Fayoum Area, rather keep the current irrigation modality.

On the other hand, as one of the challenges of the current irrigation modality in the area, downstream farmers of Meska sometimes face difficulty to take sufficient water due to unequal water management between upstream and downstream at Meska level, which leads to unsatisfied farming practices for downstream farmers. Therefore, as one of the modernizations of irrigation modality without reducing drainage volume to the lakes, it is recommended to promote Meska rehabilitations together with the rehabilitation of main and branch canals for the efficient and equal water use of farmers.

Table 4.10.12 Drainage Change to the 2 Lakes with the Introduction of Modern On-farm Irrigation and Canal Lining

Modern On-farm Ratio/ Lining Ratio	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	0%
From On-farm sprinkler, MCM	292	311	331	350	370	389	409	428	448	467	487
From Canals (non-lined), MCM	86	86	86	86	86	86	86	86	86	86	86
Total, MCM	378	398	417	437	456	476	495	515	534	554	573
Reduction Ratio, %	34%	31%	27%	24%	20%	17%	14%	10%	7%	3%	0%
From On-farm Drip, MCM	97	136	175	214	253	292	331	370	409	448	487
From Canals (non-lined), MCM	86	86	86	86	86	86	86	86	86	86	86
Total, MCM	184	223	262	300	339	378	417	456	495	534	573
Reduction Ratio, %	68%	61%	54%	48%	41%	34%	27%	20%	14%	7%	0%
From On-farm 1/2Sp+1/2Drip, MCM	195	224	253	282	311	341	370	399	428	457	487
From Canals (non-lined), MCM	86	86	86	86	86	86	86	86	86	86	86
Total, MCM	281	310	339	369	398	427	456	485	515	544	573
Reduction Ratio, %	51%	46%	41%	36%	31%	25%	20%	15%	10%	5%	0%
From Canal with Lining, MCM	0	9	17	26	35	43	52	60	69	78	86
Reduction Ratio, %	15%	14%	12%	11%	9%	8%	6%	5%	3%	2%	0%
Sprinkler + C. Lining, MCM	292	320	348	376	404	432	461	489	517	545	573
Drip + C. Lining, MCM	97	145	192	240	288	335	383	430	478	525	573
1/2Sp+1/2Drip + C. Lining, MCM	195	232	270	308	346	384	422	459	497	535	573
Sprinkler + C. Lining, %	49%	44%	39%	34%	29%	25%	20%	15%	10%	5%	0%
Drip + C. Lining, %	83%	75%	66%	58%	50%	42%	33%	25%	17%	8%	0%
1/2Sp+1/2Drip + C. Lining, %	66%	59%	53%	46%	40%	33%	26%	20%	13%	7%	0%
Gross Crop Consumption W., MCM	1,947	T. Drainage	Req. Min. D	Ratio							
Drainage from On-farm, MCM (2018)	487										
Drainage from Canals, MCM (2018)	86	573	560	102%							

Source: JICA Survey Team

Table 4.10.13 Drainage Change to the 2 Lakes through On-farm, Canals, and Additional Requirement

Particulars	Sprinkler 100% (Old Lands)			SP50%+DR50% (Old Lands)			Drip 100% (Old Lands)		
Drainage to the Lakes (2018), MCM	573	w/ C.Lining		573	w/ C.Lining		573	w/ C.Lining	
Drainage from the On-farm, MCM	292	90%	95%	195	90%	95%	292	90%	95%
Drainage from Irri. Canals, MCM	86	66	33	86	66	33	86	66	33
Sub-total of Drainages, MCM	378	358	325	281	261	228	378	358	325
Required Drainage to Lakes, MCM	560	560	560	560	560	560	560	560	560
Additionally Required Water for Lakes to Keep the WL, MCM	**182 (32%)**	**202 (36%)**	**235 (42%)**	**279 (50%)**	**299 (53%)**	**332 (59%)**	**182 (32%)**	**202 (36%)**	**235 (42%)**

Source: JICA Survey Team

Table 4.10.14 Newly Required Amount for Fayoum Area With & Without Considering Drainage to the Lakes

Particulars	Sprinkler 100% (Old Lands)	SP50%+DR50 % (Old Lands)	Drip 100% (Old Lands)	Remarks
Annual Water (2018), MCM	2,639	2,639	2,639	For Fayoum
Domestic & industry (D&I), MCM	253	253	253	Fr. WDS, MWRI
1) Saved On-farm Water, MCM	243	344	433	
2) Saved Distribution Water w/90%, MCM	74	74	74	By C.Lining
3) Saved Distribution Water w/95%, MCM	194	194	194	By C.Lining
New Annual Water w/ above 1)	2,396	2,295	2,206	w/o drains to lakes
New Annual Water w/ above 1+2)	2,321	2,221	2,132	w/o drains to lakes
New Annual Water w/ above 1+3)	2,202	2,102	2,013	w/o drains to lakes
% against allocated 2.6 BCM	85%	81%	77%	w/o drains to lakes
Total Annual Water w/ above 1)	2,577	2,574	2,583	w/ drains to lakes
Total Annual Water w/ above 1+2)	2,524	2,521	2,529	w/ drains to lakes
Total Annual Water w/ above 1+3)	**2,437**	**2,434**	**2,443**	***), ditto**
% against allocated 2.6 BCM	**94%**	**94%**	**94%**	**Against *)**

Source: JICA Survey Team

4.10.3 Possibility of Introducing Modern On-farm Irrigation at the Cost of Rayan Lake

Qarun Lake has been existing since ancient time while Rayan Lake showed up in early 1970s. In the late 1960s, there was water level of Qarun Lake raising up sharply causing floods around the lake. Then, MWRI decided to construct a tunnel to release excessive water to western dessert from Qarun Lake. The construction of 5.9 km length tunnel had started in 1968 and completed in 1973, and since then, the Rayan Lake started coming up. The lake extends over an area of 72 sq.km as of 2020, and from the large surface, as much as around 160 MCM evaporation takes place annually.

Should there be a possibility of not keeping Rayan Lake, there might be an opportunity of introducing modern on-farm irrigation while keeping the water level of Qarun as it is. The on-farm modern irrigation method should be sprinkler and not drip as drip releases almost nil of percolation as its operation concept. Table 4.10.15 summarizes the calculation of the overall (system) irrigation efficiency, with which the total drainage into Qarun Lake could be maintained at 400 MCM with reference to the 2018 water balance.

Thus, the overall irrigation efficiency comes to 71% when keeping Qarun Lake as it is, and required total amount of water for Fayoum is estimated to be 2,371 MCM, equivalent to 91% of the allocated 2.6 BCM. This means there will be water saving of 9% with the condition that only 400 MCM drainage is released to the lake in conjunction with the introduction of sprinkler on-farm irrigation.

Next issue is to set the on-farm irrigation efficiency based on the overall irrigation efficiency of 71% and distribution efficiency. The distribution efficiency should be 87% as in Table 4.10.10, which is the back-estimated efficiency based on the current system efficiency (63%) and weighted current on-farm irrigation efficiency (72%). With the overall efficiency of 71% and distribution efficiency of 87%, the on-farm irrigation efficiency comes to 81% (71/87).

Table 4.10.16 shows combination of sprinkler irrigation and flood irrigation, which together can give a commensurate on-farm irrigation efficiency to meet the overall on-farm irrigation efficiency of 81%. The commensurate on-farm irrigation efficiency is calculated by considering the area coverage of the on-farm irrigation method, sprinkler or flood, with the efficiencies of 0.8 and 0.7 respectively, which is applied only in the Old Lands (342,838 feddan). Further, to calculate the weighted overall on-farm irrigation efficiency, existing New Lands (34,066 feddan) area should also be considered with on-farm efficiency of 0.95. Through this calculation process, the table indicates when the sprinkler is introduced to 90 % or almost 100%, the on-farm irrigation efficiency of 81% can be attained.

Thus, if sprinkler irrigation is introduced to almost all area of Fayoum, still 400 MCM drainage water can be kept, so the water level of Qarun Lake could be maintained, but at the cost of Rayan Lake. With this arrangement, to-be-saved water would be around 229 MCM, equivalent to 9% of the allocated 2.6 BCM. The Team, in fact, does not recommend to take up this approach, in which Rayan Lake would be disappearing as there are fish farmers and salt production farmers.

Table 4.10.15 Water Requirement under Qarun Lake Maintained (Rayan not Kept)

Particulars	Unit	Yr 2018	400 MCM Drainage	Remarks
H. Wassef+Lahoun	MCM	2,639	2,371 (2,118+253)	91% of 2.6 BCM (2,371 / 2,600)
Domestic & Industry	MCM	253	253	
Irrigation Available	MCM	2,386 (1,498+888)	2,118 (1,498+620)	
Evapotranspiration (ET)	MCM	1,498	1,498	
Overall Irrigation Efficiency	%	63% (1,498/2,386)	71% (1,498/2,118)	On-farm efficiency = 81% (71% / 87%, see Table 4.10.10)
Balance	MCM	888 (573/0.65)	620 (400/0.65)	
Rayan+Qarun (Drainage)	MCM	573	400	
	%	65%	65%	
Overall Loss (Percolation, etc.)	MCM	315	220	
	%	35%	35%	
Particulars	Unit	Yr 2018	400 MCM Drainage	Remarks

Source: JICA Survey Team

Table 4.10.16 Modern On-farm Irrigation Efficiency to Keep Qarun Lake (Rayan Not Kept)

On-farm Irrigation	Coverage Share by On-farm Irrigation method						Remarks
Sprinkler (E=0.80)	50%	60%	70%	80%	90%	100%	
Drip (E=0.90)	0%	0%	0%	0%	0%	0%	For New Lands, 0.95
Flood (E=0.70)	50%	40%	30%	20%	10%	0%	
Weighted On-farm Efficiency	76.8%	77.7%	78.6%	79.5%	**80.4%**	**81.4%**	

Note: area of Fayoum is divided into 2; New Lands (34,066 feddan) and Old Lands (342,838 feddan), total of which arrives at 376,904 feddan. Above on-farm irrigation is applied only to the Old Lands while New Lands keeps current drip irrigation with a high efficiency of 0.95.
Source: JICA Survey Team

4.11 Financial Support for the Introduction of Modern On-farm Irrigation

This section proposes a financial scheme and its implementation modality to provide financial assistance to the farmers who are to introduce the modern on-farm irrigation facilities. The following discussions will focus on the arrangement of two-step loan and project loan through an advance procedure.

4.11.1 Two-Step Loan (TSL)

1) Outline of the Financial Scheme

In order to propose a scheme for supporting the introduction of modern on-farm irrigation system in Egypt, JICA Survey Team at first examines the possibility of two-step loans (TSL), in which a participating financial institution (PFI) provides small loans to a large number of farmer end-users.

Considering that the introduction of modern on-farm irrigation system in Egypt is politically rational, it is also reasonable that a JICA TSL scheme should assist for satisfying the farmers' financial demand in installing the modern irrigation facility. However, in this case, the PFI could hardly set normal market interest rates of loans for the farmers. Therefore, without financial support by the Government, the PFI would not be financially sustainable as reasonable margin profits (e.g., about 3%) would not be realized to cover the costs.

Considering that JICA is highly expected to set the sub-loan conditions with higher flexibility and more convenience for end-users and PFI, the outline of the proposed scheme and loan conditions are summarized in the following term sheet. Lending conditions will be specified by MWRI in Egypt after signing L/A. The sub-loan conditions between PFI and end-users will be determined by PFI based on the MOF's financial support and on-lending conditions.

Table 4.11.1 Term Sheet of JICA TSL Scheme (draft)

Condition	Option(s)	Notes
Japanese ODA Loan Conditions (JICA – MWRI)		
Currency	JPY	
Total amount	TBD	
Tenor	30 years	Assumption: general terms, fixed, standard cf. Terms of Conditions of Japanese ODA Loans October 2022
Grace period	10 years	
Base interest rate	Fixed rate: 1.70% per year	
Repayment cycle	Semi-annually (20th day of a month)	
Interest payment cycle	Semi-annually (20th day of a month)	
On-lending Conditions (PMU – PFI)		
Currency	USD	
Total on-lending amount	TBD	
Tenor	Same as loan conditions	
Grace period	Same as loan conditions	
Base interest rate	JICA loan interest rate + Spread (cost) / year	The spread will be determined by MOF (e.g., 0.0 - 1.0% for administration and forex risk costs). Additionally, MOF may charge Front-End Fee (one-time payment at the initial stage): 0.2% of the total on-lending loan amount.
Repayment cycle	Before loan repayment	
Interest payment cycle	Before interest payment of the loan	
Sub-loan Conditions (PFI – End-user)		
Currency	EGP	
Sub-loan amount	Up to EGP50,000 / feddan	
Tenor	Up to 10 years	
Grace period	Up to 2 years	
End-user's interest rate	On-lending rate + PFI's Margin – Financial Support by GOE	PFI's margin will be determined by PFI, based on PFI's normal net interest margin (NIM) as well as market common practice.
Repayment cycle	Depending on each end-user's sub-loan agreement	
Interest payment cycle	Depending on each end-user's sub-loan	

Condition		Option(s)	Notes
		agreement	
	Loan usage	Capital investment: min 80% (purchasing modern irrigation system; e.g., sprinkler and drip irrigation) Working capital: max 20%	
	Collateral(s)	Determined by PFI	
	Guarantor(s)	Determined by PFI	
	Eligible end-users	Farmers in the target area	

Source: JICA Survey Team

2) Organizational Arrangement

The signer of the L/A for the JICA loan will be the MWRI, the borrower. MWRI will be in charge of drawing ODA Loan after signing L/A, but overall fund management such as disbursing fund and monitoring after the disbursement will be conducted by the PMU. In corporation with PFI, PMU will be also in charge of overall project management such as checking eligibility from sub-loan applications, collecting necessary information from end-users, making periodic reports to JICA, etc.

For the purpose of smooth implementation of the project, MWRI will set up a Project Management Unit (PMU) for the JICA project within the organization, and the PMU members will be around 10, including Project Director, Deputy Project Director, Managers, staff, etc.

Regarding the loan disbursement, after singing the L/A between GOJ and GOE, MWRI and PFI will enter into the Subsidiary Loan Agreement. The Subsidiary Loan Agreement mentions the role of each organization and loan conditions such as on-lending interest rates, maturity, and so forth.

3) PFI and Its Selection

In the case of such TSL scheme, it is important to carefully check the operational overview and financial status of the PFI candidates, which is a key to ensuring the continued implementation of the financial scheme. In this case, ABE and NBE are the PFI candidates, and various documents need to be collected from each of the PFI candidates, including annual reports (including financial statements) for the last three fiscal years, figures for 23 financial soundness indicators reported to the CBE (end-FY2021/22), business overview and farmer loan schemes. The documents should be availed, analyzed and, if necessary, confirmed through supplementary interviews.

However, as the MD for this Preparatory Survey does not cover the ABE and NBE, the PFI candidates, those two banks have yet to provide JICA Survey Team with the various documents and internal data that the Team needs to obtain from them. (The officer at ABE said that the JICA Survey Team should get the request from MWRI and MALR in charge of the introduction of modern on-farm irrigation system as well as the permit from CBE.)

In relation to 'governance', which is generally one of the evaluation criteria for financial institutions, the information disclosure system is an important factor. In this regard, the latest financial statements (FY2020/21) of NBE are available on the bank's website and have already been obtained and organized. ABE, on the other hand, has not disclosed any financial information. The business overview, financial soundness indicators and financial statements of NBE and ABE based on publicly available information are shown in the table below.

Table 4.11.2 Business Profile of PFI Candidate Banks

Name of bank	NBE	ABE
Type of bank	state-owned commercial bank	governmental bank
Year of establishment	1898	1930
Location of headquarter	Cairo	Cairo
Major shareholders (shareholding ratio)	MOF (%), CEB (%)	MOF (100%)
No. of branches	n.a	1,207
No. of employees	n.a	17,000
Total assets (in EGP)	2,623 billion	n.a

Name of bank	NBE	ABE
Bank's share of total assets in the Egyptian banking sector (%)	n.a	n.a
Loan outstanding (in EGP)	n.a	n.a
No. of loan customers (total)	n.a	n.a
No. of loan customers (farmers)	n.a	n.a
Loan portfolio by sector (%)	n.a	n.a
Bank's share in the Egyptian agricultural lending market (%)	n.a	n.a
Rating given by national &/or international rating companies	S&P: B (long-term) (October 2019), Moody's: stable (outlook) (October 2019), Fitch: stable (outlook), (October 2019)	-

Sources: Annual Report of NBE (FY2020/21) and ABE (not available) and their websites.
https://www.nbe.com.eg/NBE/E/#/EN/Home
https://www.devex.com/organizations/agricultural-bank-of-egypt-148547
Note: As of end-June 2022.

Table 4.11.3 Financial Soundness Indicators of Candidate PFIs in Case of TSL

Category	Measures	Formula	Egyptian Banking Sector	Unit	NBE	ABE
Capital Adequacy						
	Regulatory Capital to Risk-Weighted Assets	Capital Base / Risk-Weighted Assets	20.9	%		
	Regulatory Tier 1 Capital to Risk-Weighted Assets	Tier 1 Capital / Risk-Weighted Assets	17.1	%		
	Capital to Total Assets	Common Equity / Risk-weighted Assets	12.2	%		
	Financial Leverage	Total Assets / Capital & Reserves	6.9	x		
Asset Quality						
	Non-Performing Loans to Total Gross Loans	Non-Performing Loans / Total Gross Loans	3.2	%		
	Loan Provision	Loan Provisions / Non-performing Loans	92.1	%		
	Private sector contribution	Loans to Private Sector / Loans to Customers	58.1	%		
Earnings (Profitability)						
	Return on Assets	Profit before tax / Average Total Asset	1.2	%		
	Return on Equity	Profit after tax / Average Shareholders' Equity	16.1	%		
	Net Interest Margin	(Interest Received - Interest Paid) / Interest Earning Assets	4.2	%		
Liquidity						
	Average Liquidity Ratio (local currency)	Liquid Assets / Total Assets	44.3	%		
	Average Liquidity Ratio (foreign currencies)	Liquid Assets / Total Assets	78.4	%		
	Liquidity Coverage Ratio (LCR) (local currency)	High Quality Liquid Asset Amount / Total Net Cash Flow Amount (over a 30-day stress period)	990.0	%		
	Liquidity Coverage Ratio (LCR) (foreign currencies)	High Quality Liquid Asset Amount / Total Net Cash Flow Amount (over a 30-day stress period)	197.1	%		
	Net Stable Funding Ratio (NSFR) (total)	Total Amount of Available Stable Funding / Total Amount of Required Stable Funding	231.8	%		
	Net Stable Funding Ratio (NSFR) (local currency)	Total Amount of Available Stable Funding / Total Amount of Required Stable Funding	244.8	%		
	Net Stable Funding Ratio (NSFR) (foreign currencies)	Total Amount of Available Stable Funding / Total Amount of Required Stable Funding	184.5	%		
	Securities to Assets Ratio	Securities / Assets	25.2	%		
	Deposits to Assets Ratio	Deposits / Assets	73.4	%		
	Loans to Deposits Ratio (total)	Loans / Deposits	48.6	%		
	Loans to Deposits Ratio (local currency)	Loans / Deposits	45.5	%		
	Loans to Deposits Ratio (foreign currencies)	Loans / Deposits	66.8	%		
	Net Open Position in Foreign Currencies to Capital Base	Summing Foreign Currency Position into a single unit of account / Capital Base	-1.9	%		

Source: CBE's Monthly Statistical Bulletin No.308 (November 2022).
https://www.cbe.org.eg/en/EconomicResearch/Pulications/Oages/Month/StatisticalBulletin.aspx
Note: All data is as of 30 June 2022

Table 4.11.4 Financial Statements of Candidate PFIs, Unit: Billion LE

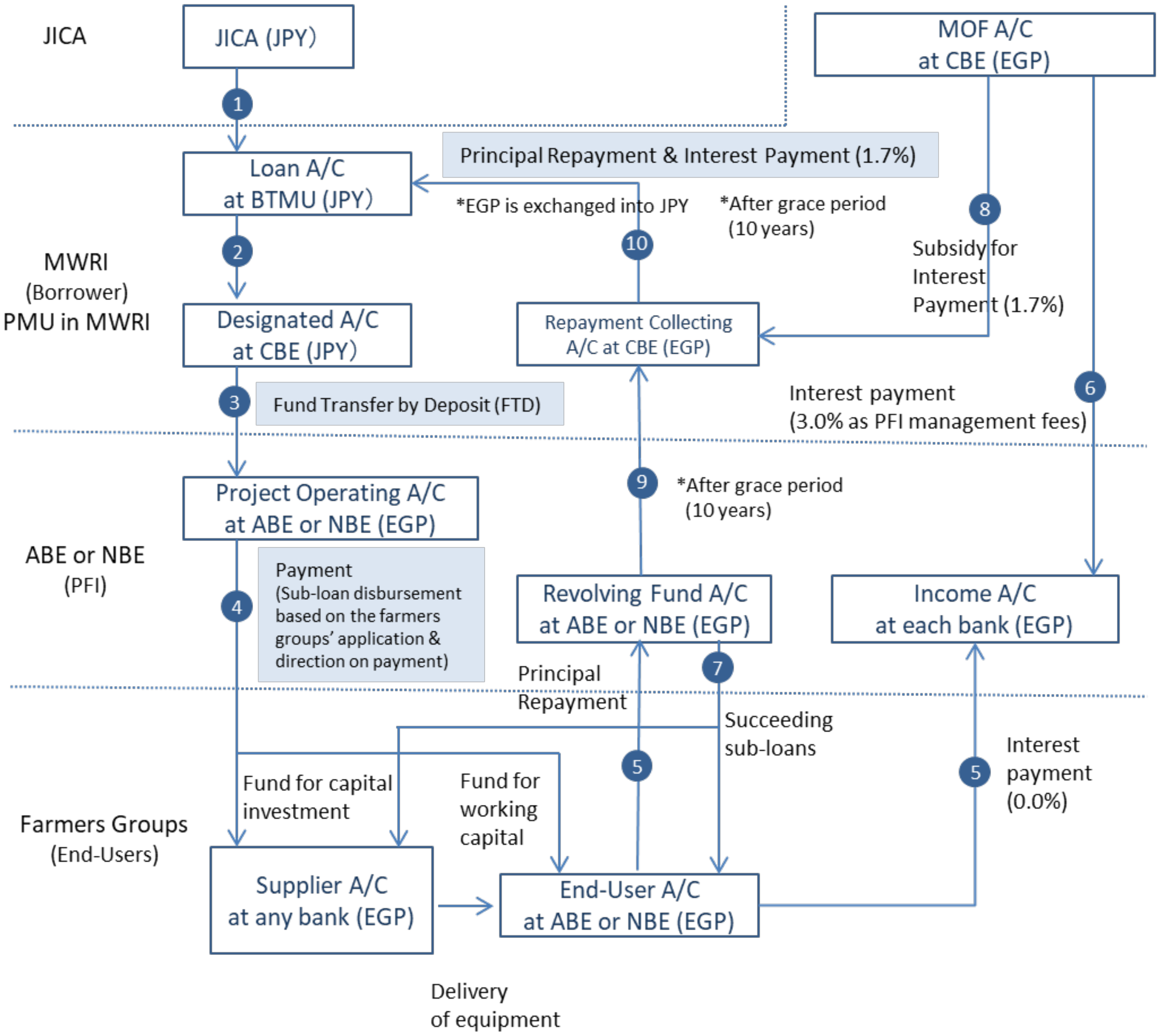
Particulars	NBE			ABE		
	2018/19	2019/20	2020/21	2018/19	2019/20	2020/21
BALANCE SHEET						
Cash and balance with Central Banks	29.4	45.4	70.4			
Due from banks	490.5	315.9	395.3			
Financial investments at fair value through profit/loss	0.3	1.2	1.4			
Loans and advances to banks, net	2.5	2.9	2.9			
Loans and advances to customers, net	514.2	682.7	1,039.7			
Financial derivatives	0.3	0.3	0.6			
Financial investments at fair value through other comprehensive income	445.0	798.8	798.9			
Financial investments at amortized cost	103.2	100.3	191.5			
Investments in subsidiaries and associates	7.8	7.9	8.4			
Fixed assets, net (after accumulated depreciation)	5.7	7.4	7.1			
Investment property	0.0	0.0	0.0			
Other assets	37.3	55.8	107.3			
Total Assets	**1,636.2**	**2,018.4**	**2,623.5**			
Due to banks	141.0	89.1	144.5			
Repurchase agreements-treasury bills	22.2	22.4	22.0			
Customer deposits	1,171.0	1,595.5	2,101.9			

Particulars	NBE			ABE		
	2018/19	2019/20	2020/21	2018/19	2019/20	2020/21
Financial derivatives	0.2	0.1	0.0			
Other loans	139.0	136.8	162.0			
Other liabilities	41.8	38.3	49.2			
Other provisions	8.1	10.1	10.4			
Pension benefits' liabilities	3.4	3.9	4.5			
Total Liabilities	**1,526.3**	**1,896.4**	**2,494.5**			
Paid-up capital	35.0	50.0	50.0			
Reserves	22.1	16.0	23.9			
CBE subordinate-loan differences between nominal and present value	29.8	36.1	34.8			
Fair value reserves for investments through other comprehensive income	2.8	6.2	4.6			
Net profit for the period / year	20.2	13.1	15.0			
Retained earnings	0.0	0.7	0.7			
Total Equity	**109.9**	**122.1**	**129.0**			
Total Liabilities and Equity	**1,636.2**	**2,018.4**	**2,623.5**			
Letter of Credit, Guarantee and other commitments	608.2	671.5	233.5			
PROFIT & LOSS STATEMENT						
Interest income on loans and similar income	184.0	187.6	215.0			
Interest expense on deposits and similar expense	(128.6)	(142.8)	(163.0)			
Net interest income	**55.3**	**44.8**	**51.9**			
Fee and commissions income	7.6	7.4	8.1			
Fee and commissions expense	(0.8)	(0.3)	(0.7)			
Net fees and commissions income	**6.8**	**7.1**	**7.4**			
Dividend income	0.7	0.6	0.6			
Net trading income	1.4	2.8	3.9			
Profit (Loss) from financial investments	(2.4)	0.4	(1.3)			
Charge of expected credit losses charge	(4.4)	(3.4)	(0.2)			
Administrative expenses	(20.2)	(20.5)	(25.3)			
Other operating income / expenses	(3.4)	(1.3)	0.7			
Profit before income tax	**33.7**	**30.6**	**37.8**			
Income tax expenses	(13.5)	(17.5)	(22.8)			
Net profit for the period	**20.2**	**13.1**	**15.0**			
Basic earnings per share / Diluted EGP	**0.34**	**0.18**	**0.21**			

Source: Annual Reports of NBE (FY2018/19, 2019/20, 2020/21)
Note: Fiscal year starts on 1st July and ends on 30 June in Egypt.

4) Fund Flow

The assumed fund flow is described in the figure below.



Note 1: The disbursement between JICA and MWRI will be "Advance Procedure", receiving a fund from JICA according to 3 or 6-month project financial forecast.

Note 2: Regarding on-lending currency (MWRI→PFI), the loan currency for GOE will be JPY. The currency disbursed from MWRI to PFI will be in EGP. The exchange risk of transferring JPY to EGP will be taken by GOE.

Note 3: MWRI will create a Designated Account in CBE in order to receive fund from Loan Account which is located in Japan under the project name.

Note 4: PFI will make the repayments directly to MWRI in EGP. At the time of principal repayment to JICA from MWRI, MWRI will need to convert the fund from EGP to JPY.

Note 5: After the fund returning from end-users, PFI will keep and manage the fund and reuse the fund to another end-users. The fund is called "Revolving Fund" and PFI has responsibility to manage the fund until PFI returns to the government.

Figure 4.11.1 Proposed Fund Flow and Workflow Under TSL

Source: JICA Survey Team

5) Conditions of the Financial Scheme

Given the present situation that JICA is expected to realize higher flexibility and more convenient for end-users, the conditions shown in the table below are recommended for the TSL scheme:

Table 4.11.5 Sub-loan Conditions (draft)

Item	Conditions
Currency	EGP
Sub-project amount	Up to EGP50,000 / feddan

Item	Conditions
Tenor	Up to 5 years for pump Up to 20 years for other irrigation equipment
End-user's interest rate	0.0%
Repayment cycle	Once a year (after the completion of sub-project)
Purpose of the financing	Purchasing modern irrigation system; e.g., pump, canal facilities, sprinkler, drip irrigation)
Collateral(s)	n.a
Guarantor(s)	n.a
Eligibility end-users	Farmers in the target area

Source: JICA Survey Team

6) Monitoring and Follow-up Mechanism

In the case of TSL, PFI will be responsible for monitoring the end-users and sub-projects individually and collectively. The relevant information will be updated at least annually through off-site and on-site inspections. On the basis of those monitoring activities, PMU will submit the following reports periodically. All the reporting formats will be prepared by PMU before the start of the loan project.

Table 4.11.6 Periodical JICA Reports in the TSL Project

	Name / Type	Timing	Notes
Concerning all aspects of project implementation:			
1	Project Status Report	Quarterly until the Project Completion Date	
2	Project Completion Report	Within 6 months after the Project Completion Date	
Concerning Sub-Loan and Sub-Project:			
3	On-going Sub-Project Summary Report	Quarterly until the Project Completion Date	
4	Current Repayment and Overdue Status Report	Annually until 3 years after the Project Completion Date	
Concerning project implementation bodies			
5	Annual Report of Executing Agency (including auditor's report)	Annually until 3 years after the Project Completion Date	
Concerning fund management:			
6	Statements of Designated Account and Project Operating Account	Annually until 3 years after the Project Completion Date	
7	Audit Report on the Statements of Designated Account and Project Operating Account	Annually until 3 years after the Project Completion Date (within 9 months after the end of each fiscal year).	
8	Statements of Expenditures (SOEs) and their Audit Reports	Annually until the Project Completion Date (within 9 months after the end of each fiscal year).	

Source: JICA Survey Team

PMU will be responsible for monitoring sub-projects individually and collectively. Steering Committee will review periodically at the assembly meetings, on the basis of the reports compiled by the PMU. For the monitoring purpose, JICA and MWRI may make on-site inspections and visit end-users and/or sub-projects (e.g., sub-project sites in farmland) when necessary. Also, JICA may inspect PMU through visiting the PMU office and interviewing with the PMU members.

Regarding the impact assessment of the loan project, JICA will conduct the first assessment, and the "project evaluation report" will be published soon after the signing of the L/A. The report stipulates the following: 1) project name, 2) necessity and justification of JICA loan, 3) objectives of the TSL project, 4) project description including schedule and result of environmental review, 5) performance indicators (operation & effect performance indicators), 6) risks caused by external factors, 7) evaluation results of past similar projects and lessons learned, and 8) evaluation plan.

The second assessment "ex-post evaluation" will be carried out within 3 years after the Project Completion date. In order to assess the project's effectiveness, impact, and sustainability, necessary baseline data will be collected from the PMU. PMU will prepare necessary evaluation results including 'Operation and Effect Performance Indicators', and submit them to JICA.

4.11.2 Project Loan by Advance Procedure

1) Outline of the Proposed Financial Scheme

Based on the results of this survey, the JICA Survey Team recommends a disbursement mechanism under Advance Procedure for the purpose of supporting the introduction of modern on-farm irrigation systems. In this scheme, the borrower of the JICA loan will be the MWRI. MWRI will be in charge of drawing ODA Loan after signing L/A, but overall fund management such as disbursing fund and monitoring after the disbursement will be conducted by the PMU.

MWRI will establish the PMU within the organization and conduct a series of necessary project activities. After MWRI requests JICA on the loan disbursement and funding supplement and receives the JICA fund, a government procurement bidding (LCB; Local Competitive Bidding) is conducted with the agreement of the farmers. Then, upon completion of the installation of modern on-farm irrigation system, the PMU, as per the farmers request, will settle the payment to the local contractors and receive the payment receipts from the contractor.

The method of repayment of the funds by the end-user farmers will be aided by the Meska repayment system, which is working effectively to support the farm-level irrigation development in Egypt. That is to say, when each farmer pays the land tax to the tax office each year (i.e., the tax office's regional office staff collects the land tax), he/she pays the redemption for Meska improvement. The repayment period will be 5 years (for pumps) or 20 years (others such as canal facilities), or otherwise equal installment over 10 years.

The advantages of this repayment method are, firstly, that farmers will not easily default on their land tax payments because they cannot purchase government-subsidized fertilizer without a land tax payment receipt, and severe collection of the Meska improvement reimbursement that is collected accordingly could reduce the risk of bad debts which is a concern under the loan scheme. Secondly, the system is most desirable for the beneficiary farmers, as it significantly reduces the burden of loan administration and repayment for each farmer. Thirdly, in the case of bank loans, farmers are usually required to pledge their farmland as collateral, which many farmers are reluctant to do, but under this method, collateral is not required.

Table 4.11.7 Term Sheet of JICA Financial Scheme

Condition	Option(s)	Notes
Japanese ODA Loan Conditions (JICA – MWRI)		
Currency	JPY	
Total amount	TBD	
Tenor	30 years	Assumption: general terms, fixed, standard cf. Terms of Conditions of Japanese ODA Loans, 1 October 2022
Grace period	10 years	
Base interest rate	Fixed rate: 1.70% per year	
Repayment cycle	Semi-annually (20th day of a month)	
Interest payment cycle	Semi-annually (20th day of a month)	

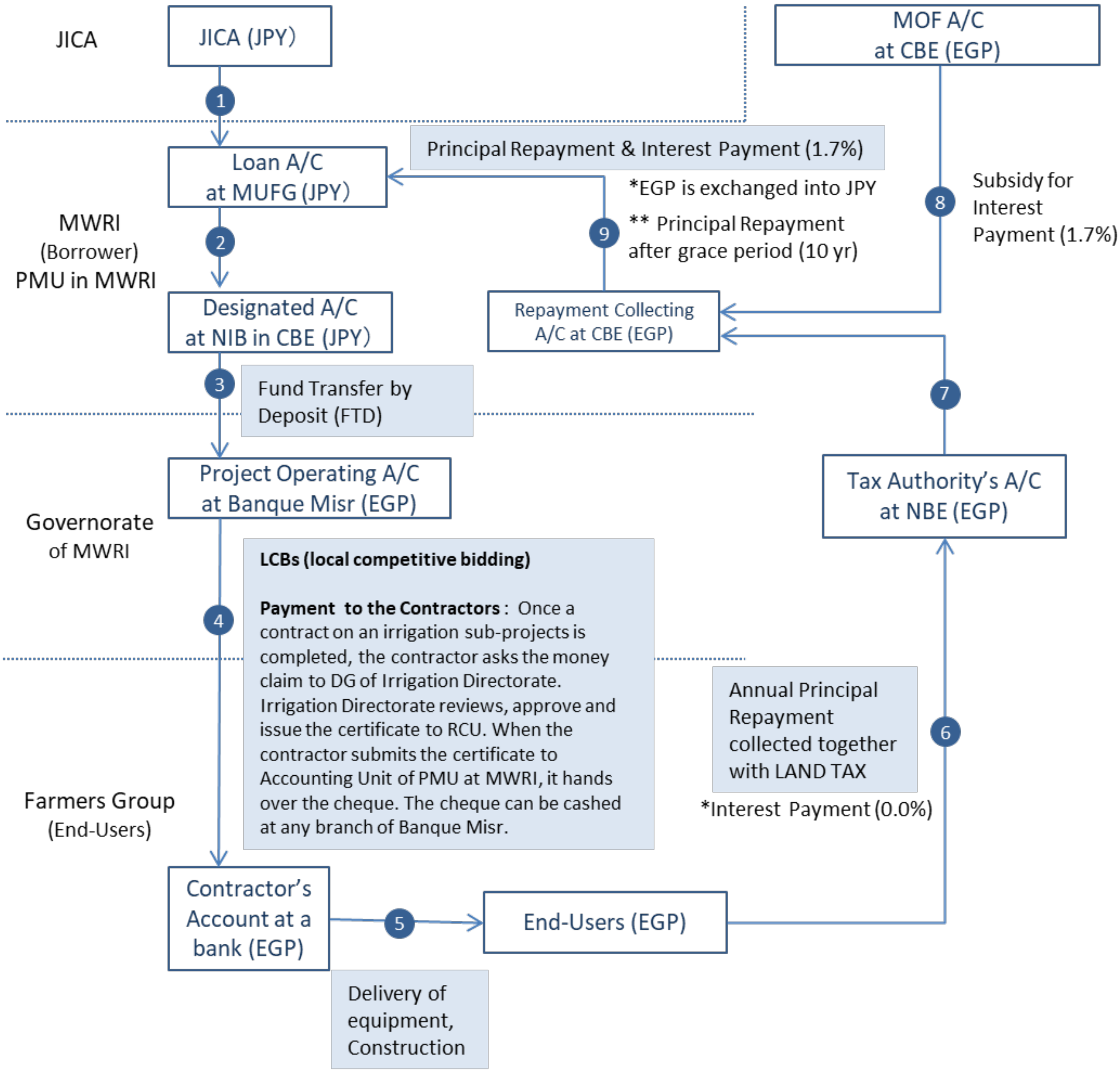
Source: JICA Survey Team

2) Organizational Arrangement

The signer of the L/A of the JICA loan will be the MWRI, the borrower. MWRI will be in charge of drawing ODA Loan after signing the L/A, but overall fund management such as disbursing fund and monitoring after the disbursement will be conducted by the PMU. For the purpose of smooth implementation of the loan project, MWRI will set up a PMU within the organization, and it will need to assign the Project Director, secretary staff, administration staff, staff of accounting & disbursement, contract specialist, technical engineers, technicians, etc.

3) Proposed Fund Flow & Workflow

The proposed fund flow and workflow under the Advanced Procedure are described in the chart below:



Note 1: The state-owned banks include NBE, Misr Bank, Cairo Bank, Alexandria Bank, and ABE.

Note 2: In terms of payment to the Suppliers, alternatively, as currently done, it is possible to take the following procedure. The Head of Regional Coordination Unit (RCU) issues a certificate of sub-project completion . The supplier submit it to PMU in MWRI so that the Head of PMU issues the Approval Letter on Payment, and reports to the Representative of MOF within MWRI. The supplier submit the Approval Letter to the Representative of MOF, and the Representative requests CBE/NIB for the payment to the supplier's account (cf. There is no Project Operating Account in this case).

Note 3: In case of TSL via PFI (e.g., ABE, NBE), the farmers as end-users would need to provide with 'land as collateral', which is not a realistic option at the moment.

Note 4: Main abbreviations
ABE = Agricultural Bank of Egypt, CBE = Central Bank of Egypt, NBE = National Bank of Egypt,
NIB = National Investment Bank

Figure 4.11.2 Proposed Fund Flow and Workflow Under Advanced Procedure

Source: JICA Survey Team

4.11.3 Recommended Financial Scheme for Modern Irrigation Development

The above discussion examined the possibility of TSL and Project Loan by Advance Procedure as a financial assistance scheme for the introduction of modern irrigation systems. MWRI initially had in mind a bank loan scheme based on an agreement signed by the five ministries concerned (TSL in the case of ODA loans), but has also considered the possibility of a Meska repayment scheme (project loan design based on an advance procedure).

One reason why TSL is not a realistic option in this case is that farmers may be concerned that a bank loan may need a collateral with their farmland, although the agreement signed by the five ministries states that collateral is not required. In addition, MWRI is concerned that farmers may reject the introduction of modern field irrigation if a bank loan is used, given the cumbersome documentation works required to obtain a bank loan.

Second, since the 2016 legal reform, ABE (leading candidate for PFI), which is responsible for agricultural finance in Egypt, has been named Principal Bank for Development and Credit (PBDAC), and the Foreign Borrowing Bureau has been abolished and is no longer allowed to borrow externally (Source: Minutes of the Meeting with ABE dated 5 July 2021). Therefore, when implementing policy finance programs for agriculture in Egypt, ABE's role is limited to handling such programs with commission from the Egyptian government, and it is difficult for the ABE to participate as a PFI in the TSL scheme by borrowing from international organizations.

Third, the JICA Survey Team can hardly shake off doubts about ABE's eligibility as a PFI candidate. In the past, ABE's NPL ratio rose to 36.3% as of 2013, and it requested the World Bank assistance the following year (World Bank, "PBDAC Restructuring Program", 2014 -), but recently it has not disclosed financial information in a timely manner, thus concerns regarding its financial soundness cannot be dispelled. This is also problematic from a governance perspective. In addition, since the 2016 legal reform, ABE has limited experience in implementing TSL for agriculture, and there are remaining concerns about its TSL implementation capacity.

4.12 Water Users Association (WUA) Establishment under Modern On-farm Irrigation

MWRI has a long experience in establishing Water Users' Association (WUA), which started in the early 1990s with a technical assistance from USAID. The establishment of WUA at first focused on Meska level farmer organization, and moved to the branch canal level, and further to the district level. Those associations are called Meska WUA, Brach Canal WUA, and District Water Board. With reference to the practices already much accumulated within MWRI, this section discusses the establishment of WUA in line with the introduction of modern on-farm irrigation.

4.12.1 Demarcation of Water Management between MWRI and Farmers

A typical irrigation system consists of water sources, intake-facilities, main canals, branch canals, and tertiary canals which are called Meska in Egypt, which altogether deliver and distribute irrigation water to the beneficiaries' farmlands. This system arrangement is briefly illustrated in Figure 4.12.1 together with the responsible entities in the construction and also Operation & Maintenance.

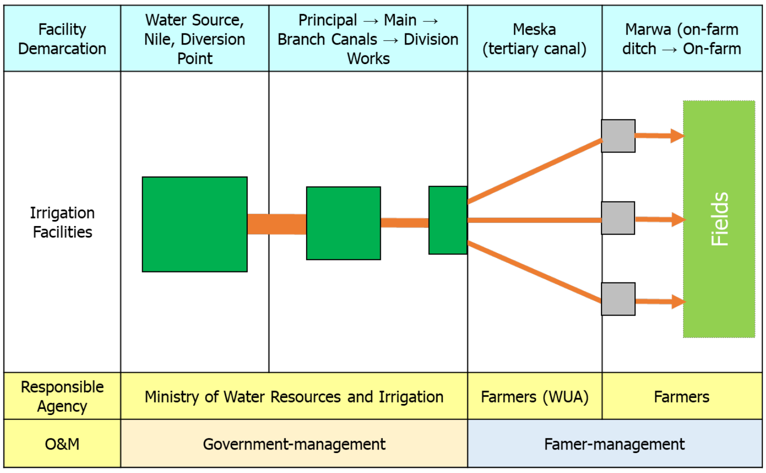


Figure 4.12.1 Set-up of Irrigation System Management, Egypt
Source: JICA Survey Team based on Information from MWRI

As is briefed above, the MWRI is responsible from the top-upstream side, e.g., water source management and head-intake facilities, to the branch canal level while the beneficiary farmers are responsible for the lower level (or terminal level) irrigations, which are the Meska, Marwa (on-farm ditch) and on-farm irrigation. Note that the intake facility of Meska is constructed and managed by MWRI.

As mentioned above, Meska and below thereof should always be managed by the farmers. It means improvements of Meska, e.g., by introduction of one-lifting pump station together with pipeline system or Meska lining, can be requested to MWRI by the farmers, but in any case, the construction cost should be paid back by the farmers with some concessional conditions on the repayment. For the day-to-day management of Meska, Marwa (on-farm ditches), and on-farm irrigation, the relevant farmers should discharge full responsibilities as a group under water users' association or by individual basis.

4.12.2 WUA Establishment under Irrigation Improvement Project (IIP)

Figure 4.12.2 shows a typical alignment of a branch canal and some Meskas. Meska coverage area ranges from as small as 20 feddans to over hundreds feddans. In case of bigger Meska covering more than, say, 100 feddans, there may be more than one lifting pumping stations corresponding to the left side of the branch canal in Figure 4.12.2, but whether these

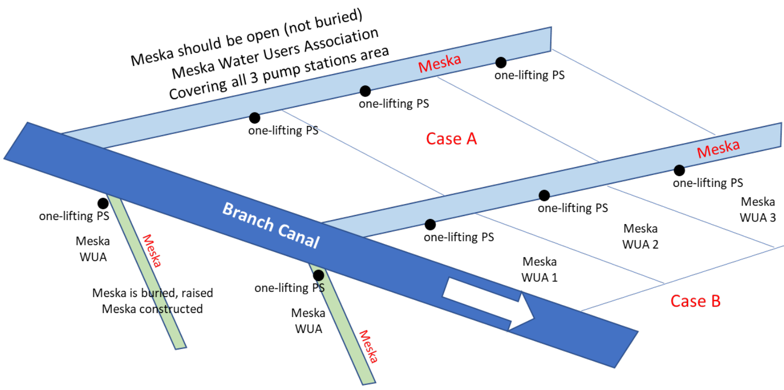


Figure 4.12.2 Typical Alignment of Meska WUA
Source: JICA Survey Team based on Information from MWRI

lifting pump stations are covered by only one WUA (case A) or each WUA established at each of these lifting pump stations (case B) all depends on the willingness of the farmers. For the former case, the WUA is called Meska WUA, and the latter may be called Meska WUA 1, Meska WUA 2, and so on.

According to the practices under IIP, WUA is established by all the concerned farmers and they select or elect their representatives. In many cases, the representatives are Chairperson, Secretary/Vice-chairperson, Treasurer, pump operator/maintenance, etc. In some cases, there may be only 3 representatives with one being the leader and others being the members. Then, all the Meska representatives under a branch canal form a WUA at the branch canal level, now called Branch Canal WUA. The Meska representatives now select or elect the representatives of the Branch Canal WUA, whose composition is almost the same as those of Meska WUA.

4.12.3 WUA Establishment under Modern On-farm Irrigation

The establishment of WUA with the introduction of modern on-farm irrigation should basically follow what has been practiced in Egypt already for many years, and try to introduce some improvements from the viewpoint of operating harder irrigation system rather than just flood irrigation which has long been practiced by farmers. The modern on-farm irrigation system to be introduced should be so designed that it is capable of operating both sprinkler system and drip system, each of which should be managed under different pressures.

It means modern on-farm irrigation requires more sophisticated skills in the Operation and Maintenance, and therefore the WUA should also be organized and structured in order to well respond to this system. In this sense, JICA Survey Team recommends that the WUA should be established at each of the one-lifting pump stations as indicated by Case B in Figure 4.12.2. The condition for the establishment of the Meska WUA should be with the consent of more than 50% of the farmers involved, same as the practices under IIP.

1) Meska Level WUA, Corresponding to Case B in Figure 4.12.2

As mentioned in sub-chapter '4.5 Modern On-farm Irrigation Development', the modern on-farm irrigation system is established with limited areas of 30 feddans as maximum. In some cases, there may be 10 feddans area as one unit of modern on-farm irrigation, likewise, 20 feddans per one unit of modern on-farm irrigation, that are all accepted. According to interviews with IIS, the average area of farmers generally ranges from 0.6 to 1.0 feddan. With 30 feddans as the largest, there will be at least 30 to as many as 50 farmer members within one unit of modern on-farm irrigation system. Taking this maximum number of farmers, and considering the system's character, the following should be undertaken in establishing WUA:

- ✓ In an organization of WUA with certain size, there should be three decentralized dimensions, i.e., planning, decision making, and implementation. It means that at first a plan is made in a sub-group, and the plan is forwarded to the decision-making body that is the General Assembly (GA), and once agreed by the farmers in the GA, the plan should be put into implementation by the farmer members under the supervision of the Management

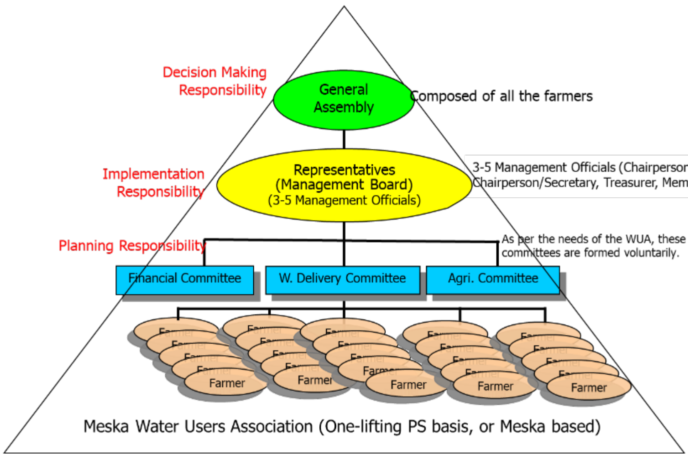


Figure 4.12.3 Organizational Structure of Meska WUA
Source: JICA Survey Team

Board. Namely, above-mentioned Planning, Decision-making and Implementation should be decentralized in an organization (see Figure 4.12.3).

- ✓ In terms of the structure, the General Assembly is the apex organ, composed of all the membership. Important issues should be discussed and decided at this level. Under the GA, Management Board is formed consisting of the Chairperson, Secretary/Vice Chairperson, Treasurer, and probably some other members. The Management Board will be in charge of the execution or day-to-day management according to the decision made by the GA. The point is the Management Board headed by the chairperson is not in charge of decision-making but in charge of execution. It means even the chairperson has only one vote in terms of decision making, but in terms of implementation, s/he is the chief executive officer (CEO).

- ✓ Under the Management Board, there can be groups in charge of planning. There can be agriculture development committee, water delivery committee, financial management committee, etc. according to their needs. One committee may be composed of say 3 – 5 volunteer members from the farmers, and preferably should have one of the Management Board members as their leaders. Example is that the leader of the agriculture development committee can be the Chairperson of the Management Board, the water delivery committee can be headed by the Secretary/Vice Chairperson, and the financial committee can be headed by the Treasurer. In any case, they cannot be in charge of decision-making but only in charge of planning. The plan is forwarded to the General Assembly for its decision.

- ✓ Then, the plan based on its decision has to be now implemented. If the plan is very important, e.g., decision of pump operation fee (irrigation fee), the decision shall usually be made by the General Assembly, which is composed of all the membership. Now who are the ones to implement the plan? Those who implement the plan are the members of the WUA and at the same time members who constituted the General Assembly to decide. Since the plan has been decided by the General Assembly composed of all the members, the members shall now implement the plan collectively under the supervision or the leadership of the Management Board.

2) WUA Establishment under Branch Canal

The concept of forming a branch canal WUA is almost the same as that of Meska WUA. As indicated in the Figure 4.12.4, structure is the same with the replacement of the General Assembly (GA) by Representative GA and farmer members by the Meska WUAs. As Meska WUA is established at the area of 30 feddans as maximum, there will be more than 30 Meska WUAs under a typical branch canal whose command area is around 1,000 feddans.

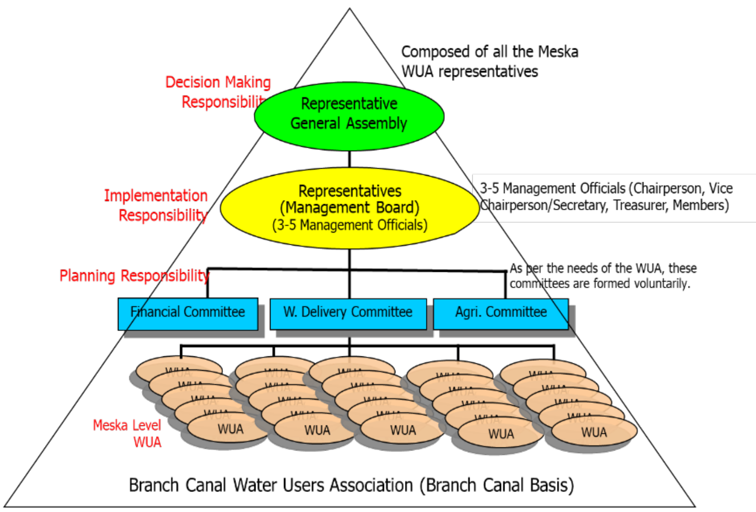


Figure 4.12.4 Structure of Branch Canal WUA
Source: JICA Survey Team

There are many branch canals whose command areas are more than 1,000 feddans. In such a case, total number of farmers under the branch canal would be more than 1,000, indicating very much difficulty of gathering all the farmers to one place for discussion and decision. Facing such difficulty of gathering all the relevant farmers, only the representative of Meska WUAs should come and get together to establish the Branch Canal WUA instead, thus the GA is now the Representative GA, and the bottom base is the member Meska WUAs. There is a case that a Branch Canal WUA has been established without having Meska WUAs. In such case, though the Meska improvement is not taking place, the representatives of Branch Canal WUA are undertaking the coordination among the farmers along their branch canal.

4.12.4 Expected Number of WUAs in the 3 Priority Sub-regions

Table 4.12.1 shows expected numbers of Meska level WUAs together with the expected numbers of farmers per WUA in the 3 priority sub-regions. As mentioned above, the minimum coverage area by one Meska level WUA is fixed at 10 feddans while the biggest coverage area to be 30 feddans according to Case B in Figure 4.12.2. Dividing the command area of the priority sub-regions by the WUA's coverage area gives the expected numbers of WUAs, namely, in total there will be minimum 4,240 WUAs to maximum around 13,000 WUAs for the 3 priority sub-regions.

In terms of number of farmers per WUA, there should be a typical (average) farmland size data. There are 2 kinds of data concerning the farmland size; 1) Bulletin of Agricultural Boundaries and Properties 2017, July 2017, CAPMAS, and 2) farmland seize interviewed in JICA Survey Team's farmer interview survey. The former data provides us with the owned farmland size while the latter one presents the farming area, namely, owned farmland minus rented out farmland plus rented farmland.

Based on the farmland size interviewed by JICA Survey Team and also the owned farmland areas from the Bulletin of Agricultural Boundaries and Properties 2017, July 2017, CAPMAS, expected number of farmers per one Meska WUA ranges from as small as 3 to as large as 29, with the averages for the 3 priority areas of 7 to 21 members. With such membership numbers per one Meska level WUA, farmers would not face many difficulties in the institutional management.

Table 4.12.1 Expected Numbers of Meska WUAs and Farmers in the 3 Priority Sub-regions

Area	Area, feddan	Expected Max. No. of WUAs	Expected Min. No. of WUAs	Average. Farmland*, feddan	Owned Farmland**, feddan	Expected No.*** of Farmers per WUA
Abo Shosha	17,881	1,788	596	1.41	1.02	7-20 / 10–29
Aros & Abo Seer	13,330	1,333	444	1.62	2.95	6-19 / 3 – 10
Kased	95,976	9,598	3,199	1.38	1.16	7-22 / 9 – 26
Total	127,187	12,719	4,240	1.41 ****	1.33 ****	7-20 / 7 - 21

*/ based on the farm economy survey conducted by JICA Survey Team
**/ based on Bulletin of Agricultural Boundaries and Properties 2017, July 2017, CAPMAS. Note that the data for Kased are the weighted farmland seize for the concerned districts of Gharbia Governorate (up – mid stream) and Kafr El Sheik Governorate (downstream).
***/ the former numbers indicate the expected numbers based on the JICA Survey Team's average farmland area surveyed, while the latter numbers indicate the expected numbers estimated based on the owned farmland area from the Bulletin of Agricultural Boundaries and Properties 2017, July 2017, CAPMAS.
****/ average numbers by each sub-priority area weighted.
Source: JICA Survey Team

4.13 Agricultural Development Plan

4.13.1 Framework of the Agricultural Development Plan

Proposed project components shall consist of the improvement of canals from principal to secondary level including canal lining and rehabilitation and construction/rehabilitation of hydraulic structures, and introduction of modern irrigation system at on-farm level with the rehabilitation of Meska. The modern irrigation system at on-farm level means introduction of sprinkler and/or drip irrigation systems including the improvement of on-farm ditch (Marwa), which are to be changed to pipelines. The agricultural development plan is formulated based on these components.

Based on the above project components, the agricultural development plan is described with the pillars of cropping pattern, cropping intensity, unit yield for crops, and training, etc. for cultivation with modern on-farm irrigation system to be introduced. Since there is a significant difference in cropping pattern between Delta and Upper Egypt, the plan is proposed each for Delta and Upper Egypt. The following summarize the basic assumptions of the development plan:

1) Cropping Pattern

Equitable water distribution with the improvement of irrigation system and introduction of modern irrigation would encourage farmers to change their cropping patterns towards more profitable ones. However, farmers may remain with the same crops as they used to cultivate and opt to take a conservative strategy worrying about difficulties of operating modern on-farm irrigation system. Therefore, the cropping pattern with project proposes such two cases: 1) no change from the current ones and 2) change to profitable horticulture crops for some extent.

The cropping pattern without project is based on the agricultural statistics of the governorates. As for the case of cropping pattern in case of increasing horticulture crops with project, market situation and labor intensity will be considered based on the statistics and the information collected from the farm economy survey carried out in this Survey and interviews to farmers already practicing the modern on-farm irrigation.

2) Cropping Intensity

Water saving by irrigation improvement including the introduction of modern irrigation will increase the water availability among farmers in a canal system with enhanced equitable water distribution. Farmers practicing modern on-farm irrigation interviewed by the JICA Survey Team also confirmed that they were able to increase the cultivated area after the introduction of modern irrigation. In fact, there may be a possibility for the farmers located downstream reaches of canals to keep some parts of their farmland uncultivated due mainly to water shortage. Yet, these uncultivated areas are very limited, thus the cropping intensity as a whole over large extent areas is already very high in Egypt. Therefore, the cropping intensity with project will be proposed unchanged from the present ones.

3) Unit Yield of Crops

Unit yield increase with project is expected from two dimensions; namely, 1) effect of increased water availability and equitable water distribution with the irrigation improvement, and 2) the effect of better crop husbandry with modern on-farm irrigation system to be introduced. Irrigation improvement enables to increase irrigation efficiency, thereby increased water availability and equitable water distribution would be realized.

Farmers especially located downstream reaches can benefit from it and increase the unit yield of crops. The degree of unit yield increase by this effect is assumed to level the unit yields between the farms located upstream and downstream reaches of canals. The difference of the yield between upstream and downstream is based on the result of the farm economy survey and the review of the existing available project documents.

As for the effect of modern on-farm irrigation, it enables rational water utilization and ideal fertilization for crop cultivation. Such elaborated crop cultivation method will bring about the increase of yield. The degree of unit yield increase is proposed based on the existing research on modern on-farm irrigation system and also interviews to the farmers practicing modern irrigation in the Old Lands of Egypt.

Table 4.13.1 Basis for Formulating Agricultural Development Plan

Pillar	Without Project	With Project
Cropping Pattern	Based on agricultural statistics	Interviews to farmers practicing modern irrigation, and also market situation
Cropping Intensity	Based on agricultural statistics	Same as the current ones (no increased planned)
Unit Yield	Based on agricultural statistics and farm economy survey	Farm economy survey, interviews to farmers practicing modern irrigation, existing studies and research documents

Source: JICA Survey Team

4) Training for Cultivation with Modern Irrigation System

Introduction of modern irrigation can lead to increase of unit yield of crops as afore-mentioned. However, the selection of appropriate equipment and also knowledge of how to use such equipment to maximize the effects of the modern on-farm irrigation would need training including practice. Therefore, a component of training for cultivation with modern on-farm irrigation is proposed.

4.13.2 Agricultural Development in Upper Egypt

1) Proposed Cropping Pattern

As discussed above, cropping pattern with project is proposed with 2 cases. Case 1 is assumed to be no change in cropping pattern and Case 2 is to alternate some of the crops to profitable horticulture crops. According to the interviews to the farmers practicing modern irrigation in the Old Lands, some farmers have shifted the crops from traditional ones to others, while ones maintained the same traditional crops according to their needs, ,e.g., they keep cultivating maize as they use it as animal feed.

Table 4.13.2 below shows the change of crops before and after the installation of modern on-farm irrigation system on their farms. The farmers in Beni Suef have changed the crops from maize and wheat to tomatoes, cowpeas, green beans, zucchini and cucumbers. Furthermore, the farmers also reported that they were able to expand the cultivated areas by generating surplus water through modern on-farm irrigation.

Considering the information from farmers practicing modern irrigation, the Case 2 cropping pattern considers the increase of the share of vegetable crops as shown in the Table 4.13.3 and Figure 4.13.1. Increase of vegetable crop is considered from the shift of berseem in winter crop and maize / sorghum in summer crop / Nile crop. According to the interviews to farmers, livestock rearing is very important for the farmers and therefore drastic decrease of these fodder crops for winter / summer and wheat, the staple food for Egyptian, is not considered as a whole regional cropping pattern. Then, slight shift of berseem, maize and sorghum to vegetables is proposed[1]. As for the cropping intensity, the present overall intensity is already so high that the intensity is kept as without project situation.

[1] The cropping pattern without project is based on the average cultivated area per crop from 2011/12 – 2015/16 (available published data). The increase of vegetables was considered the difference between this average cultivated area and the lowest cultivated area during the above period, e.g., average area of berseem is 255,769 fed and its lowest cultivated area during the period was 227,663 fed (around 90%). It is assumed that this lowest cultivated area could still sustain the livestock feed in the region and then the 5% of berseem is to shift to vegetable crop.

Table 4.13.2 Change of Crops with Introduction of Modern Irrigation

Farmer / Farmer Group	Before Modern Irrigation	After Modern Irrigation Introduced
A (Beni Suef)	Summer: Maize Summer: Eggplants	Tomatoes Eggplants (expansion)
B (Beni Suef)	Summer: Maize Winter: Wheat	Cowpeas – Zucchini Green beans – Cucumbers
C (Fayoum)	Summer: Maize Winter: Wheat	Maize (expansion) Wheat (expansion)

Source: Field Interviews by JICA Survey Team

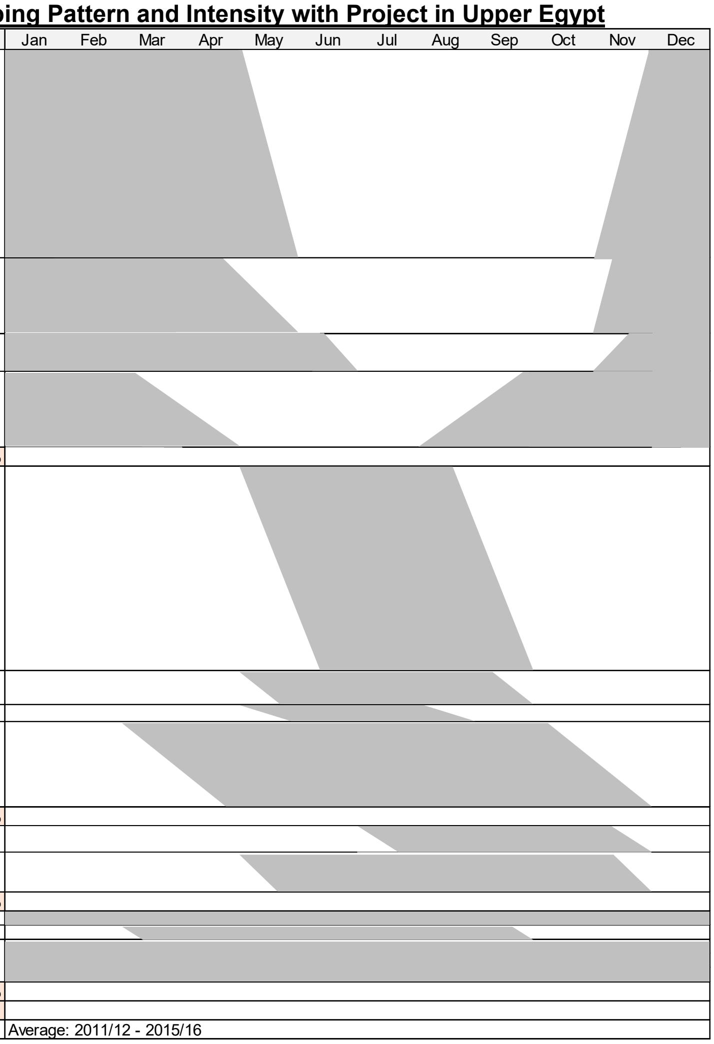
Table 4.13.3 Proposed Cropping Pattern and Intensity with Project in Upper Egypt

Season	Without Project			With Project: Case1			With Project: Case 2		
	C.I. (%)	Crop	C.I. (%)	C.I. (%)	Crop	C.I. (%)	C.I. (%)	Crop	C.I. (%)
Winter	88	Wheat	51	88	Wheat	51	88	Wheat	51
		Long berseem	23		Long berseem	23		Long berseem	21
		Sugar beet	7		Sugar beet	7		Sugar beet	7
		Vegetables & other	19		Vegetables & other	19		**Vegetables**	**21**
Summer	77	Maize	63	77	Maize	63	77	Maize	60
		Sorghum	13		Sorghum	13		Sorghum	12
		Oil crop	5		Oil crop	5		Oil crop	5
		Vegetables & other	19		Vegetables & other	19		**Vegetables & Other**	**23**
Nile	15	Maize	49	15	Maize	49	15	Maize	41
		Vegetables & other	51		Vegetables	51		**Vegetables & other**	**59**
Permanent	16	Sugar cane	20	16	Sugar cane	20	16	Sugar cane	20
		Cotton	27		Cotton	27		Cotton	27
		Fruit trees	53		Fruit trees	53		Fruit trees	53
Total	196			196			196		

Source: JICA Survey Team

Figure 4.13.1 Proposed Cropping Pattern and Intensity with Project in Upper Egypt

Season	Crop Intensity	Crop	Area (fed)	CI
Winter	88%	Wheat	567,459	51%
		Long berseem	234,518	21%
		Sugar beet	79,847	7%
		Vegetables & Others	234,930	21%
		Winter Total	1,116,754	100%
Summer	77%	Maize	586,833	60%
		Sorghum	117,367	12%
		Oil crop	48,598	5%
		Vegetables & Others	225,257	23%
		Summer Total	978,055	100%
Nile	15%	Maize	79,060	41%
		Vegetables & Others	113,770	59%
		Nile Total	192,830	100%
Permanent	16%	Sugar cane	39,768	20%
		Cotton	53,296	27%
		Fruit trees	104,273	53%
		Permanent Total	197,337	100%
Grand Total	196%		2,484,976	
Cultivated area (fed)			1,268,321	



Source: JICA Survey Team

2) Proposed Crop Yield (Crop Yield Increase)

As defined above, the unit yield increase is considered from two categories: one accrues from irrigation improvement with canal lining and structure rehabilitation/construction, another is from the introduction of modern on-farm irrigation. With the former intervention, increase of irrigation efficiency and equitable water distribution within the irrigation system will be realized. Introduction of modern on-farm irrigation system will also contribute to significantly increasing irrigation efficiency as well as rationalize the irrigation water and fertilizer application to crops, leading to the unit yield increase. The overall unit yield increase will be proposed in combination of those effects.

The degree of the increase is based on the result of the farm economy survey and the results of past studies available. Tables 4.13.4 and 4.13.5 summarize the proposed unit yield increase and the Tables 413.6 and 4.13.7 summarize the studies referred to in determining the proposed yield increase. Based on the results of the farm economy survey and interviews to farmers practicing the modern on-farm irrigation, the basic degree of yield increase is assumed. Then, referring to the various studies which present the research outputs or evaluation of the irrigation improvement projects, the basic degree is examined from its relevance with these study results by crop group.

In examining the degree of yield increase by modern on-farm irrigation, the proposed water saving ratio by drip or sprinkler irrigation is also referred to from the studies discussing the relationship between the level of water saving and yield. In summary, it is expected that the yield increase with irrigation improvement would be from 5% to 15%, with drip irrigation from 30% to 120% and sprinkler from 6% to 30%. As for modern irrigation system, since the conditions of the studies referred vary so much, a conservative increase is applied, namely 11% to 40% with drip or sprinkler.

Table 4.13.4 Proposed Unit Yield Increase

Category	Effects	Farm economy survey / farmer interview	Existing studies	Proposed Overall Unit Yield Increase with Project
Irrigation Improvement + modern irrigation	Irrigation efficiency improvement / equitable water distribution / increase of water availability	Difference between upstream of branch canal /Meska) and Downstream of branch canal / Meska) Maize: 30% (Ave. of 3 sites), Sorghum: 15% (Fayoum), Rice: 9% (Gharbia), Wheat: 18% (Ave. of 3 sties),	5% to 15%	**Irrigation improvement + Drip:** **Rice: 5%** **Maize, Sorghum: 15% + 30% = 45%** **Wheat, Berseem: 9%** **Vegetable, oil crop, legumes: 8% + 30% = 38%** **Sugar beet: 5% + 40% = 45%** **Irrigation improvement + Sprinkler:** **Rice: 5%** **Maize, Sorghum: 15% + 20% = 35%** **Wheat, berseem: 9% + 11% = 20%** **Vegetable, oil crop, legumes: 8% + 30% = 38%** **Sugar beet: 5% + 20% = 25%**
Modern on-farm irrigation	Rationale use of water and fertilizers	Sprinkler 20% (Maize) 11% (Wheat)	Drip: 30% - 120% Sprinkler: 6% - 30%	

Source: JICA Survey Team

Table 4.13.5 Summary of Proposed Yield Increase with Project

Crop	Irrigation Improvement	Drip	Sprinkler	Total
Rice	5%	-	-	5%
Maize, Sorghum	15%	30%	-	45%
	15%	-	20%	35%
Wheat, Berseem	9%	-	11%	20%
Vegetables, Oil crops, Legumes	8%	30%	-	38%
	8%	-	30%	38%
Sugar beet	5%	40%	-	45%
	5%	-	20%	25%

Source: JICA Survey Team

Table 4.13.6 Unit Yield Increase by the Existing Studies Compared to the Farm Economy Survey

Study / Project	Increase Ratio (%)	Conditions
Farm Economy Survey by the JICA	Difference between upstream of branch canal /Meska) and Downstream of branch	All traditional basin / furrow irrigation 90 farm households x 3 sites interviewed

Study / Project	Increase Ratio (%)	Conditions
Survey Team	canal / Meska) Maize: 30% (Ave. of 3 sites), Sorghum: 15% (Fayoum), Rice: 9% (Gharbia), Wheat: 18% (Ave. of 3 sties), Onion: 4% (Gharbia)	Number of samples depends on the crop Based on the yield of Summer and winter 2019/20
EU STAR[1)] (Demonstration Projects)	10%	Enhanced water distribution efficiencies, timely irrigation, equity for tail end farmers, improved water quantity and quality, improved drainage, reduced water table and water and soil salinity, etc.
IIP[1)]	5%	Meska improvement & WUA establishment Adaption of improved technology but limited application of continuous flow
IIIMP[1)]	15% (main crops)	Meska improvement & WUA /BCWUA establishment Improved water flows particularly at the tail of improved branch canal
FIMP (Farm-level Irrigation Modernization Project) WB and AFD[2)]	Target: Reduce difference between head and tail of the canal by20%: Achieved 59% 10% - 13% Yield increase (model)	Marwa modernization (PVC or lining) Meska pump electrification Farm-leveling, gypsum application Water management & agronomic practices
EU STAR Financing Options[3)]	20%-30%	Introduction of modern irrigation: Based on discussions with farmers
Assessment of Modern Irrigation Systems in North Delta[4)]	Drip / Surface Sunflower: 92% Cabbage: 97% Maize: 98%	Result of field experiment But the report introduced to some references, which shows higher yield with drip than furrow irrigation. But income increases with drip due to lower production cost (fertilizer and cultivation costs)
AMP (Agricultural Mechanization Project)[1)]	Plan: 9% to 37% by crop Achieved: 16% (Ave.)	Use of improved technology packages (demonstration plots and sample survey of farmers field)
WARUS (reuse of drainage water) JICA Master Plan[5)]	Rice: Difference between tail and head of canal: 16% Ave. yield increase: Rice: 8%, Maize: 23% Cotton & Summer vegetables: 8% Wheat, berseem: 3% Sugar beet: 5%	Water reuse pump installation: decrease water shortage Water quality improvement

1) Irrigation Modernization in the Nile Delta and Valley (Dec. 2020), EU Water Sector Technical Assistance and Reforms Support (EU Water STARS)
2) Implementation Completion and Results Report for Egypt Farm-Level Irrigation Modernization (June 2018), The World Bank
3) Financing Options for A Blended Financing Instrument to Support Irrigation Modernization at the Farm Level (Mar. 2021), EU Water Sector Technical Assistance and Reforms Support (EU Water STARS)
4) Assessment of Modern Irrigation Systems in the Old Lands of the North Delta, Technical Report for Joint Experiment Research between MWRI and JICA (Jan. 2021), Water Management Research Institute, Kafr El-Sheikh Research Station
5) The Project for Drainage Water Quality Control for Irrigation in Middle Nile Delta in the Arab Republic of Egypt (Mar. 2016), JICA, Sanyu Consultants Inc. https://libopac.jica.go.jp/search/detail?rowIndex=30&method=detail&bibId=1000025882

Table 4.13.7 Unit Yield Increase by Modern Irrigation in Various Studies

Type	Yield increase compared to furrow irrigation	Source
Drip	48% (Tomatoes) (California, USA)	Overhead and Drip irrigation system effects on tomato growth and yield in California's Central Valley, Mitchell, et. al. Horltechnology Dec. 2014 https://journals.ashs.org/horttech/view/journals/horttech/24/6/article-p637.xml
Drip	30% to 40% (Soybean) (Illinois, USA)	Efficient management of water and nutrients in drip irrigation and fertigation. Fred Below, et. al. The Fluid Journal, Winter 2017 Vol. 25, No.1. Issue #95 https://fluidfertilizer.org/wp-content/uploads/2017/03/W17-A2.pdf
Drip	62.44% (Cabbage) (West Bengal, India)	Effect of drip irrigation on yield of cabbage under mulch and non-mulch conditions. K.N. Tiwari, et. al. Agricultural Water Management, Vol 58, Issue 1, January 2003 Effect of drip irrigation on yield of cabbage (Brassica oleracea L. var. capitata) under mulch and non-mulch conditions - ScienceDirect
Drip	56% to 120% (Carrot, tomatoes, potatoes, vegetables) (Ethiopia)	Implications of Adopting Drip Irrigation System on crop yield and gender-sensitive issues: the case of Haramaya District, Ethiopia, Dawit, et. al. Journal of Open Innovation, September 2020. https://www.mdpi.com/2199-8531/6/4/96
Drip Sprinkler	Sugar beet (Wadi El-Natrown, Egypt) compared to sub-surface irrigation 44.6% (Drip) 20% (Sprinkler)	Water Saving with the use of different irrigation systems under Egyptian conditions, Morad M.M., et. al. Irrigation and Drainage, Misr J. Ag. Eng. July 2012 (PDF) WATER SAVING WITH THE USE OF DIFFERENT IRRIGATION SYSTEMS UNDER EGYPTIAN CONDITIONS (researchgate.net)

Type	Yield increase compared to furrow irrigation	Source
Sprinkler	Compared to border irrigation (India) 23% (groundnuts), 6% (garlic) 24% (chilies) Compared to flood 16% (Food grains), 19% (Oil seeds), 9% (Sugarcane)	Sprinkler irrigation – an asset in water scarce and undulating areas, M. Shiva Shanker, et. al. Irrigated Soil and Water Management for Livelihood and Environment Security 2015, ICAR Research Complex for NEH Region Umiam, Meghalaya, India (PDF) Sprinkler irrigation - An asset in water scarce and undulating areas (researchgate.net)
Sprinkler	Compared to basin, Sri Lanka 8% - 30% (red onion)	Yield performance of red onion under different irrigation management in Jaffna Peninsula, Mikunthan, et. al. JSc-EUSL Vol.5. No.1. 2008, Sri Lanka Yield performance of red onion under different irrigation management in Jaffna Peninsula, Mikunthan, et. al. JSc-EUSL Vol.5. No.1. 2008, Sri Lanka

Source: see in the column of 'source'.

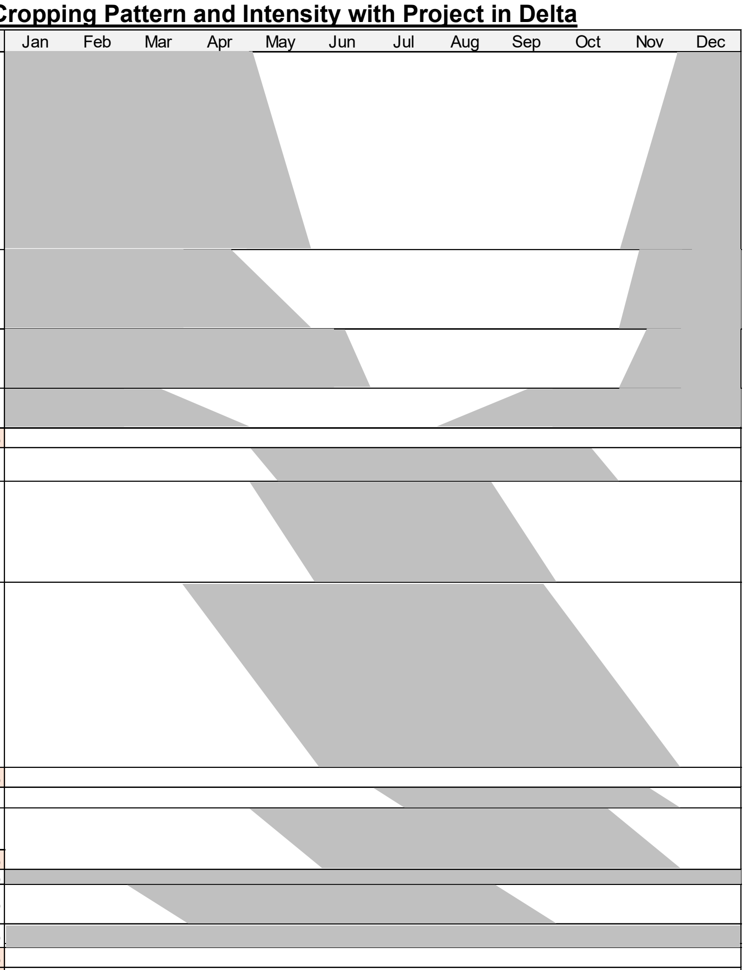
4.13.3 Agricultural Development in Delta: Kased Command Area

1) Proposed Cropping Pattern

Cropping pattern with project in the Delta (Kased area) is proposed with the same principles of the Upper Egypt. The significant difference between the Delta and Upper Egypt is the existence of rice cultivation in summer season. Rice is currently cultivated only in the Delta. Figure 4.13.2 shows the cropping pattern of Case 2. Table 4.13.8 summarizes the proposed cropping patterns of Case 1 with no change from the without project situation and Case 2 with increase of share of vegetable crops.

Figure 4.13.2 Proposed Cropping Pattern and Intensity with Project in Delta

Season	Crop Intensity	Crop	Area (fed)	CI
Winter	95%	Wheat	388,289	46%
		Long berseem	170,472	20%
		Sugar beet	142,606	17%
		Vegetables & Others	150,993	17%
		Winter Total	852,360	100%
Summer	86%	Rice	77,001	10%
		Maize	215,604	28%
		Vegetables & Others	477,408	62%
		Summer Total	770,013	100%
Nile	5%	Maize	11,745	29%
		Vegetables & Others	28,755	71%
		Nile Total	40,500	100%
Permanent	15%	Sugar cane	1,334	1%
		Cotton	91,585	70%
		Fruit trees	37,721	29%
		Permanent Total	130,640	100%
Grand Total	200%		1,793,513	
Cultivated area (fed)			895,894	Average: 2011/12 - 2015/16



Source: JICA Survey Team

Table 4.13.8 Proposed Cropping Pattern and Intensity with Project in Delta

Season	Without Project			With Project: Case1			With Project: Case 2		
	C.I. (%)	Crop	C.I. (%)	C.I. (%)	Crop	C.I. (%)	C.I. (%)	Crop	C.I. (%)
Winter	95	Wheat	46	95	Wheat	46	95	Wheat	46
		Long berseem	23		Long berseem	23		Long berseem	20
		Sugar beet	17		Sugar beet	17		Sugar beet	17
		Vegetables & other	14		Vegetables & other	14		**Vegetables & other**	**17**
Summer	86	Rice	10	86	Rice	10	86	Rice	10
		Maize	34		Maize	34		Maize	28
		Vegetables & other	56		Vegetables & other	56		**Vegetables & other**	**62**
Nile	5	Maize	59	5	Maize	59	5	Maize	29
		Vegetables & other	41		Vegetables & other	41		**Vegetables & other**	**71**
Permanent	15	Sugar cane	1	15	Sugar cane	1	15	Sugar cane	1
		Cotton	70		Cotton	70		Cotton	70
		Fruit trees	29		Fruit trees	29		Fruit trees	29
Total	200			200			200		

Source: JICA Survey Team

2) Proposed Crop Yield (Crop Yield Increase)

As afore-mentioned in the section 4.13.2, the degrees of unit yield increase with project including the ones particularly cultivated in the delta such as rice are as already shown in the Table 4.13.4.

CHAPTER 5 LOAN PROGRAMMING, PROJECT COST AND IMPLEMENTATION ARRANGEMENT

This chapter discusses the loan programming, project cost by component and necessary implementation arrangement. The cost consists of direct work and equipment cost, in-direct cost, consultant cost, physical contingency and price escalation for inflation, etc. In fact, there are several project components and sub-components, and the implementation modality differs each other such as direct force account, international competitive bidding, local competitive bidding, etc. These issues including the implementation arrangement are elaborated on below:

5.1 Loan Programming and Eligible Portions for Yen Loan

5.1.1 Project Scope and Component

Through the afore-mentioned discussions in Chapter 4, project components have been identified as a potential loan assisted project together with sub-components. The department to be involved in implementing the components is the Irrigation Development (ID) of MWRI, and under the ID, there are Irrigation Sector (IS) in charge of structure and canal improvement, Irrigation Improvement Sector (IIS) in charge of modern on-farm irrigation development. In addition, General Directorate for Canal Maintenance, which is under IS, should be included for the maintenance machinery procurement.

Following table summarizes the components and those work contents together with the relevant responsible sectors/ directorates under the ID to implement; namely, there are 8 components in total under the Project. It is noted that the component No.8 ‘Modern On-farm Irrigation’ is divided into 2 sub-components, namely, 1) procurement of the equipment and installment, and construction of the modern on-farm irrigation system, and 2) necessary trainings that the Irrigation Advisory Services under IIS should administer to those farmers who are to introduce the modern on-farm irrigation.

Table 5.1.1 Project Components with Major Work Contents by Prospective Implementing Sector

No.	Component	Contents	Responsible
1	Large Hydraulic Structure Construction (LHSC)	Construction of; 1) Kased Intake, 2) Mahlet Menouf Regulator, and 3) Sorad Regulator.	RGBS
2	Small Hydraulic Structure Construction (SHSC)	Construction of; 1) Beni Hedear Weir of Ibrahimia, 2) intakes of, e.g., Abo Seer, Omar Bek, Bahr El Kasheir, etc., 3) tail escapes, 4) culvert and aqueduct, etc.	IS
3	Hydraulic Structure Rehabilitation (HSR)	Rehabilitation of Hydraulic Structures assessed as S2 including replacement of gates, gate appurtenant.	IS
4	Large Canal Rehabilitation (LCR)	Rehabilitation including canal sectioning and slope protection, and/or partial lining for large canals, e.g., Bahr Yusef and Ibrahimia Principal Canals and Kased Main Canal.	IS
5	Branch Canal Rehabilitation and Lining (BCRL)	Rehabilitation including canal sectioning and concrete lining for the canals other than above, e.g. branch canals, small main canals. Note that concrete lining work is on-going covering around 20,000 km nationwide, so this component will be added to the loan.	IS
6	Water Management Improvement (WMI)	Procurement and installation of water management equipment, and development of visual on-time monitoring system. Note that the system concerning Bahr Yusef and Ibrahimia Command Areas are included in the Project for Construction of the New Dirout Group of Regulators, and therefore, the system here to be introduced in Kased Command Area.	IS
7	Procurement of Maintenance Machineries (PMM)	Procurement of maintenance machineries specifically for the purpose of concrete lined canals, and also machineries required for urgent repairment. Note that periodic and ordinally maintenance works are outsourced to private companies.	General Directorate of Canal Maintenance
8	Modern On-farm Irrigation (MOI) 8.1 Construction 8.2 Organizing &	8.1 Installment of modern on-farm irrigation system composed of sprinkler and drip facilities, including one-lifting pump stations and pipelines, together with the improvement of Meska by means of lining or installation of pipes.	Irrigation Improvement Sector (IIS)

No.	Component	Contents	Responsible
	Trainings	8.2 Organizing of the farmers into WUAs, and trainings to the farmers who introduce modern on-farm irrigation	
9	Project Management (PM)	Procurement of vehicles and office equipment, trainings, monitoring of project progress and evaluation of the project, and establishment of dispute board	IS

Source: JICA Survey Team

5.1.2 Eligible Scope for Yen Loan

The Project is composed of direct works including construction and rehabilitation, procurement of machineries and equipment for maintenance and water management purpose, etc. by its nature. Aside from the so-called direct costs incurred in the components, the project cost should include consultant cost, contingency, taxes, etc. Following table summarizes the major cost items and the prospected items which may be covered by international loans, and items which in most cases have to be covered by the recipient country:

Table 5.1.2 Project Components and Possible Financing Arrangement between Donor and MWRI

No.	Items	Cost Calculation by BOQ, or Rate Applied (%)	Prospective Financier
1	Large Hydraulic Structure Construction (LHSC)	BOQ1	Donor
2	Small Hydraulic Structure Construction (SHSC)	BOQ2	Donor
3	Hydraulic Structure Rehabilitation (HSR)	BOQ3	Donor
4	Large Canal Rehabilitation (LCR)	BOQ4	Donor
5	Branch Canal Rehabilitation and Lining (BCRL)	BOQ5	Donor
6	Water Management Improvement (WMI)	BOQ6	Donor
7	Procurement of Maintenance Machineries (PMM)	BOQ7	Donor
8	Modern On-farm Irrigation (MOI)	BOQ8	Donor
9	Project Management (PM), including Dispute Board	BOQ9	Donor
10	Price Escalation (for construction)	BOQ 10 2.06% for foreign currency portion 4.44% for local currency portion	Donor
11	Physical Contingency for construction	5% of BOQ 1 – 10	Donor
12	Consulting Services (CS), incl. price escalation & physical continency	BOQ12	Donor
13	Interest during Construction	1.70% for construction, 0.01 % for consultant	Donor
14	Front End Fee	0.2%	MWRI
15	Land Acquisition	Not Applicable	MWRI
16	Administration Cost, 1/)	10 % of No.1-13 (indicative)	MWRI
17	VAT, 2/	14.0%	MWRI
18	Import Tax, 3/	Depend on goods (around 5%)	MWRI

Note: 1/ administration cost in most of the projects in Egypt ranges from 10% to 20%, and since there are Project management team (No.9) and consultant team (No.11) in the Project, the administration cost is assumed to be the minimum percentage, namely, 10%.
2/ VAT may apply to both foreign cost and local cost of Direct Cost (No.1 – No.9), Consultant, and Land Acquisition.
3/ Import Tax may apply only to foreign cost of Direct Cost (No.1 – No.9) and Consultant.
Source: JICA Survey Team, Interview to ID of MWRI (No.16), JICA Headquarters (No.10, No.11, No.13, No.14, No.17, No.18)

As above-mentioned, costs directly incurred for the Project may be covered by a donor, either partly or wholly, and in addition such indirect costs as price escalation, physical contingency, consultancy fee as well as interest during construction could also be eligible for loan coverage. On the other hand, in general, MWRI should bear such costs of Front End Fee, land acquisition if any, administration cost, taxes e.g., VAT and import tax, and also interests of the loan.

It Is noted that land acquisition will not be required in the Project. This is because construction works, e.g., replacement of regulators and other structures, are to be implemented within the MWRI's premises, either within canals wherein such structures are to be newly installed, or still within the MWRI's premises which extend some perpendicular length from the shoulder of canals depending on the size of the canals[1].

In case of construction of one-lifting pump station required with the introduction of modern on-farm irrigation, the station will be constructed on a canal side land, which ownership is MWRI, or at a place where Sakya (traditional water wheel lifting device) used to be installed. The land on which the previous Sakya was installed is collectively owned by the concerned farmers, so-called common shared land. Hence, no additional land acquisition will be required under this Project.

5.2 Implementation Modality and Fund Flow Modality by Component

5.2.1 Implementation Modality by Component

To implement the Project components, the best implementation modality should be applied, e.g., direct force account, contractor/ supplier through local competitive bidding, contractor/ supplier through international competitive bidding, direct shopping, etc. One thing noted is that contractors able to undertake large scale hydraulic works are not many as such works have often been implemented by international contractors.

Table 5.2.1 proposes the implementation modality for each of the components, e.g., by local competitive bidding (LCB), international competitive bidding (ICB), and direct force account (DFA). Note that ICB does not exclude Egyptian national contractors as long as the intended contractors' qualifications can meet the required pre-qualification conditions. The table below also proposes the suitable modality of fund flow from the financing body to MWRI (for the fund flow modality, see the discussions in 5.2.2 Fund Flow Modality by Component):

Table 5.2.1 Project Components and Implementation Modality

No.	Component	Implementation Modality	Fund Flow Modality
1	Large Hydraulic Structure Construction (LHSC)	**ICB**	**Transfer**
2	Small Hydraulic Structure Construction (SHSC)	LCB	Advanced
3	Hydraulic Structure Rehabilitation (HSR)	LCB	Advanced
4	Large Canal Rehabilitation (LCR)	LCB	Advanced
5	Branch Canal Rehabilitation and Lining (BCRL)	LCB	Advanced
6	Water Management Improvement (WMI)	LCB	Advanced
7	Procurement of Maintenance Machineries (PMM)	LIB / ICB	**Transfer**
8.1	Modern On-farm Irrigation (MOI-C), Construction	LCB	Advanced
8.2	Modern On-farm Irrigation (MOI-T), Trainings	**DFA (by IAS of IIS)**	Advanced
9	Project Management (PM), including dispute board	**DFA**	Advanced
10	Consulting Services (CS)	**ICB**	Transfer

Note: ICB stands for International Competitive Bidding, LCB stands for Local (national) Competitive Bidding, LIB stands for Limited International Bidding (basically equivalent to ICB procedure but only pre-selected contractors are invited to the bidding), and DFA means Direct Force Account works to be undertaken by the MWRI's capacity.
Source: JICA Survey Team, 2023

In proposing the implementation modality, following were taken into consideration:

1) ICB should be basically applied in relatively large-scale construction works and also procurement of consultants. In this Project, the component of large hydraulic structure construction (LHSC), which undertakes construction of Kased Intake, replacement of Mahlet Menouf Regulator, and replacement of Sorad Regulator all under Kased Main Canal, should be implemented through ICB. It is noted that ICB does not prevent Egyptian national contractors on condition that the potential bidders can meet the qualification requirement.

2) Modern on-farm irrigation under this Project is divided into two sub-components; 1) construction

[1] Although depending on the size and width of the canals, in general, lands with widths of several meters from the shoulder of the canal are owned by MWRI, and in addition from that end, 20m each of both sides are for the sole use of MWRI, a restricted area by other uses.

or installation of necessary facilities for the modern on-farm irrigation, and 2) trainings for the farmers who are to introduce modern on-farm irrigation as this irrigation in the Old Lands is a quite new practice for most of the famers, and this sub-component should include organizing of concerned farmers into the WUA. The Irrigation Advisory Services (IAS) under IIS has been engaged in this kind of activities under IIP and also IIIMP. Therefore, the IAS should be engaged in this training component including organizing of famers, thus this sub-component of trainings should be undertaken by direct force account work (DFA).

3) Concerning No.7 'Procurement of Maintenance Machineries (PMM)', the Survey team recommends to adopt Limited International Bidding, so-called LIB, which is a kind of international competitive bidding but only the pre-selected contractors/ suppliers are to be invited to the bidding. The machineries to be procured should be as durable as possible as they are to be engaged in heavy civil works and also there are some specific machineries, e.g., machineries for canal maintenance, equipment for workshops, which could be provided by only a limited number of manufacturers. Also, engines for heavy machineries should follow a Tier 1 or Tier 2[2] exhaust emission standard, whose machineries are manufactured in, most cases, DAC countries.

4) The other components than above 1) Large Hydraulic Structure Construction (LHSC), 2) Modern On-farm Irrigation (MOI-T), Trainings, 3) Consulting Services (CS), and 4) Procurement of Maintenance Machineries (PMM) will be implemented with many numbers of small-medium scale lots and by engaging lots number of small-medium scale contractors and suppliers. In such cases, international contractors/ suppliers would not be interested in participating the bidding, while national Egyptian contractors and suppliers should be utilized as much as possible, and thus LCB should be applied as long as there are potential contractors and suppliers available within Egypt.

5.2.2 Fund Flow Modality by Component: Transfer and Advance

Fund flow modality should be designed with reference to the implementation modality by component and also from a viewpoint of effective fund disbursement from and accounting to the financier. A Transfer Procedure should be applied for the disbursement on the international procurements (ICB, e.g., large scale construction works and consultant services). On the other hand, an Advance Procedure is recommended for the disbursement of local procurements (LCB) including the direct force account works. Fund flow differs between Transfer Procedure and Advance Procedure, as outlined below, respectively:

1) Transfer Procedure

Procurement and payment under transfer procedure should be made basically in the following manner:

1) Tender for procurement of contractors/ inviting consultants' proposals,
2) Contract signing,
3) Payment Request from contractors/ suppliers/ consultants to the Irrigation Department (ID),
4) Payment Request from the ID to the financier (JICA),
5) Disbursement from the financier (JICA) to the Loan Account of CBE (Central Bank of Egypt) on behalf of the Government of Egypt in Yen with the designated bang (e.g., Bank of Tokyo Mitsubishi UFJ Tokyo (BTMU)), and
6) Payment to the contractors'/ suppliers'/ consultants' account in requested currencies from the Loan

[2] It means the stage I (Tier 1) and stage II (Tier 2) of the exhaust emission standards under the CAA (US Clean Air Act), as revised in 1990. The example of the regulation value is "Tier 1: 0.625g/km (NOx), 2.12g/km (CO), and 0.050g/km (PM), etc.", and "Tier 2: 0.031g/km (NOx), 2.12g/km (CO), and 0.006g/km (PM), etc.".

Account of CBE on behalf of the Government of Egypt.

2) Advance Procedure

Basic arrangements for disbursement under Advance Procedure are:

1) After signing of the Loan Agreement, Designated Account (D/A) denominated in the loan foreign currency (Yen) should be opened with CBE (Central Bank of Egypt), Cairo, after obtaining the approval of Ministry of Finance,
2) Project Operating Account (POA) denominated in EGP (Egyptian Pound) for each Irrigation Directorate where LCB procured works are to be implemented and/or each Sector under ID undertaking specific LCB works should be opened with CBE after opening of D/A. The purpose of opening of POA is to facilitate the payments in EGP to the LCB procured contractors, suppliers, and for expenditures incurred for direct force account works, etc.,
3) ID requests Irrigation Directorates/ Sectors to prepare for financial forecast of expenditure under the Project for the next 2 terms (6 months),
4) ID submits the combined Request for Disbursement to the financier (JICA) on the basis of prepared financial forecast by each of the Irrigation Directorates and Sectors,
5) The financier (JICA) disburses loan proceeds, which are to be transferred to the D/A with CBE through Loan Account (the Borrower's account),
6) ID withdraws the financier (JICA) loan proceeds from the D/A, and transfer to the POAs in EGP to the Irrigation Directorates/ Sectors applying the prevailing exchange rate on the day of withdrawal,
7) Irrigation Directorates and/or Sectors withdraw from the each POA to pay their expenditures for the Project,
8) The statement of expenditure (SOE) and related evidence documents for the payments should be prepared by the relevant Irrigation Directorates/ Sectors and these documents are reported monthly to the ID, and
9) ID prepares monthly report on the above SOE, and then submits it to the financier (JICA). Thus, the Statement of Expenditure (SOE) Procedure could be applied for the Advance Procedure under this Project, which also needs auditing report prepared by a designated auditor who shall be accepted by the financier (JICA).

The advance procedure has merit and demerit in the fund management. The merit of advance procedure is that it enables the ID to manage D/A on behalf of relevant Irrigation Directorates and Sectors under the ID. It is expected to make smooth coordination among the relevant implementing directorates and sectors under the same D/A. On the other hand, to make request for new disbursement, the usage ratio of previous disbursement needs to exceed 70%. If one of the project components were delayed, causing less expenses than 70% in total at the D/A, the next disbursement from the financier (JICA) is also delayed, thus this delay may affect all other works using the same D/A.

3) Funds Flow Management

The funds flow arrangements are diagramed in Figure 5.2.1 below basically divided into 1) Transfer Disbursement and 2) Advance Disbursement, and some explanations to the diagram are given of the following:

✓ ***Transfer Procedure*****:** Contractors and consultants procured through ICB will apply Transfer Procedures, transferring hard currencies such as Japanese Yen, U.S Dollars, Euro and EGP to the accounts of contractors and consultants. This transfer procedure should be applied to Large

Hydraulic Structure Construction (LHSC) and also Consultants Services (SC).

✓ ***Advance Procedure***: Advance Procedure will be used for local procurement such as LCB and DFA. In such cases that there are many numbers of items of procurement or many number of small contracts, transfer procedure from the JICA to many contractors/ suppliers is not practical, so this advance procedure is applied. In this procedure, an advance disbursement is made to the designated bank account of the Project first, from which number of payments can be settled at the discretion of MWRI or otherwise its nominated representative, e.g., head of project management unit (see Figure 5.2.2).

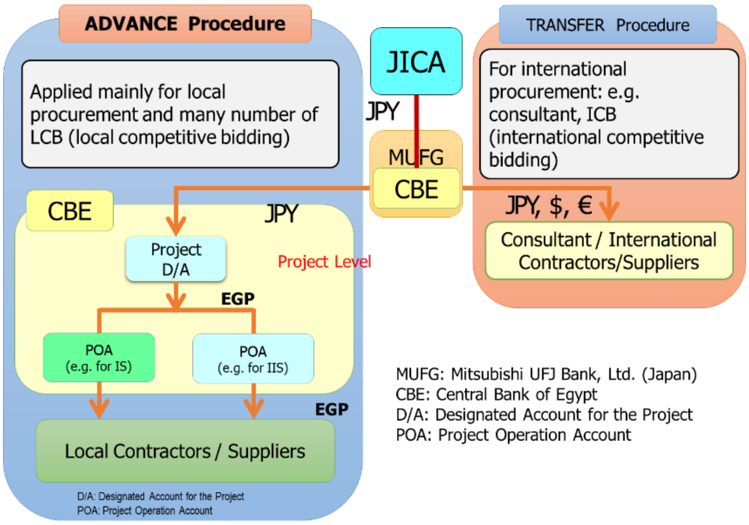


Figure 5.2.1 Funds Flow Arrangements: Transfer and Advance Disbursement

Source: JICA Survey Team

✓ In the Advance procedure, a Statement of Expenditure (SOE) scheme will be introduced to ensure effective control of expenditures and proper reporting to the donor (JICA). This SOE will exempt the implementing agency from submitting documentary evidences of expenditures, subject to an annual audit by a designated auditor approved by the donor (JICA). The SOE system will allow for greater operational efficiency for expenditure management.

✓ For the components of Small Hydraulic Structure Construction (SHSC), Hydraulic Structure Rehabilitation (HSR), and other small scope works, LCB will be firstly envisaged. Its disbursement can be done by Transfer Procedure and also by Advance Procedure with SOE depending on the number of contracts. Number of contracts may be reduced to a manageable level, and in that case, Transfer Procedure or Advance Procedure with SOE can be applied. However, for the sake of smooth and practical payment for the LCB contractors and suppliers, the JICA team recommends the advance procedure in any ways for the LCB.

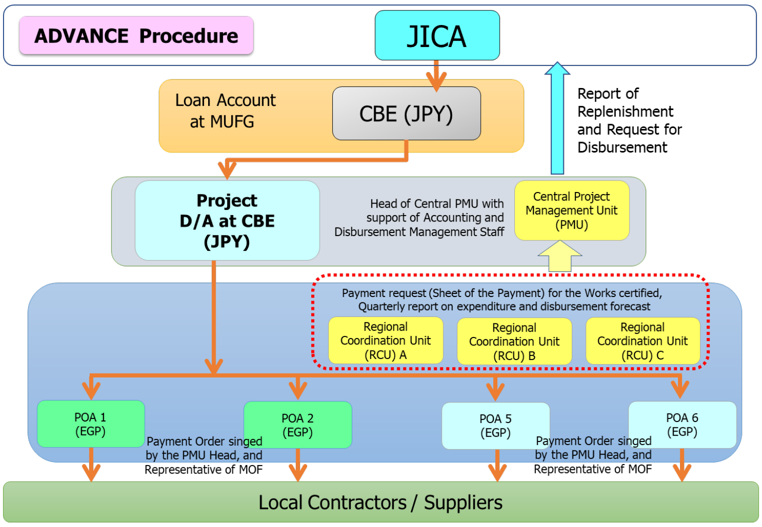


Figure 5.2.2 Schematic Flow of Advance Procedure

Source: JICA Survey Team

5.3 Cost Estimation, Packaging and Possible Scale-up

5.3.1 Basis of Cost Estimation

Undisclosed Information

Undisclosed Information

5.3.2 Project Cost by Component and Total

In estimating the project cost, the following considerations should be made for No. 2 (SHSC) Construction of Small Hydraulic Structures and Mo. 3 (HSR) Hydraulic Structures Rehabilitation, and No. 8 (MOI) Modern On-Farm Irrigation component.

1) Two components, No. 2 (SHSC) Construction of Small Hydraulic Structures and Mo. 3 (HSR) Hydraulic Structures Rehabilitation, will renew or rehabilitate small to medium-sized hydraulic structures within the priority areas (large structures in the Kased Canal Area are considered in the construction of No. 1 (LHSC) Large Hydraulic Structures). As the two priority areas in Upper Egypt (Abo Shasha and Aros & Abo Seer Areas) are very small as compared to the overall Bahr Yusef and Ibrahimia Command Areas, and if similar priority areas exist, these two components should be expanded and implemented in order to improve overall hydraulic conditions of the principal canals' command area.

2) Concerning No.8 (MOI) Introduction of Modern On-farm Irrigation, the Egyptian government is planning to introduce modern on-farm irrigation basically to the entire area except for the lower delta (target of about 4 million feddans). Even excluding the Aros & Abo Seer Area, which is located in the Fayoum Area, the Abo Shosha Area is about 18,000 feddan, while the Kased Area is very large (about 96,000 feddan). In addition, the introduction of modern on-farm irrigation is likely to take time, as it requires agreement from the farmers or farmer groups. Therefore, though the modern on-farm irrigation will cover all of the Project area, the area to be covered by the loan should be small as a starting point, taking into account MWRI's limited experiences in implementing modern on-farm irrigation facilities and the uncertainty of farmers' willingness to reimburse the cost of the facilities.

1) Possible Scale-up for the Priority Sub-region by Sector Loan Approach

The command area of Bahr Yusef and Ibrahimia Principal Canals is divided into total 79 sub-regions[1]. The 79 sub-regions are categorized into 3 levels of priority based on selected indicators as water scarcity, size, canal intensity, structure distribution, MWRI priority for improvement, and water users' formation[2]. Among those 79 sub-regions, total 14 sub-regions are given the 1st priority, and of course, Abo Shosha and Aros & Abo Seer are amongst the 14 first priority sub-regions (see Figure 5.3.1).

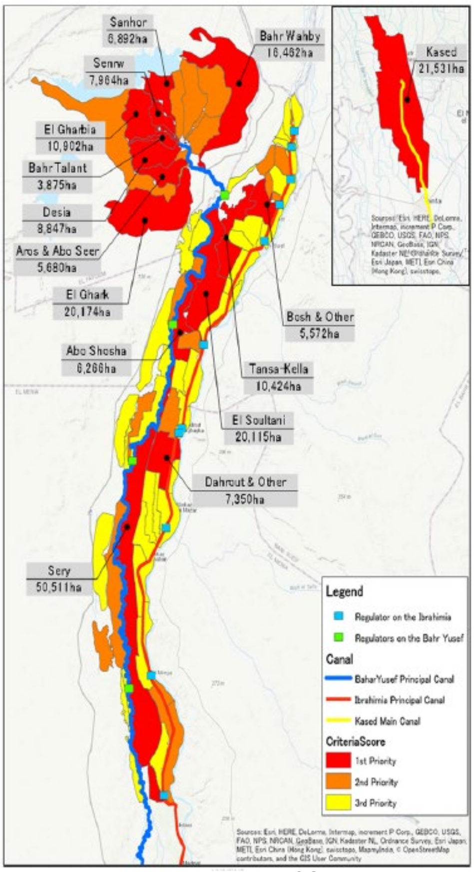


Figure 5.3.1 3 Levels of Sub-region
Source: Cooperation Planning Survey on The Irrigation Sector (Upper Egypt and Middle Delta), February 2018

Table 5.3.1 summarize the command area for the 14 first priority sub-regions, from which we can know whole 14 first priority sub-regions' area is about 15.2 times more than the summed area of Abo Shosha and Aros & Abo Seer. Note that the areas indicated in the Table 5.3.1 are based on MWRI data, same as those indicated in the report of 'Cooperation Planning Survey on The Irrigation Sector (Upper Egypt and Middle Delta), February 2018', and not based on the Team's satellite image analysis result.

Structure improvement is required not only for the priority sub-

[1] The 'sub-region' is defined as follows: an irrigation area, having a certain extent, that is irrigated by an irrigation system consisting of principal-main-branch canals, as well as Meska, Marwa and its command area.
[2] Referred to Table 6.19 (page 6-28) in the report of 'Cooperation Planning Survey on The Irrigation Sector, February 2018'.

regions of Abo Shosha and Aros & Abo Seer but also for the remaining 12 first priority sub-regions. Therefore, by applying a sort of sector approach, necessary cost for the improvement of hydraulic structures is estimated in this section. The target components under this approach are only; 1) Small Hydraulic Structure Construction (SHSC), and 2) Hydraulic Structure Rehabilitation (HSR).

Table 5.3.2 shows the costs for those 2 components only for the 2 priority sub-regions of Abo Shosha and Aros & Abo Seer, and also the estimated aggregated cast required to cover all the 14 first priority sub-regions. Thus, the cost to cover all the 14 first priority sub-regions for the 2 components of 1) Small Hydraulic Structure Construction (SHSC), and 2) Hydraulic Structure Rehabilitation (HSR) comes to 15.2 times of that of only the 2 priority sub-regions.

Table 5.3.1 14 First Priority Sub-regions under Bahr Yusef and Ibrahimia Canals with the Comparison of the 2 Priority Sub-regions

Sub-region	Governorate	Principal Canal	Area, ha*	Remarks
Bahr Wahby	Fayum	Bahr Yusef	16,462	
Bahr Talat	Fayum	Bahr Yusef	3,875	
El Ghark	Fayum	Bahr Yusef	20,174	
Aros & Abo Seer	**Fayum**	**Bahr Yusef**	**5,680**	
Sanhor	Fayum	Bahr Yusef	6,892	
Sery	West Minya	Ibrahimia	50,511	
Tansa-Kella	Beni Suef	Ibrahimia	10,424	
El Gharbia	Fayum	Bahr Yusef	10,902	
Senrw	Fayum	Bahr Yusef	7,964	
Desia	Fayum	Bahr Yusef	8,847	
Dahrout & other	East Minya	Ibrahimia	7,350	
Abo Shosha	**Beni Suef**	**Ibrahimia**	**6,266**	
El Soultani	Beni Suef	Ibrahimia	20,115	
Bosh and other	Beni Suef	Ibrahimia	5,572	
Total Area (a)			181,034	
Abo Shosha + Aros & Abo Seer (b)			11,946	
Ratio (a/b)			**15.2**	

Note: */ the areas are from MWRI records, referred in Cooperation Planning Survey on The Irrigation Sector (Upper Egypt and Middle Delta), February 2018.
Source: Cooperation Planning Survey on The Irrigation Sector (Upper Egypt and Middle Delta), February 2018.

Table 5.3.2 Cost for Abo Shosha and Aros & Abo Seer, and Aggregated Cost for the 14 First Priority Sub-regions under Bahr Yusef and Ibrahimia Canals

Sub-region	Area, ha*	Cost, EGP	Multiplied by 15.2 (EGP)	Multiplied by 15.2 (US$)
Abo Shosha	6,266			
Small Hydraulic Structure Construction (SHSC)		6,942,315	105,523,188	4,328,269
Hydraulic Structure Rehabilitation (HSR)		3,796,466	57,706,283	2,366,952
Aros & Abo Seer	5,680			
Small Hydraulic Structure Construction (SHSC)		17,485,335	265,777,092	10,901,439
Hydraulic Structure Rehabilitation (HSR)		828,040	12,586,208	516,251
Abo Shosha + Aros & Abo Seer (b)	11,946			
Small Hydraulic Structure Construction (SHSC)		24,427,650	371,300,280	15,229,708
Hydraulic Structure Rehabilitation (HSR)		4,624,506	70,292,491	2,883,203
Total Area of the 14 First Priority Sub-regions (a)	181,034			
Ratio (a/b)	15.2			

Note: */ the areas are from MWRI records, referred in Cooperation Planning Survey on The Irrigation Sector (Upper Egypt and Middle Delta), February 2018.
Source: JICA Survey Team

2) Scale of Development on the No. 8 (MOI) Introduction of Modern On-farm Irrigation.

The total area of the priority sub-regions, excluding the Aros & Abo Seer located in Fayoum Governorate, is about 114,000 feddan. The modern on-farm irrigation system consists of pumps to lift water from the canals, pipelines to deliver the pumped water to the farms, and on-farm facilities such as drip and sprinkler systems to irrigate the fields.

In the case of farmers located close to waterways, e.g., secondary canals and Meska, it is possible to conduct the modern on-farm irrigation without laying pipelines. In other words, modern on-farm irrigation can be achieved by pumping water and then directly connecting it to drip and sprinkler pipes (such as Lateral Tubes) installed within the farms. In this case, it would not be necessary to bear the costs of the pipelines that account for about half of the system.

However, if many of the above situations occur, farmers who own farmland in remote areas or somewhat far from waterways will have to bear the cost of pumps and pipelines with fewer member of farmers. As a result, the cost per farmer will increase, and this may prevent those farmers from agreeing to the introduction of modern on-farm irrigation facilities, except in the vicinity of waterways.

The introduction of modern on-farm irrigation facilities will basically be by a loan, i.e., farmers will be required to reimburse the loan over 10 years decided as of 2022. However, since the exemption of interest rates has been agreed upon by the relevant authorities, and in view of the inflation in Egypt (the annual inflation rate for 2022 is 7.3-16% by month), there could be a consensus that the project will be implemented as a public utility. Therefore, it is desirable to develop the system including pipelines in the project area as much as possible in terms of fair burden among the beneficiary farmers.

Modern on-farm irrigation facilities, including pipelines, cost about 58 thousand EGP per feddan in the construction cost alone. Using this unit cost, the overall cost would be very large (6.8 billion EGP, 281 MUS$, or 37.9 billion yen), as shown in the table below. In addition, as mentioned above, the introduction of modern field irrigation facilities requires an agreement from the farmers, so the Team believes that financing should be considered on a smaller scale in the first phase. With this, suitable financing for the modern on-farm irrigation introduction is examined below:

- ✓ The areas where it is easy to confirm the water-saving effect should be those where the lining of branch canals has already been completed, i.e., where irrigation water can be distributed to Meska as appropriate and on-time. Modern on-farm irrigation would not have a sufficient impact unless irrigation water is distributed to the branch canals and Meska in a timely manner as a prerequisite for the introduction.
- ✓ Although it varies from area to area, about 10-40% of the branch canals have already been lined with concrete. Therefore, the direction of introducing modern on-farm irrigation facilities is to; 1) select the areas that have already completed lining of branch canals and are on track for sound water distribution (region-based selection), and 2) encourage upstream farmers to introduce modern on-farm irrigation to ensure better water supply to the downstream farmers (canal system-based selection).
- ✓ The National Water Resources Plan (NWRP) projects water demand and supply for the target year of 2037. To obtain the amount of water needed in 2037 by conserving water for agricultural use, an increase of about 14% in irrigation efficiency would have to be achieved. To achieve the 14% increase in irrigation efficiency, it will be necessary to introduce modern on-farm irrigation facilities to 40% of the farmlands (see 4.1.3 Target Irrigation Efficiency and Direction of Irrigation Improvement). In other words, as 40% of the area is required to equip modern on-farm irrigation for the 2037 target year, it could be sufficient to introduce modern on-farm irrigation facilities to around half of the area (about 20%) till 2028-2030, the year when the project is expected to be completed.
- ✓ The introduction of modern on-farm irrigation facilities is not a step-by-step process, and once the facilities are introduced in a particular farmland area, the area will be complete. Therefore, when considering a phase-wise investment, it is desirable to consider the area scale from the viewpoint of how much area should be introduced to have a ripple effect on the region and to further extend the system within the region.

- ✓ Since modern on-farm irrigation is still an advanced technology for ordinary farmers (especially in poor areas such as Upper Egypt), it could be implemented on a pilot basis in selected areas where it is feasible to introduce the technology and where water-saving effects can be easily confirmed. In other words, the first phase of the introduction of modern on-farm irrigation could start on a small scale as a pilot project, and then gradually expand as results are observed in the pilot areas.

Based on the above, the Team proposes two cases for this introduction of modern on-farm irrigation: 1) introduction of modern on-farm irrigation facilities in at least 10% of the total target area, or at most 20%, based on the assumption that a certain degree of effectiveness will be achieved, or 2) introduction of modern on-farm irrigation facilities on a pilot basis in selected small-scale areas by Meska base. The scale of these two cases is presented below, and the former case which can produce a certain impact as project is taken as the base case:

2.1) Case of installing modern on-farm irrigation facilities on 10-20% of the priority area: Base Case

The bottom row of the table below shows the cost of installing modern on-farm irrigation facilities on 10% and 20% of the area. The introduction of modern on-farm irrigation is one of the national priorities and will be funded by the Egyptian national budget as well, and farmers will be required to reimburse the loan over a period of 10 years after completion of the facilities. It means that it will be possible to expand to the next stage in a revolving manner. Thus, in this case, the Team proposes that the loan could be enough to cover 10% of the area. In other words, the total loan amount for the introduction of modern on-farm irrigation facilities would be approximately 3.8 billion Yen in direct cost. This should be the base case adopted in, e.g., project economic evaluation.

Table 5.3.3 Examination on the Scale of Modern On-farm Irrigation System (10% - 20% to be covered by Modern On-farm Irrigation Except for Fayoum Area)

No.	Sub-component	Area	EGP	US$	Yen
8.1	Construction of MOI, 3 Sub-regions, feddan	127,187	6,711,513,000	275,288,000	37,114,666,000
8.2	Organizing and Training, 3 Sub-regions	feddan	134,230,000	5,506,000	742,293,000
8.11	Construction of MOI, Abo Shosha (Beni Suef)	17,881	1,054,029,000	43,233,000	5,828,779,000
8.21	Organizing & Training, Abo Shosha (Beni Suef)	feddan	21,081,000	865,000	116,576,000
8.12	Construction of MOI, Abo Seer (Fayoum)	-	Modern On-farm Irrigation Not Introduced		
8.22	Organizing & Training, Abo Sheer (Fayoum)	feddan	Ditto		
8.13	Construction of MOI, Kased (Gharbia, Kafr El Sheik)	95,976	5,657,484,000	232,054,000	31,285,887,000
8.23	Organizing & Training, Kased (Gharbia, K. El Sheik)	feddan	113,150,000	4,641,000	625,718,000
	Total of Above		6,845,743,000	280,793,000	37,856,959,000
	Targeting 10% of the Area	11,386	684,574,000	28,079,000	3,785,696,000
	Targeting 20% of the Area	22,771	1,369,149,000	56,159,000	7,571,392,000

Note: Number in the table corresponds to the component number (refer to Table 5.3.5). Also, the above costs do not include Dispute Board costs (Table 5.3.5 includes Dispute Board costs).
Source: JICA Survey Team

2.2) Case of pilot implementation of modern on-farm irrigation facilities in a selected Meskas: Reference Case

This case is examined as a reference case. In this case, a modern on-farm irrigation facility will be installed on a pilot basis on a small area. The standard Meska would cover about 100 feddan. The size of a standard modern on-farm irrigation facility is assumed to be about 30 feddan (see 4.9.5 Specifications and Costs of Typical Modern On-farm Irrigation Facilities). Thus, if the introduction of modern on-farm irrigation facilities is planned for a whole Meska, about 3 units of standard modern on-farm irrigation facilities will be constructed per Meska.

When implemented as a pilot, it is necessary to demonstrate the effectiveness of the modern on-farm irrigation system to a large number of farmers. Therefore, in Abo Shosha and Kased priority areas, Meska will be selected from upstream, midstream, and downstream, respectively, and about three units of modern on-farm irrigation facilities will be installed in each Meska. In the Abo Shosha area, one Meska will be selected for each of the upstream, midstream, and downstream areas due to its small command area, and in the Kased area, three Meskas will be selected for each of these areas due to the large command area of Kased Main Canal. Thus, 270 feddan (30 x 3 Meska x 3 units) in the former and 810 feddan (30 x 3 areas x 3 Meska x 3 units) in the latter, for a total of 1,080 feddan in both areas, will be under for the modern on-farm irrigation facilities on a pilot basis.

In the pilot implementation of modern on-farm irrigation facilities, a solar system could be installed in addition to the regular diesel engine-pump system, subject to government contribution. The solar system would require about 67,370 LE/feddan for solar panels, motor pumps, and ancillary facilities alone (see Table 4.9.19). In addition, a complete set of modern on-farm irrigation facilities operated by diesel engine system would be required, which cost comes to about 58,947 LE/feddan (an average of Drip irrigation system of 59,950 LE/feddan and Sprinkler irrigation system of 57,943 LE/feddan). As a result, the pilot implementation of a modern on-farm irrigation facility with the addition of a solar system is expected to have the following scale. The direct cost would be approximately 770 million Yen.

Table 5.3.4 Pilot Installation of Modern On-farm Irrigation Facilities (including Solar System)

No.	Sub-component	Area	EGP	US$	Yen
8.1	Construction of MOI, 3 Sub-regions, feddan	1,080	136,422,000	5,596,000	754,416,000
8.2	Organizing and Training, 3 Sub-regions	feddan	2,728,000	112,000	15,088,000
8.11	Construction of MOI, Abo Shosha (Beni Suef)	270	34,106,000	1,399,000	188,604,000
8.21	Organizing & Training, Abo Shosha (Beni Suef)	feddan	682,000	28,000	3,772,000
8.12	Construction of MOI, Abo Seer (Fayoum)	13,330	Modern On-farm Irrigation Not Introduced		
8.22	Organizing & Training, Abo Seer (Fayoum)	feddan	Ditto		
8.13	Construction of MOI, Kased (Gharbia, Kafr El Sheik)	810	102,317,000	4,197,000	565,812,000
8.23	Organizing & Training, Kased (Gharbia, K. El Sheik)	feddan	2,046,000	84,000	11,316,000
	Total of Above		139,151,000	5,708,000	769,504,000

Note: Number in the table corresponds to the component number (refer to Table 5.3.6). Also, the above costs do not include Dispute Board costs (Table 5.3.6 includes Dispute Board costs).
Source: JICA Survey Team

3) Estimated Project Cost (Sector Approach, Scaling Down of Introduction of Modern On-farm Irrigation Facilities)

Undisclosed Information

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5.3.3 Project Packaging by Component

Packaging for the components should be made by taking into account the following points, based on which packaging is recommended as shown in Table 5.3.7. It is noted that packaging here means an expected bidding lot volume for the implementation of each component works.

- ✓ Work volume should not be so small for the potential bidders to be interested while, at the same time, should not be so large which may go beyond the capacity of potential bidders. With this point, the Large Hydraulic Structure Construction (LHSC), which is planned under ICB, is recommended to be one-package, which can attract international bidders who have enough experiences for similar works.
- ✓ There are 2 more components to be implemented under ICB; 1) Procurement of Maintenance Machineries (PMM), and 2) Consulting Services (CS). The former component should be implemented by one-package considering the cost size, and the latter (consulting service) is no doubt by one-package considering the nature of the services.
- ✓ Water Management Improvement (WMI), targeting the Kased Irrigation Area, should also be implemented by one-package due to the scope which covers only one area, that is Kased Area, and also taking into account the volume of the works.
- ✓ The works for such 4 components of Small Hydraulic Structure Construction (SHSC), Hydraulic Structure Rehabilitation (HSR), Large Canal Rehabilitation (LCR) and Branch Canal Rehabilitation and Lining (BCRL) are to be implemented in different places, e.g., by 3 priority sub-regions, or by big canal e.g., Bahr Yusef Principal Canal, Ibrahimia Principal Canal and also Kased Main Canal, and also by branch canal basis. Works in a sub-region or along a canal may be small in the scale, yet, to provide opportunities to local contractors, the packaging for those 4 components is recommended to divide by area or canal.
- ✓ The component of 'Modern On-farm Irrigation (MOI-C), Construction' is implemented over wide areas, and therefore there should be many packages. The JICA Survey Team recommends one package should be in line with the command area by one Meska. Though the command area by one Meska varies very much from one place to another, a typical example of Meska in Kotor district under Gharbia directorate covers an average area of 120 feddans. With a rough cost of 1-feddan modern on-farm irrigation system being 60,000 EGP, the cost covering 120 feddans comes to 7 million EGP, which could be good enough to attract potential contractors/ suppliers. However, as the total number of packages is approximately 95, it could be possible to reduce the number of packages by ordering several Meska areas at once, taking into account the initial construction situation and the capabilities of the contractor.

Table 5.3.7 Project Packaging by Component (Expected Bidding Lot Volume)

No.	Component	Implementation Modality	Recommended Packaging	Remarks
1	Large Hydraulic Structure Construction (LHSC)	ICB	1	By one package covering Kased Intake, M. Menouf, and Sorad
2	Small Hydraulic Structure Construction (SHSC)	LCB	3	By sub-region (total 3 sub-region)
3	Hydraulic Structure Rehabilitation (HSR)	LCB	3	By sub-region (total 3 sub-region)
4	Large Canal Rehabilitation (LCR)	LCB	3	By area (Bahr Yusef, Ibrahima, and Kased)
5	Branch Canal Rehabilitation and Lining (BCRL)	LCB	37	21 for Abo Shosha + 6 for Aros & Abo Seer) + 10 for Kased Area＊
6	Water Management Improvement (WMI)	LCB	1	-
7	Procurement of Maintenance Machineries (PMM)	ICB/LIB	1	-

No.	Component	Implementation Modality	Recommended Packaging	Remarks
8.1	Modern On-farm Irrigation (MOI-C), Construction	LCB	About 95 By Meska**	10% of 2 priority areas: 11,386 feddan, one Meska covers 120 feddan
8.2	Modern On-farm Irrigation (MOI-T), Training	DFA (by IAS of IIS)	NA	-
9	Project Management (PM), including dispute board	DFA	NA	-
10	Consulting Services (CS)	ICB	1	-

Note: */ These numbers show the number of branch canals by the sub-region. **/ The area of the two priority sub-regions will be 113,857 feddan, consisting of 17,881 feddan (Abo Shosha) and 95,976 feddan (Kased). The project plans to install modern field irrigation facilities in 10% of these areas. In other words, 11,386 feddan divided by 120 feddan will be about 95 packages.
Source: JICA Survey Team

5.4 Implementation Schedule by Component, and Overall Schedule

Undisclosed Information

Undisclosed Information

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5.5 Institutional Setup for Project Implementation

This section discusses the project implementation arrangement including the responsible agency's capacity including current organizational set-up, human resources and also similar project experiences. To implement the Project, there should be a project management unit to be established at the central MWRI level in charge of overall project supervision and, in addition, regional level offices in charge of day-to-day project implementation activities.

5.5.1 Organizations Concerned for Project Implementation

The responsible organization of the project implementation is ID, and there are 3 sectors/sections which directory in charge of project implementation namely, Irrigation Affairs Sector (IS), Irrigation Improvement Sector (IIS) and Reservoirs and Grand Barrage Sector (RGBS).

The Irrigation Affairs Sector, a main sector of the ID, has so far implemented construction, improvement and rehabilitation of irrigation and drainage projects, whose duties are very compatible with the Project. As the public works, which have been implemented by the Irrigation Affairs Sector, are comparatively large, the number of personnel and the amount of its budget are larger than those of other sectors of ID.

The organization structure of the IS is given of the following, and as it is indicated, there are regional offices under each of the central directorates. The regional office is called General Directorate of Water Resources and Irrigation directly under the Irrigation Affairs Sector. There are 29 regional offices of General Directorates of Water Resources and Irrigation nationwide, which are to be the responsible organization of the project implementation at the regional level (see Figure 5.5.1).

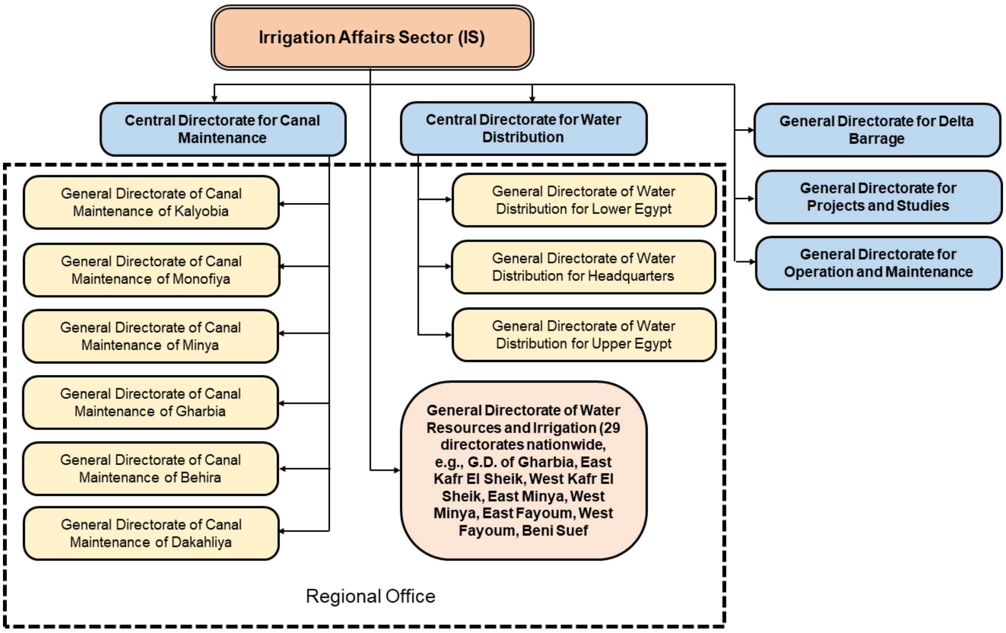


Figure 5.5.1 Organization of Irrigation Affairs Sector (IAS, or usually shortened as IS)

Source; MWRI Home Page

Irrigation Improvement Sector (IIS) is also comparative to implement the Project in the field of dealing with beneficiary farmers, e.g., establishment of Water Users' Associations(WUAs). The IIS is composed of 2 main central directorates, each of which has regional offices, called general directorate of either irrigation improvement or irrigation advisory services respectively (see Figure 5.5.2). Irrigation Advisory Services will be directly in charge of organizing farmers into WUA, which is to be in charge of operating and managing the modern on-farm irrigation system.

During the project implementation, the IIS may have to employ contract basis field staff who should be in charge of organizing the farmers, registering the WUAs, obtaining the consensus for the introduction of modern on-farm irrigation system, as well as trainings of teaching how to operate the drip and/or sprinkler system. The modern on-farm irrigation system is operated by a centralized one-lifting pump stations covering 10 to maximum 30 feddans, and thus the farmer members within the WUA should be well organized and expected to work collectively. In this sense, the role of IIS is very much important.

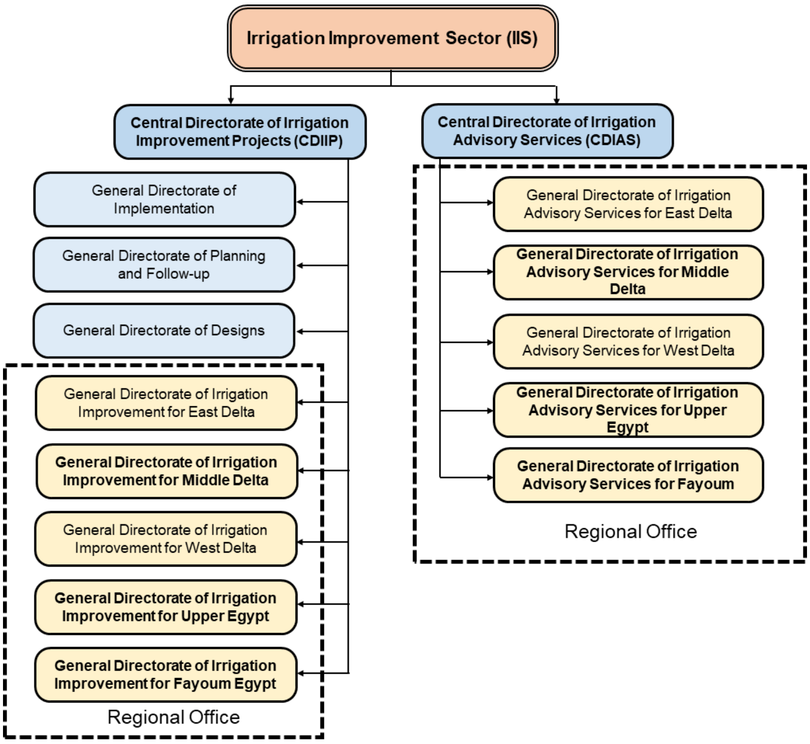


Figure 5.5.2 Organization of Irrigation Improvement Sector (IIS)
Source; MWRI Homepage

Figure 5.5.3 shows the organizational chart of RGBS, which will be in charge of the construction of Kased Intake, Mahlet Menouf and Sorad Regulators which are to be constructed all on the Kased Main Canal. RGBS has 4 central directorates at the headquarters level, and deploys operation offices at the places of major barrages such as Esna, Nagaa Hamady, Assuit, and Delta Barrages.

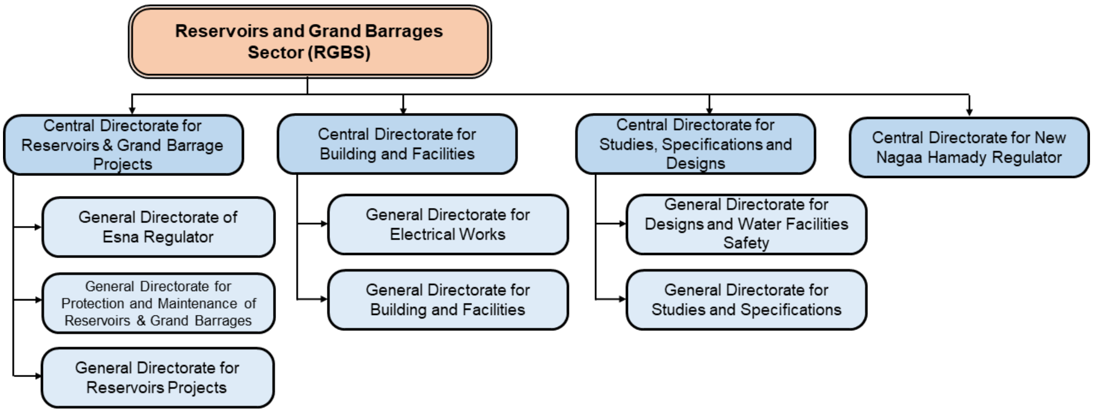


Figure 5.5.3 Organization of Reservoirs and Grand Barrages Sector (RGBS)
Source; MWRI Homepage

As aforementioned, Irrigation Affairs Sector (IS) deploys regional offices called General Directorate of Water Resources and Irrigation. The organizational set up and staff allocation vary from directorate to directorate depending on the scale of the existing irrigation systems that they have to operate and maintain day to day. However, as an example, the structure of the General Directorate of Water Resources and Irrigation for Gharbia, which is in charge of most of the Kased Command Area, can be illustrated as follows (see Figure 5.5.4):

The general directorate further deploys local offices called Irrigation District as above shown, which is the frontline office of the daily operation and maintenance of the irrigation systems within their jurisdictional area. As an example, one irrigation district office may have 100 personnel staff, and therefore if there are 6 district offices, like Gharbia, there could be about total 1,000 staff including the staff stationed at the head office of General Directorate.

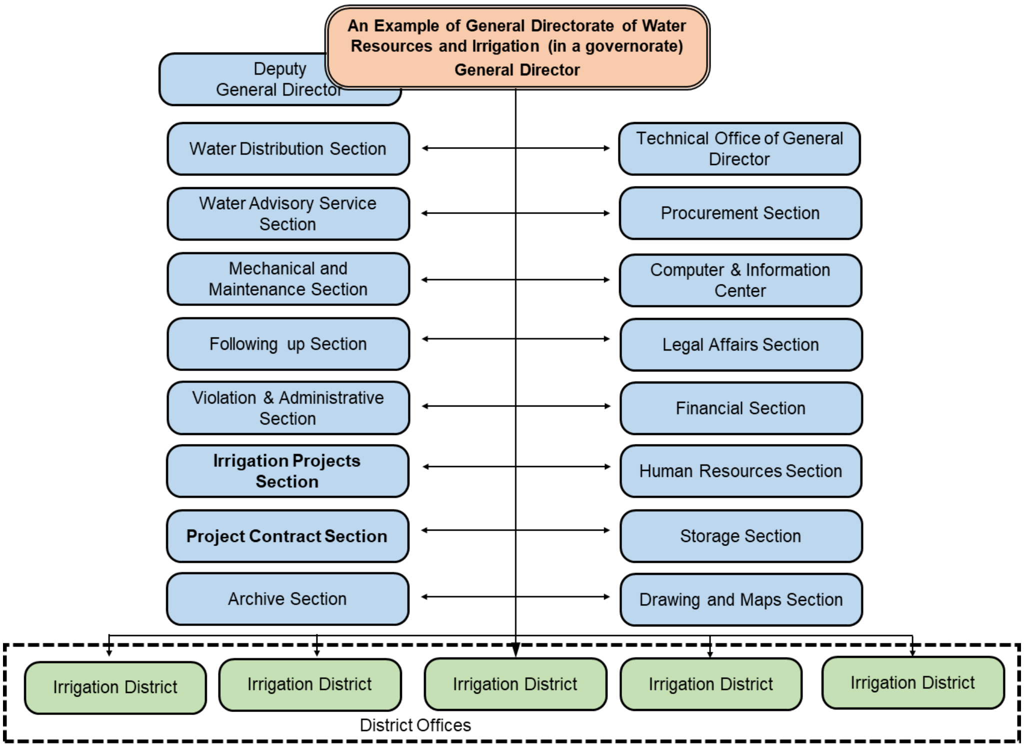


Figure 5.5.4 Example of Organizational Set-up of General Directorate of W.R. and Irrigation

Source; Interviewed to General Directorates by JICA Survey Team

5.5.2 Relevant Experiences by MWRI

MWRI has accumulated similar project experiences to those ones planned under this Survey. The following table shows only major experiences related to the planned project. These projects have been implemented without major problems albeit there were some delays against the implementation plans due to the political upheaval in 2011, prolonged negotiations with stakeholders donors, consultants and contractors, etc.

The first three projects have been implemented by RGBS, MWRI, for construction of large-scale regulators or barrages. With reference to those similar works, it can be judged that MWRI has enough capacity to manage the construction works planned for the 3 large structures on the Kased Canal, e.g., Kased Intake, Mahlet Menouf Regulator and Sorad Regulator. In fact, the work volumes required for the 3 structures are all smaller than those ones listed in the table below.

Concrete lining works on branch canals targeting as long as 20,000km had started in 2020 by the government initiative, and is now on-going as of 2022 with state budget and fully supervised by MWRI. Though the following table does not show any new construction and/or rehabilitation for small-medium sized structures, Irrigation Directorate offices have been undertaking those works as per the need. Therefore, new construction and rehabilitation works for small-medium structures planned under this Survey can be managed by MWRI.

MWRI has so far implemented, with an assistance from donors such as the World Bank, KfW, etc., Meska improvement projects. The Meska improvement projects listed in the table have included installation of pipeline Meska, which provides an outlet at each and every farm plot. Therefore, it can be said that MWRI has similar work experiences to establish one-lifting pumping station and pipelines in order to operate modern on-farm irrigation facilities. Yet, MWRI does not have experiences, except for pilot basis, on the installation of modern on-farm facilities such as sprinkler and drip. For this, there should be a technical input from the loan consultant.

Table 5.5.1 Similar Project Experiences by MWRI

Project	Major Works	Year	Appr. Cost
1) The Construction of New Dirout Group of Regulators and Improvement of Water Management Project	Regulator Construction	2021-2027 (RGBS)	6.5 billion Yen (JICA Loan)
2) New Assuit Barrages Project	Regulator Construction	2012-2018 (RGBS)	430 M.Eur (KfW)
3) Rehabilitation of Dahab, Sakoula, Mazoura, Lahoun Regulators (total 4 regulators)	Regulator Construction	1993 – 2010 (IIS)	21-25 M.US$ per regulator
4) Branch Canal Concrete Lining (Target 20,000km in 4 years), by state budget	Branch Canal Lining	2020- On-going (IS, HEPS, IIS, RGBS)	7,000km at 17.5 B.EGP (2020-21), 1,200km with 4 B.EGP (2022)
5) Irrigation Improvement Project (IIS), IIP1	Mesk Improvement	1996-2006 (IIS)	182 M.US$
6) Integrated Irrigation Improvement Management Project (IIIMP)	Meska Improvement	2007-2016 (IIS)	300 M.US$ (WB, KfW)

Note: RGBS stands for Reservoirs and Grand Barrage Sector, IIS (Irrigation Improvement Sector), IS (Irrigation Affairs Sector), HEPS (Horizontal Explanation Sector)
Source: MWRI

5.5.3 Responsible Implementation Body at Central and Regional Levels

As the Project involves several components related to different sectors and sections under MWRI, there should be a Steering Committee (SC) at the MWRI central level, which should be in charge of directing the project towards the achievement of the project purpose. Under the SC, there should be the Project Management Unit (PMU) which has the responsibility of leading all the project components to the successful completion working together with the management units established at the regional level, e.g., at Tanta for the implementation of Kased related components and at Beni Suef for Bahr Yusef and Ibrahimia Command Area related components (see Figure 5.5.5).

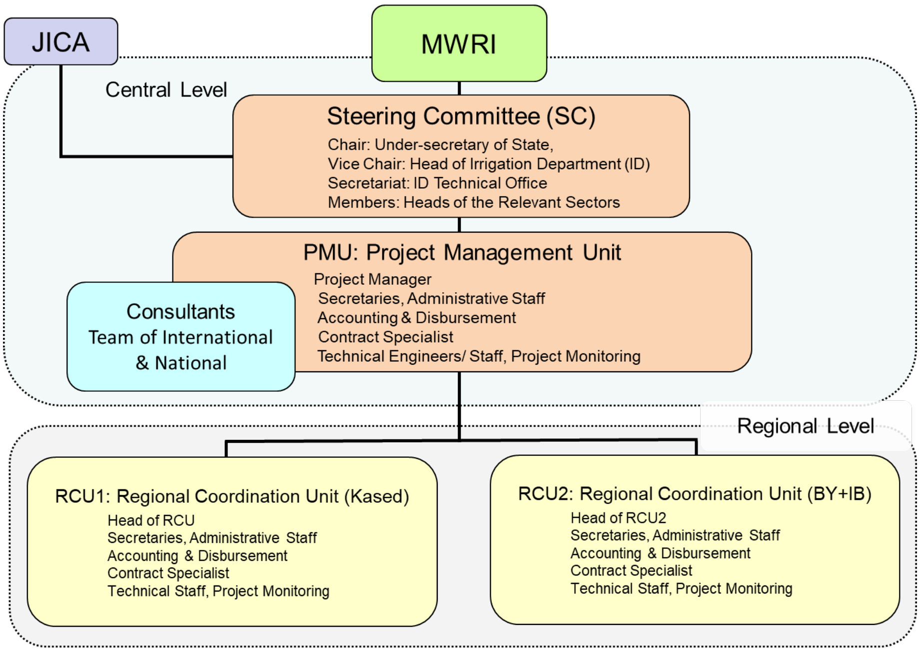


Figure 5.5.5 Institutional Arrangement of Project Implementation
Source: JICA Survey Team

1) Steering Committee

It is recommended that the Undersecretary of State of MWRI takes the SC Chairpersonship, and the Head of Irrigation Department (ID) would play its coordinating role, as Vice Chair. Under the Chair and the Vice chair, the ID Technical Office takes the secretariat in the SC. All the communication with JICA, especially on procurement and disbursement procedures, needs to be done in the name of Chairperson or by dully designated appropriate official, for instance, Head of the ID, and the Project Manager of the PMU. It is proposed that SC members should include the heads of key sectors/ sections under the MWRI, and expected establishment is as follows:

1) Chairperson: Undersecretary of the State
2) Vice Chairperson: Head of the Irrigation Department (ID)
3) Secretariat: Technical Office of ID
4) Head of Egyptian Authority of Drainage Project (EPADP)
5) Head of Planning Sector
6) Head of Irrigation Sector
7) Head of Irrigation Improvement sector
8) Head of Central Directorate for Requirements and Foreign Funding
9) Head of Central Directorate for Water Distribution
10) Mr. Eng./ Head of Central Directorate for Canal Maintenance
11) Head of Central Directorate for Irrigation in Minya
12) Head of Central Directorate for Irrigation in Beni Suef
13) Head of Central Directorate for Irrigation in Fayoum
14) Head of Central Directorate for Irrigation in Gharbia

With the foregoing, the SC is to facilitate smooth project implementation through proper allocation of the state budget, control of budget expenditures, and provision of necessary guidance. The SC has responsibility and authority on all activities such as project policy planning, coordination between sectors/sections, supervision at the central level. Also, SC has the authority to supervise financial and accounting of the Project as well in order to secure sufficient financial resources and appropriate payment for smooth project implementation.

2) Project Management Unit (PMU and RCU): Central and Regional

PMU will be established at the central level, within MWRI head office in Cairo, and also at regional level. The PMU established at regional level is called Regional Coordination Unit (RCU) under this Project, and it is proposed to establish two RCUs as one at Tanta responsible for project frontline implementation for the components related to Kased Command Area, and one at Beni Suef for the frontline implementation for all the components related to Bahr Yusef and Ibrahimia Principal Canals including those command areas, i.e., Abo Shosha and Aros & Abo Seer priority areas.

PMU members should be recruited and assigned out of the current officers/ staff according to their similar past experiences, and expected to be full engagement during the project implementation. Of course, ad-hoc (part time) assignments may additionally be considered during, e.g., implementation busy periods and also according to the progress of the implementation in order to supplement the full engaged PMU members.

The PMU should be assisted by a team of consultants, composed of international and national experts. The consultant team should be in charge of detail design with necessary topo-survey, geo-survey as per the requirement, preparation of tender documents, assistance for the project owner, the MWRI, through the tender and negotiation procedure, and also supervision of constructions and procurement under the Project. The consultant team should be based just beside the PMU to make day-to-day communication smoothly with the PMU.

As have been the cases previously implemented, the PMU at the central level is tasked with overall project management and monitoring inclusive of fund flow/ disbursement in addition to detail design, tender documents production and bidding, procurement of contractors and suppliers, etc. The Head of the PMU has the responsibility and authority for overall activities to ensure smooth progress of the Project during the implementation period. Under the supervision and control of the PMU, the RCU is responsible for managing and monitoring day-to-day implementation of the Project at the frontline field level. Within the PMU and RCU, following staff are expected:

Table 5.5.2 Proposed Staffing of PMU and RCUs

Expertise	PMU (Central)	RCU (Kased)	RCU (BY & IB)
Head	1	1	1
Secretary	2	1	1
Administration	5	3	3
Accounting & Disbursement	4	2	2
Contract Specialist	3	1	1
Technical Engineer	3	2	2
Technicians	3	2	2
CDIAS* (WUAs)	1	10	10
Project Monitoring	2	1	1

Note: */ CDIAS stands for Central Directorate of Irrigation Advisory Services
Source: JICA Survey Team

In dealing with disbursement from JICA, procurement of contractors/suppliers under ICB, and reporting to JICA, there are important issues for the staff to be aware, who are accounting & disbursement staff especially related to advance procedure, contract specialist, and project monitoring staff as follows:

1) Accounting & Disbursement; RCU staff engaged in accounting & disbursement take responsibility of managing the accounting and disbursement status and internal procedure based on the activities at the field level, and reports to the central PMU accounting & disbursement staff. They shall be well aware of eligible and non-eligible items for the financing under the loan, and the disbursement procedure which includes financial forecast, summary of payment or evidence of each payment to request next disbursement, etc.

2) Procurement of Contractors/ Suppliers under ICB: Contract specialist must be aware of the contents of JICA's procurement guidelines when the PMU is to procure contractors or suppliers under international completive bidding (ICB). Should there be discrepancies between the ministry's regulation and the JICA guideline, in principle, the latter should be prevailed. In case of local competitive bidding, PMU would follow the MWRI's procurement regulation.

3) Project Monitoring staff; this staff monitors the project progress especially in compiling the Project Status Report (PSR) which should be submitted once in every 3 months to JICA. The PSR must be compiled and submitted to JICA within 1 month after the end of every quarter until the project completion, and also the staff should prepare for the project completion report to be submitted to JICA not later than 6 months after all the activities have been completed.

5.6 Post-project Operation, Maintenance and Management

The General Directorate of Water Resources and Irrigation, a regional office of MWRI, will be responsible for the daily operation and maintenance of the hydraulic facilities to be rehabilitated and/or constructed under the Project. The maintenance equipment to be procured under Component No.7 will be undertaken by the Central Directorate for Canal Maintenance located in the cities of Tanta and Minya. Irrigation Advisory Service under the Irrigation Improvement Sector (IIS) will be in charge of modern on-farm irrigation facilities. However, since the modern on-farm irrigation facilities are owned by farmers, the IIS is primarily responsible for providing technical assistances to the farmers.

5.6.1 Operation and Maintenance of Hydraulic Structures

As mentioned above, the General Directorate of Water Resources and Irrigation is responsible for the daily operation and maintenance of hydraulic structures in each of the regional irrigation jurisdictions. Since many of the individual hydraulic structures are scattered throughout the irrigation areas, Irrigation Districts have been established as front-line offices to manage them accordingly. In the case of Gharbia

Governorate, there are six district offices, each with about 100 employees. Of these 100 employees, most are gatekeepers who operate the gates on a daily basis and technical staff who monitor the canal conditions.

With the exception of the Kased Intake, the main contents of this Project are rehabilitation and/or renewal of existing structures. In the case of new or renewal of gates, the gate type selected is the F.H. (Fahmy Henen) that has been used in the past, and the regional technical staff are already familiar with the handling of such gates. Till now, when a gate did not operate satisfactorily due to aging, etc., a chain block was sometimes installed additionally and a lot of labor works was required to lift the gate. However, after the implementation of the Project, it will be possible to operate the gate using the gate handle.

Therefore, it is judged that the operation and maintenance of the structures to be renewed and/or rehabilitated under the Project can be adequately managed by the current system, i.e., the General Directorate of Water Resources and Irrigation and its regional offices, i.e., Irrigation Districts.

5.6.2 Operation and Maintenance of Water Management Facilities

The water management system in Kased Area will be installed in the Water Allocation Section within the General Directorate of Water Resources and Irrigation (Tanta City). All data, including flow rates and water levels at each regulator, will be monitored and stored in the water management system. The said Water Allocation Section will then be able to monitor the data via Internet connection with the Water Distribution Sector (Tanta city), which is in charge of Lower Egypt, and the Central Water Distribution Sector in the MWRI HQs.

For the Kased Intake and the Sorad Regulator which is located at the border between Gharbia and Kafr El-Sheikh Governorates, as at present, the Lower Egypt Water Distribution Sector, based on the monitoring data of the water management system, will send instructions for gate operation to the Water Allocation Section in the General Directorate, and then the Water Allocation Section sends gate operation instructions to the Irrigation District. For other facilities located along the main canal or after the main canal, the Water Allocation Section will issue instructions to each irrigation district to operate the gates based on the monitoring data. These procedures are the same as the present one.

Operation and simple maintenance of the water management equipment will be done jointly by the Water Allocation Section within the General Directorate of Water Resources and Irrigation and the Water Distribution Sector (Tanta city), which has the jurisdiction over Lower Egypt. However, periodic inspections and repairs of special equipment such as communication equipment and electrical systems may require assistance from the technical staff in the Telemetry Section of the MWRI Headquarters, depending on the technical content of the equipment.

5.6.3 Maintenance of Machineries and Workshop Equipment

The regional offices of the Central Directorate for Canal Maintenance in the Project area are the Minya Office (Minya City) and the Gharbia Office (Tanta City), the former in charge of the Bahr Yusef and Ibrahimia Principal Canals and the latter in charge of the Kased Main Canal. Maintenance machineries and equipment are stored on the premises of each office and in a workshop that also serves as a warehouse attached to the office.

Each office is staffed by engineers, technicians, administrative staff, clerical staff, and operators of maintenance machineries under the supervision of the Director General. The maintenance and repair of machineries and workshop equipment are handled by engineers and technicians as before. Since most of the unfunctional machineries and equipment are due to aging, it is considered possible to maintain the machineries and equipment as long as new ones are procured. Repairs requiring special skills (e.g., electrical repairs) have been outsourced to mechanics in the private sector, and will be handled in the same manner.

The Engineers and Technicians at each office specialize in civil, mechanical, and electrical equipment, with 7 Engineers and 32 Technicians at the Minya office and 4 Engineers and 24 Technicians at the Gharbia office as of 2022. This Project will replace aging and broken machineries and equipment that cannot be repaired, and procure mobile repair vehicles that can rush to the site to repair out-of-order machineries, which will greatly reduce the burden on the engineers and technicians to maintain the machineries.

5.6.4 Operation and Maintenance of Modern On-farm Irrigation Facilities

In Fayoum, where MWRI first applied the introduction of modern on-farm irrigation, the Irrigation Advisory Service under the Irrigation Improvement Sector (IIS) is responsible for supporting the WUA in operating and maintaining the facilities. Modern on-farm irrigation facilities are owned by farmers, but as in Fayoum, the Irrigation Advisory Service has a track record of providing supports, including technical aspects. Assistance to farmers in the operation and maintenance of modern on-farm irrigation facilities will be provided by the Irrigation Advisory Service through the WUA.

5.7 Consultancy Services (Loan Consultants)

Undisclosed Information

Undisclosed Information

Undisclosed Information

5.8 Technical Assistances Required for Water Management in Egypt

The Project will introduce modern on-farm irrigation facilities in Abo Shosha and Kased sub-regions, which are considered priority areas, covering 10% each of the total area, respectively. In Egypt, the introduction of modern on-farm irrigation facilities is a high priority in order to achieve water-saving irrigation in the future, and it has been decided to introduce such facilities to about 4 million feddans nationwide (see Section 2.2.5 afore-mentioned).

The widespread introduction of modern field irrigation will have a major impact on current irrigation - drainage hydraulic regime. The basic concept of modern field irrigation is to provide exactly as much irrigation water as the crop needs, which would mean a significant reduction in drainage. Thus, with the introduction of modern on-farm irrigation, highly organized water management is needed to cope with these changes.

In the field of water management, the water management in the Kased Area planned in this Project can be adequately handled by the loan consultant to be procured. However, it will be difficult for the loan consultant to handle such issues as; simulation of hydraulic mechanism associated with the future decrease in drainage volume, monitoring including the decreasing drainage volume, and the future water management required based on these simulations, together with research aspects.

The water management mentioned here will benefit not only the Project area but also the entire country, except for the Lower Delta where modern field irrigation will not be introduced. Therefore, it is desirable to bring about technical cooperation in the field of water management, including research issues related to future changes in irrigation and drainage regime. In addition to this, as explained in "4.7 Water Management," the introduction of satellite image analysis into water management will enable appropriate allocation of irrigation water according to crop planting and growth, and further water conservation. With these in mind, the following dispatch of experts could be considered.

Table 5.8.1 Technical Assistances Required for Water Management in Egypt

Expertise	Expert		Remarks
	Person	Duration	
Overall Management (Team Leader)	1 person	Long term	5 years
Irrigation and Drainage	1	Short - middle	Total 2 years
Water Management (Irrigation System)	1	Long term	5 years
Water Management (Modern On-farm Irrigation)	1	Short term	Total 1 year
Hydraulic Simulation including groundwater movement	1	Short term	Total 1 year
GIS/ Satellite Image Analysis	1	Short term	Total 6 months
Coordination/ Secretariat with MWRI, Loan Consultant	1	Long term	5 years

Source: JICA Survey Team

CHAPTER 6 EXAMINATION OF PROJECT EFFECTS

This chapter undertakes the economic evaluation, farm income analysis with project and indicator setting for project operation and effects. At first, the economic analysis and evaluation of the whole project components is carried out. Then the farm income analysis is carried out to examine the income increase of farmer beneficiaries and affordability for cost recovery scheme of introducing the modern irrigation system. Indicators for the project operation and effects are also described in this chapter.

6.1 Economic Evaluation

6.1.1 Assumptions for Economic Analysis

The economic analysis of this project is carried out with the basic assumptions set as below:

1) Economic Internal Ratio of Return (EIRR) and Net Present Value (NPV) are applied for the economic justification of the project.
2) The opportunity cost of capital in Egypt is considered at 10%[1] and therefore, the project is economically justified when EIRR of the project exceeds this rate and the NPV with a discount rate of 10% is calculated positive.
3) Prices of year 2022 are applied for the economic analysis.
4) Standard Conversion Factor (SCF) of 0.979 is applied for converting financial (market) prices into economic prices except for some strategic goods such as rice, wheat, maize, sugar beet and fertilizers. The market price of these goods is converted into economic price with the calculation of their border price estimated from the international market price. As mentioned below, the international market prices of these goods have drastically risen due to COVID-19 and unrest of Ukraine in recent years. Considering the situation, the average prices from 2020 to 2022 are applied for estimating the economic prices of these goods. SCF was calculated using the latest available published data.

Table 6.1.1 Calculation of Standard Conversion Factor (SCF)

Item	2016	2017	2018	2019	2020	Ave.
1. Total Import (CIF)	708,289.1	1,187,063.1	1,464,815.7	1,319,132.4	1,102,238.0	**1,156,307.7**
2. Total Export (FOB)	230,318.7	469,997.8	523,833.8	513,725.8	472,305.4	**442,036.3**
3. Customs and import duties	27,534.0	33,410.9	36,848.1	40,994.9	31,644.4	**34,086.5**
4. Taxes on exports	215.7	257.8	428.8	426.8	353.9	**336.6**
5. Export Subsidy	-	-	-	-	-	**-**
6 = 1 + 2	938,607.8	1,657,060.9	1,988,649.5	1,832,858.2	1,574,543.4	**1,598,344.0**
7 = 1 + 2 + 3 - 4 + 5	965,926.1	1,690,214.0	2,025,068.8	1,873,426.3	1,605,833.9	**1,632,093.8**
8. SCF = 6/7	0.972	0.980	0.982	0.978	0.981	**0.979**

Unit: Million LE
Source: Import and Export: Statistical Year Book 2021(CAPMAS) https://www.capmas.gov.eg/Pages/Publications.aspx?page_id=5104&Year=23577; Customs and import duties and Taxes on Export: OECD (Details of Public Revenues - Egypt (oecd.org)

5) As for the project costs, the local currency portion (L/C) is converted from market prices to economic prices by SCF.
6) Taxes and subsidies are removed for the economic analysis as they are transfer costs. Price escalation is also removed from the economic analysis as it is performed with the present value.
7) Crop yields, farmgate prices, and crop production costs are estimated based on the results of the farm economy survey conducted by the JICA Survey Team in September 2021 (refer to Chapter 3, Section 3.9), additional field interviews to the farmers in October to November 2022 to supplement the results of aforementioned farm economy survey as well as adjusting the prices of items for 2022, and studies on other existing project documents to examine the soundness of the surveys by the

[1] IFAD, Sustainable Transformation for Agricultural Resilience in Upper Egypt, Project Design Report, Annex 4 Economic and Financial Analysis (Oct. 2019)

Team.

8) Economic farmgate prices, cropping pattern, and intensity are categorized into two regions, namely Upper Egypt (Abo Shosha and Aros & Abo Seer) and Delta (Kased).

9) As shown in Figure 6.1.1, the international market prices of agricultural produces except rice from 2020 to 2022 rose around 1.5 to 2 times and the prices of fertilizers rose 2.5 to 3 times in the same period. Although the domestic market prices have drastically risen since 2020, the hike of the international markets in the same period seems to exceed them. Considering such a special occasion, the average prices from 2020 to 2022 are applied to estimate the economic prices of these produces and products.

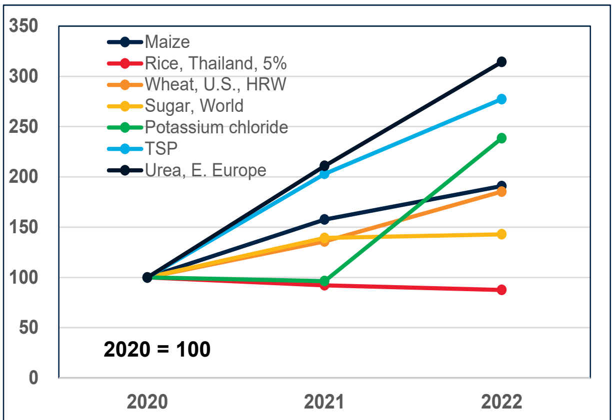


Figure 6.1.1 Trend of International Market Prices of Commodity
(Source: World Bank, "Commodity Markets Outlook, Oct. 2022")

10) Market (financial) prices of the domestic agricultural produces show different trends from the competitive international markets as there are market distortions such as government interventions. As for wheat, the government sets the purchasing price every year for farmers and they sell wheat flour to bread producers at a cheaper price than the purchasing price. Therefore, higher setting of purchasing price for farmers means more burden of subsidy for the government. That would prevent it from setting the purchasing price as high as the international market price.

Table 6.1.2 Financial and Economic Prices of Major Goods

Item	Unit	Unit Price (LE)			Remark
		Financial	Economic		
			Upper Egypt	Delta	
Maize	Ton	8.000	7,555	7,239	Border price
Wheat	Ton	6.667	9,491	9,174	Border price
Rice (Paddy)	Ton	9.000	-	5,083	Border price
Sugar beet	Ton	750	1,065	1,024	Border price
Sorghum	Ton	8,000	7,832	-	SCF
Berseem	Ton	1,000	979	979	SCF
Onion	Ton	3,000	2,937	2,937	SCF
Tomatoes	Ton	2,500	2,448	2,448	SCF
Wheat By-product	Hay	600	587	587	SCF
Rice By-product	Pellet (20Kg)	3	-	3	SCF
Fertilizers					
Urea	Ton	9,000	8,537	8,854	Border price
TSP	Ton	7,200	9,239	9,555	Border price
Pesticides					
Insecticides	Liter	150	147	147	SCF
Fungicides	Liter	150	147	147	SCF
Herbicides	Liter	100	98	98	SCF
Labor	Day	140	140	140	
Machinery					
Tractor rent (land preparation)	Hour	300	294	294	SCF
Pumping	Hour	150	147	147	SCF
Harvesting	Hour	350	343	343	SCF
Threshing	Hour	250	245	245	SCF
Seeds/ Seedling					
Rice	Bag (25kg)	440	431	431	SCF
Wheat	Kg	15	15	15	SCF
Maize	Kg	50	49	49	SCF
Sorghum	Kg	700	685	685	SCF
Sugar beet	Kg	500	490	490	SCF

Item	Unit	Unit Price (LE)			Remark
		Financial	Economic		
			Upper Egypt	Delta	
Onions	Kg	50	49	49	SCF
Tomatoes (seedling)	Tray	250	245	245	SCF
Berseem	Kg	150	147	147	SCF

Source: 1) Financial Price: Interviews to farmers by JICA Survey Team
2) Economic Price: for the prices estimated from the international market prices, the average price from 2020 to 2022 in the World Bank Commodity Price Forecast (Oct. 2022) is applied considering the drastic rise of the prices due to the international circumstances. For other prices, SCF is applied.

6.1.2 Project Costs at Economic Price

1) Initial Investment Costs

Undisclosed Information

2) Operation and Maintenance Costs

The project components are mainly categorized into two: rehabilitation/construction of irrigation facilities from the main canals up to Meska, and modern on-farm irrigation system. As for the irrigation facilities, annual operation and maintenance (O&M) cost is assumed at 3% of the initial investment cost with reference to the general practices of 1 to 3%. Whereas, the introduction of modern on-farm irrigation systems can reduce the operation costs as compared to the current individual irrigation practices, for example, reduction of working hours of the irrigation pump, which consists of fuel, lubricant and labor. As for maintenance, an additional cost for maintaining the pipeline and drip as well as pump will be required. For the maintenance cost of modern on-farm irrigation system is therefore assumed at 1% of the initial investment cost.

6.1.3 Economic Benefits

The benefits of the project are defined as (1) increase of crop unit yield, (2) reduction of crop production cost (applied only for modern on-farm irrigation), (3) change of cropping pattern: increase of profitable horticulture crop and (4) increase of cropping intensity. Based on the Agricultural Development Plan formulated in the Chapter 4, Section 4.13, these factors of benefits with project are numerically defined and estimated.

1) Unit Yield Increase of Crops

Table 6.1.4 summarizes expected unit yield increase. The detail is described in the Section 4.3. The unit yields without project situation are estimated based on the farm economy survey in the target sub-regions, the governorate statistics and the studies / researches on application of the modern on-farm irrigation in the world. Unit yields of maize, sorghum and sugar beet are applied as an average of increase by drip and sprinkler. Because farmers do not cultivate rice with modern on-farm irrigation, rice production would only receive the effect of the irrigation improvement component.

Table 6.1.4 Summary of Unit Yield Increase (%)

Crop	Season	Irrigation Type	Unit Yield W/O Project (t/fed)	Irrigation Improvement		Modern Irrigation		Total	
				Rate	t/fed	Rate	t/fed	Rate	t/fed
Wheat	Winter	Sprinkler	2.30	9%	2.51	11%	2.55	21%	2.78
Onion	Winter	Sprinkler	12.00	8%	12.96	30%	15.60	40%	16.80
Berseem	Winter	Sprinkler	12.00	9%	13.08	11%	13.32	21%	14.52
Sugar beet	Winter	Drip / Sprinkler	19.50	5%	20.48	30%	25.35	37%	26.72
Maize	Summer	Drip / Sprinkler	2.00	15%	2.30	25%	2.50	44%	2.88
Sorghum	Summer	Drip / Sprinkler	1.50	15%	1.73	25%	1.88	44%	2.16
Rice	Summer	Flood irrigation	3.50	5%	3.68	0%	3.50	5%	3.68
Tomato	Summer	Drip	14.50	8%	15.66	30%	18.85	40%	20.30

Source: JICA Survey Team (detailed is in Chapter 4, 4.3)

2) Reduction of Crop Production Cost

Production cost of the crops is expected to decrease because farmers will be able to reduce the amounts of fertilizer and irrigation water as well as labor input through the introduction of modern on-farm irrigation system. Production costs are expected to reduce by 7% to 11% of the total production cost with modern irrigation system installment as shown in Table 6.1.5. The production cost of each crop in the table includes the value of family labor.

Main items of cost reduction include fertilizer, labor and irrigation. According to the study conducted by EU Water STARS in 2021[2], it is expected the production costs are reduced by 35% of fertilizer, 35% of labor and 15% of irrigation. This study results are applied for the reduction of the production cost with modern irrigation system installation. Reduction of labor cost is applied for fertilizing and irrigation works as on the other hand, the yield increase can bring about more workload for harvesting work and some other work would be neutral between modern irrigation and conventional one. The modern irrigation system cannot be applied for rice crop, hence no change in its production cost.

Table 6.1.5 Reduction of Production Cost with Modern Irrigation System (Upper Egypt)

Crop	Production Cost Without Project (LE/fed)		Production Cost With Project (LE/fed)		Cost Reduction (%)	
	Financial Price	Economic Price	Financial Price	Economic price	Fin.	Eco.
Wheat	7,639	7,676	6,955	6,962	9.0%	9.3%
Onion	15,270	15,252	14,062	14,011	7.9%	8.1%
Berseem	6,870	7,119	6,388	6,352	7.0%	10.8%
Sugar beet	7,700	7,798	7,098	7,142	7.8%	8.4%
Maize	6,840	6,944	6,241	6,290	8.8%	9.4%
Sorghum	6,385	6,252	5,894	5,787	7.7%	7.4%
Tomato	19,350	19,200	17,463	17,312	9.8%	9.8%

Source: JICA Survey Team estimated based on the result of the study conducted by EU Water Sector Technical Assistance and Reforms Support in 2021.Production Cost includes the family labor cost.

[2] Financing Options for A Blended Financing Instrument to Support Irrigation Modernization at the Farm Level (Mar. 2021), EU Water Sector Technical Assistance and Reforms Support (EU Water STARS)

3) Cropping Pattern and Intensity

Tables 6.1.6 to 6.1.8 show the cropping pattern and intensity with and without project situations in Upper Egypt and Delta respectively as discussed in the Section 4.3. Since the service areas of Abo Shosha and Aros & Abo Seer in Upper Egypt are different, the table below is prepared for each sub-region with cultivated area by crop, though the cropping pattern and intensity are the same for both sub-regions.

For the cropping pattern, two cases are examined: Case 1 is defined as only the increase of unit yield and no change in cropping pattern, while Case 2 is defined as the increase of unit yield and increase of horticulture crops in the cropping pattern. Cropping intensity is defined no change with and without project as the intensity without project situation is already very high both in Upper Egypt and Delta.

There is a remark that there is some share of permanent crops in the cropping patterns defined in the above section 4.3. However, the cultivated areas of permanent crops in the target sub-regions are observed small. Onions and tomatoes represent winter vegetables & other crops and summer vegetables & oil crops & others respectively.

Table 6.1.6 Cropping Area and Intensity (Upper Egypt: Abo Shosha)

Season	Crop	Without Project			With Project (Case 1)			With Project (Case 2)		
		C.I. (%)		Area (fed)	C.I. (%)		Area (fed)	C.I. (%)		Area (fed)
Winter	Wheat	88	51	8,025	88	51	8,025	88	51	8,025
	Berseem		23	3,619		23	3,619		21	3,304
	Sugar beet		7	1,101		7	1,101		7	1,101
	Vegetables (Onions)		19	2,990		19	2,990		21	3,304
Summer	Maize	93	63	10,476	93	63	10,476	93	60	9,978
	Sorghum		13	2,162		13	2,162		12	1,996
	Vegetables (Tomatoes)		24	3,991		24	3,991		28	4,656
Nile	Maize	15	49	1,314	15	49	1,314	15	41	1,100
	Vegetables (Tomatoes)		51	1,368		51	1,368		59	1,582
Net Service Area (fed) Crop Intensity (C.I.)		196		17,881	196		17,881	196		17,881

Source: JICA Survey Team

Table 6.1.7 Cropping Area and Intensity (Upper Egypt: Aros & Abo Seer)

Season	Crop	Without Project			With Project (Case 1)			With Project (Case 2)		
		C.I. (%)		Area (fed)	C.I. (%)		Area (fed)	C.I. (%)		Area (fed)
Winter	Wheat	88	51	5,983	88	51	5,983	88	51	5,983
	Berseem		23	2,698		23	2,698		21	2,463
	Sugar beet		7	821		7	821		7	821
	Vegetables (Onions)		19	2,229		19	2,229		21	2,463
Summer	Maize	93	63	7,810	93	63	7,810	93	60	7,438
	Sorghum		13	1,612		13	1,612		12	1,488
	Vegetables (Tomatoes)		24	2,975		24	2,975		28	3,471
Nile	Maize	15	49	980	15	49	980	15	41	820
	Vegetables (Tomatoes)		51	1,020		51	1,020		59	1,180
Net Service Area (fed) Crop Intensity (C.I.)		196		13,330	196		13,330	196		13,330

Source: JICA Survey Team

Table 6.1.8 Cropping Area and Intensity (Delta: Kased)

Season	Crop	Without Project			With Project (Case 1)			With Project (Case 2)		
		C.I. (%)		Area (fed)	C.I. (%)		Area (fed)	C.I. (%)		Area (fed)
Winter	Wheat	95	46	41,942	95	46	41,942	95	46	41,942
	Berseem		23	20,971		23	20,971		20	18,235
	Sugar beet		17	15,500		17	15,500		17	15,500
	Vegetables (Onions)		14	12,765		14	12,765		17	15,500
Summer	Maize	100	34	32,632	100	34	32,632	100	28	26,873
	Rice		10	9,598		10	9,598		10	9,598
	Vegetables (Tomatoes)		56	53,747		56	53,747		62	59,505
Nile	Maize	5	59	2,831	5	59	2,831	5	29	1,392
	Vegetables (Tomatoes)		41	1,968		41	1,968		71	3,407

Season	Crop	Without Project		With Project (Case 1)		With Project (Case 2)	
		C.I. (%)	Area (fed)	C.I. (%)	Area (fed)	C.I. (%)	Area (fed)
Net Service Area (fed) Crop Intensity (C.I.)		200	95,976	200	95,976	200	95,976

Source: JICA Survey Team

4) Estimation of Incremental Economic Benefits

Incremental benefits of the project are calculated with the combination of Cases 1 and 2 and other categories: Cases A, B and C. Case A is only to implement the rehabilitation/construction of the irrigation facilities (Irrigation Improvement), while Case B is to implement Modern On-farm Irrigation (MOI), and then Case C is to implement both irrigation improvement and MOI (full-scale). The incremental benefits from Case1-A to Case 2-C for the three target sub-regions are shown below in Tables 6.1.10 to 6.1.16 except for the Cases B and C of the Aros & Abo Seer sub-region since the implementation of MOI in this region is not planned in the proposed project. The prices are expressed here at Economic Price for the purpose of calculating EIRR.

Table 6.1.9 Cases of Incremental Benefits with Project

Case		A: Irrigation Improvement	B: Modern On-farm Irrigation (MOI)	C: Irrigation Improvement + MOI (full-scale)
1	No Change of Cropping Pattern	Case 1-A	Case 1-B	Case 1-C
2	Increase Horticulture Crop	Case 2-A	Case 2-B	Case 2-C

Source: JICA Survey Team

Table 6.1.10 Case A: Benefit with Irrigation Improvement at Economic Price (Upper Egypt: Abo Shosha)

Season	Crop	Unit Net Return (LE/fed)		Total Return (000 LE)			Incremental Benefit (000 LE)	
		W/O Project	W/ Project Case 1/2	W/O Project	W/ Project Case 1A	W/ Project Case 2A	Case 1-A	Case 2-A
Winter	Wheat	20,023	22,402	160,684	179,776	179,776	19,091	19,091
	Berseem	4,629	5,497	16,753	19,894	18,164	3,141	1,411
	Sugar beet	12,970	13,938	14,286	15,352	15,352	1,066	1,066
	Vegetables (Onions)	19,992	22,643	59,770	67,696	74,822	7,926	15,052
Summer	Maize	8,166	10,265	85,551	107,541	102,420	21,990	16,869
	Sorghum	5,496	7,111	11,881	15,373	14,190	3,491	2,309
	Vegetables (Tomatoes)	16,296	18,968	65,038	75,702	88,319	10,664	23,281
Nile	Maize	8,166	10,265	10,732	13,491	11,288	2,759	556
	Vegetables (Tomatoes)	16,296	18,968	22,291	25,946	30,016	3,655	7,725
Total							**73,784**	**87,361**

Source: JICA Survey Team（For Unit Net Return, refer to Appendix VI. PROJECT EVALUATION Table26 - Table46. So does to the tables up to Table 6.1.5）

Table 6.1.11 Case B: Benefit with MOI at Economic Price (Upper Egypt: Abo Shosha)

Season	Crop	Unit Net Return (LE/fed)		Total Return (000 LE)			Incremental Benefit (000 LE)	
		W/O Project	W/ Project Case 1/2	W/O Project	W/ Project Case 1B	W/ Project Case 2B	Case 1-B	Case 2-B
Winter	Wheat	20,023	23,785	16,068	19,087	19,087	3,019	3,019
	Berseem	4,629	6,509	1,675	2,356	2,151	680	476
	Sugar beet	12,970	19,856	1,429	2,187	2,187	758	758
	Vegetables (Onions)	19,992	31,806	5,977	9,509	10,510	3,532	4,533
Summer	Maize	8,166	12,597	8,555	13,197	12,569	4,642	4,014
	Sorghum	5,496	8,898	1,188	1,924	1,776	735	587
	Vegetables (Tomatoes)	16,296	28,833	6,504	11,507	13,425	5,004	6,921
Nile	Maize	8,166	12,597	1,073	1,656	1,385	582	312
	Vegetables (Tomatoes)	16,296	28,833	2,229	3,944	4,563	1,715	2,334
Total							**20,668**	**22,954**

Source: JICA Survey Team

Table 6.1.12 Case C: Benefit with Full-scale Project at Economic Price (Upper Egypt: Abo Shosha)

Season	Crop	Unit Net Return (LE/fed)		Total Return (000 LE)			Incremental Benefit (000 LE)	
		W/O Project	W/ Project	W/O Project	W/ Project		Case 1-C	Case 2-C
			Case 1/2		Case 1C	Case 2C		
Winter	Wheat	20,023	26,429	160,684	183,008	183,008	22,323	22,323
	Berseem	4,629	7,576	16,753	20,647	18,851	3,894	2,098
	Sugar beet	12,970	21,211	14,286	16,153	16,153	1,867	1,867
	Vegetables (Onions)	19,992	35,121	59,770	71,426	78,945	11,656	19,175
Summer	Maize	8,166	15,255	85,551	112,769	107,399	27,218	21,848
	Sorghum	5,496	10,944	11,881	16,201	14,955	4,320	3,074
	Vegetables (Tomatoes)	16,296	32,173	65,038	80,972	94,468	15,934	29,430
Nile	Maize	8,166	15,255	10,732	14,147	11,837	3,414	1,105
	Vegetables (Tomatoes)	16,296	32,173	22,291	27,753	32,106	5,461	9,815
Total							**96,088**	**110,734**

Source: JICA Survey Team

Table 6.1.13 Case A: Benefit with Irrigation Improvement at Economic Price (Upper Egypt: Aros & Abo Seer)

Season	Crop	Unit Net Return (LE/fed)		Total Return (000 LE)			Incremental Benefit (000 LE)	
		W/O Project	W/ Project	W/O Project	W/ Project		Case 1-A	Case 2-A
			Case 1/2		Case 1A	Case 2A		
Winter	Wheat	20,023	22,402	119,788	134,020	134,020	14,232	14,232
	Berseem	4,629	5,497	12,489	14,831	13,541	2,342	1,052
	Sugar beet	12,970	13,938	10,650	11,445	11,445	795	795
	Vegetables (Onions)	19,992	22,643	44,558	50,466	55,778	5,908	11,221
Summer	Maize	8,166	10,265	63,777	80,170	76,353	16,393	12,576
	Sorghum	5,496	7,111	8,857	11,460	10,579	2,603	1,721
	Vegetables (Tomatoes)	16,296	18,968	48,485	56,435	65,840	7,950	17,356
Nile	Maize	8,166	10,265	8,001	10,057	8,415	2,057	415
	Vegetables (Tomatoes)	16,296	18,968	16,618	19,343	22,377	2,725	5,759
Total							**55,005**	**65,126**

Source: JICA Survey Team

Table 6.1.14 Case A: Benefit with Irrigation Improvement at Economic Price (Delta: Kased)

Season	Crop	Unit Net Return (LE/fed)		Total Return (000 LE)			Incremental Benefit (000 LE)	
		W/O Project	W/ Project	W/O Project	W/ Project		Case 1-A	Case 2-A
			Case 1/2		Case 1A	Case 2A		
Winter	Wheat	19,240	21,554	806,955	904,007	904,007	97,053	97,053
	Berseem	4,582	5,450	96,088	114,291	99,383	18,203	3,295
	Sugar beet	12,107	13,036	187,660	202,060	202,060	14,400	14,400
	Vegetables (Onions)	19,897	22,548	253,981	287,821	349,497	33,840	95,515
Summer	Maize	7,471	9,475	243,792	309,187	254,624	65,394	10,832
	Rice	7,153	8,051	68,652	77,270	77,270	8,619	8,619
	Vegetables (Tomatoes)	16,138	18,810	867,362	1,010,973	1,119,291	143,611	251,929
Nile	Maize	7,471	9,475	21,153	26,826	13,186	5,674	-7,967
	Vegetables (Tomatoes)	16,138	18,810	31,752	37,009	64,088	5,257	32,337
Total							**392,049**	**506,013**

Source: JICA Survey Team

Table 6.1.15 Case B: Benefit with MOI at Economic Price (Delta: Kased)

Season	Crop	Unit Net Return (LE/fed)		Total Return (000 LE)			Incremental Benefit (000 LE)	
		W/O Project	W/ Project	W/O Project	W/ Project		Case 1-B	Case 2-B
			Case 1/2		Case 1B	Case 2B		
Winter	Wheat	19,240	22,940	80,695	96,214	96,214	15,518	15,518
	Berseem	4,582	6,478	9,609	13,585	11,813	3,976	2,204
	Sugar beet	12,107	18,775	18,766	29,101	29,101	10,335	10,335
	Vegetables (Onions)	19,897	31,745	25,398	40,522	49,205	15,124	23,807
Summer	Maize	7,471	11,766	24,379	38,395	31,619	14,015	7,240
	Rice	7,153	7,153	6,865	6,865	6,865	0	0
	Vegetables (Tomatoes)	16,138	28,730	86,736	154,414	170,958	67,678	84,222
Nile	Maize	7,471	11,766	2,115	3,331	1,637	1,216	-478
	Vegetables (Tomatoes)	16,138	28,730	3,175	5,653	9,789	2,477	6,614
Total							**130,340**	**149,463**

Source: JICA Survey Team

Table 6.1.16 Case C: Benefit with Full-scale Project at Economic Price (Delta: Kased)

Season	Crop	Unit Net Return (LE/fed)		Total Return (000 LE)			Incremental Benefit (000 LE)	
		W/O Project	W/ Project Case 1/2	W/O Project	W/ Project Case 1C	W/ Project Case 2C	Case 1-C	Case 2-C
Winter	Wheat	19,240	25,511	806,955	920,604	920,604	113,649	113,649
	Berseem	4,582	7,545	96,088	118,684	103,203	22,596	7,115
	Sugar beet	12,107	20,075	187,660	212,970	212,970	25,310	25,310
	Vegetables (Onions)	19,897	35,059	253,981	303,791	368,889	49,810	114,908
Summer	Maize	7,471	14,304	243,792	324,945	267,601	81,152	23,809
	Rice	7,153	8,051	68,652	77,270	77,270	8,619	8,619
	Vegetables (Tomatoes)	16,138	32,070	867,362	1,082,241	1,198,195	214,879	330,833
Nile	Maize	7,471	14,304	21,153	28,194	13,858	7,041	-7,295
	Vegetables (Tomatoes)	16,138	32,070	31,752	39,618	68,606	7,866	36,855
Total							**530,921**	**653,803**

Source: JICA Survey Team

6.1.4 Economic Efficiency

1) Flow of Costs and Benefits

To perform the cost and benefit flow analysis to calculate EIRR and NPV, the following flows of the project costs and benefits are assumed:

- ✓ Detail design portion for the consulting services is disbursed at the 1st year, and after that according to the construction supervision and also procurement progress, the remaining consultant services are to be disbursed,
- ✓ The costs of all the components except for the branch canal lining are equally disbursed from the 2nd year,
- ✓ The cost of branch canal lining, which is supposed to be borne by the State budget, is equally disbursed from the 1st year,
- ✓ O&M costs of the components is disbursed from the following year of the disbursement of the investment costs,
- ✓ Replacement of the drip irrigation system is required every 4 years, and
- ✓ 50% of the benefits such as unit yield increase etc. is realized from the following year of the construction/installment of the facilities and 100% of the benefits is realized at the 2nd year.

2) Economic Internal Ratio of Return (EIRR) and Net Present Value (NPV)

With all the models set above and cost-benefit flows for the economic evaluation, the EIRR and NPV of the project are calculated as shown in Table 6.1.17. EIRR in the set cases are calculated from 11.2% to 20.3%. EIRR of all the cases exceed the opportunity cost of capital, 10% and the NPV calculated with the discount rate of 10% are positive in all the cases. Therefore, the project is judged feasible from the economic point of view.

Table 6.1.17 EIRR and NPV with the Project

Case	Description	EIRR	NPV (000 LE)
Case 1-A	No change of cropping pattern, Irrigation Improvement	15.9%	1,083,357
Case 2-A	Increase of horticulture crop, Irrigation Improvement	20.3%	1,994,718
Case 1-B	No change of cropping pattern, Modern On-farm Irrigation (MOI)	11.2%	65,639
Case 2-B	Increase of horticulture crop, Modern On-farm Irrigation (MOI)	13.5%	207,368
Case 1-C	No change of cropping pattern, Irrigation Improvement + MOI	15.0%	1,217,393
Case 2-C	Increase of horticulture crop, Irrigation Improvement + MOI	18.7%	2,194,872

Source: JICA Survey Team

3) Sensitivity Analysis

Sensitivity analysis is carried out with the cases of (1) 10% increase of the project cost, (2) 10% decrease of the project benefit and the combination of (1) and (2). In all the cases, EIRRs remain more than 10% and positive respectively except for the Case 1-B. It is indicated that the economic efficiency with implementation of MOI would become robust with the increase of profitable horticulture crop. Also, the NPV shows that the decrease of benefit would likely affect the economic efficiency of the project more than the increase of cost as the NPVs with less benefit are more declined than the ones with more cost.

Table 6.1.18 Sensitivity Analysis

Case	Indicators	Case 1-A	Case 2-A	Case 1-B	Case 2-B	Case 1-C	Case 2-C
(1)10% increase of Project cost	EIRR	14.2%	18.4%	9.5%	11.8%	13.4%	16.8%
	NPV (000LE)	846,883	1,758,244	-27,769	113,960	887,619	1,865,098
(2)10% decrease of Project Benefit	EIRR	14.1%	18.2%	9.4%	11.6%	13.2%	16.7%
	NPV (000LE)	738,547	1,558,772	-34,333	93,223	765,880	1,645,611
(3): (1) + (2)	EIRR	12.6%	16.5%	7.8%	10.0%	11.7%	14.9%
	NPV (LE)	502,073	1,322,298	-127,741	-185,116	436,106	1,315,837

Source: JICA Survey Team

6.2 Farm Income Analysis

The main purpose of the Farm Income analysis here is to evaluate the profitability of farming activities with project situation and affordability of the farmers for the repayment of the cost to install modern on-farm irrigation system. Since the main beneficiaries of the proposed project are individual farmers, the Farm Income analysis focuses on individual farmers in the target sub-regions.

6.2.1 Farm Income Model

A Farm Income model is established with the same one applied for the above economic analysis but the financial prices are used for the items. In this Farm Income analysis, one model for Upper Egypt (Abo Shosha and Aros & Abo Seer) and another for the Delta (Kased) are prepared. Since the same cropping pattern, cropping intensity, representative crops and net income for each crop are applied for Abo Shosha and Aros & Abo Seer, they are made into one model as the Upper Egypt.

The model is made as per feddan and the net farm income is calculated excluding the value of family labor from the production cost, since here discussed is the financial term or cash income to be left for the farmer beneficiaries, while the economic analysis above examined the economic efficiency of the project. Tables 6.2.1 and 6.2.2 show the Farm Income model for Upper Egypt and Delta respectively. The net farm income per feddan without project situation for Upper Egypt and Delta are estimated at 26,663 LE and 30,743 LE respectively.

Table 6.2.1 Farm Income Model without Project in Upper Egypt

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**88**	**0.88**						
Wheat	51	0.45	2.3	6.70	9,635	6,379	2,871	6,764
Berseem	23	0.20	12.0	1.00	2,400	5,330	1,066	1,334
Sugar beet	7	0.06	19.5	0.75	878	6,160	370	508
Onions	19	0.17	12.0	3.00	6,120	12,470	2,120	4,000
Summer	**93**	**0.93**						
Maize	63	0.59	2.0	8.00	9,440	5,300	3,127	6,313
Sorghum	13	0.12	1.5	8.00	1,440	5,405	649	791
Tomatoes	24	0.22	14.5	2.50	7,975	15,570	3,425	4,550
Nile	**15**	**0.15**						
Maize	49	0.07	2.0	8.00	1,120	5,300	371	749
Tomatoes	51	0.08	14.5	2.50	2,900	15,570	1,246	1,654
Total		**1.96**			**41,908**		**15,245**	**26,663**

Source: JICA Survey Team

Note: Gross income of wheat includes a by-product (wheat straws) (Refer to Appendix VI. PROJECT EVALUATION Table25)
Wheat: 0.45fed x 2.3t/fed x 6.70LE/kg = 6,935LE
By-product: 0.45fed x 10pack/fed x 600LE/pack = 2,700LE Total 9.635LE

Table 6.2.2 Farm Income Model without Project in Delta

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**95**	**0.95**						
Wheat	46	0.44	2.3	6.70	9,421	6,379	2,807	6,614
Berseem	23	0.22	12.0	1.00	2,640	5,330	1,173	1,467
Sugar beet	17	0.16	19.5	0.75	2,340	6,160	986	1,354
Onions	14	0.13	12.0	3.00	4,680	12,470	1,621	3,059
Summer	**100**	**1.00**						
Maize	34	0.34	2.0	8.00	5,440	5,300	1,802	3,638
Rice	10	0.1	3.5	9.00	3,195	9,000	900	2,295
Tomatoes	56	0.56	14.5	2.50	20,300	15,570	8,719	11,581
Nile	**5**	**0.05**						
Maize	59	0.03	2.0	8.00	480	5,300	159	321
Tomatoes	41	0.02	14.5	2.50	725	15,570	311	414
Total		**2.00**			**49,221**		**18,478**	**30,743**

Source: JICA Survey Team
Note: Gross incomes of wheat and rice include a by-product (wheat straws and rice straw).

6.2.2 Increase of Farm Income with Project

In this Farm Income analysis, the affordability of farmers for the repayment of the modern on-farm irrigation (MOI) system is focused and therefore, the Farm Income analysis is carried out for the Cases with MOI only (Case 1 B and Case 2-B) and full-scale project (Case 1-C and Case 2-C) as defined above. The Tables 6.2.3 to 6.2.10 show the estimation of the net farm income with project situation for each case in Upper Egypt and Delta.

Table 6.2.3 Farm Income Model with Project in Upper Egypt (Case 1-B)

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**88**	**0.88**						
Wheat	51	0.45	2.6	6.70	10,694	5,845	2,630	8,064
Berseem	23	0.20	13.3	1.00	2,664	4,542	908	1,756
Sugar beet	7	0.06	25.4	0.75	1,141	5,817	349	792
Onions	19	0.17	15.6	3.00	7,956	11,493	1,954	6,002
Summer	**93**	**0.93**						
Maize	63	0.59	2.5	8.00	11,800	4,876	2,877	8,923
Sorghum	13	0.12	1.9	8.00	1,805	5,016	602	1,203
Tomatoes	24	0.22	18.9	2.50	10,368	14,208	3,126	7,242
Nile	**15**	**0.15**						
Maize	49	0.07	2.5	8.00	1,400	4,876	341	1,059
Tomatoes	51	0.08	18.9	2.50	3,770	14,208	1,137	2,633
Total		**1.96**			**51,598**		**13,924**	**37,674**

Source: JICA Survey Team
Note: Gross income of wheat includes a by-product (wheat straws).

Table 6.2.4 Farm Income Model with Project in Upper Egypt (Case 1-C)

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**88**	**0.88**						
Wheat	51	0.45	2.78	6.70	11,272	5,929	2,668	8,604
Berseem	23	0.20	14.52	1.00	2,904	4,542	908	1,996
Sugar beet	7	0.06	26.72	0.75	1,202	5,895	354	848
Onions	19	0.17	16.80	3.00	8,568	11,633	1,978	6,590
Summer	**93**	**0.93**						
Maize	63	0.59	2.88	8.00	13,594	5,035	2,971	10,623
Sorghum	13	0.12	2.16	8.00	2,074	5,235	628	1,446
Tomatoes	24	0.22	20.30	2.50	11,165	14,348	3,157	8,008
Nile	**15**	**0.15**						
Maize	49	0.07	2.88	8.00	1,613	5,035	352	1,261
Tomatoes	51	0.08	20.30	2.50	4,060	14,348	1,148	2,912
Total		**1.96**			**56,452**		**14,164**	**42,288**

Source: JICA Survey Team
Note: Gross income of wheat includes a by-product (wheat straws).

Table 6.2.5 Farm Income Model with Project in Upper Egypt (Case 2-B)

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**88**	**0.88**						
Wheat	51	0.45	2.6	6.70	10,694	5,845	2,630	8,064
Berseem	23	0.20	13.3	1.00	2,398	4,542	818	1,580
Sugar beet	7	0.06	25.4	0.75	1,141	5,817	349	792
Onions	19	0.17	15.6	3.00	8,892	11,493	2,184	6,708
Summer	**93**	**0.93**						
Maize	63	0.59	2.5	8.00	11,200	4,876	2,731	8,469
Sorghum	13	0.12	1.9	8.00	1,654	5,016	552	1,102
Tomatoes	24	0.22	18.9	2.50	12,253	14,208	3,694	8,559
Nile	**15**	**0.15**						
Maize	49	0.07	2.5	8.00	1,200	4,876	293	907
Tomatoes	51	0.08	18.9	2.50	4,241	14,208	1,279	2,962
Total		**1.96**			**53,673**		**14,530**	**39,143**

Source: JICA Survey Team
Note: Gross income of wheat includes a by-product (wheat straws).

Table 6.2.6 Farm Income Model with Project in Upper Egypt (Case 2-C)

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**88**	**0.88**						
Wheat	51	0.45	2.78	6.70	11,272	5,929	2,668	8,604
Berseem	23	0.18	14.52	1.00	2,614	4,542	818	1,796
Sugar beet	7	0.06	26.72	0.75	1,202	5,895	354	848
Onions	19	0.19	16.80	3.00	9,576	11,633	2,210	7,366
Summer	**93**	**0.93**						
Maize	63	0.56	2.88	8.00	12,902	5,035	2,820	10,082
Sorghum	13	0.11	2.16	8.00	1,901	5,235	576	1,325
Tomatoes	24	0.26	20.30	2.50	13,195	14,348	3,730	9,465
Nile	**15**	**0.15**						
Maize	49	0.06	2.88	8.00	1,382	5,035	302	1,080
Tomatoes	51	0.09	20.30	2.50	4,568	14,348	1,291	3,277
Total		**1.96**			**58,612**		**14,769**	**43,843**

Source: JICA Survey Team
Note: Gross income of wheat includes a by-product (wheat straws).

Table 6.2.7 Farm Income Model with Project in Delta (Case 1-B)

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**95**	**0.95**						
Wheat	46	0.44	2.55	6.70	10,457	5,845	2,572	7,885
Berseem	23	0.22	13.32	1.00	2,930	4,542	999	1,931
Sugar beet	17	0.16	25.35	0.75	3,042	5,817	931	2,111
Onions	14	0.13	15.60	3.00	6,084	11,493	1,494	4,590
Summer	**100**	**1.00**						
Maize	34	0.34	2.50	8.00	6,800	4,876	1,657	5,143
Rice	10	0.1	3.50	9.00	3,195	9,000	900	2,295
Tomatoes	56	0.56	18.85	2.50	26,390	14,208	7,956	18,434
Nile	**5**	**0.05**			0			
Maize	59	0.03	2.50	8.00	600	4,876	146	454
Tomatoes	41	0.02	18.85	2.50	943	14,208	284	659
Total		**2.00**			**60,441**		**16,939**	**43,502**

Source: JICA Survey Team
Note: Gross incomes of wheat and rice include a by-product (wheat straws and rice straw).

Table 6.2.8 Farm Income Model with Project in Delta (Case 1-C)

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**95**	**0.95**						
Wheat	46	0.44	2.78	6.70	11,022	5,929	2,609	8,413
Berseem	23	0.22	14.52	1.00	3,194	4,542	999	2,195
Sugar beet	17	0.16	26.72	0.75	3,206	5,895	943	2,263
Onions	14	0.13	16.80	3.00	6,552	11,633	1,512	5,040
Summer	**100**	**1.00**						
Maize	34	0.34	2.88	8.00	7,834	5,035	1,711	6,123
Rice	10	0.1	3.68	9.00	3,291	9,000	900	2,391
Tomatoes	56	0.56	20.30	2.50	28,420	14,348	8,035	20,385
Nile	**5**	**0.05**			0			

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Maize	59	0.03	2.88	8.00	691	5,035	151	540
Tomatoes	41	0.02	20.30	2.50	1,015	14,348	287	728
Total		**2.00**			**65,226**		**17,147**	**48,079**

Source: JICA Survey Team

Note: Gross incomes of wheat and rice include a by-product (wheat straws and rice straw).

Table 6.2.9 Farm Income Model with Project in Delta (Case 2-B)

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**95**	**0.95**						
Wheat	46	0.44	2.55	6.70	10,457	5,845	2,572	7,885
Berseem	23	0.19	13.32	1.00	2,531	4,542	863	1,668
Sugar beet	17	0.16	25.35	0.75	3,042	5,817	931	2,111
Onions	14	0.16	15.60	3.00	7,488	11,493	1,839	5,649
Summer	**100**	**1.00**						
Maize	34	0.28	2.50	8.00	5,600	4,876	1,365	4,235
Rice	10	0.1	3.50	9.00	3,195	9,000	900	2,295
Tomatoes	56	0.62	18.85	2.50	29,217	14,208	8,808	20,409
Nile	**5**	**0.05**						
Maize	59	0.01	2.50	8.00	200	4,876	49	151
Tomatoes	41	0.04	18.85	2.50	1,885	14,208	568	1,317
Total		**2.00**			**63,615**		**17,895**	**45,720**

Source: JICA Survey Team

Note: Gross incomes of wheat and rice include a by-product (wheat straws and rice straw).

Table 6.2.10 Farm Income Model with Project in Delta (Case 2-C)

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**95**	**0.95**						
Wheat	46	0.44	2.78	6.70	11,022	5,929	2,609	8,413
Berseem	23	0.19	14.52	1.00	2,759	4,542	863	1,896
Sugar beet	17	0.16	26.72	0.75	3,206	5,895	943	2,263
Onions	14	0.16	16.80	3.00	8,064	11,633	1,861	6,203
Summer	**100**	**1.00**						
Maize	34	0.28	2.88	8.00	6,451	5,035	1,409	5,042
Rice	10	0.1	3.68	9.00	3,291	9,000	900	2,391
Tomatoes	56	0.62	20.30	2.50	31,465	14,348	8,895	22,570
Nile	**5**	**0.05**						
Maize	59	0.01	2.88	8.00	230	5,035	50	180
Tomatoes	41	0.04	20.30	2.50	2,030	14,348	574	1,456
Total		**2.00**			**68,519**		**18,104**	**50,415**

Source: JICA Survey Team

Note: Gross incomes of wheat and rice include a by-product (wheat straws and rice straw).

Table 6.2.11 summarizes the Incremental Farm Income of each case. The incremental farm income per feddan is estimated from 11,011 LE/feddan (Case 1-B in Upper Egypt) to 19,672 LE/feddan (Case 2-C in Delta). Apart from the production cost, the maintenance cost of the modern on-farm irrigation system is assumed at 1% of the initial investment cost as discussed at Section 6.1.2, which is estimated at 590 LE. After deducting this cost, the net farm income per feddan arrives at 10,421 LE/feddan to 19,082 LE/feddan.

The results of this farm income analysis differ significantly from those of the period when the farm household economic survey described in Chapter 3, Section 3.9 was conducted, due to the major changes in international circumstances, namely the hike of the prices for grains and chemical fertilizers due to the Covid-19 epidemic and the war in Ukraine, as well as high prices for oil and other fuels. It should be noted that farm incomes have been changing violently and fluidly due to such external factors, making it difficult to predict the future. This should be taken into consideration as a concern and risk.

Table 6.2.11 Farm Income Analysis: Incremental Farm Income per Feddan

Region		Upper Egypt				Delta			
Case		Case 1-B	Case 1-C	Case 2-B	Case 2-C	Case 1-B	Case 1-C	Case 2-B	Case 2-C
Without Project (LE/fed)	Gross Income	41,908				49,221			
	Production Cost	15,245				18,478			
	Net Farm Income	**26,663**				**30,743**			
With Project (LE/fed)	Gross Income	51,598	56,452	53,673	58,612	60,441	65,226	63,615	68,519
	Production Cost	13,924	14,164	14,530	14,769	16,939	17,147	17,895	18,104
	Net Farm Income	**37,674**	**42,288**	**39,143**	**43,843**	**43,502**	**48,079**	**45,720**	**50,415**
1) Incremental Farm Income (LE/fed)		**11,011**	**15,625**	**12,480**	**17,180**	**12,759**	**17,336**	**14,977**	**19,672**
Maintenance cost of Modern Irrigation		590	590	590	590	590	590	590	590
2) Incremental Farm Income (LE/fed)		**10,421**	**15,035**	**11,890**	**16,590**	**12,169**	**16,746**	**14,387**	**19,082**

Source: JICA Survey Team

6.2.3 Repayment for Modern On-farm Irrigation System

The cash flow analysis is carried out to examine the balance of incremental farm income and loan repayment and hence the affordability of farmers to repay the cost of modern on-farm irrigation system installation. The following are the basic assumptions and conditions for the cash flow analysis:

- ✓ Initial investment costs are financed by the government of Egypt on loan with no interest (subsidized by the government) and the repayment period of 10 years according to the protocol agreed among the banks and ministries concerned,
- ✓ Installation of the modern on-farm irrigation system is completed in the first year (Year 0),
- ✓ Operation of the modern on-farm irrigation system starts from the second year (Year 1), and cash-flow is presented up to the eleventh year (Year 10), equivalent to the loan repayment period planned by the government of Egypt,
- ✓ Initial investment cost is 59,000 LE/feddan, and 12,477 LE/feddan is incurred every after three years (Year 4 and 8) as the replacement cost of drip tubes,
- ✓ Annual repayment amount of the loan is 5,900 LE/year,
- ✓ Annual maintenance cost of the modern on-farm irrigation system is 590 LE, equivalent to 1% of the initial investment cost, and
- ✓ Incremental farm income with the modern on-farm irrigation system achieves 50% in Year 1, and 100% in Year 2. It is assumed that the farmer would get accustomed well with the modern on-farm irrigation for the first year of the installation and therefore, the achievement of the full yield increase is assumed to be a half of the expected yield increase. For the second year, it is assumed that farmers would be able to operate the system well and achieve the full benefit of the system.

The cash flow analysis is carried out for Case 1-B, Case 2-B, Case 1-C and Case 2-C. Tables 6.2.12 and 6.2.13 show the results of the analysis in Upper Egypt and Delta respectively. In the ten year-cash flow for the repayment period, the total net incremental farm income in each case in each region exceeds the total cost repaid and incurred by the farmer beneficiaries.

On the other hand, the share of cost to be paid against the incremental farm income reaches 88% and 75% for the Case 1-B (no change in cropping pattern with MOI component only) in Upper Egypt and Delta respectively, which is still affordable but if this share were lower, the farmers would be more encouraged to pay for it. Especially for the Case 1-B in Upper Egypt, around 90% of the incremental income during the repayment period will go for paying the costs of capital repayment, maintenance and replacement.

In the Case 2-B (increase of horticulture crop with MOI component only), the share of the cost against the incremental farm income goes down to 77% and 64% in Upper Egypt and Delta respectively. Shifting profitable horticulture crop in their cropping pattern will leave more benefit to the farmers, otherwise, a measure as extending repayment period would help encourage the beneficiary farmers to introduce to the modern on-farm irrigation system.

Furthermore, for the Cases 1-C and 2-C (with combination of irrigation improvement and MOI) for Upper Egypt, the share of cost against the net incremental income goes down to 68% and 61% respectively. As for the Cases 1-C and 2-C for Delta, it goes down to as low as 60% and 53% respectively. This means that the irrigation improvement, namely rehabilitation/ construction of hydraulic structures and canal lining, will greatly contribute to augmenting farm income and encouraging the farmer beneficiaries to introduce the modern on-farm irrigation system.

Table 6.2.12 Cash Flow Analysis in Upper Egypt

Case	**Case 1-B: Same Cropping Pattern; MOI only**					**Case 2-B: Additional Horticulture Crops; MOI only**				
Year	Net Income Increase	Capital Repay.	System Maintenance	Replacement of Equip.	Net Cash Flow	Net Income Increase	Capital Repay.	System Maintenance	Replacement of Equip.	Net Cash Flow
0	0	0		0	0	0	0		0	0
1	5,506	5,900	590	0	-985	6,240	5,900	590	0	-250
2	11,011	5,900	590	0	4,521	12,480	5,900	590	0	5,990
3	11,011	5,900	590	0	4,521	12,480	5,900	590	0	5,990
4	11,011	5,900	590	12,477	-7,956	12,480	5,900	590	12,477	-6,488
5	11,011	5,900	590	0	4,521	12,480	5,900	590	0	5,990
6	11,011	5,900	590	0	4,521	12,480	5,900	590	0	5,990
7	11,011	5,900	590	0	4,521	12,480	5,900	590	0	5,990
8	11,011	5,900	590	12,477	-7,956	12,480	5,900	590	12,477	-6,488
9	11,011	5,900	590	0	4,521	12,480	5,900	590	0	5,990
10	11,011	5,900	590	0	4,521	12,480	5,900	590	0	5,990
Total	**104,605**	**59,000**	**5,900**	**24,954**	**14,751**	**118,555**	**59,000**	**5,900**	**24,954**	**28,701**
	Cost / Net Income Increase 89,854 / 104,605 = **86%**					Cost / Net Income Increase 89,854 / 118,555 = **76%**				
Case	**Case 1-C: Same Cropping Pattern Irrigation Improvement + MOI**					**Case 2-C: Additional Horticulture Crops Irrigation Improvement + MOI**				
Year	Net Income Increase	Capital Repay.	System Maintenance	Replacement of Equip.	Net Cash Flow	Net Income Increase	Capital Repay.	System Maintenance	Replacement of Equip.	Net Cash Flow
0	0	0		0	0	0	0		0	0
1	7,813	5,900	590	0	1,323	8,590	5,900	590	0	2,100
2	15,625	5,900	590	0	9,135	17,180	5,900	590	0	10,690
3	15,625	5,900	590	0	9,135	17,180	5,900	590	0	10,690
4	15,625	5,900	590	12,477	-3,342	17,180	5,900	590	12,477	-1,787
5	15,625	5,900	590	0	9,135	17,180	5,900	590	0	10,690
6	15,625	5,900	590	0	9,135	17,180	5,900	590	0	10,690
7	15,625	5,900	590	0	9,135	17,180	5,900	590	0	10,690
8	15,625	5,900	590	12,477	-3,342	17,180	5,900	590	12,477	-1,787
9	15,625	5,900	590	0	9,135	17,180	5,900	590	0	10,690
10	15,625	5,900	590	0	9,135	17,180	5,900	590	0	10,690
Total	**148,438**	**59,000**	**5,900**	**24,954**	**58,584**	**163,211**	**59,000**	**5,900**	**24,954**	**73,357**
	Cost / Net Income Increase 89,854 / 148,438 = **61%**					Cost / Net Income Increase 89,854 / 163,211 = **55%**				

Source: JICA Survey Team

Table 6.2.13 Cash Flow Analysis in Delta

Case	**Case 1-B: Same Cropping Pattern; MOI only**					**Case 2-B: Additional Horticulture Crops: MOI only**				
Year	Net Income Increase	Capital Repay.	System Maintenance	Replacement of Equip.	Net Cash Flow	Net Income Increase	Capital Repay.	System Maintenance	Replacement of Equip.	Net Cash Flow
0	0	0		0	0	0	0		0	0
1	6,379	5,900	590	0	-111	7,488	5,900	590	0	998
2	12,759	5,900	590	0	6,269	14,977	5,900	590	0	8,487
3	12,759	5,900	590	0	6,269	14,977	5,900	590	0	8,487
4	12,759	5,900	590	12,477	-6,208	14,977	5,900	590	12,477	-3,990
5	12,759	5,900	590	0	6,269	14,977	5,900	590	0	8,487
6	12,759	5,900	590	0	6,269	14,977	5,900	590	0	8,487
7	12,759	5,900	590	0	6,269	14,977	5,900	590	0	8,487
8	12,759	5,900	590	12,477	-6,208	14,977	5,900	590	12,477	-3,990
9	12,759	5,900	590	0	6,269	14,977	5,900	590	0	8,487
10	12,759	5,900	590	0	6,269	14,977	5,900	590	0	8,487
Total	**121,210**	**59,000**	**5,900**	**24,954**	**31,356**	142,280	59,000	5,900	24,954	52,426
	Cost / Net Income Increase 89,854 / 121,210 = **74%**					Cost / Net Income Increase 89,854 / 140,161 = **63%**				
Case	**Case 1-C: Same Cropping Pattern Irrigation Improvement + MOI**					**Case 2-C: Additional Horticulture Crops Irrigation Improvement + MOI**				

Year	Net Income Increase	Capital Repay.	System Maintenance	Replacement of Equip.	Net Cash Flow	Net Income Increase	Capital Repay.	System Maintenance	Replacement of Equip.	Net Cash Flow
0	0	0		0	0	0	0		0	0
1	8,668	5,900	590	0	2,178	9,836	5,900	590	0	3,346
2	17,336	5,900	590	0	10,846	19,672	5,900	590	0	13,182
3	17,336	5,900	590	0	10,846	19,672	5,900	590	0	13,182
4	17,336	5,900	590	12,477	-1,631	19,672	5,900	590	12,477	705
5	17,336	5,900	590	0	10,846	19,672	5,900	590	0	13,182
6	17,336	5,900	590	0	10,846	19,672	5,900	590	0	13,182
7	17,336	5,900	590	0	10,846	19,672	5,900	590	0	13,182
8	17,336	5,900	590	12,477	-1,631	19,672	5,900	590	12,477	705
9	17,336	5,900	590	0	10,846	19,672	5,900	590	0	13,182
10	17,336	5,900	590	0	10,846	19,672	5,900	590	0	13,182
Total	**164,688**	**59,000**	**5,900**	**24,954**	**74,834**	**186,882**	**59,000**	**5,900**	**24,954**	**97,028**
Cost / Net Income Increase 89,854 / 164,688 = **55%**						Cost / Net Income Increase 89,854 / 186,882 = **48%**				

Source: JICA Survey Team

6.2.4 Repayment for Modern On-farm Irrigation in Case of Relatively Poor Farm Household

In this section, a farm income analysis is carried out for relatively poor farm households who cultivate only traditional crops such as wheat, grass, maize, and sorghum. Here we analyze the case of Upper Egypt, whose income level is lower than the model of the Delta. As shown in Table 6.2.14, the farm income per feddan of a farmer who cultivates only traditional crops without project is 21,164 LE, or about 80% of the farm income (26,663 LE) in the model used for economic evaluation.

In the case of introducing only modern on-farm irrigation and no change in cropping pattern (Case 1-B), the farm income would be 28,297 LE/feddan and the incremental farm income would be 7,133 LE/feddan. In this case, the repayment for the modern on-farm irrigation facilities over a 10-year period would be 133% of the incremental farm income, making repayment by increased income alone difficult. If the repayment period is set at 20 years, the repayment would be 96% of the incremental income.

In the case where modern on-farm irrigation is introduced with irrigation improvement (Case 1-C), the incremental income would be 11,261 LE/feddan and the amounts to be repaid for over 10-year and 20-year periods would be 84% and 61% of the incremental farm income respectively. In this case, the repayment can be made within the incremental income.

Based on the above discussions, the introduction of modern on-farm irrigation for the poor farm households should be combined with irrigation improvement such as improvement of the hydraulic structures, canal lining, and probably with the repayment period of 20 years, instead of 10 years. Technical assistance for the introduction of horticultural crops raising farm income should also be considered. Furthermore, it is recommended that subsidized policies be introduced, such as exemptions or deferments of repayments when grain prices collapse.

Table 6.2.14 Farm Income Model without Project (Upper Egypt): Traditional Crop Cultivation

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**88**	**0.88**						
Wheat	64	0.56	2.3	6.70	11,990	6,379	3,572	8,418
Berseem	36	0.32	12.0	1.00	3,840	5,330	1,706	2,134
Summer	**93**	**0.93**						
Maize	75	0.7	2.0	8.00	11,200	5,300	3,710	7,490
Sorghum	25	0.23	1.5	8.00	2,760	5,405	1,243	1,517
Nile	**15**	**0.15**						
Maize	100	0.15	2.0	8.00	2,400	5,300	795	1,605
Total		**1.96**			**32,190**		**11,026**	**21,164**

Source: JICA Survey Team

Table 6.2.15 Farm Income Model (Upper Egypt Case 1-B): Traditional Crop Cultivation

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**88**	**0.88**						
Wheat	64	0.56	2.6	6.70	13,600	5,845	3,273	10,327

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Berseem	36	0.32	13.3	1.00	4,262	4,542	1,453	2,809
Summer	**93**	**0.93**						
Maize	75	0.7	2.5	8.00	14,000	4,876	3,413	10,587
Sorghum	25	0.23	1.9	8.00	3,459	5,016	1,154	2,305
Nile	**15**	**0.15**						
Maize	100	0.15	2.5	8.00	3,000	4,876	731	2,269
Total		**1.96**			**38,321**		**10,024**	**28,297**

Source: JICA Survey Team

Table 6.2.16 Farm Income Model (Upper Egypt Case 1-C) : Traditional Crop Cultivation

Season/ Crop	Crop Intensity (%)	Cultivated Area (fed)	Yield (t/fed)	Price (LE/kg)	Gross Income (LE)	Production Cost (LE/fed)	Total Production Cost (LE)	Net Income (LE)
Winter	**88**	**0.88**						
Wheat	64	0.56	2.78	6.70	14,474	5,921	3,316	11,158
Berseem	36	0.32	14.52	1.00	4,646	4,542	1,453	3,193
Summer	**93**	**0.93**						
Maize	75	0.7	2.88	8.00	16,128	5,035	3,525	12,603
Sorghum	25	0.23	2.16	8.00	3,974	5,235	1,204	2,770
Nile	**15**	**0.15**						
Maize	100	0.15	2.88	8.00	3,456	5,035	755	2,701
Total		**1.96**			**42,678**		**10,253**	**32,425**

Source: JICA Survey Team

6.2.5 Contribution to Poverty Alleviation through the Project

The increase in farm income from the project contributes to poverty alleviation in Egypt. As noted above, farm income per feddan without project is calculated to be 26,663 LE/fed in Upper Egypt and 30,743 LE/fed in the Delta under the standard model, and 21,164 LE/fed under the relatively poor farm household model shown in 6.2.4. For an average family of 5 members in the project area, the poverty line for a household is calculated to be 51,420 LE (2019/2020 cost).

Assuming a household of 5 family members cultivating 1 feddan as a farm model, the farm income per feddan without project alone would be below the poverty line. With the increase in farm income with project, the standard model would be 43,843 LE/feddan (64% up) in Upper Egypt and 50,415 LE/feddan (64 % up) in the Delta, and the poor household model would be 32,425 LE/feddan (53% up). While an increase in farm income with project can bring the farm income level closer to the poverty line, farm income alone is still below the poverty line.

Although it is difficult to make a general statement on the relationship between farm income and the poverty line because it depends not only on the size of the farm and family but also on the income from livestock production and off-farm income, the Project can contribute to poverty alleviation to some extent by increasing farm income in rural areas where about 60% of farm households own less than 1 feddan of farmland.

6.2.6 Contribution to Food Security through the Project

Production increase with the project will contribute to enhancing the food security of Egyptian nation. In the cases of implementing full components, namely irrigation improvement and modern on-farm irrigation, it is expected that the annual increase of agricultural produce with the same cropping pattern (Case 1-C) and with the increase of horticulture crop (case 2-C) will be 223 thousand ton (11% increase from without project situation) and 343 thousand ton (16% increase) respectively.

Table 6.2.17 Annual Increase of Agricultural Produce with Project

Site	W/O P (ton)	Case 1-C (ton)	Case 2-C (ton)	Increment (ton)	
				Case 1-C	Case 2-C
Abo Shosha	223,771	249,402	261,647	25,631	37,876
Aros&Abo Seer	166,817	181,574	190,378	14,756	23,561
Kased	1,715,917	1,898,446	1,997,865	182,529	281,948

Total	**2,106,505**	**2,329,421**	**2,449,890**	**222,917**	**343,385**
(Ratio)	**1.00**	**1.11**	**1.16**	**0.11**	**0.16**

Source: JICA Survey Team

6.3 Proposed Indicators for Project Operation and Effects

Several indicators are proposed in order to measure project impacts by comparing before- and after-project. There are two types of indicators; operation and effect indicators. Operation indicators aim to measure operational status of the project, while effect indicators aim to measure effects generated by the project. In other words, as a result of improving facilities by the project, how the improved ones are utilized properly is evaluated by the operation indicators, and how the improved ones make effects to beneficiaries is evaluated by the effect indicators.

The project components are categorized into two from their characteristics and indicators are proposed separately to these two categories, namely “Rehabilitation / Construction of Hydraulic Structures and Canals” including Water Management Improvement, and “Modern On-farm Irrigation (MOI). While the former category is implemented by the initiative of the government side and primarily just upgrading the existing irrigation system, the latter brings about the drastic change of the on-farm water management as well as the on-farm irrigation method, and directly involves the farmer beneficiaries activities.

6.3.1 Rehabilitation / Construction of Hydraulic Structures and Canals

The proposed indicators for Rehabilitation / Construction of Hydraulic Structures and Canals are shown in Table 6.3.1. The list of the hydraulic structures to be rehabilitated or constructed will be prepared upon the implementation and the progress of implementation will be monitored. The length of canal lining is also monitored. At the same time the irrigation service area covered by the rehabilitated hydraulic structures and line canals will be counted as the achievement of the project.

As for the effect indicators, unit yield of major crops in the project area and also average annual farm income will surveyed. Average farm income should be surveyed by a specially organized survey team by MWRI for the purpose of measuring the project effects. At the same time, the unit yields of the major crops are measured through the survey, as well. The survey is carried out by the interviews to farmer beneficiaries. The data will be compared the baseline data set in this feasibility study.

Table 6.3.1 Proposed Indicators of Rehabilitation / Construction of Hydraulic Structures and Canals

Operation Indicators		Effect Indicators	
Definition: 1. Number of hydraulic structures rehabilitated and constructed 2. Farming area covered by the hydraulic structures rehabilitated / constructed. 3. Length of canals improved.		**Definition:** 1. Yield of major crops per unit area (ton/fed) 2. Average annual farm income (LE/feddan/year)	
Method of Data Collection: 1. Records / Documents of MWRI		**Method of Data Collection:** 1. Field interviews to farmer beneficiaries	
Baseline (2022)	**Target (3 years after Completion)**	**Baseline (2022)**	**Target (3 years after Completion)**
No rehabilitated / constructed structures	1. No. of structures rehabilitated / constructed: 135 sites (component 1: 3, component 2：19, component 3: 113) 2. Area covered by the structures rehabilitated / constructed: 127,187 feddan 3. Canal improved: 175.92km (Abo Shosha: 53.27km, Aros & Abo Seer: 32.25km, Kased: 90.40km)	1. Unit yields: Wheat: 2.30 t/fed Winter Onion: 12.0 t/fed Berseem: 12.0 t/fed Sugar beet: 19.5 t/fed Maize: 2.0 t/fed Sorghum: 1.5 t/fed Rice: 3.5 t/fed Summer Tomato: 14.5 t/fed 2. Farm income: Upper Egypt: 26,663 LE/fed Delta: 30,743 LE/fed	1. Unit yields: Wheat：2.51 t/fed Winter Onion：12.96 t/fed Berseem：13.08 t/fed Sugar beet：20.48 t/fed Maize：2.30 t/fed Sorghum：1.73 t/fed Rice 3.68 t/fed Summer Tomato：15.56t/fed 2. Farm income: Upper Egypt: 30,395 LE/fed Delta: 34,452 LE/fed

Remarks: Target areas of the component is 31,211 feddan in Upper Egypt and 95,976 feddan in Delta. The target increase of farm income is assumed no change in the cropping pattern.

Source: JICA Survey Team,

6.3.2 Modern On-farm Irrigation (MOI)

The proposed indicators for Modern On-farm Irrigation (MOI) are shown in Table 6.3.2. An operation indicator is set as the farming area, in which modern on-farm irrigation has been installed. The installment of MOI needs the agreement of the farmer beneficiaries who have to repay the investment cost. It is also required to organize farmers into water users' association to co-operate the system and therefore, the progress of this component involves a strong commitment of the farmer beneficiaries. Demonstration to show the effects of MOI by the assistance of the government is also crucial in the course of the project implementation.

Effect indicators are measured by the unit yield of major crops and average farm income. Change of cropping pattern, particularly the increase of horticulture crop will also be measured as the introduction of highly profitable horticulture crops are encouraged to farmers installing MOI. The method of the data collection is same as described for the rehabilitation / construction of the hydraulic structures.

MOI can be installed on the farm without the other category of the component, i.e. the rehabilitation / construction of the hydraulic structures, but the stabilization and increase of irrigation water conveyed up to the farm will augment the effects of the project and therefore, here the target of the indicators is set as the case of implementing both two categories.

Table 6.3.2 Proposed Indicators of Modern On-farm Irrigation

<table>
<tr><th colspan="2">Operation Indicator</th><th colspan="2">Effect Indicator</th></tr>
<tr><td colspan="2">Definition:
1. Area in which modern on-farm irrigation (MOI) has been installed</td><td colspan="2">Definition:
1. Yield of major crops per unit area (ton/fed)
2. Share of profitable horticulture crop in the cropping pattern (% of cultivated area)
3. Average annual farm income (LE/feddan/year)</td></tr>
<tr><td colspan="2">Method of Data Collection:
1. Records / Documents of MWRI</td><td colspan="2">Method of Data Collection:
1. Reference to the record in agricultural cooperatives in the project area
2. Reference to the record of Agricultural Extension Sector of the Ministry of Agriculture and Land Reclamation (MALR)
3. Field interviews to farmer beneficiaries</td></tr>
<tr><th>Baseline (2022)</th><th>Target (3 years after Completion)</th><th>Baseline (2022)</th><th>Target (3 years after Completion)</th></tr>
<tr><td>1. No area with modern on-farm irrigation</td><td>1. Area with modern on-farm irrigation: 11,386 fed</td><td>1. Unit yields:
Wheat: 2.30 t/fed
Winter Onion: 12.0 t/fed
Berseem: 12.0 t/fed
Sugar beet: 19.5 t/fed
Maize: 2.0 t/fed
Sorghum: 1.5 t/fed
Rice: 3.5 t/fed
Summer Tomato: 14.5 t/fed
2. Share of horticulture:
<table><tr><th></th><th>U.E.</th><th>Delta</th></tr><tr><td>Winter</td><td>19%</td><td>14%</td></tr><tr><td>Summer</td><td>24%</td><td>56%</td></tr><tr><td>Nile</td><td>51%</td><td>41%</td></tr></table>
3. Farm income:
Upper Egypt: 26,663 LE/fed
Delta: 30,743 LE/fed</td><td>1. Unit yields:
Wheat：2.78 t/fed
Winter Onion：16.80 t/fed
Berseem：14.52 t/fed
Sugar beet：26.72 t/fed
Maize：2.88 t/fed
Sorghum：2.16 t/fed
Rice：3.68 t/fed
Summer Tomato：20.30 t/fed
2. Share of horticulture
<table><tr><th></th><th>U.E.</th><th>Delta</th></tr><tr><td>Winter</td><td>21%</td><td>17%</td></tr><tr><td>Summer</td><td>28%</td><td>62%</td></tr><tr><td>Nile</td><td>59%</td><td>71%</td></tr></table>
3. Farm income:
Upper Egypt: 43,843 LE/fed
Delta: 50,415 LE/fed</td></tr>
<tr><td colspan="4">Remarks: Assumed that modern on-farm irrigation is installed in the area with the rehabilitation / construction of structures and canal improvement have been implemented.</td></tr>
</table>

Source: The JICA Survey Team

CHAPTER 7 ENVIRONMENTAL AND SOCIAL CONSIDERATION

7.1 Project Components

The Project aims to improve the irrigation system from upstream to the terminal level of canals and promotes efficient use of limited water resources by increasing the irrigation efficiency of the entire irrigation system. As shown in the schematic in Figure 7.1.1, the irrigation system consists of canals at various levels, from principal canals to on-farm canals, which convey agricultural water to farmlands. The Project aims to improve the irrigation efficiency of the entire irrigation system by rehabilitating the canals at the principal, main, and branch levels and introducing modern on-farm irrigation facilities (drip and/or sprinkler systems) combined with Meska rehabilitation works.

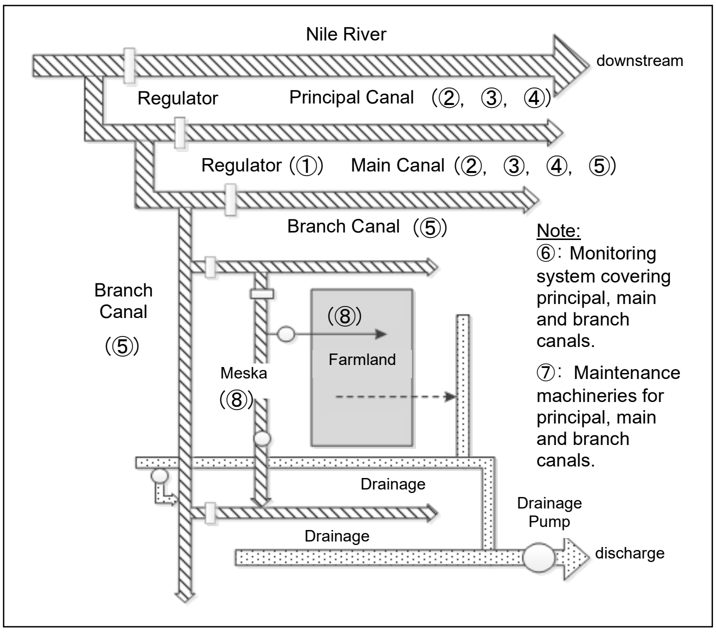


Figure 7.1.1 Schematic Image of Irrigation Canal System in Irrigational Sub-Regions (Source: JICA Survey Team)
(Note: Nos. in illustration correspond to project components in Table 7.1.1)

The proposed project components are shown in Table 7.1.1. The project components are sorted into three categories according to the nature of the components: 1) civil works at various levels of the canal system including hydraulic structure improvement and canal rehabilitation (refer to the components of No. 1, 2, 3, 4 and 5 in the table), 2) procurement and installment of equipment and machinery for supporting water management and canal maintenance of MWRI (components No. 7 and 8 in the table), and 3) introduction of a modern irrigation system at the on-farm level together with the Meska improvement (component No. 8 in the table).

Some negative environmental impacts related to the construction works are expected for category 1), while for category 2), only a few negative impacts are expected since the components only require procurement and installation of the equipment and machinery. For category 3), some negative environmental and social impacts are expected, mainly at the operational stage.

The project is classified as a Category B by the JICA environmental and social consideration categorization system because the project area is not in the sensitive area and the sector of the project does not likely have significant impacts on the environmental and social conditions indicated in the JICA environmental and social consideration guidelines issued in April 2010. Furthermore, the project does not fall under the category of a project impacting other indivisible projects.

The project sets up three priority irrigational sub-regions. In these priority sub-regions, small-scale canals (e.g., branch canals and small main canals) will be fully rehabilitated, and modern on-farm irrigation will be introduced throughout the area, in addition to the partial rehabilitation of large-scale canals (e.g., Bahr Yusef Principal Canal, Ibrahimia Principal Canal, and Kased Main Canal) upstream of the sub-regions. The project locations of the Bahr Yusef and Ibrahimia Principal Canals, the Kased Main Canal, and three priority sub-regions are shown in Figure 7.1.2.

Table 7.1.1 Proposed Project Components

No.	Component [*1]	Contents	Q'ty	Location
1	Large Hydraulic Structure Construction (LHSC)	Construction of; 1) Kased Intake, 2) Mahlet Menouf Regulator, and 3) Sorad Regulator.	3 structures, covering 95,976 feddan (40,309 ha)	On Kased Main Canal
2	Small Hydraulic Structure Construction (SHSC)	Construction of; 1) Beni Hedear Weir of Ibrahimia, 2) intakes of, e.g., Abo Seer, Omar Bek, Bahr El Kasheir, etc., 3) tail escapes, 4) culvert and aqueduct, etc.	38 structures, covering 127,187 feddan (53,418 ha)	On Bahr Yusef Principal Canal, On Ibrahimia Principal Canal, On Kased Main Canal, On small canals of three priority irrigational sub-regions[*2]
3	Hydraulic Structure Rehabilitation (HSR)	Rehabilitation of Hydraulic Structures assessed as S2, including replacement of gates and gate appurtenant.	144 structures, covering 127,187 feddan (53,418 ha)	
4	Large Canal Rehabilitation (LCR)	Rehabilitation including canal sectioning and slope protection and/or partial lining for large canals, e.g., Bahr Yusef and Ibrahimia Principal Canals and Kased Main Canal.	84.4 km	Bahr Yusef Principal Canal, Ibrahimia Principal Canal, Kased Main Canal
5	Branch Canal Rehabilitation and Lining (SCRL)	Rehabilitation including canal sectioning and concrete lining for the canals other than above, e.g., branch canals and small main canals. Note that concrete lining work is on-going covering around 20,000 km nationwide, so this component will be managed with the state budget.	268.6km	Small canals of three priority irrigational sub-regions[*2]
6	Water Management Improvement (WMI)	Procurement and installation of water management equipment, and development of a visual on-time monitoring system. Note that the system concerning Bahr Yusef and Ibrahimia Command Areas is included in the Project for Construction of the New Dirout Group of Regulators, and therefore, the system here to be introduced in the Kased Command Area.	1 lot	MWRI Office
7	Procurement of Maintenance Machineries (PMM)	Procurement of maintenance machineries specifically for the purpose of concrete-lined canals, and also machineries required for urgent repairment. Note that periodic and ordinary maintenance works are out-sourced to private companies.	1 lot	MWRI Office
8	Modern On-farm Irrigation (MOI) 8.1 Construction 8.2 Organizing & Training	8.1 Installment of modern on-farm irrigation system composed of sprinkler and drip facilities, including one-lifting pump stations and pipelines, together with the improvement of Meska by means of lining or installation of pipes. 8.2 Organizing of the farmers into WUAs, and providing training to the farmers who introduce modern on-farm irrigation	127,187 feddan (53,418 ha)	Priority irrigational sub-regions[*2] (Note: only Meska improvement is applied for Aros & Abo Seer sub-regions)
9	Project Management (PM)	Procurement of vehicles and office equipment, training, monitoring of project progress and evaluation of the project, and dispute board		

*1: Each project component is divided into the three categories below, according to the nature of the components.
- (blue) : Civil works at various levels of the canals
- (orange) : Procurement and installation of equipment and machineries
- (green) : Introduction of modern on-farm irrigation system (civil works and equipment installation)

*2: Three priority areas are set up as "Priority Irrigational Sub-regions."
1) Aros & Abo Seer priority sub-region (in Fayoum, irrigated by Bahr Yusef Principal Canal system)
2) Abo Shosha priority sub-region (in Beni Suef, irrigated by Ibrahimia Principal Canal system)
3) Kased priority sub-region (in Gharbia and Kafr El Sheik, irrigated by the Kased Main Canal system)

Source: JICA Survey Team

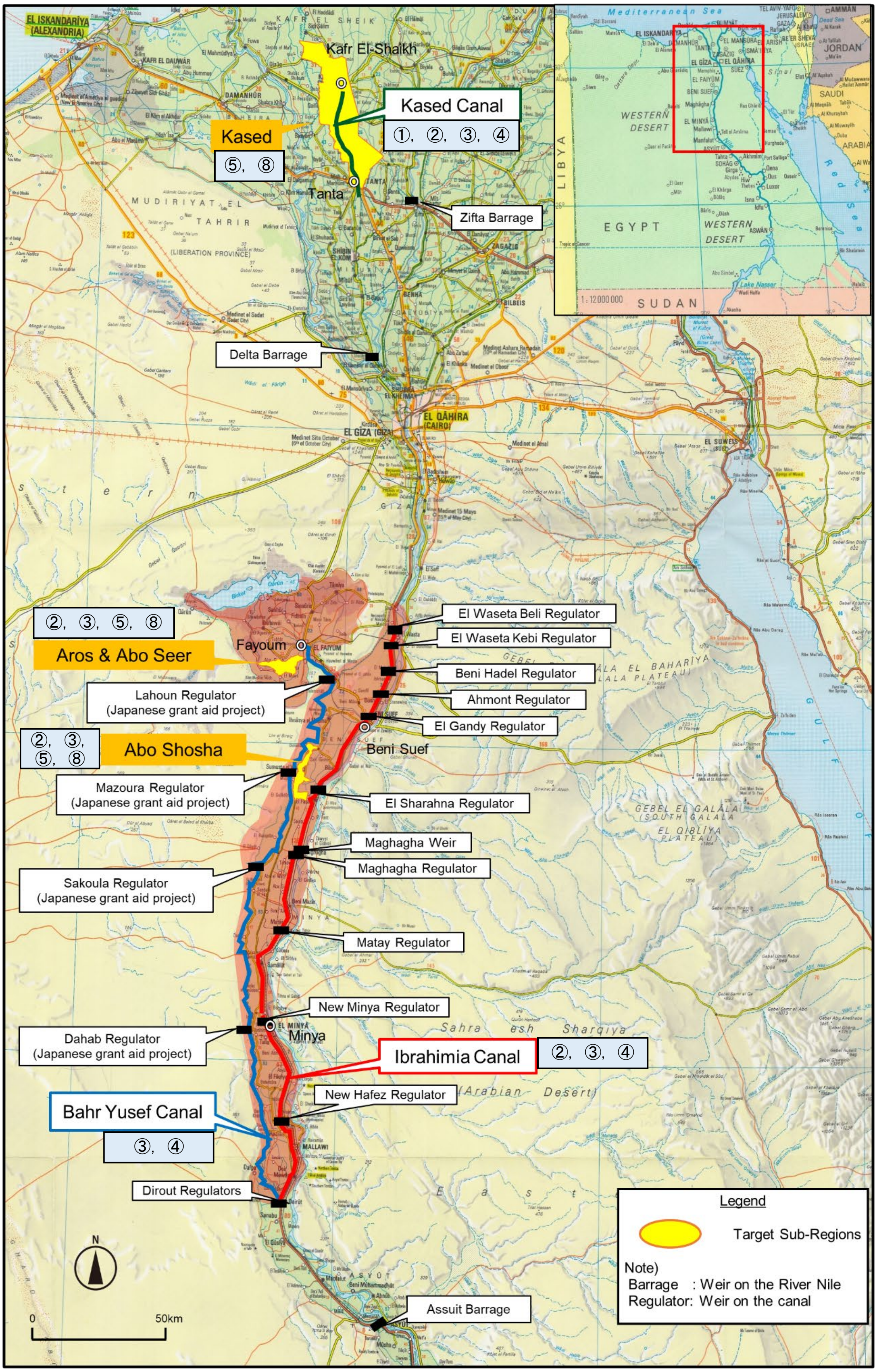


Figure 7.1.2 Locations of Project Components (Source: JICA Survey Team)
(Note: Nos. in illustration correspond to project components in Table 7.1.1)

It has been decided by the Egyptian government that the introduction of modern on-farm irrigation (corresponding to project component No.8) will be mandatory in all parts of Egypt except for some areas in the future. The Project plans to promote the introduction of modern on-farm irrigation in two priority sub-regions: Abo Shosha, at 17,881 feddan (7,510 ha), and Kased at 95,976 feddan (40,309 ha). For Aros & Abo Seer, only Meska improvements are planned for 13,330 feddan (5,599 ha), without the introduction of modern on-farm irrigation.

The Project plans to promote modern on-farm irrigation systems along Meska. One modern on-farm irrigation system covers 30 feddans (12.6 ha) of farmlands at maximum and covers the farmlands of several farmers. Therefore, the system will be installed by groups, which will be set up as Water Users' Associations (WUAs). The WUA will be responsible for the operation and maintenance of the system (refer to Figure 7.1.3: Concept of Modern On-farm Irrigation System Installation with Setting Up of WUA).

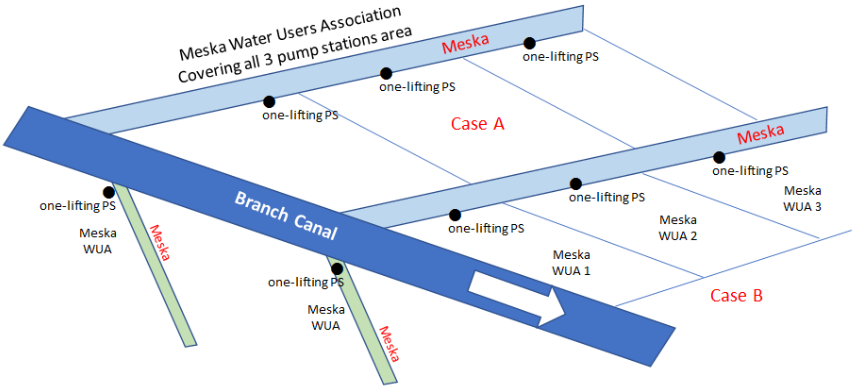


Figure 7.1.3 Concept of Modern On-Farm Irrigation System Installation with Setting up of WUA (Source: JICA Survey Team)

A modern on-farm irrigation facility consists of a system with a pump, pipelines, and watering equipment (e.g., drip tubes and/or sprinklers). Meska will also be improved by civil works such as concrete lining or pipe replacement together with modern on-farm irrigation facility arrangements. Meska improvement work will be implemented within the area of the existing Meska (refer to Figure 7.1.4: Model of Modern On-farm Irrigation Facility Arrangement).

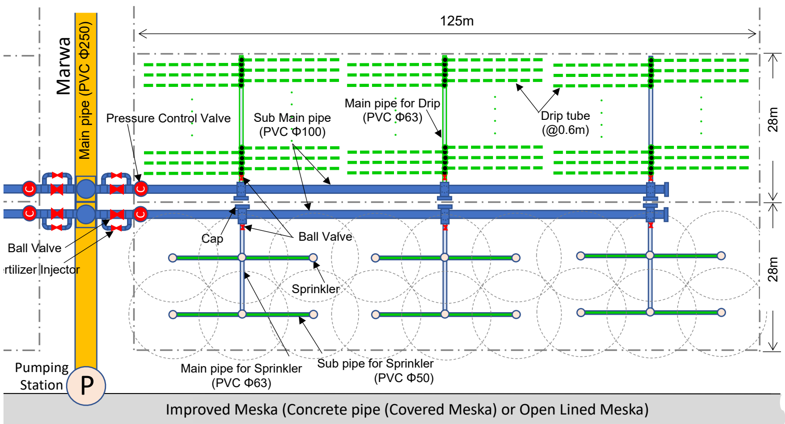


Figure 7.1.4 Model of Modern On-Farm Irrigation Facility Arrangement
(Source: JICA Survey Team)

Land for the pump facility will be used for the Sakia (water wheel), which is conventionally used for the purpose of raising water from Meska. Pipelines will be installed on the land of existing Marwa (on-farm small canals) with backfilling of soils. Accordingly, both works of Meska improvement and the modern on-farm irrigation facility will be carried out within the boundary of existing land use. New Lands acquisition and resettlement are not necessary.

7.2 Legislative and Institutional Framework of Environmental and Social Consideration

7.2.1 Legislative and Institutional System for Environmental and Social Consideration in Egypt

1) Institutional Framework

The Ministry of Environment (MOE) and its related agency, the Egyptian Environmental Affairs Agency (EEAA), are the environmental administrative bodies in Egypt. The EEAA is in charge of the review and approval of new projects in terms of environmental aspects in Egypt.

Figure 7.2.1 shows the organizational chart of the EEAA. In the EEAA, there are five sectors under the CEO-Deputy Chairman. The EIA Central Department, which is under the Environmental Management Sector, oversees the EIA review.

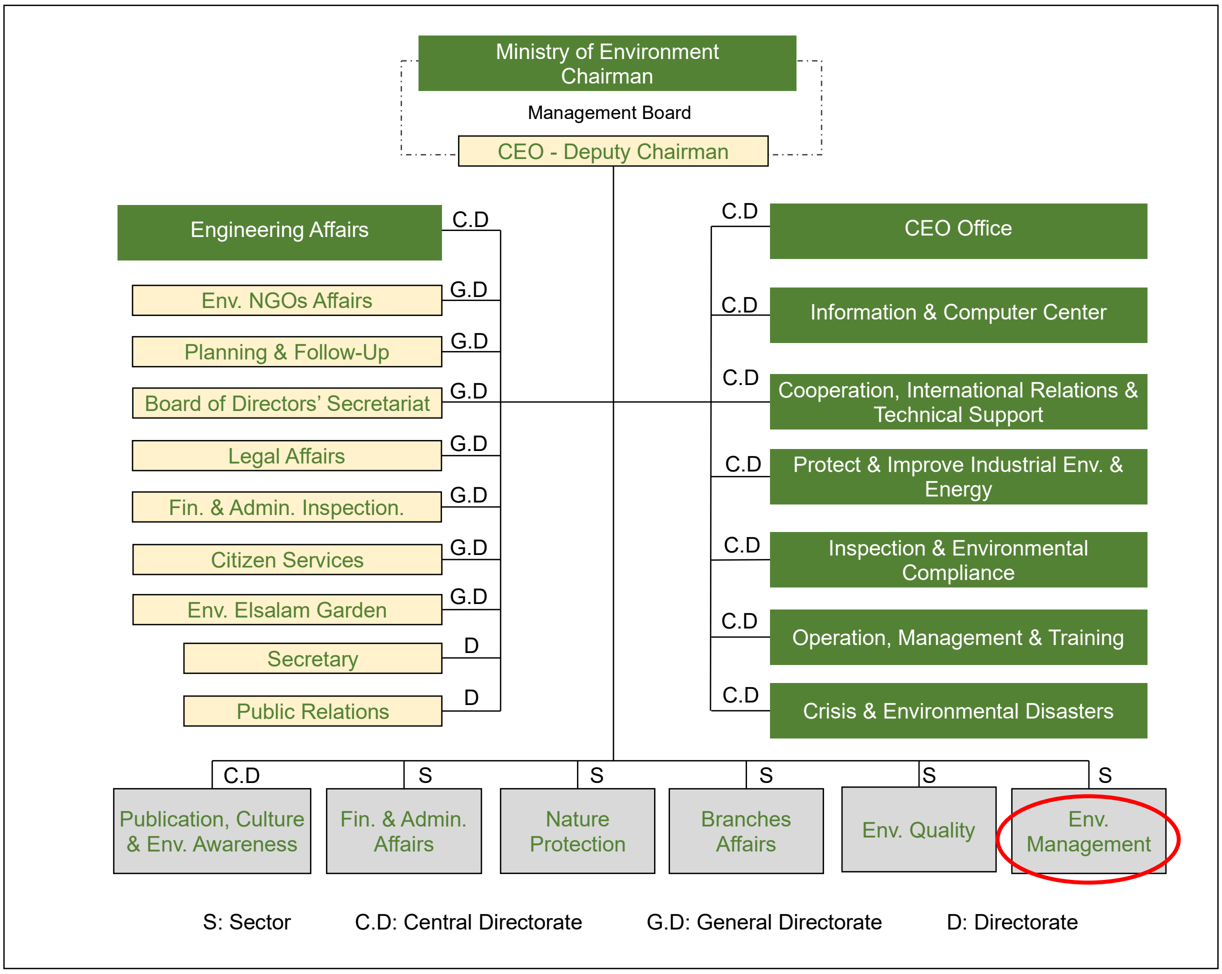


Figure 7.2.1 Organization Chart of the EEAA
(Source: EEAA website)

2) Environmental Laws and the EIA system in Egypt

The basic law concerning environmental management in Egypt is the Environment Law (Law No. 4/1994). The Environment Law stipulates the necessity of an environmental impact assessment (EIA) by project implementers and provides authorization to the EEAA to review and approve projects.

The EIA system in Egypt is regulated by the EIA Guidelines (2nd edition, 2009). The EIA Guidelines stipulate requirements and necessary steps of the EIA procedure. Based on the EIA Guidelines, projects are classified into three levels, Category A, B, or C. Definitions of the environmental category classifications are shown in Table 7.2.1 below.

Table 7.2.1 Definitions of the Environmental Category Classification by EIA Guidelines in Egypt

Category A :	Projects that are expected to have minimal environmental impact. Form A must be submitted as an application form for environmental review.
Category B :	Projects that are not expected to have a major impact, but are expected to have some environmental impact. Form B must be submitted as an application for environmental review.
Category C:	Projects that are expected to have a significant environmental impact. A full-scale EIA study and report must be submitted.

Source: Edited by JICA Survey Team based on the Guidelines of Principles and Procedures for Environmental Impact Assessment 2nd edition, 2009

The environmental categorization list given in the EIA guideline is shown in Table 7.2.2. It is assumed that the environmental categorization of this project will be Category B or C since the project is a medium to large-scale irrigation project. The decision on the environmental categorization will be given by the EEAA through the EIA review process (see. Figure 7.2.2: Flow of the Decision of Environmental Category in Egypt). Accordingly, MWRI needs to share the project information with the EEAA, as the project implementer, and receive the decision of environmental category from the EEAA. It is assumed that the timing of the discussion between MWRI and EEAA for the environmental category decision is after the discussion of DFR and decision-making of the project implementation by MWRI.

Table 7.2.2 The Environmental Categorization List by EIA Guidelines in Egypt
(Land Reclamation Projects, Irrigation and Drainage Projects)

Classification	Nature of the projects
Category A	• Land reclamation projects between 100 and 400 feddan
Category B	• Land reclamation projects between 400 and 2,000 feddan • Medium-scale irrigation and drainage projects
Category C	• Land reclamation projects of more than 2,000 feddan • Construction of waterways • Large-scale irrigation and drainage projects, dams, and barrages

Source: Edited by JICA Survey Team based on the Guidelines of Principles and Procedures for Environmental Impact Assessment 2nd edition, 2009

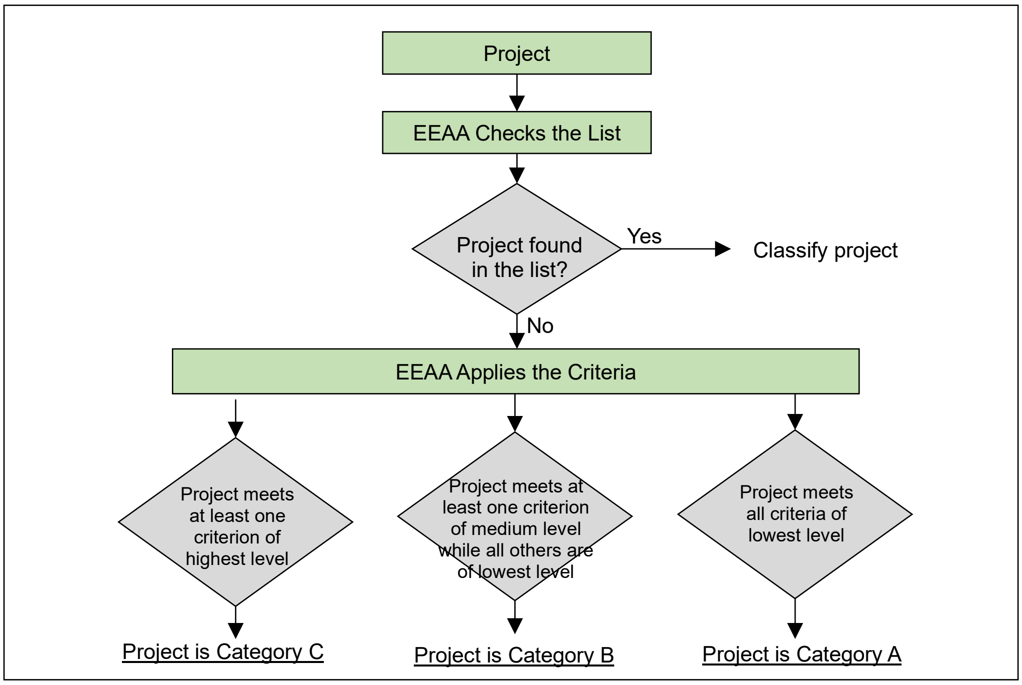


Figure 7.2.2 Flow of the Decision of Environmental Category for the Project in Egypt
Source: Guidelines of Principles and Procedures for Environmental Impact Assessment 2nd edition, 2009

A summary of the EIA review procedure is as follows:

1) MWRI, which will be the project implementer, confirms the category classification with the EEAA and receives a decision on the category classification from the EEAA.
2) MWRI submits application documents to the EEAA in accordance with the category classification.
   In the case of Category A: Application Form A
   In the case of Category B: Application Form B
   In the case of Category C: EIA Study Report (full-scale EIA study is necessary)
3) The EEAA reviews the application documents and decides on approval or disapproval, recommendations, need for additional information, etc. The submitted application documents and their review results are registered by EEAA.
4) In all the cases of Category A, B, and C, the EIA documents mentioned above are necessary to be submitted, and the review results and decision of approval or disapproval by the EEAA shall be given in writing within 30 days of the submission of application documents.

The contents of the EIA study report described in the EIA Guidelines, which is applied in the case of Category C, are shown in Table 7.2.3. The EIA study report should be prepared by an environmental consultant or an environmental consulting firm. If the project falls into Category C as the result of categorization by the EEAA, it is assumed that five months are necessary for procurement, survey, and preparation of the report. Therefore, six months are necessary in total considering the review period of the EEAA. In past similar projects of MWRI (e.g., the Dirout Regulator Construction Project), the National Water Research Institute (NWRC), which is a related institute of MWRI, conducted the EIA surveys and related works. Therefore, it is assumed that the NWRC is one of the candidates to implement such surveys and works.

Table 7.2.3 Contents of EIA Study Report Described in the EIA Guidelines in Egypt (In the Case of Category C Projects)

Contents of EIA Study Report					
1)	Executive Summary	7)	Environmental Management Plan		
2)	Project Description		-	Summary of Impacts	
3)	Laws and Regulations		-	Description of Mitigation Measures	
4)	Baseline Description		-	Description of Monitoring Program	
5)	Assessment of Impacts		-	Institutional Arrangements	
6)	Alternative Analysis	8)	Public Consultation		

Source: Edited by JICA Survey Team based on the Guidelines of Principles and Procedures for Environmental Impact Assessment 2nd edition, 2009

3) Laws/Regulations related to Protected Areas

The Law for Nature Protectorates (Law No. 102/1983) prohibits development activities that lead to environmental destruction or degradation within the protected areas. Construction works and economic activities (e.g., agriculture, industrial and commercial activities) are prohibited in the protected areas. In the neighboring areas of protected areas, any activities which will have an impact on the nature of protected areas are prohibited except with the permission of EEAA.

4) Laws/Regulations related to Waste Disposal

Removal of existing structures and disposal of construction materials during the construction works must comply with the Waste Management Law (Law No. 202/2020) and its executive regulation. The law stipulates that construction wastes must be disposed through licensed persons at designated sites.

5) Laws/Regulations related to Cultural Property

The Antiquities Protection Law (Law No. 117/2020) restricts construction work in areas where historical monuments or ancient buildings are located. In close areas, an approval from the Ministry of Culture is required for the implementation of construction work. If buried cultural assets are found during construction works, the construction contractor must report immediately to the ministry.

6) Laws/Regulations related to Involuntary Resettlement and Land Acquisition

The procedure of land expropriation and resettlement in Egypt is regulated by Law No. 10/1990 on Expropriation of Real Estate for Public Benefit and Improvement. Law No. 10 provides steps and requirements in case of the displacement of properties and acquisition of lands by a public project. A summary of the procedure regulated in Law No. 10 is shown in Table 7.2.4.

Table 7.2.4 Summary of Law No. 10: Expropriation of Real Estate for Public Benefit and Improvement

Purpose of expropriation to be applied in the law	The law is limited to public purposes and applies only to private real estate including lands and its appurtenances.
Decision of expropriation	The decision that a project falls under the category of public purpose is determined by presidential decree.
Publication	A copy of the presidential decree stating the project is a public purpose and the related documents (such as project outline and maps of the required properties) are published in the Official Gazette. These documents are put on the signboard at the local administrative offices, police stations, and courts.
Right to entry and investigation	The implementing organization of the expropriation has the right to conduct a field survey including a land survey of the designated land. Prior to the field survey, owners of the asset, who are called the Project Affected Persons (PAPs), are notified about the schedule of the survey by registered mail.
Appraisal and evaluation of the assets	The appraisal and evaluation of assets (property and land) are conducted by a committee consisting of representatives of the implementing organization of the expropriation, representatives of the local administrative office where the project is implemented, and the Chief of Treasury. The PAP should be present at the appraisal and evaluation of the above committee. After completion of the appraisal, both the committee and the PAP sign the appraisal report.
Costing of the compensation budget	The amount of compensation is determined by the Compensation Committee. The amount of compensation is calculated based on the market price at the time of the decision of expropriation.
Notice of the compensation amount	The calculation report of the compensation amount with necessary information (land area, property, names and addresses of owners) shall be posted in (1) the official gazette and two major newspapers in the area, (2) the office of the implementing organization of the expropriation, and (3) the local administrative office. Notification to the PAP shall be made by registered mail 15 days prior to the public announcement and the PAP is requested to evacuate the property within 5 months in the same registered mail.
Right of objection by PAPs	The PAP has a right to file a written objection within 30 days from the date of public notice. Further, the PAP has a right to appeal to the court within 60 days from the date of public notice if the PAP is dissatisfied with the response to the objection.
Completion of expropriation	If no objection or appeal is filed within the period, the case is finalized.

Source: Law No. 10/1990 on Expropriation of Real Estate for Public Benefit and Improvement

7) Labor Law

There is the Labor Law (Law No. 12/2003) in Egypt. Management of employment and work conditions of construction works must comply with the law.

8) International Conventions Ratified by Egypt

The Egyptian government has ratified several international conventions related to environmental and social issues, as shown in Table 7.2.5. Out of the list of conventions shown in Table 7.2.5, the climate change conventions and the Ramsar Convention on Wetland Conservation are the most relevant conventions to the project based on the nature of the project components.

Table 7.2.5 International Conventions Related to Environmental and Social Consideration Ratified by the Egyptian Government

Category	Name of Convention	Year of Ratification/ Signature
Climate Change	United Nations Framework Convention on Climate Change	1992
	Kyoto Protocol to the United Nations Framework Convention on Climate Change	1999
	Vienna Convention for the Protection of the Ozone Layer	1985
	Montreal Protocol on Substances that Deplete the Ozone Layer	1994
	Paris Agreement	2016
Hazardous Substances and Wastes	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	1993
	Stockholm Convention on Persistent Organic Pollutants	2002
Nature Conservation	Convention on Biological Diversity	1992
	Ramsar Convention: Convention on Wetlands of International Importance Especially as Waterfowl Habitat	1988

Source: Edited by JICA Survey Team based on the website of EEAA

7.2.2 Environmental Standards in Egypt

1) Air Pollution

Environmental standards of air pollution in Egypt are shown in Table 7.2.6, which will be referred to in the monitoring plan for the construction works such as the operation of construction machinery and so on.

Table 7.2.6 Environmental Standards for Air Pollution in Egypt

Pollutants	Averaging time	Standard value (μg/m^3)	
		Egypt	IFC Guideline[*1] (Reference)
Sulfur dioxide (SO_2)	Hour : 24 hours : Year:	350 150 60	500 (10 min) 20 -
Nitrogen dioxide (NO_2)	Hour : 24 hours : Year:	400 150 -	200 - 40
Ozone (Ox)	Hour : 8 hours :	200 120	- 100
Suspended particles matter (SPM)	24 hours : Year :	230 90	- -
Particle matter less than 10 μm (PM10)	24 hours : Year :	150 70	50 20
Black Smoke (BS)	24 hours : Year :	150 60	- -
Lead (Pb)	Year :	1	-

*1: IFC (International Finance Corporation)

Source: Executive Regulation, Law No. 4/1994 Environmental Protection Law

2) Noise and Vibration

Egyptian environmental standards of noise are shown in Table 7.2.7, which will be referred to in the monitoring plan for noise levels during construction work and operation of facilities, especially in the nighttime. Irrigation canals pass through both agricultural and city areas; therefore, the noise levels for monitoring by the project should be in the category of “Residential suburbs with little traffic” or “Residential areas in the city” in Table 7.2.7.

Table 7.2.7 Environmental Standards related to Noise in Egypt

Area	Standard value (dB)			
	Egypt		IFC Guideline[*1] (Reference)	
	Daytime (7:00-22:00)	Nighttime (22:00-7:00)	Daytime (7:00-22:00)	Nighttime (22:00-7:00)
Residential areas located on roads less than 12m and by some of the workshop	65	55	55	45

Area	Standard value (dB)			
	Egypt		IFC Guideline[*1] (Reference)	
	Daytime (7:00-22:00)	Nighttime (22:00-7:00)	Daytime (7:00-22:00)	Nighttime (22:00-7:00)
Residential Areas located on roads less than 12m width and by some of the workshop	70	60		
Industrial areas with light industries	70	60	70	70
Industrial areas with heavy industries	70	70		

*1: IFC (International Finance Corporation)
Source: Executive Regulation, Law No. 4/1994 Environmental Protection Law

Egyptian environmental standards do not specify vibration standards during construction works. Therefore, Japanese standards will be referenced to the monitoring plan for the construction works.

Table 7.2.8 Vibration Standards for Construction Works

Type of Construction Works	Standard value (dB)	
	Egypt	Japanese Law (Reference)
Piling works, crushing works, excavation works, demolition works, etc.	-	75

Source: Vibration regulation law in Japan

3) Water Quality

Environmental standards for water quality in public areas are regulated by "Law No. 48: Regarding the Protection of the Nile River and Waterways against Pollution." Water quality standards of the effluent going into the Nile River and canals are shown in Table 7.2.8, which will be referred to in the monitoring plan of the project. Since drainage from construction work in the canals will be anticipated, some related water quality parameters such as pH, oils, and suspended substances are to be monitored, and countermeasures are to be implemented.

Table 7.2.9 Environmental Standards for Effluent Water Quality in Egypt

Parameters	Unit	Standard value	
		Egypt	Japanese Law[*1] (Reference)
pH	-	6 - 9	5.8 - 8.6
Chemical Oxygen Demand (COD)[*2]	mg/l	80	120
Oils and Greases	mg/l	10	30
Total Suspended Solid (TSS)	mg/l	50	120
Sulphides (as H_2S)	mg/l	1	-
Cyanide	mg/l	None	1
Phosphate	mg/l	2	8
Total Nitrogen (T-N)	mg/l	10	60
Phenol	mg/l	None	5
Insecticides	mg/l	None	1 (as organic phosphate pesticides)
Mercury	mg/l	0.001	None
Lead	mg/l	0.001	0.1
Cadmium	mg/l	0.003	0.03
Arsenic	mg/l	0.01	0.1
Chrome	mg/l	0.01	0.5
Copper	mg/l	1	3
Nickel	mg/l	0.02	-
Zinc	mg/l	1	2
Portable enumeration for the colonic group	Per 100 cm^3	5,000	3,000

*1: Water pollution prevention law in Japan, *2: Measurement by potassium dichromate method
Source: Article 66 Discharge into Non-Potable Surface, Decree No. 402.2009, Amending the Executive Regulation of Law No. 48/1982, Regarding the Protection of the Nile River and Waterways against Pollution

4) Wastes

The Law on Waste Management (Law No. 202/2020) specifies management methods by classifying waste into hazardous waste and non-hazardous waste. Disposal of pesticides used in agriculture must be handled as hazardous waste, while disposal of agricultural residues such as rice straw and livestock wastes must be handled as non-hazardous waste. Pesticides that need to be disposal must be handled by licensed professional contractor. For agricultural residues, reuse in agriculture must be promoted by composting or other means, and disposal by open burning is prohibited.

EEAA has been dealing with the issue of proper waste management as one of the most important issues in recent years, and has prepared educational materials (e.g., Agricultural Waste Recycle Guide) on the effective use of agricultural residues, such as how to recycle rice straw, to educate farmers.[1] These materials will be referred to in the provision of technical training for farmers by MWRI (training in the demonstration farm for modern on-farm irrigation) to be described later.

5) Management of Pesticides

The Agricultural Pesticide Committee (APC) of the Ministry of Agriculture and Land Reclamation (MALR), which is responsible for the registration and licensing of pesticides distributed in Egypt, has published Technical Recommendations for Agricultural Pest Control (2020)[2] as a technical guide of pesticides use for farmers. It provides technical information on pesticide use, including the types of pests and diseases by crop, appropriate types and amounts of pesticides, and safe use and storage of pesticides.

Furthermore, it provides pest control methods that combine various techniques, such as biological control (e.g. use of natural enemies) and physical control (e.g. use of repellent materials). These materials will be referred to in the provision of technical training for farmers by MWRI (training in the demonstration farm for modern on-farm irrigation) to be described later.

7.2.3 GAP Analysis

The gaps between the JICA environmental and social consideration system and the Egyptian laws/regulations related to the environmental and social consideration system were analyzed. The results of the GAP analysis between the JICA Environmental Guidelines and the Egyptian EIA Guidelines are shown in Table 7.2.10. While some gaps related to the items of the impact analysis and monitoring are found, most of the requirements by the JICA Environmental Guidelines are covered by the Egyptian EIA Guidelines.

On the other hand, there are gaps between JICA policy and Egyptian laws/regulations on involuntary resettlement and land acquisition, as shown in Table 7.2.11. While involuntary resettlement and land acquisition by the project is not expected so far, JICA policy must be complied with as the project policy if the necessity of resettlement or land acquisition arises.

Table 7.2.10 GAP Analysis between JICA Environmental and Social Consideration Guidelines and Egyptian Laws / Regulations

Items	JICA Environmental and Social Consideration Guidelines	Egyptian Laws / Regulations	GAPs	Policy for filling GAPs
Principles	Environmental impacts that may be caused by projects must be assessed and examined in the earliest possible planning stage. Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan (Appendix 1, the JICA Guidelines).	In the EIA Guidelines (2nd edition, 2009), it is stated that environmental and social impacts of the project, alternatives, and mitigation measures, etc. must be assessed and examined in the project planning stage.	-	-
Information disclosure	EIA Reports must be written in the official language or in a language widely used in the country in which	The EIA Guidelines specify that the EIA report	-	-

[1] Agricultural Waster Recycle Guide, EEAA (https://www.eeaa.gov.eg/MediaCenter/81/sub/159/index)

[2] http://www.apc.gov.eg/Files/Releases/Recom.20-English.pdf

Items	JICA Environmental and Social Consideration Guidelines	Egyptian Laws / Regulations	GAPs	Policy for filling GAPs
	the project is to be implemented. When explaining projects to local residents, written materials must be provided in a language and form understandable to them. EIA Reports are required to be made available to the local residents of the country in which the project is to be implemented. The EIA Reports are required to be available at all times for perusal by project stakeholders such as local residents and copying must be permitted. (Section 2.1 and the 3rd item of Appendix 2, JICA Guidelines)	should be written in the official languages. It also states that the EIA report should be made available to the local communities affected by the project, and a summary of the EIA report should be disclosed on the website of the EEAA.		
Public consultation	For projects with a potentially large environmental impact, sufficient consultations with local stakeholders, such as local residents, must be conducted via disclosure of information at an early stage, at which time alternatives for project plans may be examined. In preparing EIA reports, consultations with stakeholders, such as local residents, must take place after sufficient information has been disclosed. Records of such consultations must be prepared. Consultations with relevant stakeholders, such as local residents, should take place if necessary throughout the preparation and implementation stages of a project. Holding consultations is highly desirable, especially when the items to be considered in the EIA are being selected, and when the draft report is being prepared. (Section 2.4 and Appendix-2, the JICA Guidelines)	The EIA Guidelines state that consultations with local communities and other stakeholders should be conducted from the project planning stage through public consultations, and the records of the consultations should be included in the EIA report.	-	-
Impacts to be Assessed	The impacts to be assessed with regard to environmental and social considerations include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, namely, migration of population and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety. In addition to the direct and immediate impacts of projects, their derivative, secondary, and cumulative impacts as well as the impacts of projects that are indivisible from the project are also to be examined and assessed to a reasonable extent. It is also desirable that the impacts that can occur at any time throughout the project cycle should be considered throughout the life cycle of the project. (Section 2.3, the JICA Guidelines)	The EIA Guidelines state that the impacts on the physical environment (water, air, soil, noise, etc.), biological environment (ecosystems, vegetation, etc.), and social environment (livelihoods, impact of involuntary resettlement and land acquisition, etc.) need to be assessed. It also states that it is necessary to consider the impacts over the life cycle of the project, including impacts during construction and operation. However, the impacts associated with indivisible projects are not within the scope to be assessed.	The impacts associated with indivisible projects to be assessed.	Include the impacts associated with indivisible projects to be assessed.
Monitoring, Grievance Handling and so on	Project proponents etc. should make efforts to make the results of the monitoring process available to local project stakeholders. When third parties point out, in concrete terms, that environmental and social considerations are not being fully undertaken, forums for discussion and examination of countermeasures are established	The EIA Guidelines specify that relevant materials should be made available in a timely manner and the consultations should be conducted between the	Availability of the results of the monitoring process to the local stakeholders,	Disclosure of the results of the monitoring process to the local stakeholders

Items	JICA Environmental and Social Consideration Guidelines	Egyptian Laws / Regulations	GAPs	Policy for filling GAPs
	based on sufficient information disclosure, including stakeholders' participation in relevant projects. Project proponents etc. should make efforts to reach an agreement on procedures to be adopted with a view to resolving problems. (Section 8.3 and 8.4, JICA Guidelines)	project implementer and local stakeholders and local NGOs in the community. However, it is not clearly noted whether the results of the monitoring process are included in the scope of relevant materials mentioned above.	NGOs.	and NGOs, as necessary.
Ecosystem and Biota	Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests. (Section 6.1, the JICA Guidelines)	The EIA Guidelines specify that impacts on the ecosystem and biota should be assessed in the scope of the biological environment indicated in the EIA Guidelines.	-	-
Indigenous People	Any adverse impacts that a project may have on indigenous peoples are to be avoided when feasible by exploring all viable alternatives. When, after such an examination, avoidance is proved unfeasible, effective measures must be taken to minimize impacts and to compensate indigenous peoples for their losses. (Section 8, the JICA Guidelines)	No laws/regulations are confirmed in Egypt	Consideration to Indigenous people	Consideration will be given for indigenous people based on JICA Guideline

Source: JICA Survey Team

Table 7.2.11 GAP Analysis between JICA Policy on Involuntary Resettlement and Land Acquisition and Related Egyptian Laws / Regulations

No.	JICA Environment and Social Consideration Guidelines	Egyptian Laws / Regulations	GAPs	Policy for filling GAPs
1.	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	The Constitution guarantees the protection of private property and the right to inherit property. The Constitution also guarantees that the right of ownership of property shall not be confiscated except for the public interest and with giving prior compensation.	Examination of the avoidance or the minimization of the impacts.	Examination of the avoidance or the minimization of the impacts.
2.	When after such examination, avoidance is proved unfeasible, population displacement is unavoidable, effective measures to minimize impact and to compensate for losses must be agreed upon with the people who will be affected. (JICA GL)			
3.	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	Compensation for the acquisition of individual property and real estate is provided in the regulation, but the necessity of the assistance for restoring livelihoods is not required.	Necessity of the livelihood restoring support.	Implementation of the livelihood restoring support.
4.	Compensation must be based on the full replacement cost as much as possible. (JICA GL) (Cost of any registration and transfer taxes shall be included in compensation.)	Evaluation of the compensation amount is determined by the evaluation committee based on the market price at the time of the decision of the resettlement or the land acquisition.	It is unclear in Egyptian law if compensation amount must include taxes and fees or not.	Compensation based on the full replacement cost.
5.	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	Compensation must be done prior to displacement.	-	-
6.	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	There is no provision for the preparation and disclosure of resettlement action plans.	Preparation and disclosure of the resettlement action plans.	Preparation and disclosure of the resettlement action plans
7.	In preparing a resettlement action plan, consultations must be held with the	Affected persons (PAPs) are notified individually in	- Prior consultation and information	Implementation of public meetings in

No.	JICA Environment and Social Consideration Guidelines	Egyptian Laws / Regulations	GAPs	Policy for filling GAPs
	affected people and their communities based on sufficient information made available to them in advance. (JICA GL) When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. (JICA GL)	advance, but there is no provision for prior consultation with the community. Furthermore, the manner of such consultations, such as form and language, is not specified.	disclosure with PAPs and community. - Implementation of consultations with the explanations in a form, manner, and language that is understandable to the affected people.	the planning and monitoring stages. And public meetings shall be held in Arabic that is understandable by the local people.
8.	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	Not specified.	Appropriate participation of PAPs and community.	Implementation of the public meeting in the planning, implementation and monitoring stage.
9.	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	Appeals against relocation can be made by PAPs to the commission within one month of public notice, while appeals against the amount of compensation are accepted within four months of public notice.	Unclear process of grievance handling mechanism.	Establishment of grievance handling mechanism.
10.	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socio-economic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits. (WB OP4.12 Para.6)	After the declaration of expropriation of land by public works, a census survey is conducted by the committee. After this survey, no alteration action is allowed to seek the benefit of compensation. On the other hand, there is no clear provision for setting a cut-off date.	Setting of cut-off date.	Setting of cut-off date.
11.	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	Eligible persons of the compensation are those who have formal legal right to the land. Illegal occupants are not covered as eligible persons of compensation.	Eligibility of compensation for illegal occupants of the land.	Illegal occupants are considered in the scope of eligible persons. However, compensation must not be considered for the land.
12.	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP4.12 Para.11)	Not specified.	Prioritization of land-based resettlement strategy.	Examination of the compensation option by providing alternative lands.
13.	Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para.6)	Not specified.	Providing support for the transition period.	Providing support for the transition period.
14.	Particular attention must be paid to the needs of vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP4.12 Para.8)	Not specified.	Particular attention to vulnerable groups.	Particular attention to vulnerable groups.
15.	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	Not specified.	Preparation of abbreviated resettlement plan.	Preparation of abbreviated resettlement plan.

Source: JICA Survey Team

7.3 Environmental and Social Impact Evaluation

7.3.1 Current Environmental and Social Conditions of the Project Area

1) Natural Environment

The natural environmental characteristics, such as geophysical features, meteorology, topography, and water quality, in the project area, are referred to in "3.1.1 Spatial Settings and Contextual Positioning," "3.1.3 Meteorology: Temperature, Rainfall and Humidity," and "3.1.4 Hydrology and Water Available for Irrigation". Farming conditions, such as soil condition, farming area, and culture, are referred to in "3.2 Agriculture in the Project Area" and "3.7 Long Term Trend of Cropped Area by Satellite Image Analysis". Information related to protected areas and biodiversity is described below.

2) Protected Area

➢ **National Protected Area**

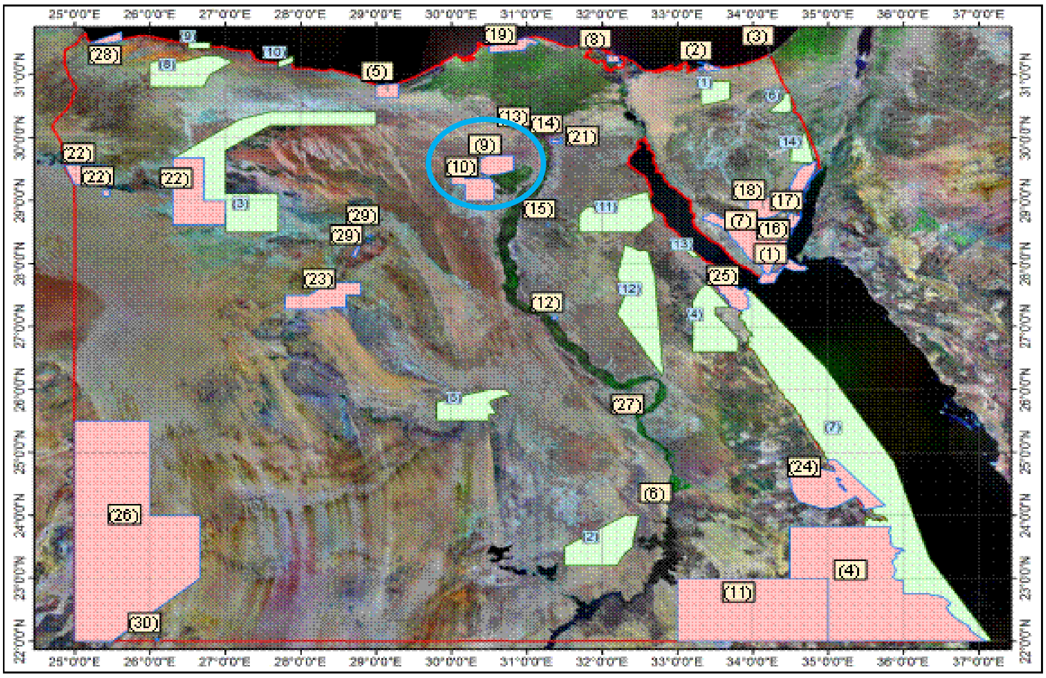
The list of national designated protection areas in Egypt is shown in Table 7.3.1, and their locations are shown in Figure 7.3.1. There are thirty areas which have been designated as national protection areas in Egypt. In the Fayoum Governorate, where the Aros & Abo Seer sub-region is located, the Lake Qarun Protectorate (No. 9) (hereinafter as referred to "Qarun Lake") and the Wadi El Rayan Protectorate (No. 10) (hereinafter as referred to "Rayan Lake") are designated. While the Sannur Cave Protectorate (No. 15) is in Beni Suef Governorate, its location is in the eastern desert more than 40 km from the Nile River, which is far from the project area. In Gharbia Governorate, there are no designated protection areas.

The closest project area to the boundary of the Qarun Lake protectorate is the construction area of the Bahr Yusef Principal Canal. The terminal point of the Bahr Yusef Principal Canal is located around 18 km from the boundary of the Qarun Lake protectorate. On the other hand, the closest project area to the boundary of the Rayan Lake protectorate is the construction area of the Aros & Abo Seer sub-region. The terminal point of the Aros & Abo Seer sub-region is located around 10 km from the boundary of the Rayan Lake protectorate. (Detailed locations are referred to in Figure 7.3.5 in a later section).

Table 7.3.1 List of the National Designated Protection Areas in Egypt

No.	Name	Area (km^2)	Governorate	No.	Name	Area (km^2)	Governorate
1	Ras Mohamed National Park	850	South Sinai	16	Nabq Protectorate	600	South Sinai
2	Zaranik Protectorate	230	North Sinai	17	Abu Galum Protectorate	500	South Sinai
3	Ahrash Protectorate	8	North Sinai	18	Taba Protectorate	3,595	South Sinai
4	El Omayed Protectorate	700	Matrouh	19	Lake Burullus Protectorate	460	Kafr El Sheikh
5	Elba National Park	35,600	Red Sea	20	Nile Islands Protectorates	160	All Governorates on the Nile
6	Saluga and Ghazal Protectorate	0.5	Aswan	21	Wadi Degla Protectorate	60	Cairo
7	St. Katherine National Park	4,250	South Sinai	22	Siwa	7,800	Matrouh
8	Ashtum El Gamil Protectorate	180	Port Said	23	White Desert	3,010	Matrouh
9	Lake Qarun Protectorate	250	El Fayoum	24	Wadi El-Gemal/Hamata	7,450	Red Sea
10	Wadi El Rayan Protectorate	1,225	El Fayoum	25	Red Sea Northern Islands	1,991	Red Sea
11	Wadi Alaqi Protectorate	30,000	Aswan	26	El Gulf El Kebeer	48,523	New Valley
12	Wadi El Assuti Protectorate	35	Assuit	27	El-Dababya	1	Qena
13	El Hassana Dome Protectorate	1	Giza	28	El-Salum	383	Matrouh
14	Petrified Forest Protectorate	7	Cairo	29	El-Wahat El-Bahreya	109	6th October
15	Sannur Cave Protectorate	12	Beni Suef	30	Mount Kamel Meteor Protectorate	8	New Valley

Source: Protectorates declared in the framework of Law 102 of the year 1983.



Remarks: Yellow numbers (pink areas) are national designated protection areas and correspond to the numbers in Table 7.3.1. Blue numbers (light green areas) are areas proposed as future protected areas.

Figure 7.3.1 Location of the National Designated Protection Areas in Egypt

Source: Edited by the JICA Survey Team based on the map shown on the EEAA website

➢ IBAs and KBAs

Important Bird Areas (IBAs) and Key Biodiversity Areas (KBAs) in Egypt are shown in Figure 7.3.2 and Figure 7.3.3. There are thirty-four (34) IBAs and thirty-eight (38) KBAs registered in Egypt. Qarun Lake and Rayan Lake are also registered as IBAs and KBAs. The other registered sites are not related to the project site.

1	Lake Bardawil	13	Aswan Reservoir	25	St. Katherine
2	Zaranik	14	Lake Nasser	26	Gabel Maghara
3	El Malaha	15	Hurghada Archipelago	27	Quseima
4	Bitter Lakes	16	Tiran Island	28	Wadi Gerafi
5	Lake Manzalla	17	Wadi Gimal Island	29	El Qasr Desert
6	Lake Burullus	18	Qulan Island	30	Suez
7	Lake Idku	19	Zabargad Island	31	Gabel El Zeit
8	Lake Maryut	20	Siyal Islands	32	El Qa Plain
9	Lake Qarun	21	Rawabel Islands	33	Ras Mohammed
10	Wadi El Rayan	22	Nabaq	34	Ain Sukhna
11	Wadi El Natum	23	Gabel Elba		
12	Upper Nile	24	The Abraq Area		

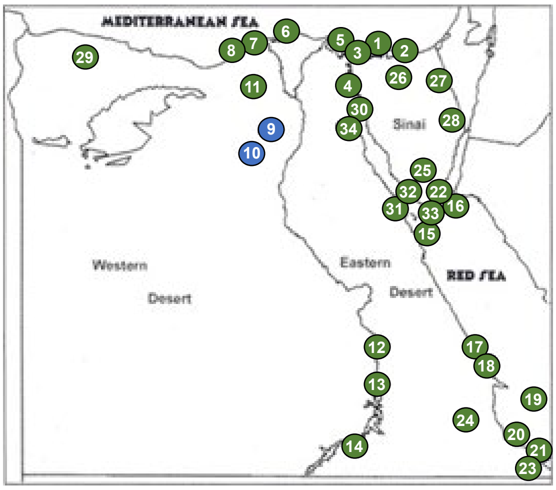


Figure 7.3.2 IBAs (Important Birds Areas) in Egypt

(Source: Edited by the JICA Survey Team based on EEAA website)

1	Lake Bardawil	13	Aswan Reservoir	25	St. Katherine	37	Coastal Dune
2	Zaranik	14	Lake Nasser	26	Gabel Maghara	38	Sallum Gulf
3	El Malaha	15	Hurghada Archipelago	27	Quseima		
4	Bitter Lakes	16	Tiran Island	28	Wadi Gerafi		
5	Lake Manzalla	17	Wadi Gimal Island	29	El Qasr Desert		
6	Lake Burullus	18	Qulan Island	30	Suez		
7	Lake Idku	19	Zabargad Island	31	Gabel El Zeit		
8	Lake Maryut	20	Siyal Islands	32	El Qa Plain		
9	Lake Qarun	21	Rawabel Islands	33	Ras Mohammed		
10	Wadi El Rayan	22	Nabaq	34	Ain Sukhna		
11	Wadi El Natrun	23	Gabel Elba	35	El Omayed		
12	Upper Nile	24	The Abraq Area	36	Ras El Hekma coastal dunes		

Note: No.1 - 34 sites shown above table are same as IBAs sites

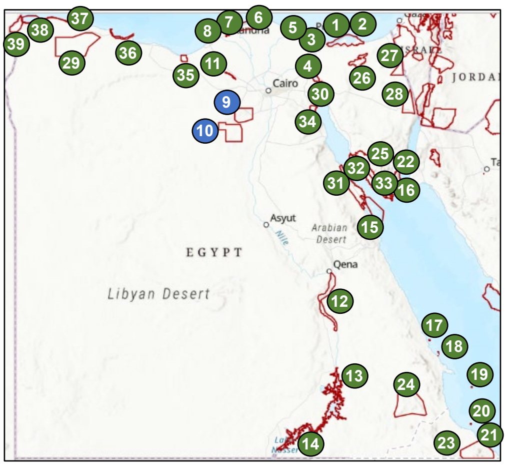


Figure 7.3.3 KBAs (Key Biodiversity Areas) in Egypt
(Source: Edited by the JICA Survey Team based on KBA Website)

➢ Ramsar Wetlands

Ramsar wetlands in Egypt are shown in Figure 7.3.4. There are four (4) wetlands registered under the Ramsar Convention. Qarun Lake and Rayan Lake are also registered as Ramsar wetlands as important wetlands (both registration years are 2012). The other registered sites are not related to the project site.

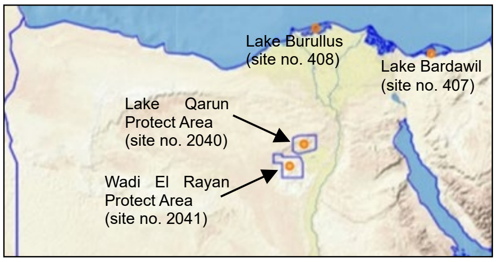


Figure 7.3.4 Ramsar Wetlands in Egypt
(Source: Ramsar Wetlands Website)

➢ Others (Heritages)

There are eight (8) UNESCO World Heritage sites in Egypt. Seven (7) of them are cultural heritage sites and one (1) is a natural heritage site. While the Wadi Al-Hiltan "Whale Valley" is located on the northwestern side within the boundary of the protectorate area of Rayan Lake, the project area is far away from the location of Wadi Al Hiltan (Detailed locations are referred to in Figure 7.3.5 in a later section). The other registered sites are not related to the project site.

Table 7.3.2 World Heritage Sites in Egypt (Culture and Nature)

No.	Name of heritage site	Governorate	Type
1.	Abu Mena	Alexandria	Culture
2.	Ancient Thebes with its Necropolis	Luxor	
3.	Historic Cairo	Cairo	
4.	Memphis and its Necropolis – the Pyramid Fields from Giza to Dahshur	Giza	
5.	Nubian Monuments from Abu Simbel to Philae	Aswan	
6.	Saint Catherine Area	South Sinai	
7.	Wadi Al-Hitan (Whale Valley)	Fayoum	Nature

Source: UNESCO World Heritage

3) Biodiversity

➢ National Biodiversity Overview

Egypt has 143 internationally important species, 1,500-2,000 non-petaled plant species, 2,302 petaled plant species, 111 mammal species, 480 bird species, 109 reptile species, 9 amphibian species, and over 1,000 fish species identified (as of 2016).[3]

The Nile River Basin and Delta region is on the main migration route of birds between Eurasia and East Africa, with about 200 migratory bird species passing through twice a year. According to the latest statistics (Bird Life International: 2023), 377 bird species have been identified in the country and 16 species are threatened with extinction (Endangered: 5, Vulnerable: 11). In addition, in the Western Desert,

[3] Egyptian Biodiversity Strategy and Action Plan (2015 - 2030), Ministry of Environment, Egypt (January 2016)

where Rayan Lake is located, the number of mammals is decreasing year by year, and species such as gazelles and hyenas are threatened with extinction.

- **Biodiversity of Qarun and Rayan Lakes**[4]

In Qarun Lake, 88 species of birds, more than 12 species of fish, and several species of reptiles have been identified. As the internationally important species, Black-necked Grebe *(Podiceps nigricollis)*, Shoveler *(Anas clypeata)*, Slender-billed Gull *(Larus genei)*, Slender-billed Gull *(Larus genei)*, and Little Tern *(Sterna albiforns)* have been identified. As Endangered (EN) or Vulnerable (VU) species, Rhim gazelle *(Gazella leptoceros)* and Dorcas gazelle *(Gazella dorcas)* have been identified. Mammals such as striped hyena *(Hyaena hyaena)* and fennec fox *(Vulpes zerda)* have been identified as Least Concern (LC) species.

In Rayan Lake, 164 bird species, 29 fish species, 24 mammal species, 14 reptile species, and 38 plants have been identified. Same bird species of international importance as Qarun Lake have been identified in Rayan Lake, too. Some ducks, eagles, hawks, and swans have been identified as rare species. As the Endangered (EN) or Vulnerable (VU) species, some migratory birds such as the Ferruginous duck (Aythya nyroca) and the Pallid Harrier (Circus macrourus) and some mammals such as striped hyena (Hyaena hyaena) and fennec fox (Vulpes zerda) have been identified.

On the southern coast of Qarun Lake, several salt production plants are operated to extract salt from the lake, helping to reduce the lake's salinity. As ecotourism activities, desert safaris, and boat tours are operated by several companies. There are aquaculture farms in the surrounding area of both Qarun and Rayan Lakes.

4) Impacts on Qarun Lake and Rayan Lake

As mentioned above, both lakes are sanctuaries of birds, and are designated as national protected areas, IBAs/KBAs, and Ramsar wetlands. The impact of the project on both lakes should be carefully considered.

Locations of the project components (Bahr Yusef Principal Canal, Ibrahimia Principal Canal, Aros & Abo Seer sub-region, and Abo Shosha sub-region) and two lakes are shown in Figure 7.3.6. Distances along the boundary of Qarun Lake and the project areas are about 18 km from the closest point of the Bahr Yusef Principal Canal, about 35 km from the closest point of the Ibrahimia Principal Canal, about 20 km from the closest point of the Aros & Abo Seer sub-region, and about 50 km from the closest point of the Abo Shosha sub-region.

On the other hand, distances along the boundary of Rayan Lake and the project areas are about 26 km from the closest point of the Bahr Yusef Principal Canal, about 37 km from the closest point of the Ibrahimia Principal Canal, about 10 km from the closest point of the Aros & Abo Seer sub-region, and about 27 km from the closest point of the Abo Shosha sub-region. The irrigation water distributed into the Fayoum area finally drains to Qarun and Rayan Lakes after passing agricultural lands and converting drainage.

Although partial rehabilitation (civil works) of the Bahr Yusef Principal Canal is planned in this project, the Bahr Yusef Principal Canals and both lakes are not close to each other (about 18 km from Qarun Lake and about 26 km from Rayan Lake), and the impact of the rehabilitation work on the Bahr Yusef Principal Canal on both lakes is not expected to be serious. In the Aros & Abo Seer area, rehabilitation of canals and hydraulic structures at the main and branch canal levels will be implemented, but the Aros & Abo Seer area is not close to both lakes (about 20 km from Qarun Lake and about 10 km from Rayan

[4] Edited by JICA survey team based on information RIS (Information Sheet on Ramsar Wetland).

Lake) and the impacts of the civil works are not expected to be serious.

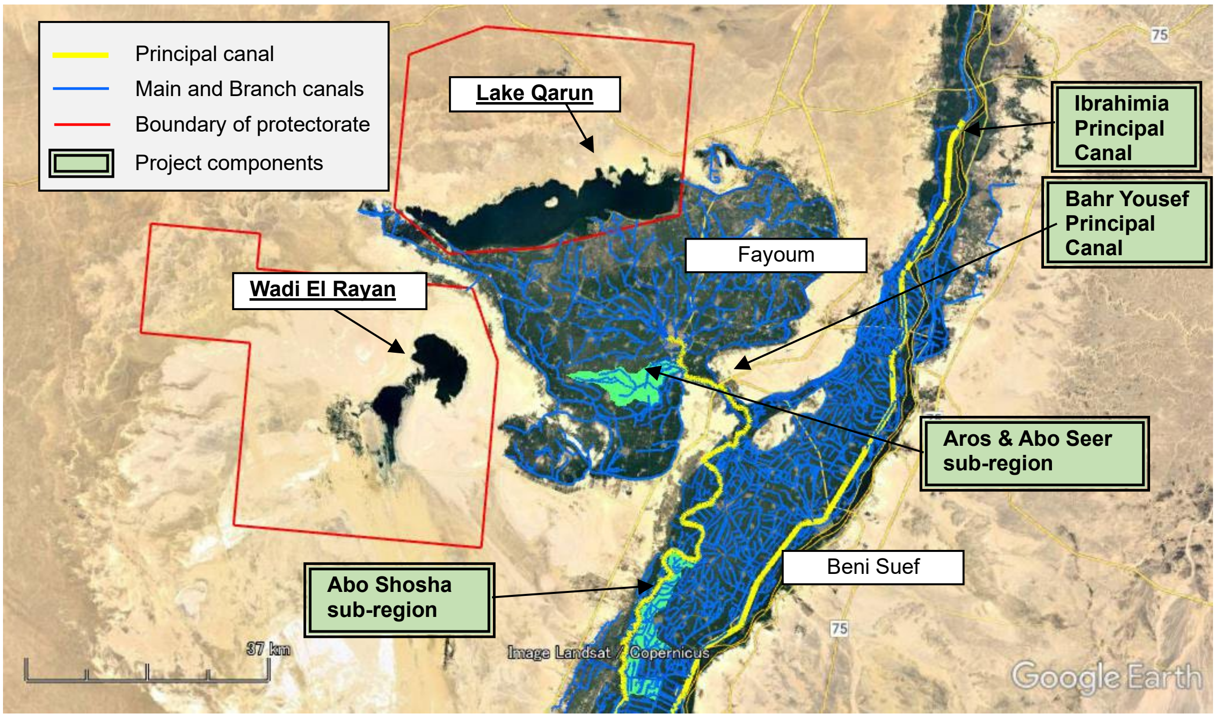


Figure 7.3.5 Location of the Project Components and Two Lakes (Lake Qarun and Wadi El Rayan)
Source: JICA Survey Team

On the other hand, the introduction of modern on-farm irrigation should be carefully considered since one of its features is water-saving agriculture, which means the volume of drainage from farmlands will be reduced significantly during operation. Drainage from farmlands is one of the sources of water for Qarun and Rayan Lakes, and the introduction of modern on-farm irrigation in the wider area of Fayoum will have a significant impact on both lakes, which are included in the Ramsar Wetlands (For the detailed analysis results, refer to "4.8 Irrigation Development in Fayoum with Modern On-farm Irrigation."). Considering the above, the possible contents of the project components are examined in "7.3.2 Examinations of Alternatives," which is discussed in the next part.

5) Polluted Condition in the Project Area

➢ Air Quality

In general, carbon monoxide, nitrogen oxides, particulate matter, and others are known as air pollutants. Air pollution sources are such as soot from factories, vehicle exhaust, open burning of solid waste, dust from construction sites, dust from roads, and so on. The monitoring results of regular monitoring stations by the national monitoring system in Egypt show that the air pollution loads of carbon monoxide and nitrogen oxides are within acceptable limits (no monitoring stations exceed the standard out of 87 stations in total), while the annual average levels of particulate matter such as PM10 and PM25 are usually above the permissible limits. (Annual average of PM10 in urban areas in 2012: 154 $\mu g/m^3$, standard value: 70 $\mu g/m^3$)[5].

➢ Water Quality

Water quality of the Nile River, which is the source of intake for irrigation canals, is relatively good in Upper Egypt and gradually deteriorates as the river flows south of Cairo to the downstream in Delta. Water quality of the Nile River in the Upper Egypt ranges from 5.83 to 9.71 mg/l for DO (dissolved

[5] State of the Environment 2022, Ministry of Environment, Egypt

oxygen) and 5.64 to 9.9 mg/l for COD (chemical oxygen demand), which are within the acceptable level of the environmental standard of Law 48. On the other hand, the water quality of the Nile River in the Rosetta branch of the Delta, which is south of Cairo, ranges from 6.5 to 7.08 mg/l for DO and 11.5 to 13.2 mg/l for COD, which are within the acceptable level for DO but above the standard level for COD[6].

➢ **Wastes**

In Egypt, the amount of waste generated is increasing every year as the population grows. Annual waste generation is around 20.9 million tons [7]. Types of waste are domestic garbage, construction waste, industrial waste, agricultural waste, and so on. Seven disposal sites are operated in Fayoum, four in Beni Suef, three in Minia, and five in Gharbia of Central Delta[8].

6) Social Condition in the Project Area

The population of the project area is referred to in "3.1.2 Area, Population and Beneficiaries". The social conditions of the project area, such as a form of inhabitancy, health and medical care, education, and other infrastructure, are referred to in "3.1.6 Social Condition". Socio-economic conditions of the farmers, such as household economy, land ownership and holding, and composition of family members, are referred to in "3.3 Farm Household Economy Based on Farmer Interviews and Questionnaire". Existing activities of the WUA, which is organized by farmers, are referred to in "4.7 Water Users Association (WUA) Establishment under Modern On-farm Irrigation". Other social conditions are described below.

➢ **Indigenous People**

Most people living in Egypt are Egyptian (99.7%) and few others are other ethnic groups (0.3%)[9]. Other ethnic groups include indigenous peoples such as the Nubians. There are no indigenous communities in the project area.

➢ **Vulnerable People**

Social protection issue in Egypt is administrated by the Ministry of Social Solidarity. The Ministry is responsible for social protection and social inclusion of vulnerable people. Specifically, the Ministry supports vulnerable people through basic income supports and employment supports. The Ministry also registers and manages NGOs involved in such activities. Vulnerable people targeted by the Ministry are poor families, woman headed families, elderly people, disabled people, orphans and unemployed.

The Ministry is implementing two programs, called as Takaful (solidarity) program and Karama (dignity) program for supporting poor families as safety net of them[10]. Takaful program supports poor families satisfied specific condition through financial support with providing 325 EGP monthly. Poor families with children are given additional 60 - 140 EGP monthly per child (maximum: three children per household) for education purpose of children. Eligibility is reviewed every three years.

Karama program supports the elderly and disable people through financial support. For elderly, more than 65 years old with no income through employment or no regular income through social security pension are given financial support. For disabled people, such households are given 325 – 550 EGP per disabled person. Takaful and Karama programs are implementing through world bank support (Strength Social Net Project) covering 3.1 million households (11.1 people) in 27 governorates nationwide. 75 %

[6] State of the Environment 2022, Ministry of Environment, Egypt
[7] State of the Environment 2022, Ministry of Environment, Egypt
[8] National Solid Waste Management Program (NSWMP) Egypt, SWM Governorate Survey
[9] The World Fact Book (CIA, 2006 estimation)
[10] https://www.worldbank.org/en/news/feature/2018/11/15/the-story-of-takaful-and-karama-cash-transfer-program

households are woman headed families (as of November 2020) [11].

Aside from that, the Egyptian Food Bank (established in 2006), NGO registered under the Ministry, is working with a network of 5,000 CDAs[12] in 27 governorates nationwide. The Egyptian Food Bank provides monthly food subsidies to 150,000 poor families. Source of subsidies is funds donated by more than 100 Egyptian and foreign companies and the budget size is about 750 million EGP (about 5 billion yen: 2020) [13].

➢ **Land Acquisition and Resettlement**

In Egypt, all citizens are granted the right to own land. Land registration is handled by the Ministry of Housing, Utilities and Urban Development (MOH) for residential land and the Ministry of Agriculture and Land Reclamation (MALR) for agricultural land.

The procedure of land expropriation and resettlement is regulated in the Law on Expropriation of Real Estate for Public Benefits and Improvement (Law No. 10/1990) (see. Table 7.2.4 aforementioned). Basically, the procedures for involuntary resettlement are followed the same law, however, there are some gaps between the law and JICA guidelines in terms of the implementation of livelihood support and compensation based on the full replacement cost. It is necessary to fill the gaps with JICA guidelines (see. Table 7.2.11).

7.3.2 Examination of Alternatives

In this part, the project components are divided into two, "Project Component No.1-7: Civil Works on Canals and Procurement Works" and "No.8: Modern On-Farm Irrigation," for examination of alternatives considering the characteristics of the project components. The same categorization is adapted to other examinations in later parts of this chapter.

1) Alternative Examinations on Project Components No.1-7 (Civil Works on Canals and Procurement Works)

Three alternatives were examined, including Option 0 (without project) (See. Table 7.3.3). Option 1 is the rehabilitation of existing canals and hydraulic structures, while Option 2 is the new construction of them. As a result of the examination of these alternatives, Option 1 (the current project proposal) was selected since the plan secures the benefits of the project and has advantages in terms of technical, financial, and environmental aspects compared with the alternatives.

Table 7.3.3 Result of Alternative Examinations
(For Project Components No.1 - 7: Civil Works on Canals and Procurement Works)

Environmental items	Option 0 (without project)	Option 1 Rehabilitation of canal/facilities	Option 2 New canal construction
Construction site	-	Available in the existing area	New construction sites are necessary.
Technical/ financial aspects	-	Techniques to be applied have already been established. The incurred cost is much lower than the cost of new construction.	This requires a new survey, design, and construction work to realize.
Environmental aspects	-	X Some impacts during construction works are expected. The impacts on the eco-system are less than with the plan for new canal construction.	XX Environmental and social assessment for New Lands is required. The impacts on the eco-system are larger than with the

[11] https://www.worldbank.org/en/results/2020/11/17/takaful-and-karama-a-social-safety-net-project-that-promotes-egyptian-women-empowerment-and-human-capital

[12] Community Development Association (CDA): CDA is the community-based association. There are a lot of CDAs in all over the Egypt and community collects funds through CDA for its activities, including religious events, day-care of children, etc.

[13] Information Gathering and Confirmation Study for IFNA All-Africa Expansion (JICA, 2020)

Environmental items	Option 0 (without project)	Option 1 Rehabilitation of canal/facilities	Option 2 New canal construction
			other two options.
Resettlement and land acquisition	None	None	XXX Large-scale land acquisitions and related surveys are required.
Effect of project	None	++ The project enables farmers to secure stable and efficient irrigation water.	++ Same as Option 1
Project cost	None	Medium	Very high
Selection	-	**Selected**	-
Reason	Water resource use will be severe since efficient water use is not promoted.	This option is technically, financially, and environmentally advantageous and is expected to have the same benefits as the new canal construction would in Option 2.	Project benefits are the same as in case of Option 1, but there are disadvantages in technical, financial, and environmental aspects.

Source: JICA Survey Team
X: small-scale negative impact, XX: middle-scale negative impact, XXX: large-scale negative impact
+: small-scale positive impact, ++: middle-scale positive impact, +++: large-scale positive impact

2) Alternative Examinations on Project Component No.8 (Modern On-Farm Irrigation)

Four alternatives were examined, including Option 0 (without project) (See. Table 7.3.4). The current project proposal, which is Option 2 (to introduce Meska Improvement and Modern On-Farm Irrigation in all priority areas including Aros & Abo Seer in Fayoum), was evaluated to have a high negative impact on Qarun and Rayan Lakes. In 2022, the Egyptian government planned to promote modern on-farm irrigation including in the Fayoum area in which Aros & Abo Seer is located; however, it is difficult to recommend implementing it as the JICA project considering the future impact on the Fayoum area.

Instead of that, Option 3 was examined, which is the plan to cancel promoting modern on-farm irrigation in the Aros & Abo Seer area and only apply Meska improvements and hydraulic structure improvement for them. In the other two priority sub-regions, the full package (combination of Meska improvement and modern on-farm irrigation) will be introduced as the same as the current project proposal.

As a result of the above examination, Option 3 was selected since the plan secures a certain level of benefits of the project and avoids significant negative impacts on the environment.

Table 7.3.4 Result of Alternative Examinations
(For Project Component No.8: Modern On-Farm Irrigation)

Environmental items	Option 0 (without project)	Option 1 Meska improvement only in three priority sub regions	Option 2 Meska Improvement + Modern On-Farm Irrigation in three priority sub regions	Option 3 Meska Improvement only in Aros & Abo Seer area, Meska Improvement + Modern On-Farm Irrigation in two other priority sub regions
Technical aspects	−	Simple compared to the other two options on the right.	Technical support for the operation of the modern on-farm irrigation facility for WUA is necessary.	Same as left
Financial aspects		Lower cost compared to the other two options on the right.	Farmers' household economy will be affected by the installation of modern on-farm irrigation since the installation costs will be borne by the farmers themselves.	Same as left
Environmental aspects	−	X Smaller impacts on the environment compared to the other two options on the right.	XXX Introduction of modern on-farm irrigation in the whole area of Fayoum will have significant negative impacts on water quantity and quality, and the	X In Fayoum, only Meska improvement will be carried out, and the promotion of modern on-farm irrigation will be cancelled. In this arrangement,

Environmental items	Option 0 (without project)	Option 1 Meska improvement only in three priority sub regions	Option 2 Meska Improvement + Modern On-Farm Irrigation in three priority sub regions	Option 3 Meska Improvement only in Aros & Abo Seer area, Meska Improvement + Modern On-Farm Irrigation in two other priority sub regions
			wise-use of Qarun and Rayan Lakes designated as the Ramsar wetlands. This option impacts the eco-system of two lakes. (For the detailed analysis results, refer to “4.8 Irrigation Development in Fayoum with Modern On-Farm Irrigation”)	the significant negative impacts on Qarun and Rayan Lakes, including the impacts on the eco-system of the lakes, are avoided.
Social aspects	−	+ Equally water distribution will be achieved by Meska improvement.	++ Improvement of water distribution and farm economy are expected through the full package effect of Meska improvement and modern on-farm irrigation. X Some of farmers in Fayoum are conservative against the installation of modern on-farm irrigation, hence the seeking consent of farmers are not easy.	++ Improvement of water distribution and farm economy are expected through the full package effect of Meska improvement and modern on-farm irrigation.
Effect of project	None	+ Although the unequal water management will be solved, a water-saving effect is not expected by the project.	+++ The full package effect of Meska improvement and modern on-farm irrigation will be achieved, and significant water savings are expected.	++ Water saving effect is limited in the Fayoum area because of only implementing the Meska improvement.
Selection	−	-	-	Selected
Reason	Water resources will be severe since efficient water use is not promoted.	Large-scale water saving effects are not expected; thus, the water resources will be severe.	This plan targets only the priority sub-region, Aros & Abo Seer, in Fayoum; however, it cannot be denied that effects will spread throughout the area of Fayoum and finally affect the environment of Qarun and Rayan Lakes. Therefore, it is difficult to recommend promoting the plan as a JICA project.	The plan secures a certain level of project benefits by applying Meska improvement and avoids significant negative impacts on Qarun and Rayan Lakes in the Fayoum area. Considering the balance of project benefits and the impacts on the environment, this plan is considered the optimum option.

Source: JICA Survey Team

X: small-scale negative impact, XX: middle-scale negative impact, XXX: large-scale negative impact

+: small-scale positive impact, ++: middle-scale positive impact, +++: large-scale positive impact

7.3.3 Scoping and TOR of Environmental and Social Consideration Survey

Scoping result for the pre-evaluation of the environmental and social impacts of the project is shown in Tables 7.3.5 and 7.3.6.

Table 7.3.5 Results of Scoping

(For Project Components No.1 - 7: Civil Works on Canals and Procurement Works)

Category	No.	Environmental item	Selection as scoping result		Reason
			Before / during construction	Operation stage	
Pollution	1	Air Quality	✓	-	**Construction Stage:** ***Exhaust from the construction machinery and vehicles*** can be the cause of air pollution in the neighboring areas of construction work. **Operation Stage:** Air pollution by the operation of facilities is not anticipated.
	2	Water Quality	✓	✓	**Construction Stage: *Drainage of construction work* in the canals and *sewage from the workers' camp*** can cause water pollution in the neighboring area. **Operation Stage: *Regular water quality monitoring of canals is recommended for irrigation use.***
	3	Waste / Garbage	✓	✓	**Construction Stage: *Generation of construction wastes and garbage*** during the construction works, such as wastes from removal of existing structures, removal of sands from the excavated works, garbage from the workers' camp, and so on., are anticipated. **Operation Stage:** Systematic dredging of canals is necessary to ensure continuous water passage during the operation stage. During this work, it is anticipated to ***generate dredged sands which should be disposed of properly*** at disposal sites.
	4	Soil Contamination	✓	-	**Construction Stage: *Leakage of the oils*** from construction machinery can be the cause of soil contamination. **Operation Stage:** Soil contamination by the operation of facilities is not anticipated.
	5	Noise and Vibration	✓	✓	**Construction Stage: *Noises and vibrations by the construction machinery and vehicles*** can cause noise and vibrations in the neighboring area of the construction sites. **Operation Stage:** In the case of pump stations being planned in the project component, ***operation of the pump can cause noise and vibrations*** in the neighboring area of the stations.
	6	Subsidence	-	-	Land subsidence is not anticipated to be affected since most of the works will be rehabilitation of existing structures.
	7	Odor	-	-	Generating odors to the surrounding area is not anticipated.
	8	Sediment	-	-	The sediment of rivers or ponds is not anticipated to be affected since the works will be carried out within and along the canals.
Natural environment	9	Protected Areas	✓	✓	**Construction Stage and Operation Stage:** ***Impacts on the Qarun and Rayan Lakes*** by the civil works of the project (rehabilitation of main and branch canals) ***should be confirmed***.
	10	Ecosystem	✓	✓	
	11	Hydrology	-	-	The streams, riverbeds, or ponds are not anticipated to be affected since most of the works will be carried out within and along the canals.
	12	Topography and Geology	-	-	The existing topography and geology of the area is not anticipated to be affected since large scale earth filling and cutting works are not planned.
Social environment	13	Resettlement	✓	✓	**Construction Stage and Operation Stage:** Relocation of houses and resettlement of people are not planned in the project. ***The necessity or lack thereof of land acquisition by the project should be confirmed***.
	14	The poor	✓	✓	**Construction Stage: *Positive impacts are expected*** since the project may create job opportunities for construction works. **Operation Stage: *Positive impacts are expected*** since the project may contribute to the income generation of beneficiaries including poor people through the

Category	No.	Environmental item	Selection as scoping result		Reason
			Before / during construction	Operation stage	
					agricultural infrastructure development in the area.
	15	Ethnic Minorities and Indigenous Peoples			Ethnic minorities and indigenous people are not confirmed in and around the project area.
	16	Livelihood / Local Economy	✓	✓	**Construction Stage:** ***<u>Positive impacts are expected</u>*** since the project may create job opportunities for construction works. **Operation Stage:** ***<u>Positive impacts are expected</u>*** since the project may contribute to the income generation of beneficiaries including poor people through the agricultural infrastructure development in the area.
	17	Land Use and Local Resource Utilization	-	-	The project does not affect the existing land use and local resource utilization since the project components are mainly rehabilitation work of the existing irrigation system.
	18	Water Usage or Water Rights and Rights in Common	✓	✓	**Construction Stage:** ***<u>The construction works may affect the existing water usage in the area</u>*** since farmers need irrigation water from existing canals during rehabilitation work of canals. **Operation Stage:** ***<u>Positive impacts are expected</u>*** since the project will promote efficient water use through rehabilitation of irrigation facilities as well as promotion of the modern on-farm equipment in the terminal farm field.
	19	Existing Social Infrastructure and Services	✓	✓	**Construction Stage:** Due to the increase of construction vehicles, ***<u>local transportation around the construction area may be affected</u>***. And the construction work may affect the existing usage of the roads and irrigation facilities. **Operation Stage:** ***<u>Positive impacts are expected</u>*** on local transportation since the rehabilitation of maintenance loads along canals will be implemented together with the canal rehabilitation by the project.
	20	Social Institutions	✓	-	**Construction Stage:** Construction work may affect the usage of branch irrigation canals managed by Water Users' Associations (WUAs). ***<u>Sufficient explanation of the content and schedule of construction work to the WUAs should be given at a suitable time</u>***. **Operation Stage:** Since the project works on rehabilitation of existing facilities, operation way of such facilities will be not changed. Thus, impacts on social institutions are not expected.
	21	Misdistribution of Benefits and Damages	-	✓	**Construction Stage:** Since the project works on rehabilitation of existing facilities, no impacts are expected on misdistribution of benefits and damages of beneficially. **Operation Stage:** ***<u>Positive impacts are expected</u>*** since rehabilitated irrigation systems will distribute irrigation water equally over an area.
	22	Conflict	-	✓	**Construction Stage:** Since the project works on rehabilitation of existing facilities, construction works will not lead any conflicts. **Operation Stage:** ***<u>Positive impacts are expected</u>*** since rehabilitated irrigation systems will distribute irrigation water equally over an area.
	23	Cultural heritage	-	-	Cultural heritage sites are not confirmed in and around project area.
	24	Landscape	-	-	Construction of buildings which affect the landscape is not planned.
	25	Gender	-	-	Since the project works on rehabilitation of existing facilities, construction works and operation of facilities will not impact on gender.
	26	Rights of Children	-	-	Since the project works on rehabilitation of existing facilities, construction works and operation of facilities will not impact on right of children.

Category	No.	Environmental item	Selection as scoping result		Reason
			Before / during construction	Operation stage	
	27	Hazards (Risks), Infectious diseases such as HIV/AIDS	✓	-	**Construction Stage:** ***There are risks of spreading infectious diseases*** such as COVID-19 and HIV due to the entering of construction workers into the area. **Operation Stage:** Operation of rehabilitated facility is not expected to cause infectious diseases or any other impact.
	28	Work Environment (including safety)	✓	-	**Construction Stage:** There are risks of work accidents during construction work. ***Safety and health of construction workers shall be considered*** during construction work. **Operation Stage:** Since operation method of rehabilitated facility is not changed, work environment for the operation of facility is not change.
Others	29	Accidents	✓	-	**Construction Stage:** ***There are risks of accidents*** by operating construction machinery, vehicles, and so on, during construction work. **Operation Stage:** Operation of rehabilitated facility is not expected to cause increase of work accidents, since the operation way is not changed.
	30	Transboundary Impact, Climate Change	-	✓	**Construction Stage:** Some greenhouse gases will be produced during construction work, but the amount is limited. **Operation Stage:** ***Positive impacts are expected.*** Adaptability against the fluctuation of water resources during future climate change, such as drought, will be improved since efficient irrigation water use will be enhanced through the project.

Source: JICA Survey Team

Table 7.3.6 Results of Scoping
(For Project Component No.8: Modern On-Farm Irrigation)

Category	No.	Environmental item	Selection as scoping result		Reason
			Before/ during construction	Operation stage	
Pollution	1	Air Quality	✓	-	**Construction Stage:** ***While scale of anticipated negative impacts are small, impacts during construction work are expected***. **Operation Stage:** Air pollution by the operation of facilities is not anticipated.
	2	Water Quality	✓	✓	**Construction Stage:** ***While scale of anticipated negative impacts are small, impacts during construction work are expected***. **Operation Stage:** ***Water quality may be affected*** by the operation of modern on-farm irrigation ***due to the clogging of drip tubes and sprinklers***.
	3	Waste / Garbage	✓	✓	**Construction Stage:** Negative impacts are expected by ***generation of the construction wastes and possible throwing of garbage by workers.*** **Operation Stage:** ***Water quality may be affected*** by the operation of modern on-farm irrigation ***due to the clogging of drip tubes and sprinklers***.
	4	Soil Contamination	✓	✓	**Construction Stage:** Since the work will be carried out in the farm field, ***soil contamination during construction works is anticipated***. **Operation Stage:** ***Reducing agricultural inputs (pesticides and fertilizers) is expected*** by promoting modern on-farm irrigation farming techniques. On the other hand, there is concern that the change from the conventional method (flood irrigation) to the modern on-farm irrigation method ***may lead to soil salinity damage*** due to losing the function of soil leaching by flood

Category	No.	Environmental item	Selection as scoping result		Reason
			Before/ during construction	Operation stage	
					irrigation.
	5	Noise and Vibration	✓	✓	**Construction Stage:** ***<u>While scale of anticipated negative impacts are small, impacts during construction work are expected</u>***. **Operation Stage:** ***<u>Noise and vibrations from the pump facility</u>*** should be considered.
	6	Subsidence	-	-	Land subsidence is not anticipated to be affected since most of the works will be rehabilitation of existing structures.
	7	Odor	-	-	Generating odors to the surrounding area is not anticipated.
	8	Sediment	-	-	The sediment of rivers or ponds is not anticipated to be affected since the works will be carried out within and along the canals.
Natural environment	9	Protected Areas	✓	✓	**Construction Stage and Operation Stage:** ***<u>Impacts on the Qarun and Rayan Lakes</u>*** by the introduction of modern on-farm irrigation ***<u>should be confirmed</u>***.
	10	Ecosystem	✓	✓	
	11	Hydrology	-	-	The streams, riverbeds, or ponds are not anticipated to be affected since most of the works will be carried out within and along the canals.
	12	Topography and Geology	-	-	The existing topography and geology of the area is not anticipated to be affected since large scale earth filling and cutting works are not planned.
Social environment	13	Resettlement	✓	✓	**Construction Stage and Operation Stage:** Relocation of houses and resettlement of people are not planned in the project. ***<u>The necessity or lack thereof of land acquisition by the project should be confirmed</u>***.
	14	The Poor	-	✓	**Construction Stage:** No impacts are expected on poor people by the implementation of construction work. **Operation Stage:** Since the installation cost of the modern on-farm irrigation facility will be borne by the farmers themselves, ***<u>this may affect to the household economy of farmers</u>***.
	15	Ethnic Minorities and Indigenous Peoples	-	-	Ethnic minorities and indigenous people are not confirmed in and around the project area.
	16	Livelihood / Local Economy	-	✓	**Construction Stage:** No impacts are expected on livelihood and local economy by implementation of construction work. **Operation Stage:** Since the installation cost of the modern on-farm irrigation facility will be borne by the farmers themselves, ***<u>this may affect to the household economy of farmers</u>***.
	17	Land Use and Local Resource Utilization	-	-	There are no impacts expected on land use and local resource utilization by construction work and operation.
	18	Water Usage or Water Rights and Rights in Common	✓	✓	**Construction Stage:** ***<u>The construction work may affect the existing water usage</u>*** due to the Meska improvement work. **Operation Stage:** Since the on-farm water management method will be changed from the conventional way (flood irrigation) to the modern irrigation way (water saving irrigation), ***<u>the existing water use of farmers will be affected</u>***.
	19	Existing Social Infrastructure and Services	✓	✓	**Construction Stage:** ***<u>In case a walkway exists along the Meska, risk of accidents of passengers increases during construction work.</u>*** **Operation Stage:** If the new Meska will be buried by the improved work, the upper part of the Meska will be used as walking space, ***<u>which will contribute to the local traffic</u>***.
	20	Social	-	✓	**Construction Stage:** No impacts are expected on social

Category	No.	Environmental item	Selection as scoping result		Reason
			Before/ during construction	Operation stage	
		Institutions			institutions by implementation of construction work. **Operation Stage:** The modern on-farm irrigation facility will be used on a group basis (WUA basis). In the area where a WUA has not already been organized, ***the way of water management will be changed from the existing water use by individual farmers to the water use by a group of farmers***.
	21	Misdistribution of Benefits and Damages	-	✓	**Construction Stage:** No impacts are expected on misdistribution of benefits and damages by implementation of construction work. **Operation Stage:** If water management by WUA is not properly conducted, ***the misdistribution of benefits among farmers may happen.***
	22	Conflict	-	✓	**Construction Stage:** No impacts are expected on conflict by implementation of construction work. **Operation Stage:** If water management by WUA is not properly conducted, ***conflict among farmers may arise.***
	23	Cultural heritage	-	-	Cultural heritage sites are not confirmed in and around project area.
	24	Landscape	-	-	Construction of buildings which affect the landscape is not planned.
	25	Gender	-	✓	**Construction Stage:** No impacts are expected on gender by implementation of construction work. **Operation Stage:** If the WUA is composed solely of men, ***there is concern that women's opinions will not be reflected***.
	26	Rights of Children	-	-	No impacts are expected on rights of children by implementation of construction work and operation of facility.
	27	Hazards (Risks), Infectious Diseases such as HIV/AIDS	-	-	**Construction Stage:** Construction contractors will be selected from local contractors. Workers from outside area is not expected. Thus, infectious diseases such as HIV/AIDs are not brought from outside workers. **Operation Stage:** Not impacts are expected by operation of facility.
	28	Work Environment (including safety)	✓	✓	**Construction Stage:** There are risks of work accidents during construction work. ***Safety and health of construction workers shall be considered*** during construction work. **Operation Stage:** The modern on-farm irrigation facility to be installed will have a pump facility. ***Accidents of farmers during pump operation will be concerned.***
Others	29	Accidents	✓	✓	**Construction Stage:** ***There are risks of accidents for both construction works and local people*** during construction work. **Operation Stage:** The modern on-farm irrigation facility to be installed will have a pump facility. ***Accidents of farmers during pump operation will be concerned.***
	30	Transboundary Impact, Climate Change	-	✓	**Construction Stage:** Greenhouse gas emissions from the construction work are assumed to be negligible and are not expected to have an impact on climate change. **Operation Stage:** ***Positive impacts are expected.*** Adaptability against the fluctuation of water resources in future climate change, such as drought, will be improved since efficient irrigation water use will be enhanced through the project.

Source: JICA Survey Team

TOR of the environmental and social considerations survey considering the scoping result is shown in the below table.

Table 7.3.7 TOR of the Environmental and Social Considerations Survey

Category	Survey Items	Means
Air Pollution	• Confirmation of emissions standards. • Grasping impacts during construction.	By confirming laws and regulations, reviewing project components and the field survey.
Water Pollution	• Confirmation of effluent standards. • Confirmation of water quality of irrigation canals. • Grasping impacts of construction drainage and places of construction work. • Grasping impacts of irrigation canal during operation stage.	By confirming laws and regulations, reviewing project components and the field survey.
Waste/Garbage	• Confirmation of waste disposal regulations. • Confirmation of disposal sites for construction waste and removal of the existing facility. • Confirmation of the way of treating excavated sands.	By confirming laws and regulations, reviewing project components, and hearing from related orgnizations.
Soil Contamination	• Grasping impacts during construction works.	By confirming laws and regulations, reviewing project components and field survey.
Noise and Vibration	• Confirmation of noise and vibration standards. • Anticipation of the noise and vibration level during construction works and operation of facility.	By confirming laws and regulations, reviewing project components and field survey.
Protected Areas/ Ecosystem	• Confirmation of the detailed locations of the planned project sites and the protected land including Ramsar sites.	By field survey, data collection, and hearing from related organizations.
Land Acquisition	• Necessity of land acquisition by the project. • Confirmation of exsiting land use and land owners in case land acquisition is planned by the project.	By field survey, hearing from related organizations, discussions with local authorities.
The Poor/ Livelihoods/ Local Economy	• Living situations of the poor people in the project area. • Possibility of the hiring of construction workers from local people.	By field survey, hearing from related organizations, discussions with local authorities.
Water Usage	• Grasping imacts on water use of farmers during construction works. • Grasping impacts of efficient water use which will be enhanced by the project.	By field survey and hearing from related organizations.
Existing Social Infrastructure and Services	• Grasping use conditions of the existing social infrastructure and services around the project area.	By field survey, hearing from related organizations.
Social Institutions	• Condition of the Water Users' Association (WUAs) in the project area.	By field survey, hearing from related organizations.
Misdistribution of Benefits and Damages/ Conflict	• Grasping impacts of water management which will be enhanced by the project	By field survey, hearing from related organizations
Gender	• Confirmation of relationshop of geneder ascpects and project.	By field survey, data collection from existing documents.
Hazards (Risks), Infectious Diseases such as HIV/AIDS	• Confirmation of risks of infectious deseases by construction workers from outside.	Data collection from existing documents.
Work environment (including safety)	• Confirmation of safety measures by laws, regulations.	Confirmation of the case of similar projects.
Accidents	• Confirmation of traffic conditions near the construction sites. • Grasping impacts during construction work.	Confirmation of the case of similar projects.
Transboundary impact, climate Change	• Grasping impacts of the project for contributing to climate change.	By field survey, data collection from existing documents.

Source: JICA Survey Team

7.3.4 Result of Environmental and Social Considerations Survey

Results of the environmental and social considerations survey are shown in Tables 7.3.8 and 7.3.9.

Table 7.3.8 Result of the Environmental and Social Considerations Survey
(For Project Components No.1 - 7: Civil Works on Canals and Procurement Works)

Category	Survey Results
Air Pollution	Major sources of air pollution in the project area are smoke from factories, exhaust from motor vehicles, burning of solid wastes in open areas, and dust from buildings, construction sites, and roads. As a result of the project, some air pollutants will be generated due to the operation of construction machinery and other vehicles during construction work. However, the impact is expected to be limited since the period of construction work is limited and the scale of the construction works is not large.

Category	Survey Results
Water Pollution	Since the drainage water quality during construction work is regulated by Law 48 (Egyptian law), the project must comply with the law. Since the civil works in the existing canals are planned in the project, possible countermeasures against drainage, such as setting up of oil fences and/or silt fences, should be carefully arranged. The below table shows the result of the water quality survey which was carried out by this preparatory survey. These results will be referred to for the setting up of baseline data for the water quality monitoring of canals during the construction stage and monitoring stage. EC, Salinity and TDS (Total Dissolved Solid) shown in the result table of on-site test are indicators that indicate the salinity level of existing canals. It is recommendable to monitor salinity level of irrigation canal whether acceptable level or not for farming.

Water Quality Survey Result on Irrigation Canals (On-site Test) (Aug. - Sep. 2022)

Canal name	Survey point	pH (-)	EC (uS/cm)	Salinity (ppm)	TDS (ppm)
Egyptian Standard (Law 48)		6-9	-	-	-
Japanese law (Water pollution prevention law)		5.8-8.6	-	-	-
FAO guideline[*1]		6.5-8.4	3,000	-	2,000
Ibrahimia Principal Canal	Dirout Regulator	8.35	318	160	227
	New El Minia Regulator	7.86	278	150	216
	Maghagha Regulator	7.84	312	160	222
	El Geneidy Regulator	7.80	345	170	246
	El Wasta Regulator	7.65	1410	710	939
Bahr Yusef Principal Canal	Dahab Regulator	7.39	353	180	234
	Saqula Regulator	7.66	347	170	247
	Mazoora Regulator	7.57	349	170	245
	El Lahoun Cross Regulator	7.29	478	240	343
Kased Main Canal	Dawould Bridge	7.83	345	170	208
	Al Kased Regulator	7.61	347	170	249
	Mahlet Menouf Regulator	7.23	342	170	244
	Sourad Cross Regulator	7.65	368	180	259
	Rewi Intake	7.50	352	180	248
	El Muhit El Sharqui Intake	7.40	380	190	259
	Sandella Regulator	7.14	403	200	286
Abo shosha Main Canal	Abo Shosha Weir	7.77	307	150	218
	El Qoleia Regulator	7.72	305	150	189
	Megally Regulator	7.69	421	220	306
Abo seer Main Canal	Bahr Arous Intake	7.09	383	190	222
	Al Soudany Bridge	7.19	469	230	332
	Botrous Bridge	7.16	504	250	360

*1: Water quality for agriculture, FAO, 1994

Source: JICA Survey Team

Water Quality Survey Result on Irrigation Canals (Laboratory Test) (Aug. - Sep. 2022)

Canal name	Survey point	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)
Egyptian Standard (Law 48)		80	50	10	2
Japanese law (Water pollution prevention law)		120	120	60	8
Kased Main Canal	Sourad Cross Regulator	1	17	0.575	0.129
	Sandella Regulator	8.3	49	1.058	0.18
Abo shosha Main Canal	Abo Shosha Weir	9	13	0.502	0.063
	El Qoleia Regulator	7	21	0.504	0.074
Abo seer Main Canal	Bahr Arous Intake	6	31	2.671	0.12

Source: JICA Survey Team

Category	Survey Results
Waste/Garbage	As the impacts of the project, construction wastes are expected to be generated from construction work, including waste materials from concrete work and waste materials from the removal of existing structures. In addition, waste soils will be generated during the dredging works of canals. These construction wastes should be transported and disposed of properly at designated disposal sites.
Soil Contamination	During construction work, there is a possibility of contamination of soils due to the leakage of oils from construction machinery, but the impact will be limited. In addition, no toxic substances or chemicals will

<table>
<tr><th>Category</th><th>Survey Results</th></tr>
<tr><td></td><td>be used during construction.</td></tr>
<tr><td>Noise and Vibration</td><td>Generating noise and vibrations is expected during construction work such as pile foundation work, sheet pile driving work, operation of construction machinery, and removal of existing structures. The project must comply with Egyptian standards for noise and vibrations during construction work. Proper and regular maintenance of trucks and construction machinery is necessary to prevent generating noise and vibrations. Although the rehabilitation work of canals will mainly be carried out in rural areas, some canals pass through city areas. Special attention should be paid to minimizing the noise and vibration impact on the surrounding environment during the construction work in and near residential areas.</td></tr>
<tr><td>Protected Areas/ Ecosystem</td><td>Qarun and Rayan Lakes in the Fayoum area are designated as the national protected areas. Both lakes are also registered as IBAs/KBAs and Ramasar Wetlands. Both lakes are the hibitats of water birds and migrant birds. Some endangered or vulnerable spiecies (such as Rim gazzells, Dorcas gazells and some birds) are confirmed in both lakes.

Through the site survey, it was confirmed that the end point of the Bahr Yusef canal is far away (more than 20 km) from the two lakes and the Aros & Abo Seer area is not close to the lakes either (more than 15 km away) (see Figure 7.3.2 for geographical location). Therefore, it is assumed that the rehabilitation works on these canals will not directly affect the flora and fauna of both lakes. The impacts of construction work are manageable by taking proper mitigation measures against construction drainage.

The existing water quality of Qarun and Rayan Lakes, as confirmed in the site survey, is shown in the table below.

<u>Water Quality Survey Results on Qarun and Rayan Lakes (On-site Test) (Sep. 2022)</u>
<table>
<tr><th>Lake name</th><th>pH
(-)</th><th>EC
(uS/cm)</th><th>TSS
(mg/l)</th><th>T-N
(mg/l)</th><th>T-P
(mg/l)</th><th>Salinity
(ppm)</th></tr>
<tr><td rowspan="3">Qarun Lake</td><td>7.62</td><td>46,400</td><td>61</td><td>2.882</td><td>0.163</td><td>30,100</td></tr>
<tr><td>TDS
(ppm)</td><td>NH_3
(mg/l)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>23,900</td><td>2.3</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lake name</td><td>pH
(-)</td><td>EC
(uS/cm)</td><td>TSS
(mg/l)</td><td>T-N
(mg/l)</td><td>T-P
(mg/l)</td><td>Salinity
(ppm)</td></tr>
<tr><td rowspan="3">Rayan Lake</td><td>8.01</td><td>36,200</td><td>15</td><td>0.405</td><td>0.072</td><td>23,100</td></tr>
<tr><td>TDS
(ppm)</td><td>NH_3
(mg/l)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>23,100</td><td>0.08</td><td></td><td></td><td></td><td></td></tr>
</table>
Source: JICA Survey Team

It is recommended to carry out regular monitoring of the distribution water volume at Hassaen Wassef Intake and the Lahoun Regulator during the operation stage to confirm whether the regulated water amount in the Fayoum area is enough to ensure water allocation to the two lakes.</td></tr>
<tr><td>Land Acquisition</td><td>Through the site survey, it was confirmed that all the construction works will be implemented within the area of the existing canals. And, informal settlements and/or informal buildings such as informal small shops, etc. are not confirmed in the construction areas. Accordingly, new resettlement and land acquisition will not be necessary during the construction work. The lands for the storage of construction materials will be secured in the management area of existing canals owned by MWRI.</td></tr>
<tr><td>The Poor/ Livelihoods/ Local Economy</td><td>According to the statistics of CAMPAS (Central Agency for Public Mobilization and Statistics), the percentage of people below the National Proverty Line has been increasing in recent years, with 27.8% in 2015 and 32.5% in 2017. This project is expected to have a positive impact on the poor population since the project may provide employment opportunities for local people during the construction work.</td></tr>
<tr><td>Water Usage</td><td>Since the construction work of canals in the project is mostly rehabilitation of existing canals, the irrigation water supply during the construction period may be affected. Especially for the Kased Canal, where the construction of large hydraulic structures will be implemented, mitigation measures should be taken, such as minimization of the construction period and setting up temporary canals as necessary.</td></tr>
<tr><td>Existing Social Infrastructure and Services</td><td>Some of the hydraulic structures to be rehabilitated by the project have the function of bridges for crossing canals. Since the bridges will not be able to be used during the construction period, this may affect the existing traffic condition of local residents. Necessary measures such as establishing appropriate detour routes and proper management of construction vehicles will be required.</td></tr>
<tr><td>Social Institutions/ Misdistribution of Benefits and Damages/ Conflict</td><td>Although the number of Meska level WUAs is small in priority sub-regions, branch canal level WUAs (BC WUAs: Branch canal WUAs) are organized in the area. During the construction works of branch canals, it is necessary to coordinate with the BC WUAs about the period and timing of construction works so as to mitigate the impact on the existing water use of farmers.</td></tr>
<tr><td>Hazards (Risks),</td><td>Common infectious diseases in Egypt include diarrhea, hepatitis A, and typhoid fever. The incidence of</td></tr>
</table>

Category	Survey Results
Infectious Diseases such as HIV/AIDS	HIV is low, less than 0.1 %. However, the number of HIV cases among young people is increasing with a ratio of 25 – 30% per year since 2020. As for COVID-19, the cumulative number of cases as of November 2022 is about 510 thousand cases, with 157.5 infections and 8.7 deaths per 100 thousand people. With the influx of workers into the area during the construction period, the increased risk of spreading infectious diseases is assumed, and appropriate management for securing the working and sanitary environment of workers is necessary.
Work environment	It is observed that there are construction workers without safety helmets and safty shoes in some construction sites of Egypt. It is necessary to take adequate safety measures and to educate workers carefully by safety conference.
Accidents	Most of the irrigation canals in each level have a maintenance road beside the canals. Along the Ibrahimia and Bahr Yusef Principal Canals, the road is used as a driveway for vehicles. In some sections, the railway runs along canals. It is necessary to allocate traffic and safety guards properly to prevent entering of local residents at construction places. In addition, it is necessary to take care of the health and safety of construction workers by preventing accidents during construction work.
Transboundary Impacts, climate change	Accoding to the Egypt National Climate Change Strategy 2050, improvement of irrigation efficiency is identified as one of the adaptation measures in the irrigation and agriculture sectors. Specific measures include canal rehabilitation, canal lining, and introduction of modern field irrigation facilities as examples. It is expected that the effects of this project will improve adaptation and resilience to climate change.

Source: JICA Survey Team

Table 7.3.9 Results of the Environmental and Social Considerations Survey (For Project Component No.8: Modern On-Farm Irrigation)

Category	Survey Results
Air Pollution	Main civil works on this component are rehabilitation of exsiting Meskas by concrete lining and so on. Large scale and continuous heavy machinery works are not planned, thus, the air pollution of surrounding area is not anticipated.
Water Pollution, Waste / Garbage	For the canals of the principal, main, and branch levels, periodic maintenance such as dredging is conducted by MWRI. On the other hand, the maintenance and management of the Meska, which is the terminal canal of the irrigation system, are managed by Meska level WUAs organized by local farmers. Dumping of household garbage and other wastes is seen in some Meskas due to the lack of proper maintenance by WUA or farmers. In the modern on-farm irrigation system, drip or sprinkler irrigation systems will be installed. There is concern about the clogging of tubes if the water quality of the Meska deteriorates with garbage or sediments. To avoid this, awareness creation activity of WUA for periodic cleaning of Meskas will be planned by the soft support of the project.
Soil Contamination	The amount of agricultural inputs such as pesticides and fertilizers can be reduced by applying drip or sprinkler irrigation techniques properly. On the other hand, conventional flood irrigation has the secondary effect of flushing out salt in the soil (leaching), which prevents soil salinity damage. Therefore, it is important for modern on-farm irrigation to perform the functions of both water-saving irrigation and existing conventional flood irrigation. Modern on-farm irrigation facility to be intoduced by the project will be designed to have both fuctions. In order for farmers to practice appropriate facility operation based on these characteristics of modern on-farm irrigation, technical traning will be provided for farmeres by the soft support of the project. There is no past records related to the soil contamination of farmlands by heavy metals in project area and factory complexes of heavy metals are not confrimed in the project area.
Noise and Vibration	During construction works, construction works with generating noize and vibration, such as piling works or breaking works of existing structure, are not planned in this project component. During operation stage, pump facility is operated. As the result of confirmtion of exsisting meska pump in project sites, size of pump is usally small. Since the pump facility to be installed under this component will be same scale, therefore, impacts on vibration or noise of neighboring residents is not anticipated.
Protected Areas / Ecosystem	Qarun and Rayan Lakes in the Fayoum area are designated as the national protected Areas. Both lakes are also registered as IBAs/KBAs and Ramasar Wetlands. Both lakes are the hibitats of water birds and migrant birds. Some endangered or vulnerable spiecies (such as Rim gazzells, Dorcas gazells and some birds) are confirmed in both lakes. As described in the examination of alternatives (7.3.2 Examination of Alternatives), the introduction of modern on-farm irrigation in the priority sub-region (Aros & Abo Seer) in the Fayoum area by the project may result in spreading modern on-farm irrigation to the whole Fayoum area in the future, significantly impacting the Qarun and Rayan Lakes. To avoid severe impacts to both lakes, it should be seleted to cancel the implementation of introducing modern on-farm irrigation in Aros & Abo Seer area, instead only implementing Meska improvements and related hydraulic structure improvements, based on the result of examination of altenatives.

Category	Survey Results
Land Acquisition	A modern on-farm irrigation facility consists of a pump, pipelines, and watering apparatuses (drip tubes and/or sprinklers). Land for the pump facility will be used for the Sakia (water wheel), which is conventionally used for raising water from the Meska. Pipelines will be installed on the land of existing marwa (on-farm small canals) with backfilling of soil. Accordingly, both works of Meska improvement and modern on-farm irrigation facilities will be implemented within the lands of existing land use. And, there are no informal settlements and/or informal buildings such as informal small shops, etc. confirmed in the existing areas. Therefore, New Land acquisition and resettlements will not be necessary for installation of the modern on-farm irrigation facility.
The Poor / Livelihood/ Local Economy	It is assumed that the cost of installing modern on-farm irrigation system is not cheap for farmers. In the existing ongoing Meska improvement project implemented by MWRI, MWRI operates a long-term repayment system (10 years, no interest) and collect costs at same timing of collecting land tax from farmers, which has functioned well. In the project, such functional financial schemes will be introduced for supporting farmers financially (including extension of repayment years 10 to 20 years). Further, technical training on proper farming techniques will be provided for increasing farmer incomes by the soft support of the project.
Water Usage	In the operation of the modern on-farm irrigation facility, the watering method of farmlands will be changed from the conventional way (flood irrigation) to the modern irrigation way (water-saving irrigation with sprinklers and/or drip tubes). Further, the water management method will be changed from pumping water by individual farmers to using a collective pump to be operated by a group. Water distribution will be managed by rotation through the pipeline system. To apply these changes in water management, technical training on the new water management method will be provided for WUAs by the soft support of the project. In the interview with farmers conducted during this survey, many questions were raised regarding the operation of modern on-farm irrigation such as the selection of adequate watering equipment to be applied for local soil conditions, recommended farming crops, and specific water management practices when installing modern on-farm irrigation. And, many requests for setting up demonstration farms were raised to solve these questions. For this reason, setting up of demonstration farms and implementation of technical training are planned by the soft support of the project.
Existing Social Infrastructure and Services	An example of the Meska improvement is an improvement from the existing open canal to the culvert canal (buried canal). There are advantages of converting to a culvert canal such as the prevention of water-passing obstacles due to the dumping of trash, and the effective use of newly created land on the top of the culvert as the walkway. On the other hand, an advantage of retaining an open canal is the ability to check the water level of the canal visually. According to the interviews with farmers, there were different opinions based on region, with farmers near the cities supporting the culvert type while those in rural areas support the open canal type. The project plans to take these regional characteristics into account in the design of the Meska improvements.
Social Institutions / Misdistribution of Benefits and Damages / Conflict	Implementing the Meska improvement is expected to solve the dissatisfaction of downstream farmers because it contributes to equal water distribution between upstream and downstream regions of Meska. However, it is necessary to properly maintain the Meska by the WUA. For this reason, WUA enhancement is important through the support of the WUA by the project. It is also expected that the WUA will also function to coordinate disputes among its members. The project plans to enhance WUA and provide technical training on water management of WUA by the soft support.
Gender	Based on the hearing from existing WUAs, the numbers of women are confirmed. For the WUAs to be organized by the project, the same consideration for women should be given for securing women’s participation. The project plans to involve women’s participation avtively in the organizing of WUA and technical training provided by soft support.
Work environment	It is observed that there are construction workers without safety helmets and safty shoes in some construction sites of Egypt. It is necessary to take adequate safety measures and to educate workers carefully by safety conference.
Accidents	A pump facility will be installed as a part of modern on-farm irrigation system. Since the pump will be operated by WUA, technical training will be provided by soft support of the project in order to prevent accident during operation.
Transboundary Impacts, climate change	Accoding to the Egypt National Climate Change Strategy 2050, improvement of irrigation efficiency is identified as one of the adaptation measures in the irrigation and agriculture sectors. Specific measures include canal rehabilitation, canal lining, and introduction of modern field irrigation facilities as examples. It is expected that the effects of this project will improve adaptation and resilience to climate change (See. 7.10.2 for detail in later part).

Source: JICA Survey Team

7.3.5 Impact Evaluation

Based on the results of the examination of alternatives and the environmental and social considerations survey, Tables 7.3.10 and 7.3.11 summarize the impact evaluation of the environmental and social examination.

For the impact evaluation of the components of modern on-farm irrigation, Option 3 discussed in the “7.3.2 Examination of Alternatives” was applied. Option 3 is the plan to avoid significant impacts on Qarun and Rayan Lakes by canceling the modern on-farm irrigation facility and instead implementing a hydraulic structure improvement and Meska improvement in the Aros & Abo Seer priority area. The same consideration is adapted to other examinations in later parts of this chapter.

Table 7.3.10 Impact Evaluation
(For Project Components No.1 - 7: Civil Works on Canals and Procurement Works)

No.	Environmental item	Selection as scoping result		Evaluation based on the results of environmental and social considerations		Reason
		Before/ during construction	Operation stage	Before/ during construction	Operation stage	
Pollution						
1	Air Quality	✓	-	B(-)	N/A	**Construction Stage:** Exhaust from the construction machinery and vehicles can be the ***cause of air pollution in the neighboring area of construction work***. **Operation Stage:** Air pollution by the operation of facilities is not anticipated.
2	Water Quality	✓	✓	B(-)	B(+)	**Construction Stage: *Drainage of construction work* in the canals and *sewage from the workers' camp*** can be the causes of water pollution in the neighboring area. **Operation Stage:** Improvement of the water quality of canals is expected with continuous use of maintenance machinery (dredging machinery). ***It is recommended to conduct regular monitoring of water quality of canals to confirm the project contribution impacts***.
3	Waste / Garbage	✓	✓	B(-)	B(-)	**Construction Stage: *Generation of construction wastes and garbage*** during the construction work, such as wastes from removal of existing structures, removal sands from the excavated works, garbage from the workers' camp, and so on., are anticipated. **Operation Stage:** Maintenance machinery (dredging machinery) will be procured for regular maintenance work of MWRI by the project. During this work, it is anticipated that ***dredged sands will be generated, which should be disposed of properly*** at disposal sites.
4	Soil Contamination	✓	-	D	N/A	**Construction Stage:** Although leakage of the oils from construction machinery can be the cause of soil contamination, ***such impacts will be limited*** since the construction work will be carried out within the area of existing canals. **Operation Stage:** Soil contamination by the operation of facilities is not anticipated.
5	Noise and Vibration	✓	✓	B(-)	D	**Construction Stage: *Noise and vibrations of the construction machinery and vehicles*** can cause noise and vibrations in the neighboring area of the construction sites. **Operation Stage:** No impacts are expected since the large pump facilities are not included in the project component.
6	Subsidence	-	-	N/A	N/A	Affecting land subsidence is not anticipated since most of the works will be rehabilitation of existing structures.
7	Odor	-	-	N/A	N/A	Generating odors to the surrounding area is not anticipated.

No.	Environmental item	Selection as scoping result		Evaluation based on the results of environmental and social considerations		Reason
		Before/ during construction	Operation stage	Before/ during construction	Operation stage	
8	Sediment	-	-	N/A	N/A	The sediment of rivers and ponds is not anticipated to be affected since the works will be carried out within and along the canals.
Natural environment						
9	Protected Areas	✓	✓	B(-)	B(-)	**Construction Stage:** Both Qarun and Rayan Lakes are designated as protected areas, IBAs/KBAs and Ramsar wetlands. In both lakes, water birds and some endangered mammals are observed. Aros & Abo Seer area where the rehabilitation of main and branch canals is not located near Qarun and Rayan Lakes. ***It is evaluated that impacts can be lessened by taking appropriate mitigation measures for construction draining during construction work***. **Operation Stage:** No impacts to both lakes are anticipated unless the regulated annual distribution amount in Fayoum area is changed. In other words, regulated distribution amount shall be allocated to Fayoum area to avoid impact on the water volume of both lakes. ***It is necessary for MRWI to continue to monitor the water distribution amount in Fayoum area with a regulated annual amount.***
10	Ecosystem	✓	✓	B(-)	B(-)	
11	Hydrology	-	-	N/A	N/A	The streams, riverbeds, or ponds are not anticipated to be affected since most of the work will be carried out within and along the canals.
12	Topography and Geology	-	-	N/A	N/A	The existing topography and geology of the area are not anticipated to be affected since large scale earth filling and cutting works are not planned.
Social Environment						
13	Resettlement / Land Acquisition	✓	✓	D	D	**Construction Stage and Operation Stage:** ***Relocation of houses and resettlement of people are not necessary***. Since the construction works are planned within the area of the existing irrigation canals, ***land acquisitions are not necessary***.
14	The Poor	✓	✓	B(+)	B(+)	**Construction Stage:** ***Positive impacts are expected*** since the project may create job opportunities for construction works. **Operation Stage:** ***Positive impacts are expected*** since the project may contribute to the income generation of beneficiaries including poor people through the agricultural infrastructure development in the area.
15	Ethnic Minorities and Indigenous Peoples	-	-	N/A	N/A	Ethnic minorities and indigenous people are not confirmed in and around the project area.
16	Livelihood / Local Economy	✓	✓	B(+)	B(+)	**Construction Stage:** ***Positive impacts are expected*** since the project may create job opportunities for construction works. **Operation Stage:** ***Positive impacts are expected*** since the project may contribute to the income generation of beneficiaries including poor people through the agricultural infrastructure development in the area.
17	Land Use and Local Resource Utilization	-	-	N/A	N/A	The project does not affect the existing land use and local resource utilization since the project is mainly rehabilitation work of the existing irrigation system.
18	Water Usage or Water Rights	✓	✓	B(-)	B(+)	**Construction Stage:** ***The construction work may affect the existing water usage of farmers in the area***. Adequate mitigation measures such as securing

No.	Environmental item	Selection as scoping result		Evaluation based on the results of environmental and social considerations		Reason
		Before/ during construction	Operation stage	Before/ during construction	Operation stage	
	and Rights in Common					temporary water are necessary. **Operation Stage:** ***<u>Positive impacts are expected</u>*** since the project will promote efficient water use through rehabilitation of irrigation facilities as well as promotion of the modern on-farm equipment in the terminal farm field.
19	Existing Social Infrastructure and Services	✓	✓	B(-)	B(+)	**Construction Stage:** Due to the increasing of construction vehicles, ***<u>local transportation around construction area may be affected</u>***. Adequate mitigation measures such as securing detour routes or mitigating tragic jams are necessary to be taken. **Operation Stage:** ***<u>Positive impacts are expected</u>*** on local transportation since the rehabilitation of maintenance loads along canals will be implemented together with the canal rehabilitation by the project.
20	Social Institutions	✓	-	B(-)	N/A	**Construction Stage:** Construction work may affect the usage of branch irrigation canals managed by Water Users' Associations (WUAs). ***<u>Sufficient explanation of the content and schedule of construction work should be given to the WUAs at a suitable time</u>***. **Operation Stage:** Since the project works on rehabilitation of existing facilities, operation way of such facilities will be not changed. Thus, impacts on social institutions are not expected.
21	Misdistribution of Benefits and Damages	-	✓	N/A	B(+)	**Construction Stage:** Since the project works on rehabilitation of existing facilities, no impacts are expected on misdistribution of benefits and damages of beneficially. **Operation Stage:** ***<u>Positive impacts are expected</u>*** since rehabilitated irrigation systems enable irrigation water to be distributed equally in an area.
22	Conflict	-	✓	N/A	B(+)	**Construction Stage:** Since the project works on rehabilitation of existing facilities, construction works will not lead any conflicts. **Operation Stage:** ***<u>Positive impacts are expected</u>*** since rehabilitated irrigation systems enable irrigation water to be distributed equally in an area.
23	Cultural Heritage	-	-	N/A	N/A	Cultural heritage sites are not confirmed in and around project area.
24	Landscape	-	-	N/A	N/A	Construction of the buildings which affect the landscape is not planned.
25	Gender	-	-	N/A	N/A	Since the project works on rehabilitation of existing facilities, construction works and operation of facilities will not impact on gender.
26	Rights of Children	-	-	N/A	N/A	Since the project works on rehabilitation of existing facilities, construction works and operation of facilities will not impact on right of children.
27	Hazards (Risks), Infectious Diseases such as HIV/AIDS	✓	-	B(-)	N/A	**Construction Stage:** ***<u>There are risks of spreading infectious diseases</u>*** such as COVID-19 and HIV due to the entering of construction workers into the area. **Operation Stage:** Operation of rehabilitated facility is not expected to cause infectious diseases or any other impact.
28	Work Environment (including safety)	✓	-	B(-)	N/A	**Construction Stage:** It is observed that there are construction workers without safety helmets and safty shoes in some construction sites of Egypt.***<u>Safety and health of construction workers shall be considered</u>*** during construction work. **Operation Stage:** Since operation method of

No.	Environmental item	Selection as scoping result		Evaluation based on the results of environmental and social considerations		Reason
		Before/ during construction	Operation stage	Before/ during construction	Operation stage	
						rehabilitated facility is not changed, work environment also not change.
Others						
29	Accidents	✓	-	B(-)	N/A	**Construction Stage:** ***<u>There are risks of accidents</u>*** by operating construction machinery, vehicles, and so on during construction work. **Operation Stage:** Operation of rehabilitated facility is not expected to cause increase of work accidents, since the operation way is not changed.
30	Transboundary Impact, Climate Change	-	✓	N/A	B(+)	**Construction Stage:** Some greenhouse gases will be produced during construction work, but the amount is limited. **Operation Stage:** ***<u>Positive impacts are expected.</u>*** Adaptability to the fluctuation of water resources in future climate change, such as drought, will be improved since efficient irrigation water use will be enhanced through the project.

A(+/-): Significant positive/negative impact is expected. B(+/-): Positive/negative impact is expected to some extent.
C: Extent of impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.
Source: JICA Survey Team

<u>Table 7.3.11 Impact Evaluation</u>
<u>(For Project Component No.8: Modern On-Farm Irrigation)</u>

No.	Environmental item	Selection as scoping result		Evaluation based on the results of environmental and social consideration		Reason
		Before/ during construction	Operation stage	Before/ during construction	Operation stage	
Pollution						
1	Air Quality	✓	-	D	N/A	**Construction Stage:** Construction with heavy machinery that would result in deterioration of air quality in the surrounding area is not anticipated. **Operation Stage:** Air pollution by the operation of facilities is not anticipated
2	Water Quality	✓	✓	D	B(-)	**Construction Stage:** Main works are small canal rehabilitation, and the construction work of small canal will be drained and then dried. Therefore, no impact from construction drainage is anticipated. **Operation Stage:** ***<u>Water quality may affect</u>*** the effective proper operation of modern on-farm irrigation ***<u>due to the clogging of drip tubes and sprinklers</u>***. Environmental awareness creation for prevention of garbage throwing into canal will be included in WUA enhancement by the soft support of the project.
3	Waste / Garbage	✓	✓	B(-)	B(-)	**Construction Stage:** ***<u>Generation of excavated soils, construction wastes and possible throwing of garbage by workers are anticipated.</u>*** **Operation Stage:** ***<u>Water quality may affect</u>*** the effective proper operation of modern on-farm irrigation ***<u>due to the clogging of drip tubes and sprinklers</u>***. Environmental awareness creation for prevention of garbage throwing into canal will be included in WUA enhancement by the soft support of the project.
4	Soil Contamination	✓	✓	B(-)	B(-) B(+)	**Construction Stage:** Since the work will be carried out in the farm field, ***<u>leakage of the oils in the farmlands</u>***

No.	Environmental item	Selection as scoping result		Evaluation based on the results of environmental and social consideration		Reason
		Before/ during construction	Operation stage	Before/ during construction	Operation stage	
						is anticipated. **Operation Stage:** ***Reducing agricultural inputs (pesticides and fertilizers) is expected*** by promoting modern on-farm irrigation farming techniques. On the other hand, there is concern that the change from the conventional method (flood irrigation) to the modern on-farm irrigation method ***may lead to soil salinity damage*** due to losing the function of soil leaching by flood irrigation. To avoid this, design of the modern on-farm irrigation facility of the project will be planned to have function of flood irrigation, too.
5	Noise and Vibration	✓	✓	D	D	**Construction Stage:** No construction work generating noise and vibration, such as piling or breaking of existing structures, is anticipated. **Operation Stage:** The pump will be small and installed near or within the farmland. Therefore, impacts on neighboring residential areas are not expected.
6	Subsidence	-	-	N/A	N/A	Land subsidence is not anticipated to be affected since most of the work will be rehabilitation of existing structures.
7	Odor	-	-	N/A	N/A	Generating odors to the surrounding area is not anticipated.
8	Sediment	-	-	N/A	N/A	The sediment of rivers or ponds is not anticipated to be affected since the works will be carried out within and along the canals.
Natural Environment						
9	Protected Areas	✓	✓	D	D	**Construction Stage and Operation Stage:** Both Qarun and Rayan Lakes are designated as protected areas, IBAs/KBAs and Ramsar wetlands. In both lakes, water birds and some rare mammals are observed. The alternative analysis resulted that introduction of modern on-farm irrigation in Aros & Abo Seer of Fayoum area would have a severe impact on the reduction of water quantity in both lakes. Based on this result, project will not take option to introduce modern on-farm irrigation facilities in Fayoum. Therefore, no impacts on protected areas and ecosystems are expected.
10	Ecosystem	✓	✓	D	D	
11	Hydrology	-	-	N/A	N/A	The streams, riverbeds, and ponds are not anticipated to be affected since most of the works will be carried out within and along the canals.
12	Topography and Geology	-	-	N/A	N/A	The existing topography and geology of the area are not anticipated to be affected since large scale earth filling and cutting works are not planned.
Social Environment						
13	Resettlement / Land Acquisition	✓	✓	D	D	**Construction Stage and Operation Stage:** Relocation of houses and resettlement of people are not planned in the project. ***The necessity or lack thereof of land acquisition by the project should be confirmed***.
14	The Poor	-	✓	N/A	B(-)	**Construction Stage:** No impacts are expected on poor people by the implementation of construction work. **Operation Stage:** Since the installation cost of the modern on-farm irrigation facility will be borne by the farmers themselves, ***this may affect to the***

No.	Environmental item	Selection as scoping result		Evaluation based on the results of environmental and social consideration		Reason
		Before/ during construction	Operation stage	Before/ during construction	Operation stage	
						household economy of farmers. Considering this situation, project plans to introduce functional financial scheme such as Meska repayment system for supporting farmers financially. Further, technical support on farming practice and setting up of demonstration farms will be implemented by the soft support of the project to support farmers' income improvement.
15	Ethnic Minorities and Indigenous Peoples	-	-	N/A	N/A	Ethnic minorities and indigenous people are not confirmed in and around the project area.
16	Livelihood / Local Economy	-	✓	N/A	B(-)	**Construction Stage:** No impacts are expected on livelihood and local economy by implementation of construction work. **Operation Stage:** Since the installation cost of the modern on-farm irrigation facility will be borne by the farmers themselves, ***this may affect to the household economy of farmers***. To mitigate this, project plans to introduce functional financial scheme such as Meska repayment system for supporting farmers financially. Further, technical training on farming practice and setting up of demonstration farms will be implemented by the soft support of the project to support farmers' income improvement.
17	Land Use and Local Resource Utilization	-	-	N/A	N/A	There are no impacts expected on land use and local resource utilization by construction work and operation.
18	Water Usage or Water Rights and Rights in Common	✓	✓	B(-)	B(-)	**Construction Stage:** ***The construction work may affect the existing water usage*** due to the Meska improvement work. An adequate construction schedule shall be planned and explanations to the farmers prior to the construction are necessary. **Operation Stage:** Since the on-farm water management method will be changed from the conventional way (flood irrigation) to the modern irrigation way (water saving irrigation), ***the existing water use of farmers will be affected***. To mitigate this, technical training on water management techniques will be provided to WUA by the soft support of the project.
19	Existing Social Infrastructure and Services	✓	✓	B(-)	B(+)	**Construction Stage:** In case a walkway exists along the Meska, risk of accidents of passenger increases at construction places. ***Farmer's passage should be careful walking during construction work.*** **Operation Stage:** If the new Meska will be buried by the improved work, the upper part of the Meska will be used as walking space, ***which will contribute to local traffic***. Selection of the type of Meska (buried or open) should be considered based on the features of the local area.
20	Social Institutions	-	✓	N/A	B(-)	**Construction Stage:** No impacts are expected on social institutions by implementation of construction work. **Operation Stage:** The modern on-farm irrigation facility will be installed on a group basis (WUA basis). In the area where a WUA has not been organized,

No.	Environmental item	Selection as scoping result		Evaluation based on the results of environmental and social consideration		Reason
		Before/ during construction	Operation stage	Before/ during construction	Operation stage	
						water management will be changed from the existing water use by individual farmers to water use by a group of farmers. To mitigate this, technical training on water management techniques will be provided to WUA by the soft support of the project.
21	Misdistribution of Benefits and Damages	-	✓	N/A	B(-)	**Construction Stage:** No impacts are expected on misdistribution of benefits and damages by implementation of construction work. **Operation Stage:** If water management by the WUA is not properly conducted, ***the misdistribution of benefits among farmers may happen.*** To mitigate this, technical training on water management techniques will be provided to WUA by the soft support of the project.
22	Conflict	-	✓	N/A	B(-)	**Construction Stage:** No impacts are expected on conflict by implementation of construction work. **Operation Stage:** If water management by the WUA is not properly conducted, ***conflict among farmers may happen.*** To mitigate this, technical training on water management techniques will be provided to WUA by the soft support of the project.
23	Cultural Heritage	-	-	N/A	N/A	Cultural heritage sites are not confirmed in and around project area.
24	Landscape	-	-	N/A	N/A	Construction of buildings which affect the landscape is not planned.
25	Gender	-	✓	N/A	B(-)	**Construction Stage:** No impacts are expected on gender by implementation of construction work. **Operation Stage:** If the WUA is composed solely of men, ***there is concern that women's opinions will not be reflected***. The project plans to involve women's participation actively in the organizing of WUA and technical training provided by soft support.
26	Rights of Children	-	-	N/A	N/A	No impacts are expected on rights of children by implementation of construction work and operation of facility.
27	Hazards (Risks), Infectious Diseases such as HIV/AIDS	-	-	N/A	N/A	**Construction Stage:** Construction contractors will be selected from local contractors. Workers from outside area is not expected. Thus, infectious diseases such as HIV/AIDs are not brought from outside workers. **Operation Stage:** Not impacts are expected by operation of facility.
28	Work Environment (including safety)	✓	✓	B(-)	B(-)	**Construction Stage:** There are risks of work accidents during construction work. ***Safety and health of construction workers shall be considered*** during construction work. **Operation Stage:** The modern on-farm irrigation facility to be installed will have a pump facility. ***Accidents of farmers during pump operation will be concerned.*** Technical training on safety operation will be provided by soft support of the project in order to prevent accident during operation.
Others						
29	Accidents	✓	✓	B(-)	B(-)	**Construction Stage:** ***There are risks of accidents for both construction works and local people*** during construction work. **Operation Stage:** The modern on-farm irrigation facility to be installed will have a pump facility.

No.	Environmental item	Selection as scoping result		Evaluation based on the results of environmental and social consideration		Reason
		Before/ during construction	Operation stage	Before/ during construction	Operation stage	
						Accidents of farmers during pump operation will be concerned. Technical training on safety operation will be provided by soft support of the project in order to prevent accident during operation.
30	Transboundary Impact, Climate Change	-	✓	N/A	B(+)	**Construction Stage:** Greenhouse gas emissions from the construction work are assumed to be negligible and are not expected to have an impact on climate change. **Operation Stage:** ***Positive impacts are expected.*** Adaptability to the fluctuation of water resources in future climate change, such as drought, will be improved since efficient irrigation water use will be enhanced through the project.

A(+/-): Significant positive/negative impact is expected. B(+/-): Positive/negative impact is expected to some extent.
C: Extent of impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses.)
D: No impact is expected.
Source: JICA Survey Team

7.4 Mitigation Measures and Monitoring Plan

7.4.1 Mitigation Measures and Cost

1) Mitigation Measures and Cost for Project Components No.1-7 (Civil Works on Canals and Procurement Works)

During the construction period, some negative impacts are expected such as air pollution, waste, and noise. To lessen these negative impacts, necessary mitigation measures will be taken during construction work (e.g., proper maintenance of construction machinery and vehicles, use of vehicles with soundproofing equipment, consideration of the construction time, prevention measures for accidents, securing safety for residential people, etc.). Countermeasures of construction drainage during construction works of canals will be also taken (e.g., setting of oil fences, silt fences, etc.).

Necessary mitigation measures during the construction period will be conducted by construction contractors. Each implementation section of MWRI will be responsible for supervising. During the operation period, the water quality of irrigation canals, dredging work conditions, and disposal conditions of dredging soils will be monitored, periodically.

Table 7.4.1 Mitigation Measures with Responsible Organizations and Costs
(For Project Components No.1 - 7: Civil Works on Canals and Procurement Works)

No.	Environmental Item	Mitigation Measures	Implementation	Responsible	Cost
(Construction Stage)					
1.	Air Quality	● Conduct regular checks and full maintenance of construction machinery and vehicles. ● Spray water in and around entrances of construction sites and on the road along which machinery is to move.	Contractor	RGBS/ IS	Inclusive in construction cost
2.	Water Quality	● Conduct countermeasures against muddy water and oil leakages during construction work in canals, such as installing silt fences and oil fences, to minimize the impacts downstream of canals. ● Arrange necessary numbers of temporary toilets or septic tanks in the construction sites.	Contractor	RGBS/ IS	Inclusive in construction cost
3.	Waste /	● Dispose construction wastes generated by construction	Contractor	RGBS/	Inclusive in

	Garbage	work or removal of existing structures properly at designated disposal sites. ● Prevent workers throwing garbage during construction work. ● Prevent untreated effluent from workers' camp by setting up temporary toilets and/or septic tanks.		IS	construction cost
4.	Noise and Vibration	● Set up construction work hours properly (avoid night work near residential areas). ● Plan the construction schedule properly to avoid concentration of works generating noise. ● Conduct regular check and maintenance of construction vehicles.	Contractor	RGBS/ IS	Inclusive in construction cost
5.	Protected Areas / Eco-system	● Same countermeasures as "Water Quality"	Contractor	IS	Inclusive in construction cost
6.	Water Usage	● Conduct countermeasures to minimize impacts of farmers' existing water use, such as arrangement of temporary canals.	Contractor	RGBS/ IS	Inclusive in construction cost
7.	Existing Social Infrastructure and Services	● Allocate necessary traffic guards and control traffic conditions to secure existing local traffic. ● If the bridges are equipped in the hydraulic structure for crossing the canal, necessary detour routes are secured.	Contractor	RGBS/ IS	Inclusive in construction cost
8.	Social Institutions	● Conduct necessary explanation to related BC WUAs on schedules and impacts during construction work prior to the construction work on main and branch canals	Contractor /IAS	RGBS/ IS	Inclusive in construction cost
9.	Hazards (Risks), Infectious Diseases such as HIV/AIDS	● Conduct training on health and prevention measures for infectious diseases for construction workers periodically.	Contractor	RGBS/ IS	Inclusive in construction cost
10.	Work Environment (including safety)	● Conduct proper safety training for construction workers. ● Comply with the safety measures for construction workers during construction work (e.g., using safety tools, helmets, etc.).	Contractor	RGBS/ IS	Inclusive in construction cost
11.	Accidents	● Conduct safety training for construction workers and drivers for safety measures and safe driving. ● Set up traffic signs and construction signboards. ● Allocate traffic guard staff. ● Conduct safety measures to prevent falls such as installing fences and putting signboards at excavation workplaces.	Contractor	RGBS/ IS	Inclusive in construction cost
(Operation Stage)					
1.	Water Quality	● Conduct periodic monitoring of the water quality of canals (principal canals and main canals) to check proper water quality for irrigation.	IS	IS	Inclusive in maintenance work of IS
2.	Waste / Garbage	● Conduct periodic monitoring of the condition of maintenance works by MWRI and confirm proper treatment of dredged soil by MWRI.	GD Canal Maintenan ce	GD Canal Mainten ance	Inclusive in maintenance work of GD Canal Maintenance
3.	Protected Areas/ Ecosystem	● Allocate specified annual distribution volume to Fayoum Area. ● Monitor drain volume to Qarun and Rayan Lakes.	IS	IS	Inclusive in maintenance work of IS

RGBS: Reservoirs and Grand Barrages Sector (MWRI), IS: Irrigation Sector (MWRI), GD: General Directorate
Source: JICA Survey Team

2) Mitigation Measures and Cost for Project Component No.8 (Modern On-Farm Irrigation)

The scale of the construction work for one system of a modern on-farm irrigation facility is small since each system only covers farmlands of at least 10 feddans to at most 30 feddans (4.2 – 12.6 ha). Mitigation measures to be taken during construction work are mainly for the safety measures of contractors and local people in the construction area.

On the other hand, social impacts on beneficiary farmers during the operational stage of modern on-farm irrigation are anticipated, including changes in water management methods and farming techniques, the need for group based water management, and the need for farmer's share of installation costs. Implementation of the soft support by the project could be a mitigation measure of such anticipated social impacts.

The responsible section of MWRI for implementing this component is IIS (Irrigation Improvement Sector) and the soft support for farmers will be implemented by IIS themselves. Construction work will be implemented by construction contractors and supervised by IIS. Implementation of necessary mitigation measures should be taken and managed by IIS through the implementation of the soft support of WUA.

The soft support of WUA will start before the construction stage. The environmental and social impacts evaluated in 7.3.11 should be mitigated through the implementation of the soft support by IIS. Therefore, the implementation of necessary mitigation measures and their monitoring also must start before the construction stage and continue after the start of the operation.

Corresponding table for the result of impact evaluation and corresponding mitigation measures is shown in Table 7.4.2 and the contents of mitigation measures are shown in Table 7.4.3, respectively.

Table 7.4.2 Corresponding Table for the Result of Impact Evaluation and Mitigation Measures (For Project Components No.8: Modern On-Farm Irrigation)

Item No.	Environmental Item	Evaluation Results at Construction Stage	Corresponding Mitigation Measures in Table 7.4.3	Evaluation Results at Operation Stage	Corresponding Mitigation Measures in Table 7.4.3
2.	Water Quality	N/A	-	B(-)	Before Construction Stage No.1 (Continue in Operation Stage)
3.	Waste/Garbage	B(-)	Construction Stage No.1	B(-)	
3.	Soil Contamination	B(-)	Construction Stage No.2	B(-)	Before Construction Stage No.2 (Continue in Operation Stage)
14.	The Poor	N/A	-	B(-)	Before Construction Stage No.3 (Continue in Operation Stage)
16.	Livelihood /local economy	N/A	-	B(-)	
18.	Water usage or Water Rights and Rights of Common	B(-)	Construction Stage No.3	B(-)	Before Construction Stage No.4 (Continue in Operation Stage)
19.	Existing social infrastructures and services	B(-)	Construction Stage No.4	B(+)	-
20.	Social institutions	N/A	-	B(-)	Before Construction Stage No.4 (Continue in Operation Stage)
21.	Misdistribution of benefit and damage	N/A	-	B(-)	
22.	Conflict	N/A	-	B(-)	
25.	Gender	N/A	-	B(-)	Before Construction Stage No.5 (Continue in Operation Stage)
28.	Work Environment	B(-)	Construction Stage No.5	B(-)	Before Construction Stage No.6 (Continue in Operation Stage)
29.	Accident	B(-)	Construction Stage No.6	B(-)	

Source: JICA Survey Team

Table 7.4.3 Mitigation Measures with Responsible Organizations and Costs
(For Project Components No.8: Modern On-Farm Irrigation)

No.	Environmental Item	Mitigation Measures	Implementation	Responsible	Cost
(Before Construction Stage)					
1.	Water Quality and Waste / Garbage	● Incorporating an awareness package into the soft support of WUA.	IIS	IIS	Inclusive in project cost
2.	Soil contamination	● Incorporating measures for leaching into the design of the modern on-farm irrigation system ● Setting up of demonstration farms and implementation of technical support for WUAs (pesticide and fertilizer control).	IIS	IIS	Inclusive in project cost
3.	Poor/ Livelihood / Local Economy	● Mitigating farm household economy through introducing a proper financial scheme (e.g., Meska repayment system) ● Setting up of demonstration farms and implementation of technical training (farming).	IIS	IIS	Inclusive in project cost
4.	Water Usage/ social institutions/ conflict	● Setting up of demonstration farms and implementation of technical training (water management).	IIS	IIS	Inclusive in project cost
5.	Gender	● Involving women in the WUA and improving their positions.	IIS	IIS	Inclusive in project cost
6.	Work environment/ accident	● Setting up of demonstration farms and implementation of technical training (Safety Operation).	IIS	IIS	Inclusive in project cost
(Construction Stage)					
1.	Waste / Garbage	● Dispose construction wastes generated by construction work or removal of existing structures properly at designated disposal sites. ● Prevent workers from throwing garbage during construction work.	Contractor	IIS	Inclusive in construction cost
2.	Soil Contamination	● Prevent leakages of construction equipment in farmlands by conducting periodic maintenance of equipment.	Contractor	IIS	Inclusive in construction cost
3.	Water Usage	● Conduct proper explanation of construction schedule of Meska improvement to the farmers to minimize impacts on exiting water use of farmers.	Contractor	IIS	Inclusive in construction cost
4.	Existing Social Infrastructure	● Install guard fences in case of walkways along the existing Meska.	Contractor	IIS	Inclusive in construction cost
5.	Work Environment (including safety)	● Conduct proper safety training for construction workers. ● Comply with the safety measures for construction workers during construction work (e.g., using safety tools, helmets, etc.).	Contractor	IIS	Inclusive in construction cost
6.	Accidents	● Conduct safety training for construction workers and drivers for safety measures and safe driving. ● Set up traffic signs and construction signboards. ● Allocate traffic guard staff. ● Conduct safety measures to prevent falls such as installing fences and putting signboards at excavation workplaces.	Contractor	IIS	Inclusive in construction cost
(Operation Stage)					
Same items as "Before construction stage"		● Continuance of support program for WUAs upon completion.	IIS	IIS	Inclusive in maintenance work of IS

IIS: Irrigation Improvement Sector (MWRI)
Source: JICA Survey Team

7.4.2 Monitoring Plan and Cost

1) Monitoring Plan for Project Components No.1-7 (Civil Works on Canals and Procurement Works)

Monitoring in the construction period will be implemented by construction contractors and supervised by the PMU (Project Management Unit) and RCU (Regional Coordination Unit), which are the implementation units of the project organized by MWRI. Monitoring in the operation period will be implemented and each unit will be responsible for each component.

Table 7.4.4 Monitoring Plan with Responsible Organizations and Costs

(For Project Components No.1 - 7: Civil Works on Canals and Procurement Works)

No.	Environmental Item	Monitoring Items	Monitoring Points	Frequency	Implementation	Responsible	Cost
(Construction Stage)							
1.	Air Quality	● Record of inspection and maintenance of construction machinery and vehicles	Construction sites	Monthly	Contractor	PMU/ RCU	Inclusive in construction cost
2.	Water Quality	● Condition of measures for construction drainage ● Water quality monitoring (downstream of construction point) (pH, EC, TSS, oils) ● Record of setting of temporary toilets and septic tanks	Downstream of construction points of canals	Monthly	Contractor	PMU/ RCU	Inclusive in construction cost
3.	Waste / Garbage	● Record of disposal conditions due to the removal of existing facilities ● Record of the setting of garbage pits	Construction sites	Monthly	Contractor	PMU/ RCU	Inclusive in construction cost
4.	Noise and Vibration	● Construction record (time) ● Noise and vibration level	Construction sites (near residential areas)	Monthly	Contractor	PMU/ RCU	Inclusive in construction cost
5.	Protected Areas/ Ecosystem	● (Same as "No.2 Water Quality")	(Same as "No.2 Water Quality")				
6.	Water Usage	● Conditions of the setting up of temporary canals. ● Record of explanation meeting to BC WUA for construction work	Construction sites	Monthly	Contractor/ IAS	PMU/ RCU	Inclusive in construction cost
7.	Social institutions						
8.	Existing Social Infrastructure	● Existence of traffic jams ● Setting conditions of detour route	Construction sites	Monthly	Contractor	PMU/ RCU	Inclusive in construction cost
9.	Hazards (Risk), Infectious diseases such as HIV/AIDS	● Record of safety education and sanitary education to workers	Construction sites	Monthly	Contractor	PMU/ RCU	Inclusive in construction cost
10.	Work Environment, Safety, Accidents	● Record of safety meetings ● Record of numbers of accidents ● Conditions of allocating traffic guards, sign boards, etc.	Construction sites	Monthly	Contractor	PMU/ RCU	Inclusive in construction cost

(Operation Stage)							
1.	Water Quality	● Record of regular water quality monitoring of irrigation canals (principal and main canals) (pH, EC, TSS, oils)	Principal and main canals	Biannually	IS	IS	Inclusive in maintenance work of IS
2.	Waste / Garbage	● Record of regular monitoring of maintenance work on the irrigation canals (principal and main canals)	Principal and main canals	Biannually	GD Canal Maintenance	GD Canal Maintenance	Inclusive in maintenance work of GD Canal Maintenance
3.	Protected Area/ Ecosystem	● Irrigation volume allocated into the Fayoum area ● Drain volume to Qarun and Rayan Lakes	Intakes and drainages connecting to lakes*1	Annually	IS, EPAD	IS, EPAD	Inclusive in ordinary work of IS and EPADP

PMU: Project Management Unit, RCU: Regional Coordination Unit, IS: Irrigation Sector (MWRI), GD: General Directorate, EPAD: Egyptian Public

*1: 2 places of intake facilities (Hassaen Wassef Intake, Lahoun Regulator) and 10 places of drainages

Source: JICA Survey Team

2) Monitoring Plan and Cost for Project Component No.8 (Modern On-Farm Irrigation)

Monitoring of the implementation status of mitigation measures through WUA's supporting program will be implemented by IAS itself by preparing activity reports. PMU and RCU will be responsible and supervise the monitoring. Monitoring of the implementation status during the construction period will be implemented by construction contractors and supervised by PMU and RCU.

Table 7.4.5 Monitoring Plan with Responsible Organizations and Costs
(For Project Component No.8: Modern On-Farm Irrigation)

No.	Environmental Item	Monitoring Items	Monitoring Points (or method)	Frequency	Implemen-tation	Respon-sible	Cost
(Before Construction Stage)							
1.	Water Quality and Waste / Garbage	● Status of WUA training (existence of environmental awareness creation activity)	IIS activity report	Monthly	IIS	PMU/ RCU	Inclusive in project cost
2.	Soil Contamination	● Existence of measures for leaching ● Conditions of setting up of demonstration farms and technical training (pesticide and fertilizer control)	IIS activity report	Monthly	IIS	PMU/ RCU	Inclusive in project cost
3.	Poor/ livelihoods / local Economy	● Confirmation of financial scheme and status of consent with WUA ● Conditions of setting up of demonstration farms and technical training (farming)	IIS activity report	Monthly	IIS	PMU/ RCU	Inclusive in project cost
4.	Water Usage/ social institutions/ conflict/ misdistribution of benefit and damage	● Conditions of setting up of demonstration farms and technical training (water management)	IIS activity report	Monthly	IIS	PMU/ RCU	Inclusive in project cost
5.	Gender	● Number of women members of WUA and activities	IIS activity report	Monthly	IIS	PMU/ RCU	Inclusive in project cost
6.	Work environment/	● Conditions of setting up of demonstration farms and	IIS activity report	Monthly	IIS	PMU/ RCU	Inclusive in project cost

	accident	technical training (for safety operation)					
(Construction Stage)							
1.	Waste / Garbage	● Record of disposal conditions due to the removal of existing facilities ● Record of the setting of garbage pits	Construction sites	Monthly	Contractor	PMU/ RCU	Inclusive in construction cost
2.	Soil Contamination	● Existence of oils in farmlands	Construction sites				
2.	Water Usage	● Record of explanation meeting for construction schedule	Construction sites	Monthly	Contractor	PMU/ RCU	Inclusive in construction cost
3.	Existing Social Infrastructure	● Existence of traffic jams ● Setting conditions of detour route	Construction sites	Monthly	Contractor	PMU/ RCU	Inclusive in construction cost
4.	Work Environment, Safety, Accidents	● Record of safety meetings ● Record of numbers of accidents ● Condition of allocating traffic guards, signboards, etc.	Construction sites	Monthly	Contractor	PMU/ RCU	Inclusive in construction cost
(Operation Stage)							
Same items as "Before construction stage"		● Continuance of monitoring and completion	IIS activity report	Monthly	IIS	PMU/ RCU	Inclusive in project cost

PMU: Project Management Unit, RCU: Regional Coordination Unit, IIS: Irrigation Improvement Sector (MWRI)
Source: JICA Survey Team

7.5 Implementation Structure

Implementation structures related to mitigation measures and monitoring systems are illustrated in Figures 7.5.1, 7.5.2, and 7.5.3. During construction works, responsible unit of MWRI and supervise consultant supervise the implementation of mitigation measures and monitoring by construction contractors. Supervision consultant advises IIS for their activities related to soft support activities (mitigation measures) and monitoring of modern on-farm irrigation components. Preparation and reporting of monitoring reports and submission to JICA are responsible for RCU/PMU.

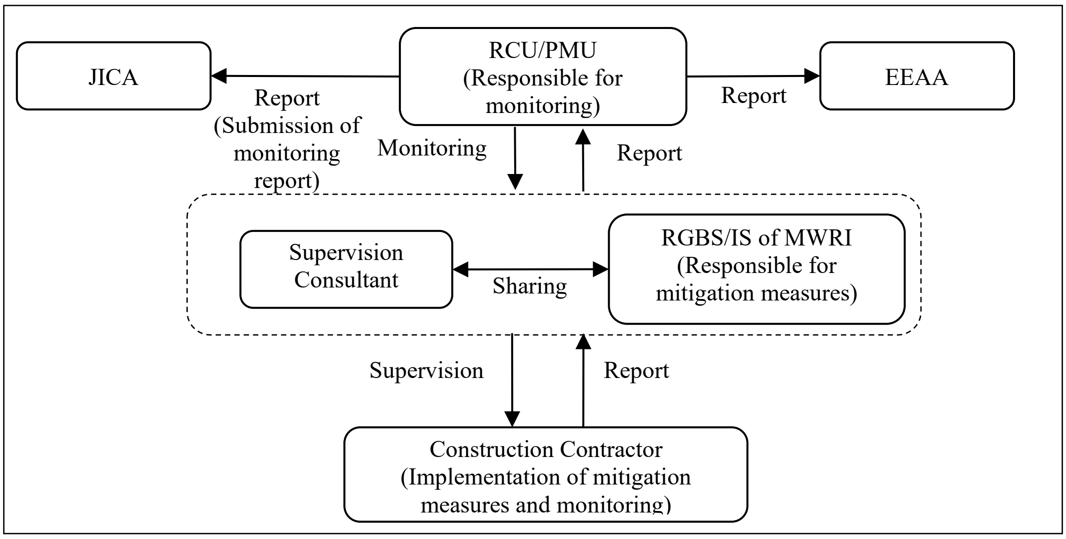


Figure 7.5.1 Implementation Structure of Mitigation Measures and Monitoring during Construction (For Project Components No.1 - 7: Civil Works on Canals and Procurement Works)
Source: JICA Survey Team

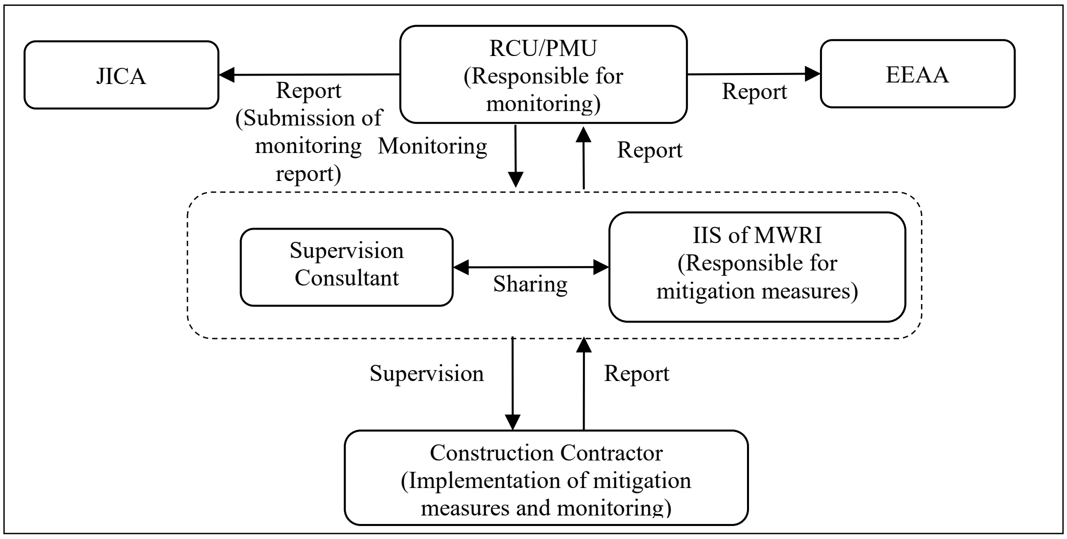


Figure 7.5.2 Implementation Structure of Mitigation Measures and Monitoring during Construction (For Project Component No.8: Modern On-Farm Irrigation)

(Source: JICA Survey Team)

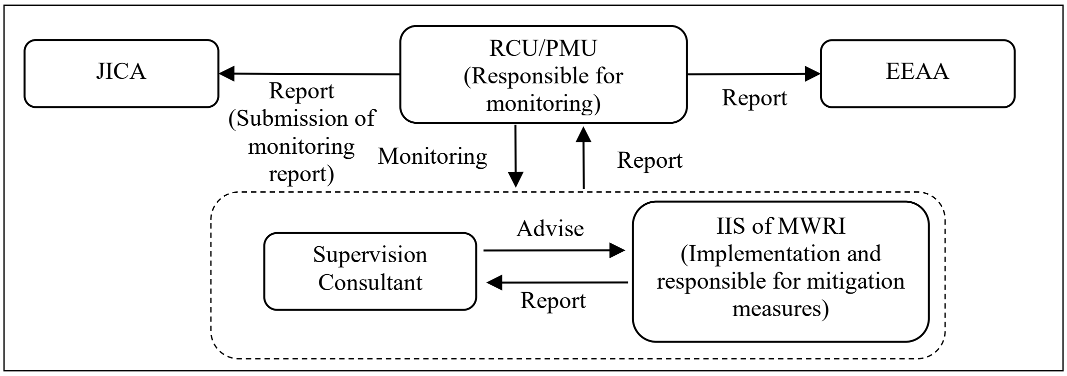


Figure 7.5.3 Implementation Structure of Soft Support Activity (Mitigation Measures) and Monitoring before Construction Stage and Operation Stage (For Project Component No.8: Modern On-Farm Irrigation)

(Source: JICA Survey Team)

7.6 Grievance Handling

1) Grievance Handling for Project Components No.1-7 (Civil Works on Canals and Procurement Works)

Local units at the village and district level are the direct contact for complaints from local people. Complaints received by local units are reported to the MWRI District office. MWRI district office reports it to RCU. RCU shares the complaints with PMU and the construction contractor. RCU/PMU and the construction contractor take action according to the nature of the complaint. The timing of the establishment of a grievance handling mechanism is planned at the commencement period of construction works. Local units at the village level and district level will notify the residential people.

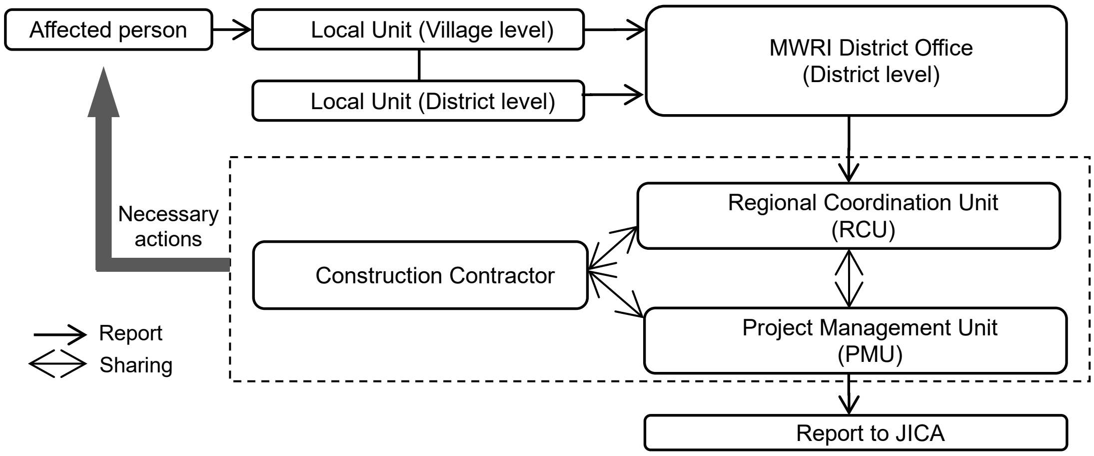


Figure 7.6.1 Flow of Grievance Handling
(For Project Components No.1 - 7: Civil Works on Canals and Procurement Works)
(Source: JICA Survey Team)

2) Grievance Handling for Project Components No.8 (Modern On-Farm Irrigation)

Modern on-farm irrigation is introduced on WUA basis. IIS provides a soft support program to WUAs prior to the construction works. Therefore, IIS is the direct contact for complaints from the beneficiary farmers. Upon receiving a complaint, IIS shares it with RCU, which is in turn share with PMU and the construction contractor. Depending on the nature of the complaint, IIS, RCU/PMU, and construction contractor take action. The timing of the establishment of grievance handling mechanism is planned at the commencement period of IIS activities to be commenced before the construction works and IIS will be in charge of notifying the WUA and farmer groups.

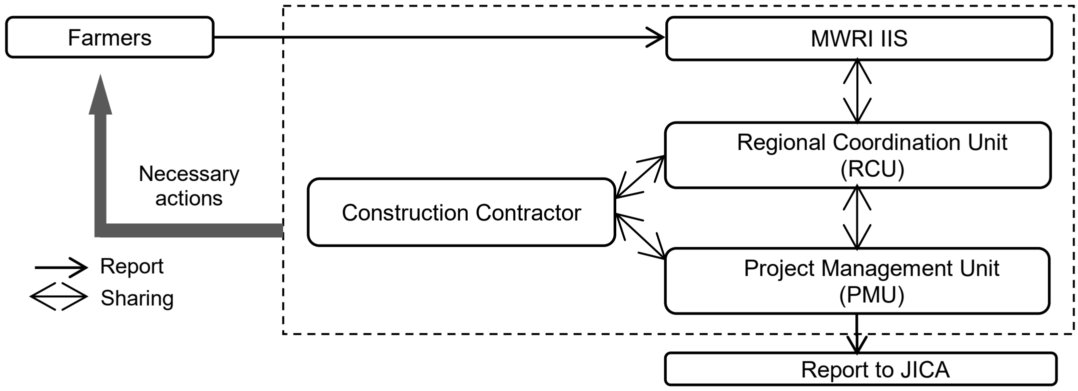


Figure 7.6.2 Flow of Grievance Handling
(For Project Component No.8: Modern On-Farm Irrigation)
(Source: JICA Survey Team)

7.7 Stakeholder Meetings

Stakeholder meetings were held in November and December 2022. The meetings were scheduled to be held in 9 villages in total, with 3 villages (one with good water conditions, one with moderate water conditions, and one with shortage water conditions) selected from each priority sub-region. The meetings were implemented under the facilitation of IIS.

Table 7.7.1 Villages for Holding Stakeholder Meetings

Village with Water Condition	Beni Suef	Fayoum	Gharbia
	Abo Shosha	Aros & Abo Seer	Kased
	Name of Villages		
Good	Dashtot	Masara Arfa	Mahlet Menouf
Moderate	El Mahmodya	El Gafra	Shobra barola
Shortage	Mazora	Bahr Abo Elmer	Damat

Source: JICA Survey Team

1) Method of Stakeholder Meetings (Date/Time, Locations, Method of Announcement, Method of meeting)

Table 7.7.2 shows the date, time, and location of the stakeholder meetings in each village. Notification of the stakeholder meetings was communicated through IIS staff to the farmers and community members in each village. Stakeholder meetings were held at public facilities (municipality office, youth center, etc.) or at the house of the farmer representative. Stakeholder meetings were conducted in the form of meetings. In the three villages of Gharbia, women did not participate in the first meeting, so separate consultation meetings were held with the purpose of facilitating women's participation.

Table 7.7.2 Date/Time and Locations of the Stakeholder Meetings

No.	Village/ Sub-region/ Governorate	Date/ Time	Venue
1	Dashtot/ Abo Shosha/ Beni Suef	13-11-2022/ 10:00 AM	Municipality office at the village
2	El Mahmodya/ Abo Shosha/ Beni Suef	14-11-2022/ 10:30 AM	House of a village head
3	Mazora/ Abo Shosha/ Beni Suef	15-11-2022/ 10:30 AM	House of a village head
4	El Gafra/ Aros & Abo Seer/ Fayoum	4-12-2022/ 11:00 AM	House of a farmer
5	Bahr Abo Elmer/ Aros & Abo Seer/ Fayoum	5-12-2022/ 11:00 AM	House of a farmer
6	Masara Arfa/ Aros & Abo Seer/ Fayoum	6-12-2022/ 11:00 AM	House of a farmer
7	Shobra barola/ Kased/ Gharbia	27-12-2022/ 10:30 AM	Youth center
8	Damat/ Kased/ Gharbia	28-12-2022/ 10:30 AM	Village sports hall
9	Mahlet Menouf / Kased/ Gharbia	29-12-2022/ 10:30 AM	Youth center
10	Mahlet Menouf / Kased/ Gharbia (for female farmers)	19-6-2023/ 11:30 AM	House of WUA head
11	Damat/ Kased/ Gharbia (for female farmers)	20-6-2023/ 11:30 AM	Village sports hall
12	Shobra barola/ Kased/ Gharbia (for female farmers)	20-6-2023/ 1:00 PM	Katoor district irrigation department office

Source: JICA Survey Team

2) Participants

Stakeholder meetings were held with village cooperatives, agricultural cooperatives, WUAs, farmers participating in WUAs, and other farmers in each village. Women representatives of WUAs were requested to participate so that their opinions could be reflected in the discussions. As noted above, separate consultations were held for women in Gharbia.

Table 7.7.3 Participants of Stakeholder Meetings

No.	Village/ Sub-region/ Governorate	Nos. of participants Total Nos. (Female nos.)	Variety of participants
1	Dashtot/ Abo Shosha/ Beni Suef	54 (Female: 15)	- IIS staff, MWRI - Village cooperative staff - Agricultural cooperative staff in the village - WUA chairman and other board members - WUA member farmers
2	El Mahmodya/ Abo Shosha/ Beni Suef	19 (Female: 3)	
3	Mazora/ Abo Shosha/ Beni Suef	26 (Female: 7)	
4	El Gafra/ Aros & Abo Seer/ Fayoum	48 (Female: 2)	
5	Bahr Abo Elmer/ Aros & Abo Seer/ Fayoum	24 (Female: 2)	
6	Masara Arfa/ Aros & Abo Seer/ Fayoum	16 (Female: 2)	
7	Shobra barola/ Kased/ Gharbia	23 (Female: 0)	

No.	Village/ Sub-region/ Governorate	Nos. of participants Total Nos. (Female nos.)	Variety of participants
8	Damat/ Kased/ Gharbia	29 (Female: 0)	- Other farmers, and so on.
9	Mahlet Menouf / Kased/ Gharbia	36 (Female: 0)	
10	Mahlet Menouf / Kased/ Gharbia (For female farmers)	14 (Female: 9)	
11	Damat/ Kased/ Gharbia (For female farmers)	35 (Female: 21)	
12	Shobra barola/ Kased/ Gharbia (For female farmers)	26 (Female: 20)	

Source: JICA Survey Team

In the stakeholder meetings held, the IIS requested the village heads and/or WUAs to involve women in the meetings. However, stakeholder meetings combining men and women in the same venue resulted in low or no participation by women. Therefore, separate stakeholder meetings targeting women were arranged later in Gharbia to incorporate women's opinions. In more conservative areas, even the participation of only women might be difficult. In such areas, it is necessary to assign female IIS staff preferentially and convince community people to hold a series of stakeholder meetings targeting women for promoting their participation in the Project and improving information disclosure for them.

3) Contents of Discussions

Discussions in the meeting were divided into two parts: the first part was an explanation and discussion of the overall project. The second part was an explanation, collection of opinions, and consolidation of opinions on the introduction of modern field irrigation facilities from participants. Details of the discussions are as follows.

【Part 1: Explanation and discussion of the overall project】

- ✓ Description of the project, implementation schedule, project area, and project components
- ✓ Construction method, related impacts, and mitigation measures
- ✓ Questions and Answers

【Part 2: Explanation, collection/consolidation of opinions on the modern on-farm irrigation】

- ✓ Explanation of facility configuration of modern on-farm irrigation facilities (Introduction cost was not explained in the meeting)
- ✓ Collection and consolidation of detailed opinions on the introduction of modern field irrigation facilities
  - Introduction of WUA-based facilities
  - Type of Meska Improvements
  - Type of field equipment (sprinkler, drip, or combination use)
  - Repayment method
  - Confirmation of willingness of introduction

4) Discussion Results

Table 7.7.4 shows the main comments and questions received in response to the explanations regarding the overall project. Participants expressed to proceed aggressively with the rehabilitation of canals and hydraulic structures. Participants were highly aware of the need to solve water shortage problems and improvements in irrigation efficiency. In the explanations, possible impacts and its mitigation measures during construction works were presented. There were no negative opinions and questions raised from participants. From female participants, it was suggested that the branch canals and Meska near the towns and villages should be culverted to prevent the dumping of garbage into the canal and also to protect the children from falling into.

On the other hand, it was observed that many farmers think it is not so easy about the introduction of modern on-farm irrigation in their villages. This is because farmers cannot imagine a successful case since there are no examples of the application of modern on-farm irrigation techniques to Old Lands around their villages. Details of the opinions regarding the introduction of modern on-farm irrigation are described in the next paragraphs.

Table 7.7.4 Main Comments and Questions Related to the Overall Project

Major Opinions/Questions from Participants	Answers by IIS
【Comments on the principal and main canals rehabilitations and hydraulic structures rehabilitations】 - Agree to the project components. Please go forward the projects.	- Rehabilitation of the principal and main canals will contribute to the MWRI's mission for improving irrigation efficiency. This project is consistent with this MWRI's objectives.
【Comments on the rehabilitation of branch canals and Meskas】 - Agree to the project components. Some of branch canals and Meskas near our village have not yet been upgraded to lining canals, so we would like to request that they be rehabilitated as soon as possible. - When repairing branch canals and Meskas, we are concerned about water pollution and public health problems due to dumping of garbage, so we would like to see measures such as covering the canals and Meskas. (Especially near the urban areas, canals should be covered to protect the sanitary condition, and also keep safety environment for children)	- MWRI plans to perform lining and other rehabilitation on all branch canals. For Meskas, WUA should be responsible for the rehabilitations financially. - Consideration should be given to appropriate design, taking into account the problem of garbage dumping.
【Comments on the introduction of modern on-farm irrigation】 - Will the introduction of modern on-farm irrigation be mandatory in near future? - There is concern that the introduction of modern on-farm irrigation will impact lowering the purchase price of products because of increasing production volume by adapting such techniques. - It is necessary to further improve of irrigation efficiency in the irrigation canals for adapting modern on-farm irrigation techniques. So, please improve irrigation efficiency by rehabilitating irrigation canals. - Is it possible to grow rice by modern on-farm irrigation facility?	- The Ministerial Decree issued in June 2022[14] has decided to introduce modern on-farm irrigation facilities in all Egyptian regions except for a few areas. All farmers should consider installing modern on-farm irrigation facility in near future. - MAWRI will provide assistance to farmers in marketing their products in the marketplace. - Objective of the project is to improve irrigation efficiency through the rehabilitation of canals and development of modern on-farm irrigation in field level together. - Possible, but it is not technically recommended. Technical support on the farm management will be given by the Project.

[14] Since the introduction of modern field irrigation facilities requires a large budget, a Joint Cooperation Protocol was signed on August 5, 2021, by the Ministry of Finance, NBE, ABE, and MWRI and MALR. The title of the document is "National Initiative for the Irrigation Improvement and the Transition to Modern Irrigation," and it provides that the Ministry of Finance will provide NBE and ABE with funds for the introduction of modern on-farm irrigation facilities, and that the farmers will receive loans from both banks. Subsequently, the Ministry of Water Resources and Irrigation decided to introduce modern on-farm irrigation facilities in the Ministerial Decree No. 143 (2022), dated May 9, 2022.

Major Opinions/Questions from Participants	Answers by IIS
- Will the introduction of modern on-farm irrigation increases soil salinity? Will this be a problem for farming?	- It is possible to design a modern on-farm irrigation facility with the functionality of conventional flood irrigation. This would allow for soil leaching and removal of soil salts.
- Please set up demonstration farms since we want to know success cases in application of conventional farmlands (Old Lands).	- Project plans to set up demonstration farms and provides technical support as part by the soft component of the project.
【Others】 - Please consider to remove water hyacinth which is breeding in the canal and consuming the water a lot.	- This is part of MWRI's waterway maintenance work. Maintenance equipment will be procured through the project.

Source: JICA Survey Team

Tables 7.7.5-7.7.7 show the detailed questions and the results of collection and consolidation of the opinions for the introduction of modern on-farm irrigation, by areas. Motivation for the introduction of modern on-farm irrigation varied among the areas. The most positive stance for the introduction of modern on-farm irrigation was found in Kased (Gharbia) in Delta, followed by Abo Shosha (Beni Suef) in Upper Egypt, and the most conservative stance was found in Aros & Abo Seer (Fayoum) in Upper Egypt.

In Aros & Abo Seer, it was raised as a problem that the size of farmlands owned by each farmer in this area is too small to introduce a modern on-farm irrigation system by group basis. Because of this reason, some of farmers raised concerns about the introduction of modern on-farm irrigation systems. If modern on-farm irrigation will be promoted in this area, such features should be considered. (It is noted that JICA Survey Team proposed that the introduction of modern on-farm irrigation in Fayoum should be not included in the project components with reasons of adverse impacts on Qarun and Rayan Lakes, as the result of detailed analysis (refer to chapter 4.10) and alternative analysis of 7.3.2).

As one of the most common requests raised at meetings, setting up of demonstration farms by the Project are necessary to show the success cases by applying modern on-farm irrigation techniques. This is because most farmers had seen and heard of successful examples in New Lands, however, they had not experienced successful examples in Old Lands. They also expressed their requests for cultivation and marketing technical support after the introduction of modern on-farm irrigation. In conclusion, it was confirmed that the implementation of the soft support program (technical assistance) by the project are essential and important.

Table 7.7.5 Collection and Consolidation Results of Particpants' Opinions for Introduction of Modern On-Farm Irrigation Facility (Abo Shosha, BeniSuef)

Items	Dashtot (Water condition/ Good)	El Mahmodya (Water condition/ Moderate)	Mazora (Water condition/ Shortage)
1. Do you favor the introduction of modern on-farm irrigation facility WUA basis (or farmer group basis)? (Yes/No)	Yes	Yes	Yes
	【Major Opinions】 • Agree to the operation and management by WUA. • Experienced farmers with modern on-farm irrigation facility (including large farmers) are encouraged to participate in the WUA.		
2. Which do you prefer "Open canal" or "Close canal" for Meska improvements?	Open canal	Closed canal	Open canal
	【Major Opinions】 • (Reason for selecting "Open canal") Easy to repair in case of blockage of Meska, and easy to watch water by eyes. • (Reason for selecting "Closed canal") Garbage dumping into the canal is problem, and we want to prevent this by culverting.		
3. Which do you prefer for the field	Combination use	Combination use	Combination use

Items	Dashtot (Water condition/ Good)	El Mahmodya (Water condition/ Moderate)	Mazora (Water condition/ Shortage)
equipment? (Drip or Sprinkler or Combination use)	【Major Opinions】 • We want to request to set up demonstration farms to demonstrate which type of water saving devices are most effective for each crop. • We want to see methods and techniques in the above demonstration farms to select best devises. • Considering water management, it would be preferable to grow the same crop by group, but it would be difficult to get the consensus of all farmers.		
4. What crops do you prefer to cultivate by modern on-farm irrigation facility?	Sugar beet, wheat, berseem, aromatic plant	Wheat, berseem, potatoes, maize	Wheat, berseem, maize, potato, aromatic plant
	【Major Opinions】 • We want to continue growing the same crops as existing. (Above crops are existing crops).		
5. Which way do you prefer for the repayment method? (Through “bank” or “collection at same timing of land tax”)	Either way is fine	Either way is fine	Either way is fine
	【Major Opinions】 • We don’t know specific difference between “bank” or “same timing as land tax”. • We don't care which repayment method is adapted as long as the interest rate is zero.		
6. Do you agree to install modern on-farm irrigation facility? (Yes/No)	Yes, with condition	Yes, with condition	Yes, with condition
	【Major Opinions】 【Dashhot village】 • We have no knowledge of modern on-farm irrigation. Thus, we want to gain the knowledge of the benefits and profitability of it. • We know examples of tomato cultivation on reclaimed farmland (New Lands) and it is successful. We have visited New Lands and learned of the benefits of low fertilizer application and high yields. However, there are no examples in our village (Old Lands). Farmers needs to learn from the examples. • We want to see demonstration farms set up in the village to show best practices and to see the results if it is suitable for Old Lands ***(Conditions for introduction)***. 【El Mahmodya village】 • We know that modern on-farm irrigation has many advantages (increased yields, greater water savings, consumption saving (fertilizer, labor, etc.)). However, we don’t know if it is effective in Old Lands or not. We want to see demonstration farms set up ***(Conditions for introduction)***. • It is possible to offer our own farmland for the establishment of demonstration farms. 【Mazora village】 • In our village, there are many farmers who have New Lands, and we know successful cases of modern on-farm irrigation in New Lands. However, we don’t know if it is effective in Old Lands or not. We want to see success examples at demonstration farms (for example: 2 feddans) ***(Conditions for introduction)***.		

Source: JICA Survey Team

Table 7.7.6 Collection and Consolidation Results of Particpants’ Opinions for Introduction of Modern On-Farm Irrigation Facility (Aros & Abo Seer, Fayoum)

Items	Masara Arfa (Water condition/Good)	El Gafra (Water condition/ Moderate)	Bahr Abo Elmer (Water condition/ Shortage)
1. Do you favor the introduction of modern on-farm irrigation facility WUA basis (or farmer group basis)? (Yes/No)	No	No	No
	【Major Opinions】 • (Reason of “No”) The scale of the modern on-farm irrigation facility to be introduced seems too large. There are many farmers with less than 5 karat of farmland. So, if the size of the facilities to be introduced is too large, the number		

Items	Masara Arfa (Water condition/Good)	El Gafra (Water condition/ Moderate)	Bahr Abo Elmer (Water condition/ Shortage)
	of farmers will increase. There is concern about group based installation and management of the facility. • (Reason of "No") Even in neighboring farmers, there is concern that farmers may not agree to the introduction of the system by group.		
2. Which do you prefer "Open canal" or "Close canal" for Meska improvements?	Open canal	Open canal	Open canal
	【Major Opinions】 • (Reason for selecting "Open canal") Easy to repair in case of blockage of Meska, and easy to watch water by eyes. Less sedimentation is expected.		
3. Which do you prefer for the field equipment? (Drip or Sprinkler or Combination use)	Depend on crops	Depend on crops	Combination use
	【Major Opinions】 • (Reason for selecting "Depend on crops") It seems that Drip is more expensive than Sprinkler. Equipment to be installed depends on the crop to be grown. • (Reason for selecting "Depend on crops") No knowledge of the modern on-farm irrigation. • (Reason for selecting "Combination use") Certain crops such as Berseem are suitable for sprinklers. Combination use, which can be selected depending on the crop, would be optimal.		
4. What crops do you prefer to cultivate by modern on-farm irrigation facility?	Wheat, berseem, maize, cabbage, tomato, leek, onion and cucumber	Wheat, berseem, potatoes, maize	Wheat, berseem, maize
	【Major Opinions】 • We want to continue growing the same crops as existing. (Above crops are existing crops).		
5. Which way do you prefer for the repayment method? (Through "bank" or "collection at same timing of land tax")	Agricultural bank	Agricultural bank	Agricultural bank
	【Major Opinions】 • Not familiar with the system of "collection at same timing of land tax". Don't know what difference between land tax and bank.		
6. Do you agree to install modern on-farm irrigation facility? (Yes/No)	No	No	No
	【Major Opinions】 【Masara Arfa village】 • We know that modern on-farm irrigation has many advantages (increased yields, greater water savings, consumption saving (fertilizer, labor, etc.)). However, we have not seen the example adapting Old Lands. • There are differences in farmland size among the various farmers. There are also differences in the elevation of the farmland. Because of these conditions, we are concerned about whether the introduction of modern on-farm irrigation facility will be successful. 【El Gafra village】 • I have seen examples of modern on-farm irrigation facility in New Lands, but have not seen any in Old Lands and am concerned about their success. • I feel that the introduction of modern on-farm irrigation may be difficult for Old Lands because of the high cost. • I feel that it may be difficult to introduce modern on-farm irrigation because each farmer's land is small. • I would like to see demonstration farms set up. 【Bahr Abo Elmer village】 • I feel that it may be difficult to introduce modern on-farm irrigation facility because each farmer's land is small. The maximum facility configuration should be less than 10 feddan. • It is depending on the costs.		

Source: JICA Survey Team

Table 7.7.7 Collection and Consolidation Results of Particpants' Opinions for Introduction of Modern On-Farm Irrigation Facility（Kased, Gharbia）

<table>
<tr><th>Items</th><th>Mahlet Menouf
(Water condition/
Good)</th><th>Shobra barola
(Water condition/
Moderate)</th><th>Damat
(Water condition/
Shortage)</th></tr>
<tr><td rowspan="2">1. Do you favor the introduction of modern on-farm irrigation facility WUA basis (or farmer group basis)? (Yes/No)</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td colspan="3">【Major Opinions】
• it would be easy to implement and operate the facility on a WUA basis.</td></tr>
<tr><td rowspan="2">2. Which do you prefer "Open canal" or "Close canal" for Meska improvements?</td><td>Both type</td><td>Both type</td><td>Both type</td></tr>
<tr><td colspan="3">【Major Opinions】
• (Reason for selecting "Both type") Only Meskas passing through residential areas should be culverted, while Meskas passing through farmland should be open. Open canal is easier to maintain and check water levels. On the other hand, culvert canal is to be used in residential areas to prevent dumping of household garbage.</td></tr>
<tr><td rowspan="2">3. Which do you prefer for the field equipment? (Drip or Sprinkler or Combination use)</td><td>Combination use</td><td>Depend on crops</td><td>Depend on crops</td></tr>
<tr><td colspan="3">【Major Opinions】
• We want to request to set up demonstration farms to demonstrate which type of water saving devices are most effective for each crop.
• We want to select best devises for each crop.
• We want to request the project to recommend best matching of devices and crops, if possible.</td></tr>
<tr><td rowspan="2">4. What crops do you prefer to cultivate by modern on-farm irrigation facility?</td><td>Same as existing crops (Traditional cops and vegetables)</td><td>Same as existing crops (Traditional cops and vegetables)</td><td>Same as existing crops (Traditional cops and vegetables)</td></tr>
<tr><td colspan="3">【Major Opinions】
• We want to continue growing the same crops as existing.</td></tr>
<tr><td rowspan="2">5. Which way do you prefer for the repayment method? (Through "bank" or "collection at same timing of land tax")</td><td>Agricultural bank</td><td>Collection by tax authority</td><td>Collection by tax authority</td></tr>
<tr><td colspan="3">【Major Opinions】
• (Reason for selecting "Agricultural bank") Because we are familiar with agricultural banks.
• (Reason for selecting "collection at same timing of land tax") Because it is same method used in case of introducing Improved Meska. Also, in the case of bank, the land must be pledged as collateral. In case of tax authority, there is no such concern.</td></tr>
<tr><td rowspan="2">6. Do you agree to install modern on-farm irrigation facility? (Yes/No)</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td colspan="3">【Major Opinions】
【Mahlet Menouf village】
• We know applications in New Lands. We have high hopes that it may be successful in Olds lands. We have great interest in the introduction of modern on-farm irrigation facilities under the project.
• We would like to see a trial run of operations and best practices in Old Lands through the establishment of demonstration farms.

【Shobra barola village】
• We are expecting to the introduction of modern on-farm irrigation facilities through this project.
• We would like to know the success case by setting up demonstration farms.

【Damat village】
• We are expecting to the introduction of modern on-farm irrigation facility through this project.
• We would like to request demonstration farms incorporated into the project component.</td></tr>
</table>

Source: JICA Survey Team


Dashhot village, Beni Suef


Masara Arfa village, Fayoum


Mahalt Mnof, Gharbia

Figure 7.7.1 Pictures of the Stakeholder Meetings (Souce: JICA Survey Team)

7.8 Land Acquisition and Resettlement

1) Lands for Project Components No.1-7 (Civil Works on Canals and Procurement Works)

All the canals (principal, main, and branch level) and hydraulic structures planned for rehabilitation in this project are located within existing irrigation canals. These irrigation canals are located within the management area of MWRI, and houses are not located in the planned construction areas. Further, there are no informal settlements, informal agricultural lands, and/or informal buildings such as informal small shops, etc. confirmed in the planned construction areas. Therefore, New Land acquisitions and resettlements are not expected. It is noted that land for the storage of construction materials will be secured within the management area of MWRI along irrigation canals. During the construction work of existing canals, a sufficient explanation of the construction schedule will be given and examination of construction work such as setting up of temporary canals will be considered as necessary for minimizing the impacts on the existing water use of farmers.

2) Lands for Project Component No.8 (Modern On-Farm Irrigation)

In this project component, modern on-farm irrigation facilities will be installed together with Meska improvement. One system of a modern on-farm irrigation facility consists of one lifting pump and pipeline system and watering equipment (sprinklers, drip tubes, etc.).

New Land acquisition will not be necessary for the Meska improvement since the planned work is the rehabilitation of existing Meskas. Lands for the pump facility will be used for the Sakia (water wheel), which is conventionally used for raising water from Meska. Pipelines will be installed on the land of existing Marwa (on-farm small canals) with backfilling of soils. Therefore, the facilities will be arranged within the existing land use and New Land acquisition will be not necessary. Further, there are no houses, informal settlements, informal agricultural lands, and/or informal buildings such as informal small shops, etc. on these lands, and therefore, New Land acquisition and resettlement will be not necessary.

During the construction works of existing Meskas, sufficient explanation of the construction schedule will be given and mitigation of the effect of construction works such as setting up of temporary canals will be considered as necessary for minimizing the impacts on the existing water use of farmers.

7.9 Environmental Check List and Monitoring Forms

7.9.1 Environmental Check List (Draft)

An environmental check list (draft) for the project is shown below.

Table 7.9.1 Environmental Check List (Draft)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N (b) N (c) N/A (d) N/A	(a) EIA report shall be prepared by MWRI before or in Detail Design Stage. (b)) EIA report shall be submitted before or in by MWRI to obtain approval from EEAA in Detail Design Stage. (c) N/A (d) N/A
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) Y (b) Y (both are currently in progress as of November, 2022)	(a) Contents of the project and the potential impacts will have been explained by MWRI and shared with local stakeholders through the series of stakeholder meetings in November and December 2022. (b) Results of the stakeholder meetings are reflected to the project design.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) Examined under social and environmental considerations.
2 Pollution Control	(1) Water Quality	(a) Are considerations given to water pollution of the surrounding water bodies, such as rivers and groundwater by effluents or leachates from agricultural lands? Are adequate use/disposal standards for fertilizers, agrochemicals, and livestock wastes established? Is a framework established to increase awareness of the standards among farmers? (b) Is a monitoring framework established for water pollution of rivers and groundwater?	(a) Y (b) Y	(a) Mitigation measures against the effluent from construction works will be carried out by the construction contractor. Training will be provided to beneficiaries (farmers) on the proper management, use, and disposal of fertilizers and pesticides through technical assistance by MWRI. (b) Water quality of canals will be monitored during construction and operation stage.
	(2) Wastes	(a) Are wastes properly treated and disposed of in accordance with the country's regulations?	(a) Y	(a) Mitigation measures against the waste from construction works will be carried out by the construction contractor.
	(3) Soil Contamination	(a) Is there a possibility that impacts in irrigated lands, such as salinization of soils will result? (b) Are adequate measures taken to prevent soil contamination of irrigated lands by agrochemicals, heavy metals and other hazardous substances? (c) Are any agrochemicals management plans prepared? Are any usages or any implementation structures organized for proper use of the plans?	(a) Y (b) Y (c) Y	(a) There is a possibility of salinization of soils with the introduction of modern on-farm irrigation. (b) Against the possibility of salinization, technical arrangement will be done such as equipping the function of leaching soils in the modern on-farm irrigation facility. And, technical assistance will be provided to the beneficiaries (farmers) by MWRI. (c) Enhancement of beneficiaries (farmers) on agrochemical management will be planned through the training provided by MWRI.
	(4) Subsidence	(a) In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	(a) N	(a) No large groundwater extraction is planned by the project
	(5) Odor	(a) Are there any odor sources? Is there a possibility that odor problems will occur to the inhabitants?	(a) N	(a) Order problems are not anticipated.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
3 Natural Environment	(1) Protected Areas	(a) Is the project site or discharge area located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) Y→N	(a) Introduction of modern on farm irrigation throughout Fayoum, where Qarun and Rayan Lakes (designated as protected areas) are located, may have a significant negative impact on the Lakes. To avoid this impact, the introduction of modern on-farm irrigation in Fayoum area was reconsidered to be out of project scope and possible alternatives were examined.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site or discharge area encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) Is there a possibility that the project will result in the loss of breeding and feeding grounds for valuable wildlife? If they are lost, are there substitutes for the grounds near the original locations? (d) Is there a possibility that overgrazing will cause ecological degradation, such as impacts on wildlife habitats and desertification? (e) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem?	(a)N (b)N (c)N (d)N (e)Y	(a) Qarun and Rayan Lakes (Ramsar sites) are not located besides the project area and the project will not affect significantly to the two lakes except for the component of modern on-farm irrigation. (b) Same as (a) (c) Same as (a) (d) Same as (a) (e) Project component of the introduction of modern on-farm irrigation in Fayoum was reconsidered to be out of project scope and possible alternatives were examined.
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is the compensations going to be paid prior to the resettlement? (e) Is the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a)N (b)N/A (c)N/A (d)N/A (e)N/A (f)N/A (g)N/A (h)N/A (i)N/A (j)N/A	(a)Both resettlement and land acquisition are not required for the project components. (b)N/A (c)N/A (d)N/A (e)N/A (f)N/A (g)N/A (h)N/A (i)N/A (j)N/A
4 Social Environment	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	(a)Y (b)N/A (c)Y (d)Y (e)N	(a) The introduction costs of modern on-farm irrigation will be borne by beneficiaries (farmers). To reduce the financial burden on farmers, the effective financial

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(b) Is proper allotment made for rights to agricultural land use? Is there a possibility that the allotment will result in inequitable distribution or usurpation of land and available resources? (c) Are proper allotments, such as water rights allotment in the project area made? Is there a possibility that the allotments will result in inequitable distribution or usurpation of water rights and available resources? (d) Is there a possibility that the amount of water used (surface water, groundwater) by the project will adversely the downstream fisheries and water uses? (e) Is there a possibility that water-borne or water-related diseases (e.g., schistosomiasis, malaria, filariasis) will be introduced? Is adequate consideration given to public health education, if necessary?		scheme will be introduced to support farmers. (b) Not applicable (c) One of the project purpose is to contribute equal irrigation water distribution among agricultural water users (farmers). (d) Same as (c) (e) Not applicable
	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a)N/A	Not applicable
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a)N/A	Not applicable
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a)N/A (b)N/A	Not applicable
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) N (b) Y (c) Y (d) Y	(a) No violations (b) Necessary arrangements will be given by the contractor and monitored by MWRI. (c) Same as (b) (d) Same as (b)
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a) Y (b) Y (c) Y	(a) Mitigation measures during construction works are planned with the evaluation of impacts. (b) Same as (a) (c) Same as (a)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a)Y (b)Y (c)Y (d)Y	(a) Monitoring plan is prepared. (b) They are included in the monitoring plan. (c) They are secured in the project cost. (d) They are included in the monitoring plan.

Source: JICA Survey Team

7.9.2 Monitoring Forms (Draft)

Monitoring forms (draft) for project components No.1-7 (civil works on canals and procurement works) and project component No.8 (modern on-farm irrigation) are shown in Tables 7.9.2 and 7.9.3, respectively.

Table 7.9.2 Monitoring Form (Draft)

（For Project Components No.1-7: Civil Works on Canals and Procurement Works

MONITORING FORM (Draft)

(1) During the Construction Stage

1) Responses/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period	Monitoring Frequency	Monitoring Organization
Number and contents of formal comments made by the public		Monthly	**Implementer:** PMU/RCU **Responsible:** PMU/RCU
Number and contents of responses from the people			

2) Air Quality

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Operation and maintenance condition of truck and heavy machinery for preventing air pollution		Construction sites	Monthly	**Implementer:** Contractor **Responsible:** PMU/RCU

3) Water Quality

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Countermeasures for construction drainage of canal rehabilitation work for preventing water pollution		Construction sites	Monthly	**Implementer:** Contractor **Responsible:** PMU/RCU
Installation condition of temporally toilet and septic tank for workers in the base camp and construction sites		Construction sites		

Monitoring Item		Monitoring Results during Report Period	Monitoring Frequency	Monitoring Frequency	Monitoring Organization
Water quality measurement	pH EC (uS/cm) TSS (mg/l) Oil and grease (mg/l)		Downstream of canal work points	Monthly	**Implementer:** Contractor **Responsible:** PMU/RCU
	Note 1: Egyptian standard of drain water quality regulated by Law 48				

	pH: 6-9, TSS: 50mg/l, Oil and greases: 10mg/l Note 2: Japanese law (water pollution prevention law) pH: 5.8-8.6, TSS: 120mg/l, Oil and greases: 30mg/l Note 3: Average of EC level measured in OD survey: 414 uS/cm Note 4: Baseline water quality shall be measured in advance of construction commencement. Note 5: Measuring points shall be set up three points (upstream, midstream, and downstream) of Aros Canal, Abo Shosha Canal and Kased Canal. Measuring points for Bahr Yusef and Ibrahimia shall be set up at downstream of canal rehabilitation work points.

4) Waste/ Garbage

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Disposal condition of existing removal facilities		Construction sites	Monthly	**Implementer:** Contractor **Responsible:** PMU/RCU
Garbage containers arrangement condition at work places				

5) Noise and vibration

Monitoring Item		Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Working time zone during the construction work near the residential place and complainants from residential people			Construction sites near the residential place	Monthly	**Implementer:** Contractor **Responsible:** PMU/RCU
Noise measurement near residential place	Noise level (Unit: dB)				
Vibration level during pile works, crushing works, excavation works, demolition works	Vibration level (Unit dB)		Construction sites		
Note 1: Egyptian standard of noise level at residential area is below. Residential area located on roads less than 12m: 65 dB at day time and 55 dB at night time. Residential area located on roads more than 12m: 70 dB at day time and 60 dB at night time. Note 2: IFC Guideline: 55 dB at day time and 45 dB at night time. Note 3: Vibration regulation law in Japan: 75 dB					

6) Protected Areas/ Ecosystem

Same as "(3) Water Quality"

7) Water Usage/Social institutions

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Temporary canal use condition during construction works for existing agricultural water use		Construction sites	Monthly	**Implementer:** Contractor **Responsible:** PMU/RCU
Explanation meeting of the construction schedule to BC-WUAs				

8) Existing social infrastructures and services

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Existence of traffic near the construction sites due to construction works at canals		Construction sites	Monthly	**Implementer:** Contractor **Responsible:** PMU/RCU
Setting up of the bypass road, if necessary				

9) Hazards (Risk) Infectious diseases such as HIV/AIDs

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Record of holding sanitary education meeting		Construction sites	Monthly	**Implementer:** Contractor **Responsible:** PMU/RCU

10) Work environment (including safety) /Accidents

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Record of holding construction safety meeting		Construction sites	Monthly	**Implementer:** Contractor **Responsible:** PMU/RCU
Number of accidents				
Safety measures conditions (allocation of traffic guards, putting up of sign board, fencing etc.)				

(2) During Operation Stage

1) Water Quality

Monitoring Item		Monitoring Results during Report Period	Monitoring Frequency	Monitoring Frequency	Monitoring Organization
Water quality measurement	pH EC (uS/cm) TSS (mg/l) Oil and grease (mg/l)		Principal Canal and Main Canals	Biannually	**Implementer:** IS (MWRI) **Responsible:** IS (MWRI)
	Note 1: Egyptian standard of drain water quality regulated by Law 48 pH: 6-9, TSS: 50mg/l, Oil and greases: 10mg/l Note 2: Japanese law (water pollution prevention law) pH: 5.8-8.6, TSS: 120mg/l, Oil and greases: 30mg/l Note 3: Average of EC level measured in OD survey: 414 uS/cm				

2) Waste/ Garbage

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Canal maintenance work condition		Principal Canal and Main Canals	Biannually	**Implementer:** GD Canal Maintenance (MWRI) **Responsible:** GD Canal Maintenance (MWRI)

3) Protected Area (Water volume to the Lake Qarun and Rayan)

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Annual irrigation water allocation to the Fayoum Area	Total volume: MCM/year	Refer to below	Annually	**Implementer:** Contractor **Responsible:** IS and EPADP (MWRI)
Annual drainage volume to the two lakes	Total volume: MCM/year			
Note 1: Regulated irrigation allocation amount to the Fayoum area is 2,600 MCM (million m3)/year. Note 2: Regulated drainage volume to the two lakes is 500 MCM (million m3)/year. Note 3: Actual allocated irrigation water volume in Fayoum area is measured at Hassen Wassef Intake and Lahoun Regulator by the IS ordinary work. The actual drainage volume to the two lakes is measured at 10 drainages connected to the lakes by the EPADP ordinary work.				

Table 7.9.3 Monitoring Form (Draft)

(For Project Component No.8: Introduction of Modern On-Farm Irrigation)

MONITORING FORM (Draft)

(1) Before the Construction Stage

1) Responses/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period	Monitoring Frequency	Monitoring Organization
Number and contents of formal comments made by the public		Monthly	**Implementer:** PMU/RCU **Responsible:** PMU/RCU
Number and contents of responses from the people			

2) Setting up of Demonstration Farms for Trainings

Monitoring Item	Monitoring Results during Report Period	Measures of Monitoring	Monitoring Frequency	Monitoring Organization

Setup of Demonstration Farms		IIS Activity Report	Monthly	**Implementer:** IIS **Responsible:** PMU/RCU

3) Water Quality and Waste/ Garbage

Monitoring Item	Monitoring Results during Report Period	Measures of Monitoring	Monitoring Frequency	Monitoring Organization
Training activity on Environmental Awareness to WUA		IIS Activity Report	Monthly	**Implementer:** IIS **Responsible:** PMU/RCU

4) Soil contamination

Monitoring Item	Monitoring Results during Report Period	Measures of Monitoring	Monitoring Frequency	Monitoring Organization
Designing of leaching facility		IIS Activity Report	Monthly	**Implementer:** IIS **Responsible:** PMU/RCU
Training activity on pesticides and fertilizer control to WUA				

5) Poor/ Livelihood/ Local economy

Monitoring Item	Monitoring Results during Report Period	Measures of Monitoring	Monitoring Frequency	Monitoring Organization
Consent from WUA on the financial scheme		IIS Activity Report	Monthly	**Implementer:** IIS **Responsible:** PMU/RCU
Training activity on farming to WUA				

6) Water Usage/ Social institutions/ Conflict/ Misdistribution of benefit and damage

Monitoring Item	Monitoring Results during Report Period	Measures of Monitoring	Monitoring Frequency	Monitoring Organization
Training activity on water management to WUA		IIS Activity Report	Monthly	**Implementer:** IIS **Responsible:** PMU/RCU

7) Gender

Monitoring Item	Monitoring Results during Report Period	Measures of Monitoring	Monitoring Frequency	Monitoring Organization
Women's participation in WUA (Numbers of women members and activities in WUA)		IIS Activity Report	Monthly	**Implementer:** IIS **Responsible:** PMU/RCU

8) Accident

Monitoring Item	Monitoring Results during Report Period	Measures of Monitoring	Monitoring Frequency	Monitoring Organization
Training activity on safety operation of facility to WUA		IIS Activity Report	Monthly	**Implementer:** IIS **Responsible:** PMU/RCU

(2) During Construction Stage

1) Responses/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period	Monitoring Frequency	Monitoring Organization
Number and contents of formal comments made by the public		Monthly	**Implementer:** PMU/RCU **Responsible:** PMU/RCU
Number and contents of responses from the people			

2) Waste/ Garbage

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Disposal condition of existing removal facilities		Construction sites	Monthly	**Implementer:**

Garbage containers arrangement condition at work places				Contaractor **Responsible:** PMU/RCU

3) Soil Contamination

Monitoring Item	Monitoring Results during Report Period	Measures of Monitoring	Monitoring Frequency	Monitoring Organization
Existence of oils in farmlands		Construction sites	Monthly	**Implementer:** Contaractor **Responsible:** PMU/RCU

4) Water Usage

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Explanation meeting of the construction schedule to WUAs		Construction sites	Monthly	**Implementer:** Contractor **Responsible:** PMU/RCU

5) Existing social infrastructures and services

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Safety measures for passengers of Meska (setting up of guard fence, etc.)		Construction sites	Monthly	**Implementer:** Contractor **Responsible:** PMU/RCU

6) Work environment (including safety)/Accidents

Monitoring Item	Monitoring Results during Report Period	Monitoring Place	Monitoring Frequency	Monitoring Organization
Record of holding construction safety meeting		Construction sites	Monthly	**Implementer:** Contractor **Responsible:** PMU/RCU
Number of accidents				
Safety measures conditions (allocation of traffic guards, putting up of sign board, fencing etc.)				

(3) During Operation Stage

Same as "Before construction stage," including technical support by IIS.

7.10 Climate Change

7.10.1 Mitigation for Climate Change (Reduction of GHG Gas Emissions)

Component No. 8 (Introduction of Modern On-Farm Irrigation) of the project would contribute to the reduction of GHG gas (greenhouse gas emissions). With the introduction of modern on-farm irrigation facilities, water use at the farm level will be changed from the use of individual pumps by farmers to the use of collective pumps. Thus, a reduction of GHG gas emissions with a reduction of pump power consumption is expected.

Table 7.10.1 shows the estimated GHG gas emissions converted by CO2 based on the calculation tool (JICA Climate Fit). Reduction of 10,356 t CO2/year is expected in case of implementation of the project. As per 1 feddan, reduction of 0.09 t CO2/year is expected.

Table 7.10.1 Estimation of Reduction Volume of CO2 in case of Project Implementation

Description		Value	Unit
Emission reduction		10,356	tCO_2/year
Baseline emission		40,311	tCO_2/year
	Production capacity (or other appropriate factors) in the baseline	0	-
	Production capacity (or other appropriate factors) in the project	0	-
	Electricity consumption in the baseline in year y	75,631	MWh/year
	CO_2 emission factor of the grid electricity	0.533	t-CO_2/MWh
	Net calorific value of fuel i	0	TJ/t
	CO_2 emission factor of fuel i	0	t-CO_2/TJ
Project emission		29,955	tCO_2/year
	Electricity consumption in the project in year y	56,201	MWh/year
	CO_2 emission factor of the grid electricity	0.533	t-CO_2/MWh
	Net calorific value of fuel i	0	TJ/t
	CO_2 emission factor of fuel i	0	t-CO_2/TJ

Calculation condition of baseline electricity consumption (MWh/year)

Description		Unit	Value	Calculation condition
Crop area (feddan)	(a)	feddan	113,857	Kased 95,976 + Abo Shosha 17,881
No. of farmers	(b)	-	133,600	Kased 117,000 + Abo Shosha 16,600
No. of pumps	(c)	-	133,600	1 unit per farmers (individual pump)
Output of pump	(d)	KW/unit	3.7	Average output
Operation hour in a day	(e)	hrs/day	3	Average operation hours
Operation days in a year	(f)	days/year	51	
- Summer Crop	-	days	36	6 months, 6 days per month (=1 day/5 days)
- Winter Crop	-	days	15	5 months, 3 days per month (=1 day/10 days)
Consumption in a year	(g)=(d)*(e)*(f)	KWh/year	75,630,960	
	(h)=(g)/1,000	MWh/year	75,631	
Consumption per feddan in a year	(i)=(h)/(a)	MWH/year/feddan	0.664	

Calculation condition of project electricity consumption (MWh/year)

Description		Unit	Baseline	Calculation condition
Crop area (feddan)	(a)	feddan	113,857	Kased 95,976 + Abo Shosha 17,881
No. of farmers	(b)	-	133,600	Kased 117,000 + Abo Shosha 16,600
No. of pumps	(c)	-	3,450	1 unit per 33 feddans (collective pump)
Output of pump	(d)	kW/unit	15	Average output
Operation hour in a day	(e)	hrs/day	6	Average operation hours
Operation days in a year	(f)	days/year	181	
− Summer Crop	-	days	126	6 months, 21 days per month (=5 days/7 days)
− Winter Crop	-	days	55	5 months, 11 days per month (=5 days/14 days)
Consumption in a year	(g)=(d)*(e)*(f)	KWH	56,200,500	
	(h)=(g)/1,000	MWH	56,201	
Consumption per feddan in a year	(i)=(h)/(a)	MWH/feddan	0.494	

Source: JICA Survey Team

7.10.2 Adaptation for Climate Change

Egypt National Climate Change Strategy 2050 outlines policies for enhancing resilience and adaptive capacity to climate change in Goal 2. Rehabilitation of canal system and introduction of modern on-farm irrigation planned by the project is consistent with the climate change adaptation measures proposed in the strategy (See. gray colored and underlined part in Table 7.10.2). By implementation of the Project, efficient use of water resources (14% increase in irrigation efficiency) is expected. Thus, the Project contributes to enhancing the resilience and adaptative capacity for climate change in Egypt.

Table 7.10.2 Measures on Enhancing Resilience and Adaptive Capacity to Climate Change in Egypt

Goal 2: Enhancing Resilience and Adaptive Capacity to Climate Change, and Alleviating the Associated Negative Impacts		
Objective (2.c):	Preserving country's resources from the impacts of climate change	1) Determining the priorities of the proposed adaptation measures for all concerned sectors. 2) Develop policies to reduce waste and raise the efficiency of water resource use. 3) Using more efficient technologies to rationalize water and energy consumption and reduce food waste. 4) Development of water harvesting and rainwater collecting systems. 5) Raising awareness about the conservation of water, energy and land resources. 6) Encourage and implementing flood water harvesting systems and its utilization.

		7) Use more efficient irrigation systems. 8) Increasing the coverage of sewage treatment plants and industrial wastewater in different areas to recycle water, maintain its quality and maximize its use. 9) Carrying out maintenance and disinfection work for fresh water sources (canals and drains) on an ongoing basis and to cover as many of them as possible. 10) Ensuring that services cover the poorest rural areas. 11) Developing non-conventional water resources. 12) Preserving agricultural land and water resources by maintaining the fertility of agricultural soil continuously. 13) Develop different varieties and hybrids of strategic crops that are highly productive and tolerant to adverse weather conditions. 14) Allocating new agricultural lands to increase the agricultural area. 15) Rationalizing water consumption in agriculture. 16) Improving crop management systems. 17) Protection of fisheries. 18) Identify ways and means to integrate biodiversity considerations into assessments of impacts, vulnerability, and climate change adaptation. 19) Encouraging local production for the production of sanitary ware and fixtures that apply international water saving standards. 20) Strengthen supply chains and logistics systems to reduce wastage during shipping and handling.
Objective (2.d):	Resilient infrastructure and services in the face of climate change impacts	1) Determining the priorities of the proposed adaptation measures for all concerned sectors. 2) Protecting coastal lowland and implementing integrated coastal zone management. 3) Improving water and sanitation systems and services, particularly in hotspots and underserved areas most vulnerable to the impacts of climate change and establishing of environmentally compatible sewage stations in the Nile Marinas. 4) Improving roads to be more resilient to the impacts of climate change such as high temperatures, floods and sea level rise. 5) Ensuring that the impacts of climate change are included as part of the planning and design of large agricultural projects, such as the New Delta project, greenhouses, fish farms, poultry and livestock production projects. 6) Developing infrastructure in rural communities including water and irrigation infrastructure (example: expansion in rehabilitation and lining of canals and private canals, development and modernization of irrigation and agricultural systems and management of the agricultural process) 7) Infrastructure development for healthcare facilities.

Remarks : Gray and underlined parts are consistent with project components.
Source: Egypt National Climate Change Strategy 2050

CHAPTER 8 ISSUES IN PROJECT IMPLEMENTATION AND MANAGEMENT

When the Project is implemented, some risks and impacts are expected in the process of implementation. Therefore, this chapter describes issues to be considered in the project implementation and management. The points to be considered are organized in a risk management sheet and are also summarized for individual cases.

8.1 Risk Management Sheet

The proposed items of the risk management sheet could consist of; 1) stakeholder risk, 2) executing agency risk composed of capacity risk, governance risk, fraud, and corruption risk, and 3) project risks such as design risk, program & donor risk, and delivery quality risk. The following table summarizes the risk identification and its management, concluding that the overall risk rating should be medium for probability and medium for the impacts.

Table 8.1.1 Risk Management Framework

Project Name: The Irrigation Water Resources Management Improvement Project
Sector: Water Resources, Irrigation and Agriculture
In charge: the Ministry of Water Resources and Irrigation (MWRI)

Potential project risks	Assessment	
1. Stakeholder Risk	Probability: H/M/L	M
(Description of risk) ✓ Land acquisition: basically the structures are rehabilitated on the location of the existing structures or constructed inside the canals and furthermore, the lands along the canals principally belong to MWRI. Therefore, land acquisition would not happen. Only temporal renting land such as using it as a stock yard, etc. during construction period may happen. Note: In the unlikely event that land acquisition occurs, and any temporary land use during construction will be the responsibility of MWRI (not covered by the loan). ✓ Installation of modern on-farm irrigation may delay: Installing modern on-farm irrigation will drastically change the farming method and moreover the farmers have to repay the investment cost. It may take time for farmers to be convinced to take the soft loan to determine such a big change of farming.	Impact: H/M/L	M
	Analysis of probability and impact:	
	✓ The proposed components for rehabilitation/construction of hydraulic structures will not create large environmental and social impacts and therefore there is little possibility of receiving negative impact to the project judging from the stakeholder meetings. ✓ As for canal lining, it may affect the biological environment. However, irrigation canal is not a natural river to protect natural environment and farmers in the stakeholder meetings have high priority of efficient water management and no substantial economic activities on the canals such as fisheries. Canal lining would also have little possibility to receive negative impacts from the inhabitants of the project areas. ✓ As for modern on-farm irrigation (MOI), some farmers have concern about applicability of the MOI in the Old Lands especially with the concern about soil salinization. Soil assessment should be conducted before installing modern on-farm irrigation facilities, and surface irrigation should be carried out as required during the winter season to flush out salts after the facilities have been installed (note that the design allows for surface irrigation to be conducted because valves are provided at the side of the farm field).	
	Mitigation measures:	
	✓ Enough explanation of investment benefits to the beneficiary farmers for MOI on the economic return with subsidized loan facility and salinity mitigation measures.	
	Action during the implementation:	
	✓ Establish demonstration farms of the MOI and advocacy activities such as site visit to the farmers already practicing MOI.	
	Contingency plan (if applicable):	
	Not applicable	
2. Executing Agency Risk		
2.1. Capacity Risk	Probability: H/M/L	M
(Description of risk) ✓ The procedure for tender of construction may be delayed due to lack of enough experience of ODA loan project by the officers of MWRI. ✓ As for the MOI, there is a risk of delayed implementation due to consensus making among farmers who would be the members of a WUA to manage the	Impact: H/M/L	M
	Analysis of probability and impact:	
	✓ Construction schedule will be delayed	
	Mitigation measures:	
	✓ Finalize the tender documents and specifications etc. in time and conduct tendering as per schedule. ✓ Re-examination/ adjustment of construction plan and mobilization plan (especially machinery allocation plan, labor and materials as well) etc.	

Potential project risks	Assessment	
MOI system as well as individual decision for the investment. ✓ Canal lining would encourage farmers to make decision for MOI installation and also, it can create synergy effects of unit yield increase.	✓ Formulation of management unit both at central level (Project Management Unit) and at field level (Regional Coordination Unit: one in Beni Suef City covering upper Egypt area and one in Tanta City covering Kased Area). ✓ Deployment of staff for farmer organization and demonstration farm establishment for advocating farmers	
	Action during the implementation:	
	✓ Assistance in tender procedure by the consultant. ✓ Assistance in advocacy and verification of effects of MOI by the IAS staff and consultant ✓ Adjusting schedule to shorten the construction period (over time, night work etc.). Also, make sure to avail of enough construction machineries ✓ Project Steering Committee (Central Level) and Project Management Unit(Regional Level) will be established in advance of the commencement of the project implementation.	
	Contingency plan (if applicable):	
	Technical cooperation project for promoting water management and MOI promotion.	
2.2. Governance Risk	Probability: H/M/L	M
(Description of risk) ✓ Procedure from consultation to approval of ODA Loan in government has been fixed, but the decision making process within the government of Egypt, lack of experience for procedure in administration and involving multiple government offices (MWRI, Ministry of International Cooperation, Ministry of Foreign Affairs and Ministry of Finance, etc.) may cause slow decision making and procedural delay.	Impact: H/M/L	L
	Analysis of probability and impact:	
	✓ Project implementation will be delayed.	
	Mitigation measures:	
	✓ Develop the capacity about procedures of Japanese ODA loan in the relevant government offices. ✓ Advocacy to the related ministries	
	Action during the implementation:	
	✓ Public relations on the project benefits with the project implementation will be disseminated to the whole country.	
	Contingency plan (if applicable):	
	Not applicable	
2.3. Fraud & Corruption Risk	Probability: H/M/L	L
(Description of risk) ✓ Article 218 of the Constitution states: "The state is committed to combating corruption, and the law defines the competent oversight bodies and agencies for that. Based on this, a set of laws has been legislated to prevent and combat corruption. ✓ Project implementation under the management of the third party such as consultant can reduce the risk of corruption.	Impact: H/M/L	H
	Analysis of probability and impact:	
	✓ If corruption occurred, the project may be suspended or be postponed.	
	Mitigation measures:	
	✓ The government of Egypt should supervise public organizations whether they maintain the law of anti-corruption.	
	Action during the implementation:	
	✓ Procurement will be implemented with high transparency under at the presence of the consultant under assistant concept	
	Contingency plan (if applicable):	
	Not applicable	
3. Project Risk		
3.1. Design Risk	Probability: H/M/L	L
(Description of risk) ✓ There is a risk that bidding procedure, especially in international competitive bidding process, may take long term, thus, the components of Large-scale Hydraulic Structures and procurement of machineries may be delayed accompanied with the process of manufacturing, transportation, custom clearance and others.	Impact: H/M/L	M
	Analysis of probability and impact:	
	✓ The expected risks are very small, because preparation, administration and procurement works for the projects are not so different from the project for Construction of New Dirout Group of Regulators now under implementation by MWRI.	
	Mitigation measures:	
	✓ Appropriate preparation of tender documents.	
	Action during the implementation:	
	✓ Modifying the schedule of each plan	
	Contingency plan (if applicable):	
	Not applicable	
3.2. Program & Donor Risk	Probability: H/M/L	M
(Description of risk) ✓ Organization of water users' association and installment of MOI may take time in progress as it needs the agreement between the government and farmer beneficiaries as well as among farmers.	Impact: H/M/L M	H
	Analysis of probability and impact:	
	✓ Dissemination of project and involvement of advanced farmers for information exchange may help accelerate the progress. ✓ Exchange of information and coordination with other programs may reduce the risk.	

Potential project risks	Assessment	
✓ There are a few similar projects in the country by government as well as by donors. Delay of implementation of filed extension services for MOI, e.g., delay of demonstration plot establishment, may be caused due to overlap with other extension programs.	Mitigation measures:	
	✓ Dissemination of the project and establishment of demo-farms to display the effects of the component. ✓ Adjustment with other government programs, providing higher priority to the Project component and fine-tune all the activities each other.	
	Action during the implementation:	
	✓ Adjustment of the extension component by carrying out periodical evaluation and follow-up workshops (before and after every crop season)	
	Contingency plan (if applicable):	
	Not applicable	
3.3. Delivery Quality Risk	Probability: H/M/L	M
(Description of risk) ✓ Knowledge of field engineers and extension officers on MOI is limited and aging field engineers and extension officers hinders the capacity of the field activity to progress the activities. ✓ On the other hand, there are extension officers and advanced farmers who assist ordinary farmers to apply MOI in in the New Lands.	Impact: H/M/L	H
	Analysis of probability and impact:	
	✓ Lack of knowledge, low performance of the field engineers make stagnant progress in the field.	
	Mitigation measures:	
	✓ Enough training to develop the capacity of the key staff to operate and maintain the MOI system. ✓ Recruitment of junior engineers at the field level.	
	Action during the implementation:	
	Collaboration with the MALR and outsourcing private sector, e.g., advanced farmers, NGO	
	Contingency plan (if applicable):	
	Not applicable	
4. Other Risk	Probability: H/M/L	L
(Description of risk) ✓ As an external factor, farmer beneficiaries may find difficult to repay the cost for modern on-farm irrigation installation in the event of crop failure or a collapse in grain prices in market may affect the	Impact: H/M/L	L
	Analysis of probability and impact:	
	✓ Since there is very little rainfall in Egypt and the Nile River water is controlled by the High Aswan Dam, natural calamities such as cyclones floods would not most likely occur, Therefore, the risk of crop failure is very low. On the other hand, the drop of farmgate prices could happen due to the drop of international grain market prices in today's fluid world order.	
	Mitigation measures:	
	✓ Farmers should be motivated to introduce the facilities by providing them with explicit information in advance to exempt or defer repayment in the event of crop failure and collapse of grain prices.	
	Action during the implementation:	
	✓ It has been considered applying the measure to extend the repayment period for the initial investment from 10 to 20 years by combining the modern on-farm irrigation installation with the Meska improvement, whose repayment system allows a period of 20 years for the repayment.	
	Contingency plan (if applicable):	
	Not applicable	
5. Overall Risk Rating	Probability: H/M/L	M
(Overall comments)	Impact: H/M/L	M
✓ The project is mainly categorized into two: one is irrigation improvement consisting of hydraulic structure rehabilitation / construction, canal improvement and water management improvement. The other is installing MOI development. As for the irrigation improvement, this category can be controlled by the government side and no cost sharing with the farmer beneficiaries and therefore, the implementation risks are considered less. On the other hand, the MOI needs the agreement of the farmer beneficiaries as they have to repay the investment cost and also organization of farmers will become necessary. Therefore, the risks of slow progress on MOI component are predicted high. Intensive monitoring and measures in the course of implementation is required for extending the MOI.		

Source: JICA Survey Team

8.2 Issues to Consider in Implementation

The following are some of the issues to be considered in the implementation of the project: beneficiary participation in water management, positive acceptance from beneficiaries for the introduction of modern field irrigation facilities, gender mainstreaming, and support for the introduction of modern field irrigation facilities among poor farmers.

8.2.1 Beneficiary Participation in Water Management

To realize the efficient use and equitable distribution of water resources, the rehabilitation of facility and modernization of system are not sufficient, but water management including Meska level or below has to be improved at the same time. In this sense, farmers' participation in water management through WUAs is very important[1].

While the operation of branch canals or above is under the domain of MWRI at the current status, Meskas and Marwas are operated by farmers as their collective or individual properties. With the consent of the beneficiary farmers, the structures of Meskas and Marwas are improved, and a new operation system is introduced to them, and then farmers take full responsibility for the Management, Operation & Maintenance of the irrigation system at the Meska level and below. In order to perform such responsibility, the farmers at a Meska or Marwa are obliged to establish a water users' association (WUA). Some tasks in which beneficiaries are expected to play a role are exemplified below.

- ✓ Operation & Maintenance of facilities and systems
- ✓ Schedule management of irrigation rotation between beneficiaries under one collective pump
- ✓ Collection of fees for Operation & Maintenance
- ✓ Conflict resolution between farmers

In order to build and improve the capacities of beneficiaries for these tasks, a set of training should be provided to beneficiaries. Furthermore, the operation of modern on-farm irrigation systems, such as drip or sprinkler, requires certain skills and knowledge. Some training and technical assistance from IAS should be provided to all individual farmers for learning the way of Operation & Maintenance of modern on-farm irrigation systems, and the understanding of any necessary control at collective levels for the effective use of these systems needs to be shared between beneficiaries, such as the maintenance of filters for the prevention against clogging of drips.

On the occasion of the establishment of WUA, the ownership and empowerment of farmers should be promoted. As mentioned in Chapter 4.7, ideally one block of farmlands which is irrigated by one collective pump station should be built with a land size of 10 to 30 feddans considering the effective Operation & Maintenance of the modern on-farm irrigation system. One WUA should be established on each farmland block unit. The delineation of boundaries between farmlands is the starting point for the establishment of WUA, and beneficiaries have to play the central role in this process.

In an actual situation, whether a certain farmland should be covered by a particular pump station or that land should be included in the other farmland block which is irrigated by the different pumps has to be decided based on farmers' opinions. If there was a block of farmlands with around 30 feddans irrigated by the same Meska, farmers in that block might face fewer difficulties in their decision-making to install one collective pump station to irrigate all their farmlands.

However, if one Meska's covering area exceeds such size and water is distributed into several Marwas, each of which covers a considerable size of farmland, some considerations may be necessary for practical and manageable Operation & Maintenance of the irrigation system: optimum number of pumps to install at the intake of Marwas and size of the areas to be covered by one collective pump, etc.

The administrative way of demarcation with only maps on the desk without the consideration of actual land situations would face serious consequences in the future. Farmers themselves know the

[1] Based on Law 213 of 1994, the establishment of viable WUA is a conditionality for Meska improvement under WB's IIIMP. MWRI (2016) *PMU Completion Report (IBRD Loan no 7291-EGT) Integrated Irrigation Improvement and Management Project (IIIMP)*

geographical conditions and features of water flow, so their involvement in this planning and consensus-making process is necessary to guarantee sustainable management. And their participation in the very early stage might generate ownership and lead to better Operation & Maintenance.

8.2.2 Positive Acceptance of Modern On-farm Irrigation from the Beneficiaries

Because costs for constructions and installments have to be repaid by beneficiaries, getting positive acceptance from beneficiaries is very important not only for the horizontal expansion of improved areas but also for the sustainability of structures and water management systems. Necessary measures should be considered during the whole course of the proposed project. In particular, with periodic assessments about the progress of the project and adoption rates of proposed irrigation systems by beneficiaries, some amendments or improvements of the project implementation should be considered in the face of any delay of the project. Here are some strategies which could contribute to the higher involvement of beneficiaries.

- ✓ **Beneficiary Involvement in the design and planning process about structures and systems**. Intentionally involving farmers in the technical design and planning process not only increases ownership of beneficiaries but also enhances sustainability. It is vital to accommodate farmers' design preferences and get agreements about installation works and layouts in their fields for the smooth implementation of the project[2].
- ✓ **Explanation about the repayment mechanism in detail**. Providing farmers with accurate and detailed information about the repayment mechanism is very important for the smooth progress of loan contracts and for avoiding undesirable delays in cost recovery. Number of installments, the timing of the end of grace period and the first installment, absence of interests, the way of collection, and so on should be explained in advance.
- ✓ **Extension or segmentation of the repayment period**. Longer repayment periods without interest would lower the barriers for farmers to take a loan. In the case of very low adoption rates of modern on-farm irrigation systems, the extension or segmentation of the repayment period should be considered. For example, WB's IIIMP Project adopted 20 years or more as the repayment period for the cost of civil works, although the cost of the collective pump had to be repaid within three years[3]. If applying the segmentation by components, the durable life of each structure or machine must be taken into account.
- ✓ **Awareness raising through the demonstration farm**. Both irrigation officers and ordinary farmers quite often point out that there should be the demonstration farm for modern on-farm irrigation systems before full-scale extension efforts will be made. It is sometimes emphasized that farmers want to see actual products, and without checking the effects of irrigation systems in the real fields with their own eyes, they may not accept the installation. It is very much understandable that the introduction of new items such as drip or sprinklers with certain costs is not so easy for farmers. According to the stakeholders meeting in the selected villages of the project area by the JICA Survey Team, it has been found that many farmers have known about the benefits of the modern on-farm irrigation systems from witnessing the practice in the New Lands, but they are not sure if they work in the Old Lands. Therefore, some efforts for displaying how much water can be saved and how much crop yield can be increased by the installation of new systems in the actual plots, including technical assistance projects, are worth considering.

[2] WB (2022) *Project Performance Assessment Report - Arab Republic of Egypt – Integrated Irrigation Improvement and Management Project and Farm-Level Irrigation Modernization Project* (Report No. 173462) https://openknowledge.worldbank.org/server/api/core/bitstreams/04394c94-f6ab-5b26-a2e7-19e29d304597/content

[3] Ibid.

8.2.3 Gender Consideration in the Project Implementation

In Egypt, the agricultural sector, which is the main source of employment for women, is gender segmented, and it is said that women are more likely to engage in low-wage, part-time, seasonal jobs in comparison with men[4]. Such gender norms are identified as an important backdrop of this segmentation, and they are more prevalent in rural areas, especially in Upper Egypt[5]. According to some sources, based on the gender division, men are basically responsible for growing crops at farmlands: plowing the farms, irrigating and fertilizing the crops[6]. On the other hand, women tend to engage in seeding, harvesting, or indoor livestock rearing and are assigned to domestic care work[7].

In terms of irrigation, men are deemed as better irrigators than women due to their physical strength, knowledge, and experience[8]. Since irrigation is perceived as a masculine activity, women's involvement in irrigation is often denied or dismissed[9]. In addition, it is sometimes emphasized as a reason why women cannot participate in irrigation that night-time irrigation is socially inappropriate for women, and women are said they can hardly clean water canals[10].

Although it is surely important to remove any discriminate custom to acquire gender equality, it should be noted that gender divisions between women and men are emerged not always from strict social norms but also as a result of concern for or attention to women. For example, the restriction of night-time irrigation by women in a sense works to protect women from sexual abuse in the dark. Similarly, it could be said that thanks to the working divisions between women and men, women are free from the hard work of on-farm activities such as carrying heavy farming machines and tools.

In the proposed components, the replacement of portable individual pumps and earthen on-farm canals (Marwa) by a single collective pump station and pipelines which distribute water at the Marwa level would contribute to more participation in irrigation activities by female farmers.

In addition to gender norms in the agricultural sector, the old and current irrigation systems which require a long time and high labor costs for field-level irrigation have been detrimental to women's participation. To irrigate farmlands through open earthen canals, farmers need to eliminate weeds and make sure that there is no break/ breach in the canals. Moreover, moving individual pumps to and from a field is tough and time-consuming work[11]. WB (2022) reported that the reduction in labor and time through IIIMP and FIMP has enabled women to participate more in irrigation without getting dirty and exposing bare skin.

The same mechanism would work in the proposed components by canal rehabilitation especially in the case of Meska rehabilitation/ improvement and installations of collective pump, further followed by the installation of distributive pipelines. Moreover, the introduction of modern on-farm irrigation systems such as drip and sprinkler are expected to accelerate women's participation by making irrigation easier.

Considering that women's land ownership is still very low, any condition requiring landholder status

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[4] UN Women (2018) *Profile of women in rural Egypt* https://egypt.unwomen.org/sites/default/files/Field%20Office%20Egypt/Attachments/Publications/2018/05/Profile%20of%20rural%20women%20%20final%20version.pdf

[5] Ibid.

[6] IsDB (2019) and FAO (2021)

[7] IsDB (2019), FAO (2021) and JICA (2018) *Report of 'Improving Small-Scale Farmers' Market-Oriented Agricultural Project (ISMAP)' – Outcome of Gender Mainstreaming Activities*

[8] Najjar (2019) Women, irrigation and social norms in Egypt: 'The more things change, the more they stay the same?', *Water Policy* 21(4) https://www.researchgate.net/publication/331461637_Women_irrigation_and_social_norms_in_Egypt_'The_more_things_change_the_more_they_stay_the_same'

[9] Ibid.

[10] Ibid.

[11] WB (2022) *Project Performance Assessment Report - Arab Republic of Egypt – Integrated Irrigation Improvement and Management Project and Farm-Level Irrigation Modernization Project* (Report No. 173462)

should be carefully avoided. As mentioned above, female farmers have been structurally eliminated from financial opportunities or organizations because of land ownership as a requisite. If the loan program for modern on-farm irrigation requires land as collateral, female farmers would be eliminated from decision-making processes, leading to the static gender division which regards women as helpers rather than independent actors.

In terms of the establishment of WUAs, land ownership should not be a prerequisite for becoming a member of WUA for the sake of effective involvement of women in the irrigation and farming activities. Female farmers who do not hold land titles but practically engage in irrigation and crop cultivation should be included in a WUA, and further in the representative members, as a board member, of WUAs.

By doing the above arrangement, the situation where female members of the current WUA are responsible only for domestic water use and environmental awareness and not for farming activities at farmlands would be gradually dissolved. Through the process of the establishment of WUAs, the project implementation unit needs to encourage women's involvement in WUA and their active participation in irrigation and agricultural issues within the association.

8.2.4 Support to Smallholder Farmers in Introducing Modern On-farm Irrigation

As discussed in Chapter 6, the effects of the Project with modern on-farm irrigation alone are represented by EIRR 11.2% (no change in cropping system) and 13.5% (increase in horticultural crops). Since these returns exceed the 10% opportunity cost of capital, there is an economic advantage to implementing the Project even if it is limited to the introduction of modern on-farm irrigation facilities. On top of that, the EIRR increases to 15.0% (no change in cropping system) and 18.7% (increase in horticultural crops) if the irrigation facility improvements under MWRI jurisdiction are combined[12].

The farmers will be exempted from paying interest on the modern on-farm irrigation facilities, but will be reimbursed basically in 10 years. When considering the effect of the introduction of modern on-farm irrigation facilities alone, assuming no change in cropping systems for a typical farmer, the total amount of farmers' repayment as a percentage of the net increase in farm income is 86% and 74% in Upper Egypt and the Delta, respectively. The total repayments as a percentage of the net increase in farm income would decrease to 76% and 63% in Upper Egypt and the Delta, respectively, if horticultural cropping were increased. Increasing the use of profitable horticultural crops in the cropping system is a way to keep more income in the hands of farmers.

Furthermore, if, in addition to the introduction of modern on-farm irrigation, the irrigation facilities under MWRI's jurisdiction are also improved, the repayment share of increased income in Upper Egypt would drop to 61% (no change in cropping system) and 55% (increased horticultural crops), respectively. In the Delta, they would fall to 55% and 48%, respectively. This means that irrigation improvements such as rehabilitation/construction of irrigation structures and canal lining contribute significantly to the increase in the farm income, and it is necessary to improve irrigation facilities under the jurisdiction of MWRI when introducing modern on-farm irrigation to the farmers.

In the case of poor farmers whose main crop is cereals, if the farmer only adopts modern on-farm irrigation and there is no change in the cropping system, the farm income would be 28,297 LE/feddan, and the incremental farm income would be only 7,133 LE/feddan at this time. In this case, the repayment amount for the increased farm income over 10 years would be 133%, making the repayment based on

[12] Modern on-farm irrigation system can reduce the operation costs as compared to the current individual irrigation practices, for example, reduction of working hours of the irrigation pump, which consists of fuel, lubricant and labor. As for maintenance, an additional cost for maintaining the pipeline and drip as well as pump will be required. While the operation and maintenance cost of the pump is included in the crop production cost, other maintenance cost of the modern on-farm irrigation facilities is assumed at 1% of the initial investment cost. As for the replacement cost, cost of drip is accounted for replacing every fourth years (refer to Chapter 6).

the increased income alone difficult. If the repayment period is set at 20 years, the repayment ratio is still 96%, which means that for poor farmers, the introduction of modern on-farm irrigation facilities would not increase their disposable income.

If modern on-farm irrigation is introduced with improved irrigation facilities, the farm income would be 32,425 LE/feddan, assuming no change in the cropping system. The increased farm income would be 11,261 LE/feddan, and the repayment ratio for the increased income over 10 and 20 years would be 84% and 61%, respectively, allowing for the repayment based on the increased income only. The introduction of horticultural crops would further increase income, yet, poor farmers may be more hesitant to change cropping systems than the average farmers. Therefore, it would be desirable to consider repayment under the assumption that the current cropping system will be maintained.

From the above, the incentives for farmers to introduce modern on-farm irrigation are to combine the improvements of hydraulic structures and canal linings and to introduce higher value-added crops such as horticultural crops, as well as the 10-year repayment period for the poor farmers extended to 20 years. In addition, it is necessary to consider the introduction of support measures such as exemption or postponement of repayment in case of a temporary decrease in production due to climate change or other factors, or when grain prices in the market collapse.

8.2.5 Impact on Construction Cost by Modification Design on 3 Large Structures

1) Kased Intake

The Kased Intake is designed with a pile foundation, based on a boring survey conducted at the canal bank around the planned location. However, the detailed design stage will conduct the boring survey (offshore) on the canal, which is beneath the basement of the structure. Therefore, the foundation works may be redesigned depending on the results of the boring survey. If the foundation type is changed to a direct foundation type, a reduction in construction costs could be expected.

In addition, the Tanta Navigation Canal side out of the Kased Intake is designed to have a Navigation Lock requested by the Gharbia Irrigation Directorate (ID), however, since any transport ships is not currently in operation, the necessity of the Navigation Lock should be requested to the Egyptian side by an official letter. The Navigation Lock accounts for about 1/3 of the length of Kased Intake, and if the Navigation Lock is no longer necessary, the construction cost is expected to be reduced.

2) Mahlet Menouf Regulator

The foundation of the Mahlet Menouf Regulator is designed to be a foundation improvement, based on the result of boring survey which was conducted at the canal bank around the planned location. However, since the detailed design will conduct the boring survey (offshore) under beneath the basement of the regulator, the foundation works may be redesigned depending on the results of the boring survey. If the foundation improvement is not necessary, a reduction in construction costs is expected.

3) Sorad Regulator

The foundation of the Sorad Regulator is designed to be a foundation improvement, based on the result of boring survey which was conducted at the canal bank around the planned location. However, since the detailed design will conduct the boring survey (offshore) under beneath the basement of the regulator, the foundation works may be redesigned depending on the results of boring survey. If the foundation improvement is not necessary, a reduction in construction costs is expected.

CHAPTER 9 CONCLUSION AND RECOMMENDATIONS

9.1 Conclusion

Undisclosed Information

9.2 Recommendations

1) The Project has eight components. The implementation varies from international competitive bidding (ICB) for the construction of the three regulators on the Kased Main Canal and equipment procurement for maintenance to local competitive bidding (LCB) for small-scale works, and further to direct force account works (organizing and training of farmers for the introduction of modern on-farm irrigation). In particular, the number of packages for lining of branch canals (BCRL) and introduction of modern on-farm irrigation (MOI), which are intended for local competitive bidding, is large. Therefore, it is planned to establish a Project Management Unit at the central office and Regional Coordination Units in Beni Suef City in Upper Egypt and Tanta City in the Delta, and full-time MWRI staff with extensive experiences in project management and procurement should be ensured and assigned.

2) Construction planning is important for structures located within the principal and main canals, as they must be constructed within a narrow canal cross-section while passing through the water. It is desirable to select a contractor with experience working in similar size waterways in Egypt. In addition, since some of the facilities will be located beside trunk roads or adjacent to residential areas, it is necessary to select a contractor that can propose sound plans for safety measures for surrounding facilities and fully coordinate with relevant organizations as necessary. In particular,

the three new regulators to be constructed on the Kased Main Canal (Kased Intake, Mahlet Menouf Regulator, and Sorad Regulator) will be constructed under relatively high water volume conditions and at the side of a main road or near residential areas, so it is necessary to select an experienced construction company by ICB. For the construction of structures that can be constructed under dry conditions or branch canals, it is considered that domestic contractors in Egypt are capable of performing the work, and therefore, bidding by LCB is appropriate.

3) Although the Kased Intake is planned to be equipped with a lock for vessel passing at the request of the Navigation Authority, it may not be necessary to install the lock because there is no actual boat traffic in the area. If the lock is not required, it is expected to reduce costs by reducing the amount of concrete used for the structure, and by reducing the scope of temporary closure and foundation piles for construction on the left side of the canal. For the three regulators' foundations of the Kased Main Canal, foundation piles were selected for the Kased Intake, and foundation improvement was selected for the Mahlet Menouf and Sorad Regulators. If good foundation conditions are confirmed by additional in-canal borings during the detailed design, it is expected that the scope will be reduced or a direct foundation (without foundation improvement) may be adopted to reduce the cost.

4) A series of hydraulic simulation results showed that even if the modern on-farm irrigation system is introduced in the future and water saving is achieved, it is possible to raise the water level in the canals by operating regulators located within the canals as needed, and water distribution to the lower branch canals can be so possible. In this case, since the longitudinal slope of the canals in Egypt is very gentle, ranging from 1/10,000 to 1/15,000, a regulator that functions as designed is required approximately every 10 km to 15 km. In other words, it is necessary to ensure that there should be always one regulator that functions adequately approximately every 10 to 15 km to control the water level in the canals and distribute water to the lower canals, even when irrigation water amount is reduced due to future water saving with the modern on-farm irrigation introduced (new regulators to be constructed on the Kased Main Canal will be in every 10 km or so, including the existing Tanta 1 Regulator).

5) Regarding the financial assistance scheme for the introduction of modern on-farm irrigation system, the Team initially had the Two Step Loan (TSL) in mind, but in order to hedge the following three risks associated with the implementation of the TSL, a project loan with the advance disbursement method should be used; first, farmers may hesitate to introduce modern on-farm irrigation due to the complexity of bank loan application procedure; second, ABE (the most promising candidate for PFI), which accounts for about 70% of the share of lending to the agriculture sector in Egypt, abolished the Foreign Currency Borrowing Bureau in 2016, so there may be a risk that the PFI could not participate in TSL scheme; and third is the uncertainty of the NPL (nonperforming loan) problem, the lack of a timely information disclosure system, and the lack of experience in TSL (since 2016).

6) Although the economic feasibility of the project implementation has been confirmed, especially for the introduction of modern on-farm irrigation systems such as drip and sprinkler irrigation, it is essential to increase yield and reduce chemical fertilizer input through appropriate facility operation by the farmers to ensure that the benefits of the investment are realized. Increasing the planting of profitable horticultural crops is also an important issue. Therefore, it is essential to ensure that farmers be trained in cultivation techniques using modern on-farm irrigation systems and that farmers be well organized to operate the facilities. In addition, farmers should be motivated to introduce the facilities by extending the repayment period for their initial investment from 10 to 20 years, and by providing farmers with explicit information in advance to exempt or defer repayment in the event of crop failure or a collapse in grain prices in the market.

7) Modern on-farm irrigation using drip and sprinkler systems contributes not only to water and fertilizer savings but also to crop profitability through increased yields. However, farmers who are new to modern on-farm irrigation systems on Old Lands will need time to become familiar with the equipment and to achieve full-scale yield increase. Although the number is small for the farmers implementing modern on-farm irrigation on the Old Lands, some farmers are already conducting the modern on-farm irrigation, e.g., in the lower reaches of canals where water shortages are occurring. These farmers have learned how to operate modern on-farm irrigation systems from earlier adapted farmers in the New Lands, as well as from drip and other equipment suppliers and agricultural extension workers. Therefore, it is necessary to provide a series of technical training along with demonstration plots to the farmers who are introducing modern irrigation systems for the first time. The training for the farmers should be led by regional officials of the Irrigation Advisory Services (IAS).

8) For the Fayoum Area, the introduction of modern on-farm irrigation facilities such as sprinkler and drip irrigation is not recommended, as there are two lakes at the end of the Fayoum area, Quarn Lake and Rayan Lake, and the introduction of modern on-farm irrigation will significantly reduce the drainage to both lakes (e.g., a 3% reduction in drainage water with sprinklers installed on 10% of the area, and a 7% reduction if drip irrigation is used on the 10% of the area). Both lakes have many stakeholders involved in tourism, salt production, fish culture, etc., thus both the water quality and water level should be maintained as saline lakes. In other words, it is recommended to improve irrigation facilities in the Fayoum Area only in conjunction with canal rehabilitation at the main and branch levels, including the improvement of Meska to achieve efficient water management, under conditions that do not reduce the volume of drainage.

9) As an advanced water management method, the Team has proposed to introduce satellite image analysis to follow up on the planted area. This will enable MWRI to obtain information on the planted area and the area that has been harvested and to allocate water based on appropriate water requirements. Satellite imagery can also be used to identify areas that require more water supply due to poor growth. In addition, while the Project is expected to improve the efficiency of water use, it is also desirable to improve the operational management of the water distribution. Currently, the Directorate Engineers belonging to the 26 General Directorates for Irrigation nationwide operate the facilities, while the engineers of the Maintenance Section perform daily management and simple maintenance. However, this information is rarely shared except for the main barrages on the Nile River. It is therefore necessary to introduce a system, e.g., using a cloud system, to update and share the status of these facilities among the parties concerned, e.g., among the MWRI central office, and regional offices.