MINISTRY OF WATER RESOURCES
AND IRRIGATION (MWRI)
THE ARAB REPUBLIC OF EGYPT

COOPERATION PLANNING SURVEY ON THE IRRIGATION SECTOR (UPPER EGYPT AND MIDDLE DELTA) IN THE ARAB REPUBLIC OF EGYPT

FINAL REPORT

FEBRUARY 2018

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NTC INTERNATIONAL CO., LTD.

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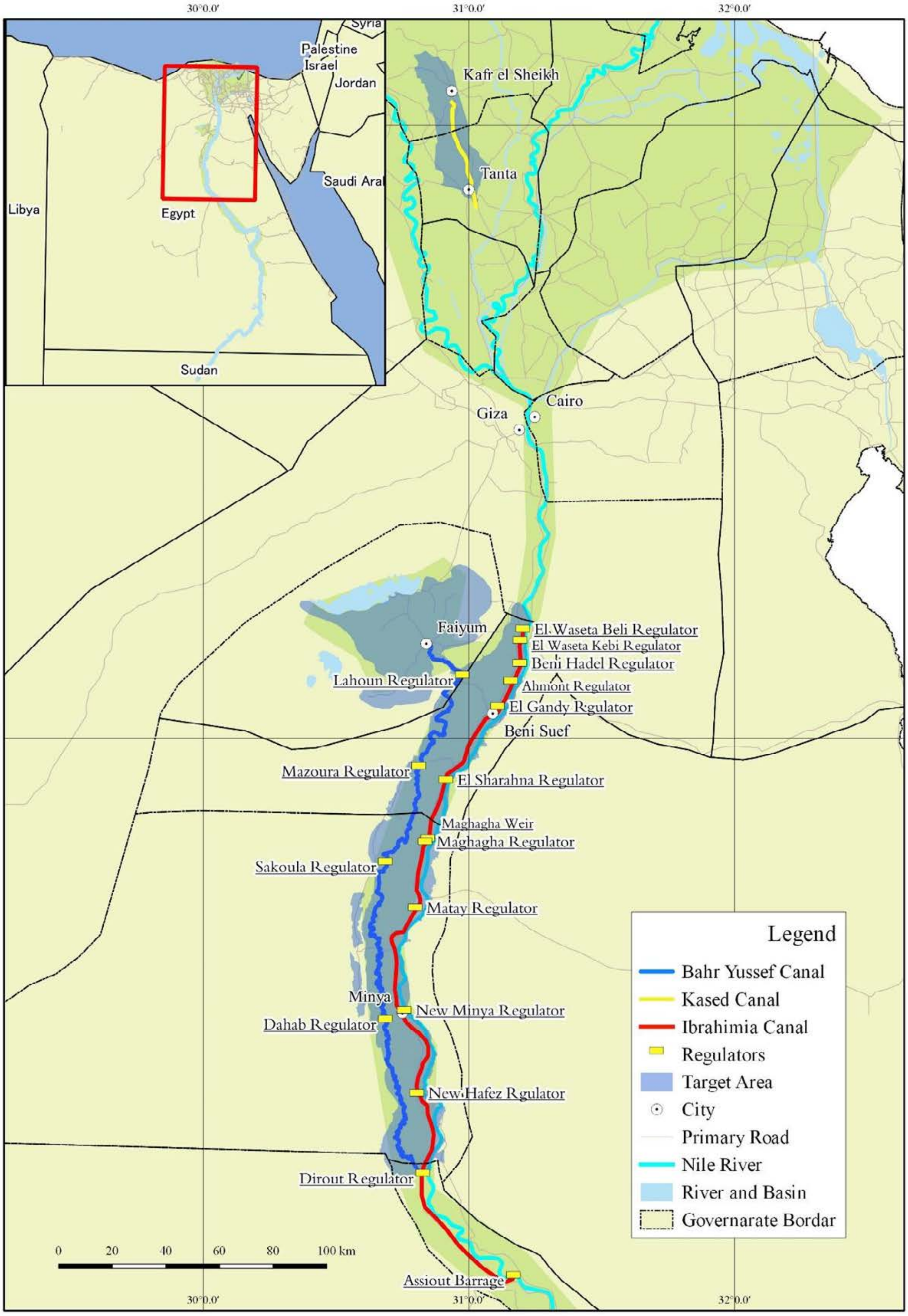

Location Map

List of Abbreviations

ABBREVIATION	ENGLISH	JAPANESE
AfDB	African Development Bank	アフリカ開発銀行
B/C	Benefit Cost	費用便益比
BCWUA	Branch Canal Water Users' Association	支線水利組合
BOD	Biochemical Oxygen Demand	生物化学的酸素要求量
BoQ	Bill of Quantities	数量明細書
CAA	Competent Administrative Authority	所轄管理庁
CBO	Community Based Organization	市民団体
CD	Central Department	本部
CDIAS	Central Department for Irrigation Advisory Service	中央灌漑指導部
CDIIP	Central Department of Irrigation Improvement Project	中央灌漑改善プロジェクト
CIWM	Comprehensive Irrigation Water Management	総合的灌漑用水管理
COD	Chemical Oxygen Demand	化学的酸素要求量
CAPMAS	Central Agency for Public Mobilization and Statistics	中央動員統計局
C/P	Counter Part	カウンターパート
DD	Detailed Design	詳細設計
DWB	District Water Board	灌漑管区委員会
DO	Dissolved Oxygen	溶存酸素濃度
EC	Electric Conductivity	電気伝導度
EEAA	Egyptian Environmental Affairs Agency	環境庁
EIA	Environmental Impact Assessment	環境アセスメント
EIRR	Economic Internal Rate of Return	経済的内部収益率
E-JUST	Egypt-Japan University for Science and Technology	エジプト日本科学技術大学
EMMP	Environment Management and Monitoring Plan	環境管理・モニタリング計画
EPADP	Egyptian Public Authority for Drainage Project	排水庁
ESA	Egyptian General Authority for Land Survey	エジプト土地調査総局
EU	European Union	欧州連合
EVI	Enhanced Vegetation Index	植生指数
FAO	Food and Agriculture Organization of the United Nations	国際連合食糧農業機関
FIRR	Financial Internal Rate of Return	財務的内部収益率
F/S	Feasibility Study	フィージビリティ調査
GD	General Directorate for Irrigation	灌漑局地方事務所
GDIAS	General Department for Irrigation Advisory Service	地方灌漑指導部
GDIIP	General Department of Irrigation Improvement Project	地方灌漑改善プロジェクト
GDP	Gross Domestic Product	国内総生産
GIS	Geographic Information System	地理情報システム
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit	ドイツ国際協力公社
GNSS	Global Navigation Satellite System	全球測位衛星システム
GWRP	Governorate Water Resource Plan	県水資源計画
IAS	Irrigation Advisory Service	灌漑指導部
IBRD	International Bank for Reconstruction and Development	国際復興開発銀行
ICB	International Competitive Bidding	国際競争入札
ICT	Information and Communication Technology	情報通信技術
ID	Irrigation District	灌漑区
IIIMP	Integrated Irrigation Improvement and Management Project	統合的水資源改善管理プロジェクト
IIP	Irrigation Improvement Project	灌漑改善プロジェクト
IIS	Irrigation Improvement Sector	灌漑改善局
IMT	Irrigation Management Transfer	灌漑管理移管
IRU	Institutional Reform Unit	制度改革室

ABBREVIATION	ENGLISH	JAPANESE
IS	Irrigation Sector	灌漑局
IWMD	Integrated Water Management District	統合水管理区域
IWRM	Integrated Water Resource Management	統合水資源管理
JRW	Joint Repair Work	共同補修工事
JSC	Joint Steering Committee	ジョイント・ステアリング・コミッティー
JICA	Japan International Cooperation Agency	国際協力機構
JST	Japan Science Technology Agency	国立研究開発法人科学技術振興機構
KfW	Kreditanstalt für Wiederaufbau	ドイツ復興金融公庫
L/A	Loan Agreement	借款契約
MALR	Ministry of Agriculture and Land Reclamation	農業土地開拓省
M/D	Minutes of Discussion	会議議事録
MED	Mechanical and Electric Department	電気機械局
MoA	Memorandum of Agreement	覚書
MODIS	Moderate Resolution Imaging Spectroradiometer	中分解能撮像分光放射計
MOH	Ministry of Housing, Utilities and Urban Development	住宅都市開発省
MWRI	Ministry of Water Resources and Irrigation	水資源灌漑省
NGO	Non-Governmental Organization	非政府組織
NPV	Net Present Value	純現在価値
NWRC	National Water Research Center	国立水資源研究センター
NWRP	National Water Resources Plan	国家水資源計画
OPEC	Organization of the Petroleum Exporting Countries	石油輸出国機構
O&M	Operation and Maintenance	維持管理
PS	Planning Sector	計画局
R/D	Record of Discussion	合意文書
RGBS	Reservoirs and Grand Barrages Sector	貯水池及び大堰局
SADS2030	Sustainable Agricultural Development Strategy towards 2030	持続的農業開発戦略 2030
SATREPS	Science and Technology Research Partnership for Sustainable Development	地球規模課題対応国際科学技術協力プログラム
SCF	Standard Conversion Factor	標準変換計数
SS	Suspended Solid	浮遊物質
SWMT	Strengthening for Water Management Transfer	水管理移管強化プロジェクト
TDA	Tourism Development Authority	観光開発庁
TOR	Terms of Reference	委託事項
UNDP	United Nations Development Programme	国連開発計画
USAID	United States Agency for International Development	アメリカ合衆国国際開発庁
WARUS	Project for Drainage Water Quality Control for Irrigation in Middle Delta	中央デルタ灌漑のための排水水質管理・再利用プロジェクト
WAIASS	World Atlas of Irrigated Agriculture for Sustainability Science	世界灌漑農業アトラス
WB	World Bank	世界銀行
WMIP	Water Management Improvement Project	ナイルデルタ水管理改善プロジェクト
WMT	Water Management Transfer	水管理移管
WTO	World Trade Organization	世界貿易機関
WUA	Water Users' Association	水利組合
WUO	Water Users Organization	水管理組織

Executive Summary

This survey was conducted to propose a cooperation program and draft cooperation projects by Japan to contribute to the "Realization of efficient use of the existing resources", a pillar of the National Water Resources Plan of Egypt. The target area covers the command areas of Bahr Yusef and Ibrahimia Principal Canals in Upper Egypt and the Kased Main Canal in the Middle Delta. The Survey defines "sub-region" as a unit of an irrigation system that delivers water from a main canal to the terminal canals, and there are 80 sub-regions in the target area. Based on the results of the Survey, it was found that the necessary amount of water to satisfy the present demand for agriculture occasionally did not reach the tail end of the irrigation systems in the target area, so more equitable water distribution is expected. In order to realize this, it is important to improve the irrigation system as a whole from upstream to the terminal and to link improvement activities of the hard component and the soft component. This report names such an approach "Comprehensive Irrigation Water Management (CIWM)" and proposes its implementation. As an example of introducing CIWM, a project of the hard component was simulated in the Tunsa-Kella sub-region (command area: 104 km^2). As a result, an improvement in the irrigation efficiency of 10% and a water saving effect of 17% with a project cost of US$15.6 million were confirmed for Plan 1, which improves small irrigation facilities that hinder sufficient water distribution as planned, compared to the present condition. An improvement of irrigation efficiency of 17% and a water saving effect of 25% with a project cost of US$22.2 million were confirmed for Plan 2, which undertakes the lining of the main canal to improve conveyance capacity in addition to Plan 1. An improvement of irrigation efficiency of 22% and a water saving effect of 31% with a project cost of US$31.3 million were confirmed for Plan 3, which undertakes the lining of branch canals in addition to Plan 2.

When these results are applied to all sub-regions of Ibrahimia and Bahr Yusef Canals, 2.1 billion cubic meters per year of water is projected to be saved after rehabilitation of all sub-regions with Plan 2, compared with the conditions before rehabilitation, according to the calculation.

The pillars of CIWM are: "1. Facility rehabilitation" for the hard component and "2. Water Management" for the soft component, while "3. Improvement of facility maintenance" is also proposed. To prolong the lifetime of the facility and minimize the maintenance cost in the target area, asset management will be introduced to the sub-regions where the rehabilitation work is completed, so improved water management will be sustained in the target area. The series of cooperation projects is planned to last for 20 years in three stages and Japan's cooperation targets a facility improvement project by an ODA loan and technical cooperation for improvements of water management and facility maintenance in stage 1. The whole project cost included in this report is a rough estimate at present. The following Feasibility Study will make the cost estimate more accurate and recalculate the effect indicators in the target area of Japan's cooperation. Since it is difficult to implement rehabilitation work in all 80 sub-regions in parallel, sub-regions were prioritized in three groups by five criteria such as urgency, importance, etc. The first prioritized group includes 15 sub-regions and the second prioritized group includes 16 sub-regions, while the third group includes 49 sub-regions. The prioritized sub-regions were clarified here for future implementations. Moreover, further surveys will collect information for the verification of the introduction of modern irrigation and conservation and utilization of land alongside canals, which were requested by the Egyptian side. These results will be reflected in Japan's cooperation based on CIWM proposed in this report.

Cooperation Planning Survey on the Irrigation Sector (Upper Egypt and Middle Delta) in the Arab Republic of Egypt

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ANNEX (Separate Volume)

Units and Currency

kg	kilogram
t, MT	metric ton = 1,000 kg
h	hour
mm	millimeter
cm	centimeter
km	kilometer
ha	hectare
feddan	feddan = 0.42 ha
HP	horsepower
km^2, sq.km	square kilometer
m^3	cubic meter
MCM	million cubic meter
BCM	billion cubic meter
MSL	mean sea level
MW	mega watt
LPS, l/s	liter per second
mm/mon	millimeter per month
mm/d	millimeter per day
m/s	meter per second
m^3/s	cubic meter per second
mg/L	milligram per liter
$\mu g/m^3$	microgram per cubic meter
ºC	degrees centigrade
%	percent
cfu	colony forming unit
µS/cm	micro Siemens per centimeter
US$	United States of America dollar
EGP	Egypt Pound
EUR	Euro

Ratio of currency conversion (As of December 2017)

	EGP	US$	¥
EGP		0.0564	6.28
US$	17.7305		111.29
JPY	0.1592	0.0090	

Chapter 1 Basic Policy of Survey

1.1 Objectives of the Study

This Survey is carried out as an information collection/confirmation survey, based on the request of the Feasibility Study (F/S) for a Japanese sector loan submitted by the Ministry of Water Resources and Irrigation (MWRI) to the Japanese Government in August 2016. The Japanese side judged the request and determined that it was appropriate to start with confirmation and arrangement of basic information of the irrigation sector.

This Survey is to integrate information on the irrigation sector, through analysis of the present situation of the Egyptian irrigation sector, issues and their causes, policy priorities, and cooperation by development partners including Japan (outcomes and status). Based on the results, future cooperation programs and concrete activities are proposed that could further contribute to the second pillar, "Realization of efficient use of the existing resources", of the National Water Resources Plan 2017: NWRP2017, which holds the central position of water resources plans administered by MWRI.

1.2 Target Area

The cooperation program expected in this Survey should be formed in consideration with advantages, histories, tasks, and factor analysis of previous Japanese cooperation in the irrigation sector based on the MWRI's request of the above-mentioned F/S of a sector loan. Therefore, important areas were selected for the Survey from extensively supported areas by previous Japanese projects in the irrigation sector in Egypt. Target areas, reasons for selection, features, and extents are shown in Table 1.1.

Table 1.1 List of Target Areas

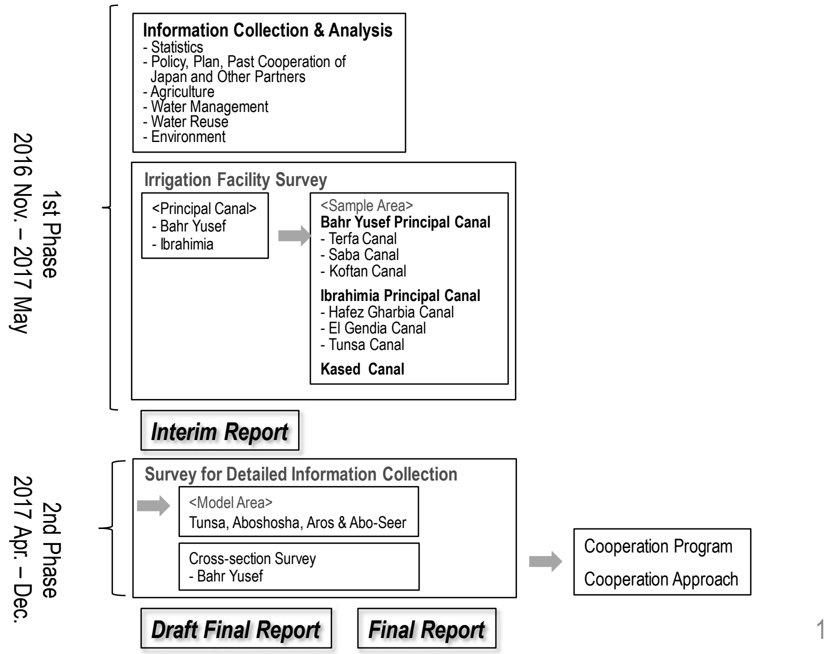
No.	Target Area	Reasons for Selection, Features and Extents
1	Bahr Yusef Canal (Upper Egypt) (From Dirout Group of Reg. to the terminal including Faiyum)	◆ MWRI demands facility improvement. ◆ Grant aid projects for facilities improvement were implemented. ◆ Improvement of Dirout Group of Regulators is conducted under Japan's loan. ◆ Bahr Yusef Canal is a natural meandering river. ◆ There is a densely inhabited district (Faiyum) downstream.
2	Ibrahimia Canal (Upper Egypt) (From Dirout Group of Reg. to El Wasta Reg.)	◆ MWRI demands facility improvement. ◆ Improvement of Dirout Group of Regulators is conducted under Japan's loan. ◆ Ibrahimia Canal is a manmade canal built by the government. ◆ It passes populated areas and farmlands tend to decrease.
3	Kased Canal (Middle Delta)	◆ MWRI demands facility improvement. ◆ Technical cooperation projects about water management transfer were conducted around the area. ◆ MWRI officers in this area are highly motivated for water management transfer. ◆ This area is a densely populated district.

Source: JICA Survey Team

1.3 Method of Survey

1.3.1 Process of Survey

This Survey was conducted in two phases: the first phase from November 2016 to May 2017 and the second phase from April to December 2017. The process of the Survey is shown below.



Source: JICA Survey Team

Figure 1.1 Process of the Survey

In the first phase, in addition to collecting and analyzing basic information of the irrigation sector, the inventory surveys on irrigation facilities of Bahr Yusef Principal Canal and Ibrahimia Principal Canal were conducted. In addition, sample areas in the target canal systems were selected through discussions with relevant officials of MWRI with the aim to understand the overall conditions of the facilities in the target areas. Based on the results of sample surveys, the Minutes of Discussion (M/D) was confirmed between MWRI and JICA on March 9th, 2017. The M/D indicates agreements on defining sub-regions as a certain size of irrigated areas that takes water from a principal canal directly and consists of the main canal, branch canals, other intermediary canals and meskas. In addition, directions of future cooperation were confirmed to be based on the Comprehensive Irrigation Water Management (CIWM), which is a concept that tackles the problem from both hard and soft component viewpoints within a sub region. In the said M/D, the expression 'Comprehensive Water Management' was used instead of 'Comprehensive Irrigation Water Management', but its meaning was standardized as CIWM after the M/D was discussed and orally approved by the Egypt side. The M/D is attached as Annex 1.

In the second phase, model areas were selected through discussions with relevant officials of MWRI to collect detailed information. Considering the overall conditions of facilities understood in the sample area surveys, the aims of the model area survey were to improve the accuracy and to gather further information on water management, facility management and agriculture required for the formulation of a development plan.

Moreover, it was decided that a detailed survey was necessary particularly for Bahr Yusef Principal Canal after the first phase. Therefore, a cross-sectional survey was conducted on Bahr Yusef canal in order to improve the accuracy of information and estimate the function of water conveyance from the shape of the canal, which was required to formulate the development plan. The surveying results are attached as Annex 8.

The results of inventory surveys on irrigation facilities of Bahr Yusef Principal Canal and Ibrahimia Principal Canal and the inventory that reflects results of sample area surveys, model area surveys and cross-sectional surveys are attached as Annex 3.

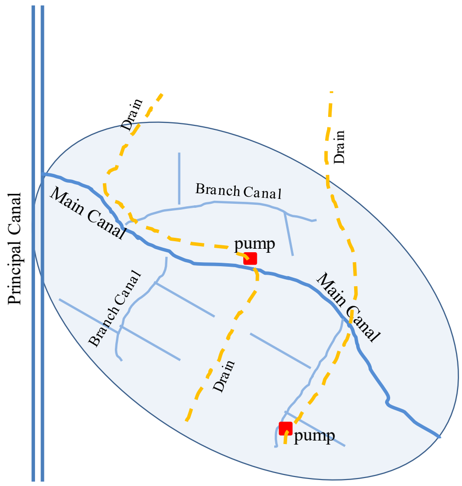
Based on the above, a draft of Japan's cooperation program was developed, taking into account the level of facility improvement, through formulating the cooperation program for the irrigation sector in

Egypt covering support for hard and soft components.

1.3.2 Survey Unit in Target Area

The irrigation system in the target area consists of a principal canal, which branches off from the Nile River to supply water to the system, and the main canals with their distribution system within the irrigated areas.

Based on this, a series of irrigation units starting from intakes at the principal canal that is composed of a main canal and distribution system up to *meska* and *marwa* covering about 3,000 feddan (1,260 ha) is set. This irrigation unit covering the main canal up to terminal canals including the facilities inside is termed here as a "sub-region" (see Figure 1.2 below).



Source: JICA Survey Team

Figure 1.2 Conceptual View of a Sub-region

Several small canals that take water directly from the principal canals and irrigate small-scale irrigation areas of several hundred feddan shall be bundled into one sub-region. In addition, Kased canal is treated as one sub-region due to its status.

Accordingly, the irrigation systems on Bahr Yousef and Ibrahimia principal canal is divided into 80 sub-regions as shown in Figure 1.3 below. Although the two principal canals are not defined as sub-regions, they individually serve as a unit for implementing future cooperation in the same way as a sub-region.

Examination of water management, delivery/distribution of water including rotation is examined in this sub-region. The sub-region is the basic unit for future cooperation

The categories of 80 sub-regions in this Survey are presented in Table 1.2 below. Figure 1.3 shows the schematic diagram of the sub-regions along Bahr Yusef and Ibrahimia canal system.

Table 1.2 Sub-regions in the Target Area

Canals	Sub-regions
Bahr Yusef Principal Canal	Irrigated area by the main canal: 31 regions
Ibrahimia Principal Canal	Irrigated area by the main canal: 48 regions
Kased Main Canal	1 region

Source: JICA Survey Team

Sample areas and model areas covered in first and second phases of the surveys in relation to the category of sub-regions are summarized in Table 1.3 below.

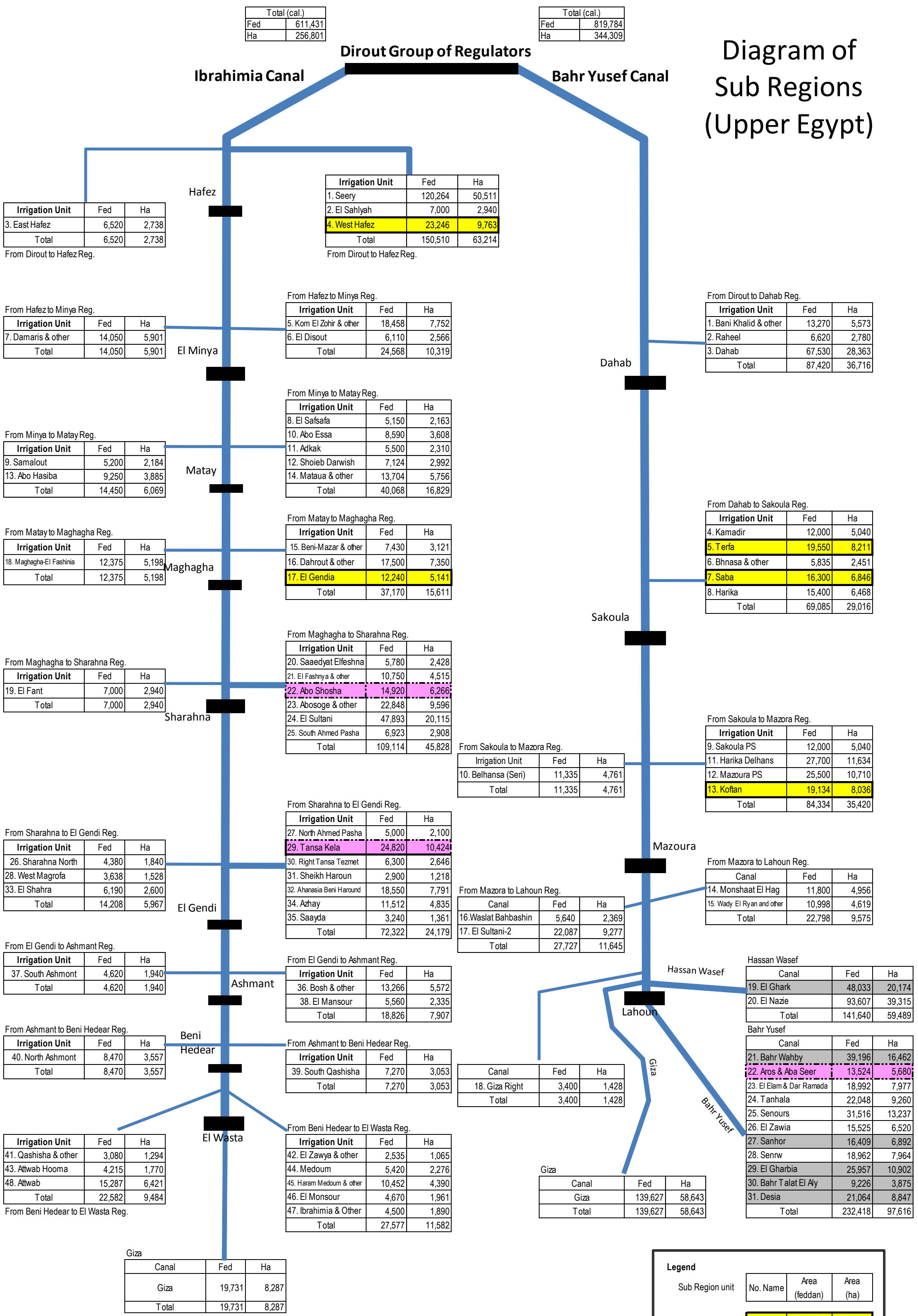
Table 1.3 List of Sample Area and Model Area

	Sub-regions Name	Canal Name	Sub-region No.
Sample Area	Turfa	Bahr Yusef Principal Canal	No. 5
	Saba	Bahr Yusef Principal Canal	No. 7
	Koftan	Bahr Yusef Principal Canal	No. 13
	West Hafez	Ibrahimia Principal Canal	No. 4
	El Gendia	Ibrahimia Principal Canal	No. 17
	Tunsa-Kella	Ibrahimia Principal Canal	No. 29
	Kased	Kased Main Canal	-
Model Area	Aros Abo seer	Bahr Yusef Principal Canal	No. 22
	Abo Shousha	Ibrahimia Principal Canal	No. 22

	Sub-regions Name	Canal Name	Sub-region No.
	Tunsa-Kella	Ibrahimia Principal Canal	No. 29

Source: JICA Survey Team

In addition, sample areas and model areas are indicated in Figure 1.3. Bold lines surround the sample areas, and a two-dot chain line surrounds the model area.



Total (cal.) — Ibrahimia Canal

	Total (cal.)
Fed	611,431
Ha	256,801

Total (cal.) — Bahr Yusef Canal

	Total (cal.)
Fed	819,784
Ha	344,309

From Dirout to Hafez Reg.

Irrigation Unit	Fed	Ha
3. East Hafez	6,520	2,738
Total	6,520	2,738

From Dirout to Hafez Reg.

Irrigation Unit	Fed	Ha
1. Seery	120,264	50,511
2. El Sahlyah	7,000	2,940
4. West Hafez	23,246	9,763
Total	150,510	63,214

From Hafez to Minya Reg.

Irrigation Unit	Fed	Ha
7. Damaris & other	14,050	5,901
Total	14,050	5,901

From Hafez to Minya Reg.

Irrigation Unit	Fed	Ha
5. Kom El Zohir & other	18,458	7,752
6. El Disout	6,110	2,566
Total	24,568	10,319

From Dirout to Dahab Reg.

Irrigation Unit	Fed	Ha
1. Bani Khalid & other	13,270	5,573
2. Raheel	6,620	2,780
3. Dahab	67,530	28,363
Total	87,420	36,716

From Minya to Matay Reg.

Irrigation Unit	Fed	Ha
9. Samalout	5,200	2,184
13. Abo Hasiba	9,250	3,885
Total	14,450	6,069

From Minya to Matay Reg.

Irrigation Unit	Fed	Ha
8. El Safsafa	5,150	2,163
10. Abo Essa	8,590	3,608
11. Adkak	5,500	2,310
12. Shoieb Darwish	7,124	2,992
14. Mataua & other	13,704	5,756
Total	40,068	16,829

From Matay to Maghagha Reg.

Irrigation Unit	Fed	Ha
18. Maghagha-El Fashinia	12,375	5,198
Total	12,375	5,198

From Matay to Maghagha Reg.

Irrigation Unit	Fed	Ha
15. Beni-Mazar & other	7,430	3,121
16. Dahrout & other	17,500	7,350
17. El Gendia	12,240	5,141
Total	37,170	15,611

From Dahab to Sakoula Reg.

Irrigation Unit	Fed	Ha
4. Kamadir	12,000	5,040
5. Terfa	19,550	8,211
6. Bhnasa & other	5,835	2,451
7. Saba	16,300	6,846
8. Harika	15,400	6,468
Total	69,085	29,016

From Maghagha to Sharahna Reg.

Irrigation Unit	Fed	Ha
19. El Fant	7,000	2,940
Total	7,000	2,940

From Maghagha to Sharahna Reg.

Irrigation Unit	Fed	Ha
20. Saaedyat Elfeshna	5,780	2,428
21. El Fashnya & other	10,750	4,515
22. Abo Shosha	14,920	6,266
23. Abosoge & other	22,848	9,596
24. El Sultani	47,893	20,115
25. South Ahmed Pasha	6,923	2,908
Total	109,114	45,828

From Sakoula to Mazora Reg.

Irrigation Unit	Fed	Ha
10. Belhansa (Seri)	11,335	4,761
Total	11,335	4,761

From Sakoula to Mazora Reg.

Irrigation Unit	Fed	Ha
9. Sakoula PS	12,000	5,040
11. Harika Delhans	27,700	11,634
12. Mazoura PS	25,500	10,710
13. Koftan	19,134	8,036
Total	84,334	35,420

From Sharahna to El Gendi Reg.

Irrigation Unit	Fed	Ha
26. Sharahna North	4,380	1,840
28. West Magrofa	3,638	1,528
33. El Shahra	6,190	2,600
Total	14,208	5,967

From Sharahna to El Gendi Reg.

Irrigation Unit	Fed	Ha
27. North Ahmed Pasha	5,000	2,100
29. Tansa Kela	24,820	10,424
30. Right Tansa Tezmet	6,300	2,646
31. Sheikh Haroun	2,900	1,218
32. Ahanasia Beni Haround	18,550	7,791
34. Azhay	11,512	4,835
35. Saayda	3,240	1,361
Total	72,322	24,179

From Mazora to Lahoun Reg.

Canal	Fed	Ha
16.Waslat Bahbashin	5,640	2,369
17. El Sultani-2	22,087	9,277
Total	27,727	11,645

From Mazora to Lahoun Reg.

Canal	Fed	Ha
14. Monshaat El Hag	11,800	4,956
15. Wady El Ryan and other	10,998	4,619
Total	22,798	9,575

From El Gendi to Ashmant Reg.

Irrigation Unit	Fed	Ha
37. South Ashmont	4,620	1,940
Total	4,620	1,940

From El Gendi to Ashmant Reg.

Irrigation Unit	Fed	Ha
36. Bosh & other	13,266	5,572
38. El Mansour	5,560	2,335
Total	18,826	7,907

Hassan Wasef

Canal	Fed	Ha
19. El Ghark	48,033	20,174
20. El Nazie	93,607	39,315
Total	141,640	59,489

From Ashmant to Beni Hedear Reg.

Irrigation Unit	Fed	Ha
40. North Ashmont	8,470	3,557
Total	8,470	3,557

From Ashmant to Beni Hedear Reg.

Irrigation Unit	Fed	Ha
39. South Qashisha	7,270	3,053
Total	7,270	3,053

Canal	Fed	Ha
18. Giza Right	3,400	1,428
Total	3,400	1,428

Bahr Yusef

Canal	Fed	Ha
21. Bahr Wahby	39,196	16,462
22. Aros & Aba Seer	13,524	5,680
23. El Elam & Dar Ramada	18,992	7,977
24. Tanhala	22,048	9,260
25. Senours	31,516	13,237
26. El Zawia	15,525	6,520
27. Sanhor	16,409	6,892
28. Senrw	18,962	7,964
29. El Gharbia	25,957	10,902
30. Bahr Talat El Aly	9,226	3,875
31. Desia	21,064	8,847
Total	232,418	97,616

Irrigation Unit	Fed	Ha
41. Qashisha & other	3,080	1,294
43. Attwab Hooma	4,215	1,770
48. Attwab	15,287	6,421
Total	22,582	9,484

From Beni Hedear to El Wasta Reg.

From Beni Hedear to El Wasta Reg.

Irrigation Unit	Fed	Ha
42. El Zawya & other	2,535	1,065
44. Medoum	5,420	2,276
45. Haram Medoum & other	10,452	4,390
46. El Monsour	4,670	1,961
47. Ibrahimia & Other	4,500	1,890
Total	27,577	11,582

Giza

Canal	Fed	Ha
Giza	139,627	58,643
Total	139,627	58,643

Giza

Canal	Fed	Ha
Giza	19,731	8,287
Total	19,731	8,287

Legend

Sub Region unit	No. Name	Area (feddan)	Area (ha)
Sample Area	No. Name	Area (feddan)	Area (ha)
Model Area	No. Name	Area (feddan)	Area (ha)
Meaqa improvement	No. Name	Area (feddan)	Area (ha)

Source: JICA Survey Team

Note: Sub-regions of each irrigation system is numbered from the upstream.

Figure 1.3 Diagram of Sub-regions (Ibrahimia and Bahr Yusef)

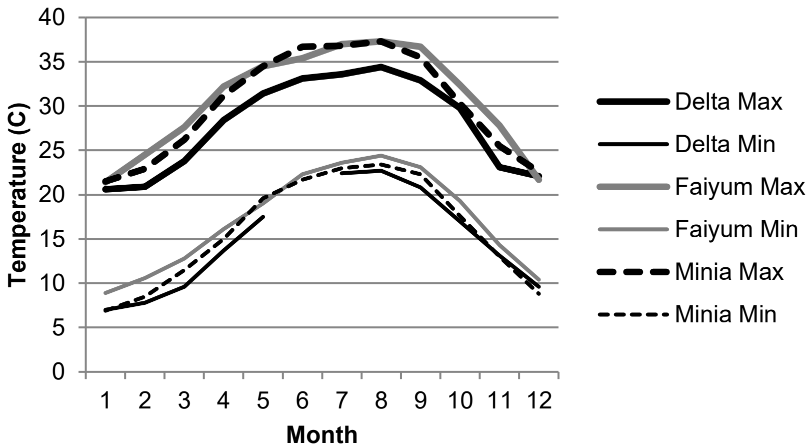
Chapter 2 Overview of Egypt

2.1 Natural Condition

2.1.1 Natural Environment

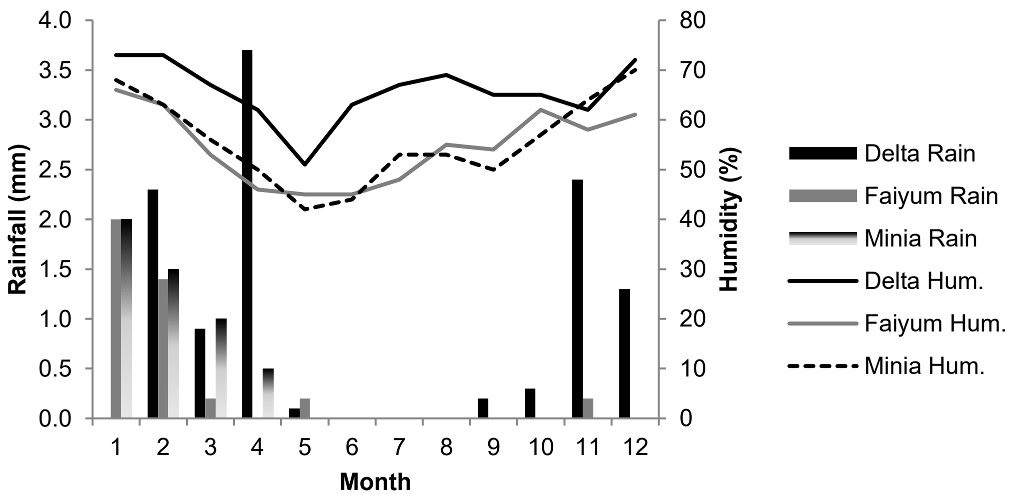
According to its geographical features, Egypt can be divided into four regions: 1. Nile Valley and Delta, 2. West desert, 3. East desert, and 4. Sinai Peninsula; the target area is in the Nile Valley and Delta. The temperature of the target area is shown in Figure 2.1; the average maximum temperature in summer is over 35 degrees, which is extremely hot, but one of the deltas is slightly milder than Upper Egypt.

The rainfall and humidity of the target area are shown in Figure 2.2. It rains mainly in winter, not in summer. Though rainfall in the Delta is the highest in Egypt, it is only 10 mm/year. In particular, there is little rainfall in Upper Egypt, which has severe dry weather.



Source: JICA Survey Team, made from weather data in 2014 in Statistical Yearbook 2016. There is no data of Gharbia and Beni Suef because of data depend on observing stations. The data for Delta comes from Mansoura. The average temperature of Mansoura in June is unexpected value, so it was excluded.

Figure 2.1 Temperature of Target Area



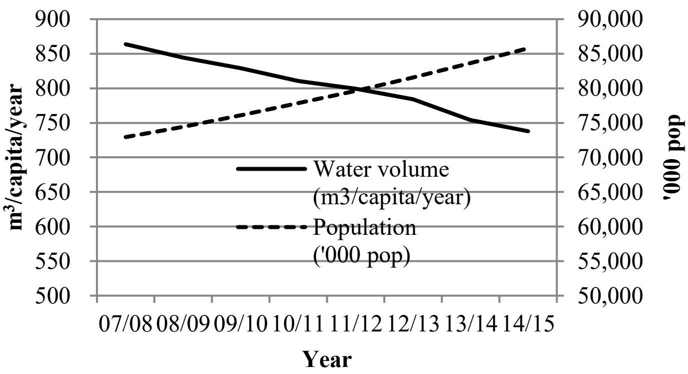
Source: JICA Survey Team, made from weather data in 2014 in Statistical Yearbook 2016. Observing stations are the same as the figure above. In addition, there is no data of rainfall of January in Mansoura.

Figure 2.2 Rainfall and Humidity of Target Area

2.1.2 Water Resources

(1) Amount of Water Resources

In Egypt, there is very little rain, except for the coastal areas. Most of the water resources depend on the Nile River. However, the population has increased drastically (1.7% per annum in 2004-2014). There is a risk that water resources will become increasingly tight in the future because of the increase in production activities according to the population increase, an increase in per capita consumption due to an improvement in living standards, water resources development in the upper stream of the Nile River, etc. In general, 1,000 m^3/capita/year is a state of water scarcity. In the case of Egypt, it was already 738 m^3/capita/year (see Figure 2.3 and Table 2.1 as of 2014/15 year. In addition, it may fall below 500 m^3/capita/year [1], which is an indicator of absolute water scarcity, in 2025 [2]. Therefore, it is an essential task to improve the efficiency of water use in order to protect the lives of people in Egypt.



Source: JICA Survey Team based on Statistical Year Book 2016, Numbers are shown in Table 2.1.

Figure 2.3 Water Availability per Capita and Population Increase

Table 2.1 Various Quantities Related to Water Resources/Water Use etc.

Item	Unit	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
Water Resources Total	Billion m^3/year	63.00	62.85	63.10	63.10	63.63	63.94	63.10	63.30
Nile water	"	55.50	55.50	55.50	55.50	55.50	55.50	55.50	55.50
Groundwater in Valley & Delta	"	6.20	6.25	6.30	6.30	7.50	7.70	6.70	6.90
Rains & Floods	"	1.30	1.10	1.30	1.30	0.63	0.74	0.90	0.90
Population	'000 pop.	72,940	74,439	76,099	77,840	79,618	81,567	83,667	85,783
Water volume	m^3/capita/year	864	844	829	811	799	784	754	738
Uses of Water Total	Billion m^3/year	70.23	73.60	73.85	73.75	74.50	75.50	76.00	76.40
Agriculture	**"**	**60.00**	**61.30**	**61.30**	**60.90**	**61.50**	**62.10**	**62.35**	**62.35**
Drinking and Healthy uses	"	6.60	9.00	9.35	9.55	9.60	9.70	9.95	10.35
Industry	"	1.33	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Others	"	2.30	2.10	2.00	2.10	2.20	2.50	2.50	2.50
% of Agriculture	**%**	**86**	**83**	**83**	**82**	**82**	**82**	**82**	**81**
% of Drinking and Healthy uses	"	9	12	12	13	13	13	13	14
% of Industry	"	2	2	2	2	2	2	2	2
% of Others	"	3	3	3	3	3	3	3	3

Source: JICA Survey Team based on Statistical Year Book 2016, Water Resources Total does not include water reuse.

On the other hand, the purpose of water use is 10% for drinking water, 2% for industrial water and more than 80% for agriculture. The share of agriculture is dominant. Efficient utilization of agricultural water is an extremely important subject with increasing population pressure. For this reason, this survey focuses on water for agriculture and conducts subsequent investigations.

According to "Water Scarcity in Egypt", the Nile basin has a low runoff rate of 4% and it is considered vulnerable to climate change because it is very sensitive to changes in temperature and rainfall. Therefore, Egypt is struggling to secure water resources through coordination with countries in the upper stream of the Nile Basin.

[1] World Water Development Report 2016, UNESCO, "An area or country is under regular water stress when renewable water supplies drop below 1,700 m^3 per capita per year. Populations face chronic water scarcity when water supplies drop below 1,000 m^3 per capita per year and absolute scarcity below 500 m^3 per capita per year."

[2] Water Scarcity in Egypt, Ministry of Water Resources and Irrigation, Egypt, February 2014

As mentioned above, the irrigation water share decreases in overall water uses. However, its use is increasing every year. Amid restrictions on water intake from the mainstream of the Nile River, various plans about water resources predict serious water shortages. In order to cope with such situation, water reuse, water in drainage used for irrigation, contributes to the increase of the amount of available water resources. The water reuse is commonly done by installing a facility that lifts the water in the drains into irrigation canals. Reflecting such circumstances, the water reuse tends to increase year by year.

Table 2.2 Quantitative Balance of Water Resources

Unit: BCM/Year

Item	10/11	11/12	12/13	13/14	14/15
Water Resources	73.75	74.16	75.40	76.00	76.40
Share of Nile Water	55.50	55.50	55.50	55.50	55.50
Recycling of Agricultural Water	9.30	9.17	10.10	11.50	11.70
Recycling of Sewage Water	1.30	1.30	1.30	1.30	1.30
Others	7.65	8.19	8.50	7.70	7.90
Water Use	73.75	74.50	75.50	76.00	76.40
Agriculture	60.90	61.50	62.10	62.35	62.35
Others	12.85	13.00	13.40	13.25	14.05

Source：Egypt: Statistical Year Book 2016 Environment 21-1 WATER BALANCE (07/2008-14/2015)

(2) Water Quality

Water resources in Egypt consist largely of the surface water of the Nile River and others such as groundwater and reusable drainage. In addition, the target area of the Survey also relies on the Nile River. Therefore, the Survey gives a general overview of the Egyptian water quality by explaining the situation of the Nile River.

The water quality of the Nile River[3] is predominantly influenced by human factors and is said to be prone to deterioration indicators such as suspended solids (SS) and bacteria counts. Among them, turbidity due to SS has been almost reduced by slough and reservoirs, ranging at a low level of 20-50 mg/L throughout the year in the area downstream of Aswan. In particular, the number of Escherichia coli groups is 500 cfu/100 ml on average even in the upstream part of the River Nile, while it may reach 150,000 cfu/100 ml level in some regions of the Nile Delta where contamination is serious, such as in the Rosetta tributary of the Nile Delta. The fecal coliform group index exceeds 50 cfu/100 ml and indicates an unsuitable range for potable use without purification.

In addition, electric conductivity (EC), an indicator of salt concentration, shows a range between 241 to 300 μS/cm in the downstream of area Aswan to Minia, 361 to 420 μS/cm in the Nile Delta, and 301 to 360 μS/cm in the middle area.[4]

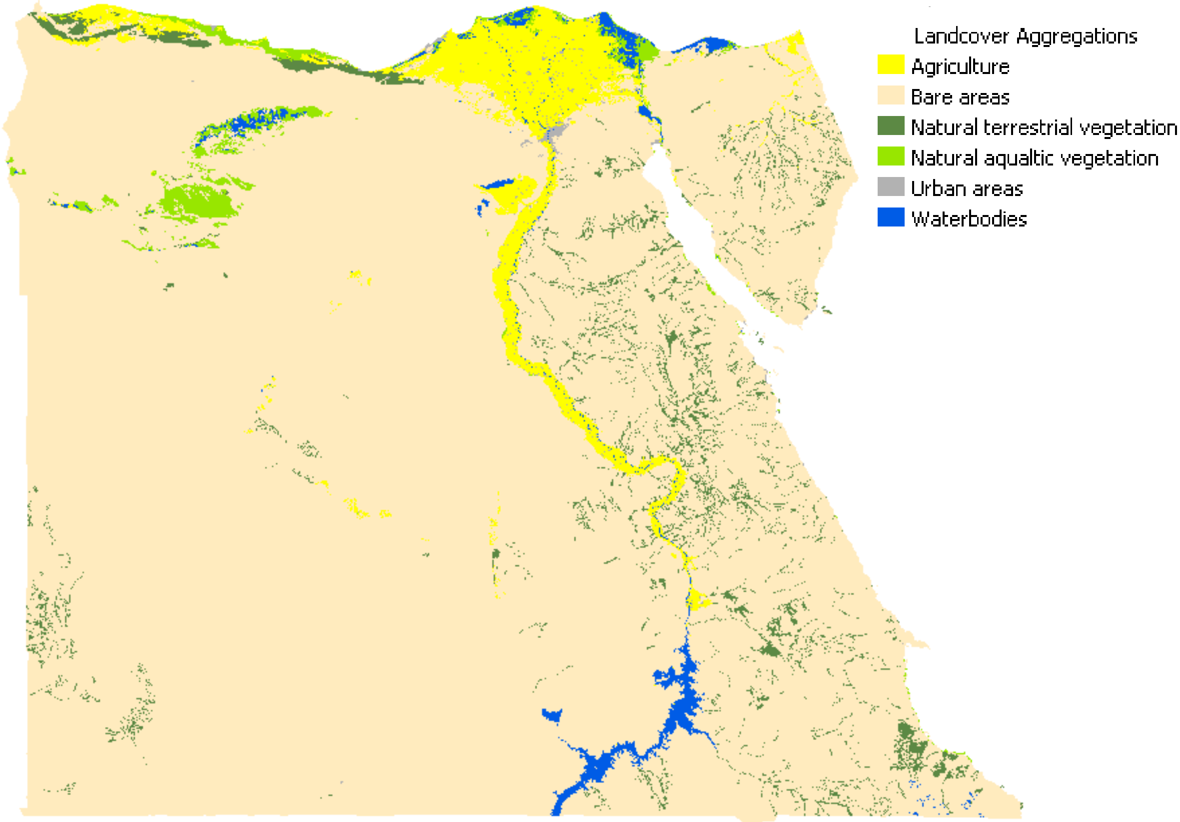
Besides this, it is pointed out that biochemical oxygen demand (BOD), an indicator of organic pollution, greatly increases in the immediate downstream area of urban areas, where domestic wastewater and factory wastewater is drained. However, it is reported that dissolved oxygen (DO), a major indicator of water quality, generally maintains an appropriate value and keeps from 6 to 9.5 ml/l. Only some exceptional cases may show values lower than 5 ml/l around areas immediately downstream of urbanized areas and a portion of the Nile Delta[5].

Furthermore, 'NWRP 2017 2.2.7 Water Quality of Surface Water' states that the water quality index has been maintained at almost the same level from Aswan to Cairo within the Nile River. It also states that the records of BOD and nitrogen content will not exceed the criteria values for the minimum requirements with some exceptions.

[3] State of the Nile River Basin 2012, MWRI web site
[4] NTEAP Regional Water Quality Monitoring Baseline Report, 2015
[5] Final report of Project for Drainage Water Quality Control for Irrigation in Middle Delta, 2016, JICA

2.1.3 Land Use

Egypt covers 1,001,450 km^2, of which land is 995,450 km^2 and water is 6,000 km^2, and its land uses are: agricultural land 3.6% (arable land 2.8%, permanent crops 0.7%), forest 0.1%, and other 96.3% including desert. Within the agricultural land, 36,500 km^2 is irrigated (2012). Figure 2.4 shows the land cover of Egypt.



Source: FAO web site

Figure 2.4 Generalized Land Cover Map of Egypt

2.2 Socioeconomics

The population of Egypt is 93 million[6], the largest population in all the Arab countries. The population growth rate from 2004 to 2014 shows an annual increase of 1.7%. Moreover, those under 30 years old account for two-thirds of the population. According to the Egyptian State Population Council, it is estimated to reach 140 million in 2030.

Egypt's unemployment rate dipped to 11.98%, below 12% in the second quarter of 2017, the first time it has been that low since the political uprising in 2011, CAPMAS said. Nearly 80% of those unemployed were young; however, the Government has pledged to reduce joblessness to 10% in the next few years; the target will require higher levels of economic growth[7].

First, the economic situation of Egypt since 2000 is looked at. As shown in Table 2.3, the economic growth of Egypt has changed in the latter half of the 2000s and 2011. The economic growth rate, which was 3.5% in 2001, 7.2% in 2008, the latter half of the 2000s, is the highest economic growth rate in the past quarter-century. In the mid-2000s, economic reforms in Egypt progressed, and its oil-producing neighboring countries had booming economies due to the rise in international crude oil

[6] Egypt's population officially reaches 93 million: CAPMAS, 2017 May, ahram online, http://english.ahram.org.eg/NewsContent/1/0/269352/Egypt/0/Egypts-population-officially-reaches--millions-CAP.aspx
[7] Reuters, 2017, Aug. 15, Cairo

prices[8]. It can be said that the Egyptian economy was in a growth phase due to the improvement of the domestic and foreign economic environment in this period. This good economic environment resulted in an increase in nominal GDP per capita, exceeding US$2,000 in 2008, and further reaching US$3,000 in 2012. On the other hand, the rise in the inflation rate became noticeable in the latter half of the 2000s. In particular, the global rise in grain prices led to an increase in the domestic price of wheat, the staple food of Egypt, which depends on imports for about a half of its food consumption, and in the same year inflation rate rose to 18.3%.

As a result of the deteriorating domestic economic environment since the political change in 2011 (revolution on January 25), the economic growth rate fell to 1.8% in 2011, 2.2% in 2012, 2.1% in 2013 and 2.2% in 2014. This period of lowest economic growth lasted four years after the 2000s. On the other hand, due to the expansion of domestic consumption caused by the stabilization of the domestic situation, the growth rate returned to 4.2% in 2015, and signs of recovery in economic growth have been observed.

In addition, the Egyptian pound (EGP) fell sharply against the US$ due to the liberalization of foreign exchange introduced from November 2016. As a result, an inflation rate of 31.95% was recorded in June 2017.

Table 2.3 Key Economic Indicators in Egypt since 2001

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
GDP growth, annual %	3.5	2.4	3.2	4.1	4.5	6.8	7.1	7.2	4.7	5.1	1.8	2.2	2.1	2.2	4.2
GDP per capita, current US$	1,403	1,239	1,148	1,071	1,197	1,409	1,681	2,062	2,349	2,668	2,817	3,226	3,264	3,366	3,615
Inflation, consumer prices, annual %	2.3	2.7	4.5	11.3	4.9	7.6	9.3	18.3	11.8	11.3	10.1	7.1	9.4	10.1	10.4
Population growth annual %	1.8	1.9	1.9	1.8	1.8	1.8	1.7	1.8	1.8	2.0	2.1	2.2	2.3	2.2	2.1
Employment in agriculture, % of total	28.5	27.5	29.9	31.8	30.9	31.2	31.7	31.6	29.9	28.2	29.2	27.1	28.0	-	-
Agriculture, value added, % of GDP	16.6	16.5	16.3	15.2	14.9	14.1	14.1	13.2	13.6	14.0	14.5	11.1	11.0	11.1	11.2

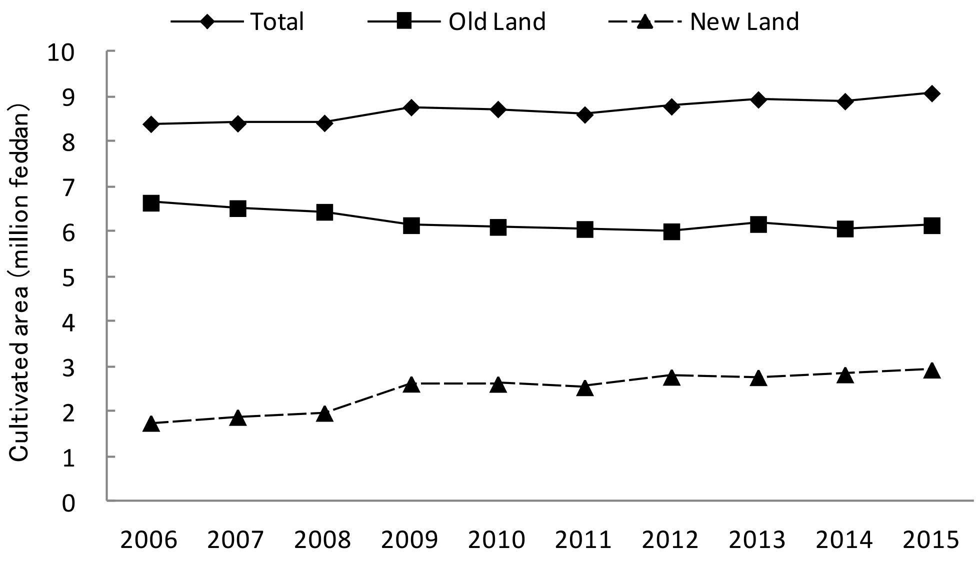
Source: Prepared by the study team based on "World Development Indicators, World Bank"

2.3 Agriculture of Egypt

2.3.1 Cultivated Area, Cropped Area, and Crop Intensity

The total cultivated area of Egypt in 2015 was 9.1 million feddan (about 3.8 million ha). Within the total cultivated area, 'old land' (arable land reclaimed in the Nile Delta and the Nile Valley) is 6.16 million feddan (about 2.59 million ha) and accounts for 68% of the total cultivated area, and 'new land' (arable land newly reclaimed) is 2.94 million feddan (about 1.23 million ha) and accounts for 32% of the total cultivated area. The trends of total land, old land, and the new land in the past ten years (from 2006 to 2015) of Egypt are shown in Figure 2.5. The total cultivated area is increasing gradually, while the old land has a decreasing trend and the new land has an increasing trend.

[8] Tsuchiya Ichiki (2013), Seeking Economic Policy by Provisional Cabinet, Governance and Economic Report, Middle East Review Vol.0, September



Source: Statistical Year Book 2016, Bulletin of The Agricultural Statistics 2014/15

Figure 2.5 Trends of Cultivated Area (from 2006 to 2015)

Regarding the winter crop (planting from October/November to May), summer crop (planting from March/April to September, Nile crop (autumn cropping, planting from June to October), and permanent crop (planting through the year), trends of cropped areas by cropping season over the past five years (from 2010 to 2014) are shown in Table 2.4 Trends of Cropped Area by Cropping Season (from 2010/11 to 2014/15. The cropping intensity of each season over the past five years is shown as winter crop (76%), summer crop (69%), Nile crop (6%) and permanent crop (24%), respectively. The average of the annual cropping intensity for the past five years is shown as about 175%. Cultivation of permanent crops throughout the year is carried out in farmlands other than winter crop areas, and the total crop rate of summer crops and permanent crops is very high, about 90% or more. Therefore, in Egypt, it is suggested that in the cultivated areas other than the permanent cropping, double cropping such as the summer crop and Nile crop is performed almost throughout the area after the winter crop. There is no major change in the cropping intensity of each season in recent years.

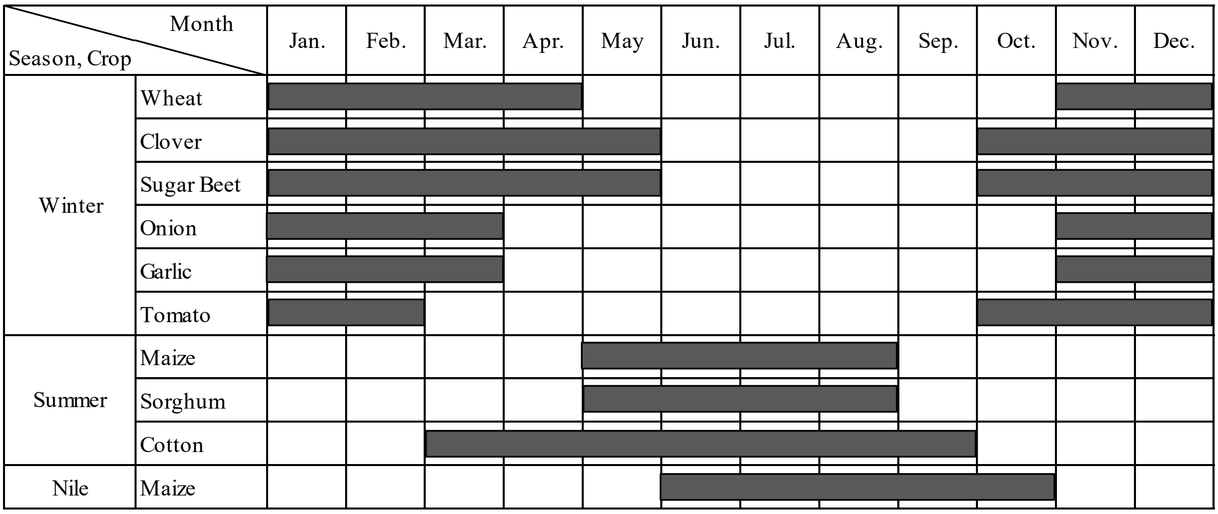
Table 2.4 Trends of Cropped Area by Cropping Season (from 2010/11 to 2014/15)

Unit: feddan

	Total Cultivated Area	Winter Crops Area and Intensity		Summer Crops Area and Intensity		Permanent Area and Intensity		Nile Crops Area and Intensity		Total Intensity (%)
		Total Area	Intensity (%)	Total Area	Intensity (%)	Total Area	Intensity (%)	Total Area	Intensity (%)	
2010/11	8,619,427	6,686,243	78	6,057,844	70	1,933,184	22	676,237	8	178
2011/12	8,799,439	6,735,607	77	6,162,003	70	2,063,832	24	603,911	7	177
2012/13	8,954,323	6,805,606	76	5,972,281	67	2,148,717	24	563,519	6	173
2013/14	8,916,465	6,727,238	75	6,207,600	70	2,189,227	25	565,568	6	176
2014/15	9,095,705	6,895,131	76	6,078,066	67	2,200,574	24	463,323	5	172

Source: Bulletin of The Agricultural Statistics 2010/11～2014/15

Figure 2.6 shows examples of cropping patterns of winter, summer, and Nile.



Source : Survey team based on the List of Cultivated Crops of Beni Suef Governorate (2016-2017)

Figure 2.6 Cropping Patterns of Winter, Summer, and Nile Crop

In Egypt, it is possible to perform double production such as winter and summer, winter and Nile by selecting the crops to be cultivated so as not to overlap with each cropping pattern.

2.3.2 Cropping Condition of Major Crops in Each Season (Cropped Area & Production)

The cropped area and production of major crops in winter are shown in Table 2.5. For the past five years, the cropped area is about 6.74 million feddan, while production is fluctuating at around 77 million tons. In winter, wheat cultivation occupies about half (47%) of the total cultivated area, and the acreage area of clover is large (about 25% of total planting area). In terms of each crop, while the cropped area and production of clover are decreasing, the cropped area and production of sugar beet and wheat are increasing. The cropped area and production of vegetables have been increasing from 2011.

Table 2.5 Cropped Area and Production of Major Crops in Winter

Unit: Area: 1,000 feddan Prod.: 1,000 Ton

Year	Total		Sugar Beet		Clover		Wheat		Barley		Beans & Green Beans	
	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area
2010	77,566	6,764	7,840	386	50,963	1,922	7,177	3,066	117	209	340	202
2011	78,195	6,681	7,486	362	50,406	1,908	8,371	3,059	122	161	255	146
2012	77,051	6,727	9,126	424	46,608	1,777	8,795	3,182	109	196	193	108
2013	75,816	6,792	10,044	460	44,318	1,670	9,461	3,401	131	188	223	116
2014	74,450	6,716	11,046	504	41,608	1,532	9,280	3,414	102	144	174	96

Year	Vegetables		Onion (winter)		Garlic		Flax		Lentil		Others	
	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area
2010	8,728	727	1,902	136	245	23	38	8	2	3	214	82
2011	8,793	788	2,018	138	296	29	40	8	2	3	406	79
2012	9,431	795	2,025	138	309	29	57	10	1	1	397	67
2013	9,308	764	1,903	126	234	22	16	3	1	1	177	41
2014	9,187	779	2,505	163	263	26	33	7	1	1	251	50

Source: Statistical Year Book 2016

The cropped area and production of major crops in summer are shown in Table 2.6. For the past five years, the cropped area is about 6.51 million feddan, while production is fluctuating at around 47 million tons. Among the total cropped area in summer, it is found that maize cultivation accounts for about 25% and rice cultivation accounts for about 21%, accounting for about half of the cropped area in summer. In terms of each crop, the cropped area and production of rice increased in 2011, and the ones of maize increased in 2012. The cropped area and production of vegetables have increased slightly in the past five years and the ones of sugar cane have not changed for the past five years.

Table 2.6 Cropped Area and Production of Major Crops in Summer

Unit: Area: 1,000 feddan Prod.: 1,000 Ton

Year	Total		Maize		Rice		Sorghum		Peanut		Soya Bean	
	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area
2010	47,213	6,418	5,365	1,691	4,327	1,093	692	329	202	159	43	36
2011	47,190	6,487	5,027	1,482	5,665	1,409	831	370	207	155	30	23
2012	48,910	6,593	6,217	1,839	5,897	1,472	751	337	205	149	26	17
2013	45,935	6,406	5,788	1,724	5,717	1,419	759	335	205	148	33	22
2014	47,372	6,638	5,711	1,718	5,460	1,364	801	352	183	134	40	28

Year	Sesame		Vegetables		Potatoes		Sugar Cane		Cotton		Others	
	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area
2010	47	88	9,363	1,087	1,585	134	15,709	320	378	369	9,503	1,112
2011	43	78	8,671	911	1,847	151	15,765	325	635	520	8,469	1,063
2012	31	58	9,310	930	1,972	158	15,550	326	294	333	8,657	974
2013	33	60	8,403	895	1,639	134	15,780	329	253	287	7,325	1,053
2014	37	64	9,016	996	1,745	144	16,055	332	308	369	8,016	1,137

Source: Statistical Year Book 2016

The cropped area and production of major crops in the Nile cropping season (Autumn Cropping) are shown in Table 2.7. The total cropped area and production of the Nile season decreased slightly in 2013 and 2014. The crops of the Nile season are cereals such as maize and vegetables such as potato. Maize is the most cultivated crops in the Nile season, but the cropped area and production of maize have decreased recently. Vegetable cultivation increased temporarily in 2011; the cropped area is around 150 thousand feddan and production is around 1.45 million tons during the past five years.

Table 2.7 Cropped Area and Production of Major Crops in Nile Cropping Season

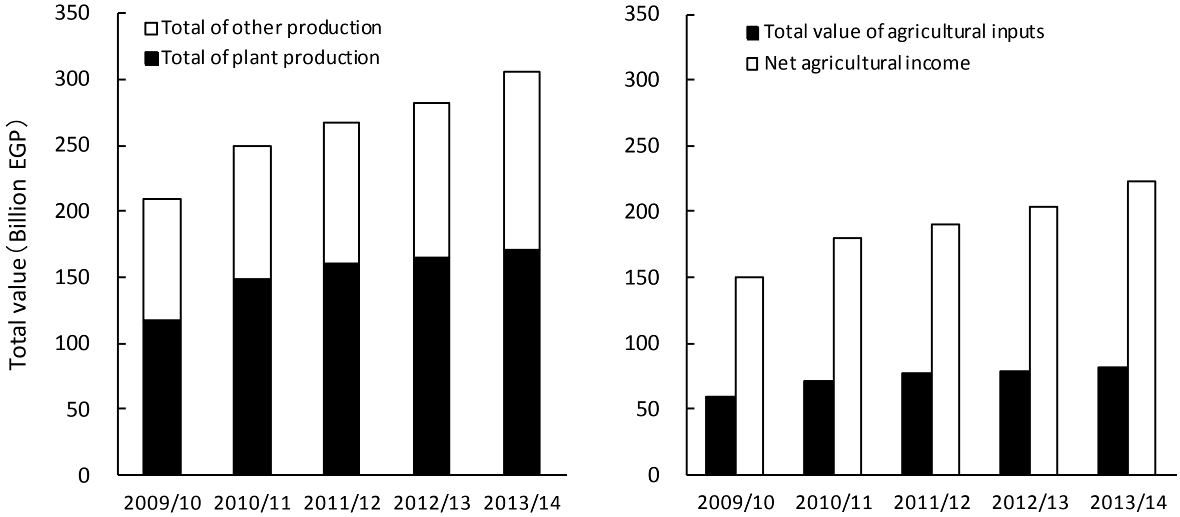
Unit: Area: 1,000 feddan Prod.: 1,000 Ton

Item	Total		Others		Vegetables		Potatoes		Maize		Sorghum		Rice	
	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area
2010	3,423	599	853	143	1,427	132	397	45	734	273	10	5	2	1
2011	3,867	675	842	150	1,659	170	540	56	808	292	8	4	10	13
2012	3,440	603	708	147	1,492	141	541	55	678	252	6	3	15	5
2013	3,156	562	614	140	1,472	150	484	52	576	216	3	2	7	2
2014	3,133	564	579	158	1,433	152	590	62	520	189	4	1	7	2

Source: Statistical Year Book 2016

2.3.3 Total Production of Agricultural Products and Changes in Agricultural Input and Net Agricultural Income

The trend of the total value of plant production is shown in Figure 2.7. Although the total value of plant production is increasing every year, from the trend of the cultivation area and the production mentioned above, it is possible that the price of agricultural crops is rising in recent years and it appeared as the increase of the total value of plant production. Agricultural inputs are also increasing, but the total value of agriculture, forestry and fisheries products (the gross value of both the total plant production and the total other production) are increasing more than agricultural inputs, so finally the net agricultural income has been increasing in recent years.



Source: Statistical Year Book 2016

Figure 2.7 Total Production of Agricultural Products and Changes in Agricultural Input and Net Agricultural Income

2.3.4 Features of Agriculture in Egypt

The features of agriculture in Egypt are as follows:

(a) The area of cultivated land tends to increase gradually year by year. The reason is that the increase of the area of newly developed land is more than the gradually decreasing existing cultivated land area (From 2006 to 2015, the cultivated land area was about 500,000 feddan, while the area of newly extended land has increased by approximately 1.18 million feddan).

(b) The cropping intensity of winter, summer, Nile and permanent crops in recent years does not show large fluctuations, and Egypt's annual cropping rate is about 175%. In Egypt, double cropping which cultivates the summer crop and Nile crop after the winter crop is actively carried out.

(c) Characteristics of agricultural crops during the winter season are while the cropped area and production of clover are decreasing, the ones for sugar beet and wheat are increasing. Wheat and clover crops account for over 70% of the total in winter crops.

(d) Characteristics of agricultural crops during the summer season are the cropped area and production of rice and maize, which are increasing. Crops of maize and rice account for about half (46%) of the total in summer crops.

(e) Among the total value of plant production, winter and summer crops have tended to increase in recent years and fruit-and-vegetable production is increasing year by year. Along with this, net agriculture income is also increasing.

2.4 Irrigation

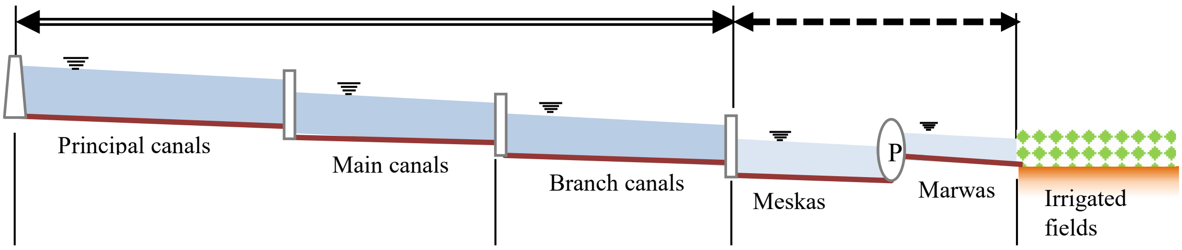
2.4.1 General

(1) History and Surrounding Environment

Irrigated agriculture in Egypt has a very long history. It had depended on inundated water and silt caused by periodic flooding of the Nile River. After construction of the Aswan and High Aswan Dam, agriculture in Egypt was drastically changed. The threat of flooding was eliminated and, at the same time, year-round cultivation came to be practicable within the command areas of the canal irrigation systems relating to the Nile River by means of a perennial water supply. The shift to such complete irrigation on a nationwide scale, taking advantage of the High Aswan Dam construction, brought alterations in the method and structure of irrigation water management in Egypt. However, the Nile River has many stakeholder countries upstream as it is an international river and Egypt faces severe water resource conditions restricted to an upper limit of 55.5 BCM (agreement with Sudan, 84 BCM (the average natural inflow into Lake Nasser between 1900 and 1959) – 185 BCM (Sudan's share) – 100 BCM (estimated reservoir loss)) following high-level discussions with those countries.

(2) Canal Classification and Responsible Bodies

In general, the Egyptian canal irrigation system conveys irrigation water through a principal/main canal and a branch canal and the water reaches farmlands passing through a tertiary canal called a *meska*. Even though there are some exceptions, the general formation of water management corresponding to the canal classification is shown in Figure 2.8. In MWRI, IS is in charge of operation and maintenance of irrigation facilities and CDIAS of IIS is in charge of BCWUA formation. CDIIP of IIS is in charge of meska improvement including WUA formation, and the facility is transferred to WUA after completion. (The structure of MWRI is described later.)



Principal canals	Main canals	Branch canals	Meskas	Irrigated fields (through Marwas)
Continuous flow		Intermittent flow by means of applying the rotation irrigation		
O&M by MWRI IS		Managed by IS or with BCWUA	Managed by traditional users or WUAs	Individual management
Government property			Private property	

Source: JICA Survey Team

Figure 2.8 Canal Classification and Responsible Bodies of O&M

Although collective irrigation management had been practiced by farmers in Egypt since ancient times, farmers' current systematic activities with modernized irrigators' organizations started in the 1980s. Water Users' Associations at tertiary canal level, known as meska, were originally established under the implementation of the IIP Project, which was managed by MWRI for the whole country. At present, water users' organizations in Egypt are categorized into three levels: WUA (Water Users' Association), BCWUA (Branch Canal Water Users' Association) and DWB (District Water Board), for the meska level, branch canal level, and main canal level, respectively.

Complete separation of irrigation and drainage canals has been adopted in Egyptian irrigation systems. In addition, since the field is generally higher than the canal, it requires a pumping facility from meska and marwa, and traditionally an animal-powered turbine was used; however, power pumps are mainstream in recent years.

(3) Rotation Irrigation

In order to use water effectively, canal-based rotation irrigation is adopted in almost all regions excluding Faiyum. It was temporarily applied before, but it is applied permanently these days. In Egypt, “Rotation irrigation” means rotational water distribution to branch canals. It works in a way that branch canals are separated into a few groups and the water that flows from the main canal is distributed to each group of relevant branch canals every few days. In general, the two types of rotation irrigation for branch canals are “Two-turn rotation” and “Three-turn rotation”. The former rotation is to separate branch canals into two groups and to shift water distribution from an on-period to an off-period every five or seven days for each group. The latter consists of three groups of branch canals and shift water distribution from a “5-day on-period and 10-day off-period” for each group. In this way, the water is delivered to the relevant meskas only during the on-period planned for the relevant branch canal. There are rare cases of applying a rotation system for water delivery to meskas.

2.4.2 Legal Framework for Irrigation and Drainage

There is no single overarching water resources law in Egypt. The main laws of relevance for water resources management include laws about irrigation and drainage on the one hand, and laws to protect the environment on the other hand. The most important laws in this respect are:

(1) Law No. 12 /1984: for the irrigation and drainage

(2) Law No. 213 /1994: for farmer participation and cost sharing

(3) Law No. 48 /1982: regarding the protection of the River Nile and waterways from pollution,

(4) Law No. 4 /1994: for environmental protection.

The main characteristics of the laws above are summarized below.

(1) Law No. 12/1984: Irrigation and Drainage

Irrigation and drainage are regulated by Law No. 12/1984 “Concerning the Issue of the Law on Irrigation and Drainage”. The following items are described in this law.

- Definition of public properties related to irrigation and drainage, for example, the River Nile, the main canals, public feeders and public drains and their embankments
- Definition of the use and maintenance of private canals and field drains and specifies arrangements for the recovery of costs of drainage works
- The rules for water allocation, for example, winter closure, rotations, and planting
- Rules for the construction of water intakes along the Nile and public canals and the need for consultations with landowners before making changes to water intakes
- Rules for the use of groundwater and drainage water such as the construction of wells or the use of drainage water and water pumps
- Rules of the development of new land and the price that has to be paid for the irrigation and drainage of land
- Rules for protection against flooding, navigation, and coastal protection, the authority to recruit people to guard and protect the banks of the River Nile and irrigation establishments against flooding, as well as measures to protect the irrigation system against damage
- The penalties for violations, such as growing rice in areas without a license
- Provisions to settle disputes and a fund for the repair of irrigation works

The law is primarily aimed at irrigation as the dominant water user and MWRI as the water manager that has to give permission for all extractions of water. Other water users are not mentioned in particular. No priority rules are given in case there might be conflicts between various categories of water users.

(2) Law No. 213/1994: Farmer Participation

WUAs at the meska level for improved irrigation systems. It also establishes a fund to finance projects related to the development and maintenance of improved meskas and to promote awareness with respect to the use of water. The law originally only concerned water users' organizations on new land. Recently the law has been adapted to include organizations on old land as well.

(3) Law No. 48/1982: Protection of Nile from Pollution

Law 48/1982 provides the basis for the protection of surface and groundwater against pollution. In the law, a distinction is made between the Nile and the irrigation canals, which are referred to as 'potable', and the drains, lakes, and ponds, which are referred to as 'non-potable'. MWRI is responsible for giving licenses for wastewater discharge, whereas the Ministry of Health is responsible for monitoring effluence. In addition, the reuse of drainage water is regulated, as well as weed control and waterway pollution by agro-chemicals.

The executive regulations of Law 48/1982 provide water quality standards for 1) the Nile river and canals, 2) treated industrial discharges into the Nile, canals and groundwater, 3) domestic and industrial discharges to drains, brackish lakes, and ponds, 4) reuse water to be mixed with Nile river or canal water, and 5) the drains, lakes, and ponds themselves.

Law 48/1982 also forbids the reuse of treated municipal wastewater. Strict enforcement of the present regulations would require very large investments by industry and municipalities.

(4) Law No. 4/1994: Environment

Law 4/1994 concerns the environment in general. Law 4/1994 refers to Law 48/1982 for specific regulations on water quality. An important element of Law 4/1994 is the establishment of the Egyptian Environmental Affairs Agency (EEAA). Law 4/1994 provides regulations for protection against pollution of seashores, ports, etc., that are not covered by Law 48/1982. The co-existence of Law 4/1982 and Law 48/1982 makes the division of responsibilities between various agencies obscure with respect to the management of the water quality in the Nile, the canals, and the groundwater.

2.4.3 Ministry of Water Resources and Irrigation

The Ministry of Water Resources and Irrigation (MWRI), the counterpart of this Survey, has two departments for irrigation, and mechanical and electrical; four public authorities for drainage, survey, shore protection and the High Aswan Dam; seven sectors including planning and regional training; and the National Water Research Center. The Irrigation Department is the largest organization in MWRI with six sectors: irrigation, groundwater, reservoirs and barrages, Nile protection, horizontal expansion, and irrigation improvement. Among them, the Irrigation Sector has the largest number (39) of regional officers in MWRI. The Irrigation Sector (IS) was assigned as a counterpart organization through discussions with the Vice Minister and the kickoff meeting attended by selected organizations in MWRI. The M/D of March 9, 2017 defines IS as a technical counterpart, while the Planning Sector (PS) as the main counterpart and the Irrigation Improvement Sector (IIS) as a cooperate sector. The organization chart of the entire MWRI is shown in Figure 2.11.

There is a Central Department (CD) for each governorate, and an undersecretary is in control of the offices of all sections. Under CD, there is a General Directorate (GD) for Irrigation and it is responsible for operation maintenance of irrigation of facilities and water distribution from the main to branch canals.

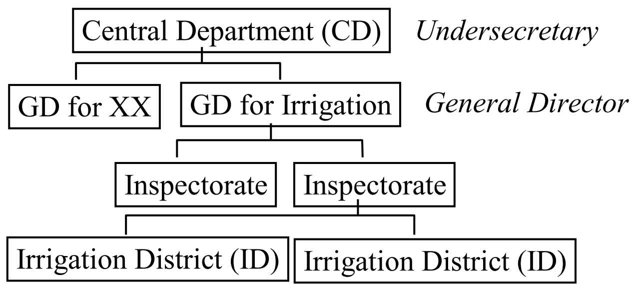


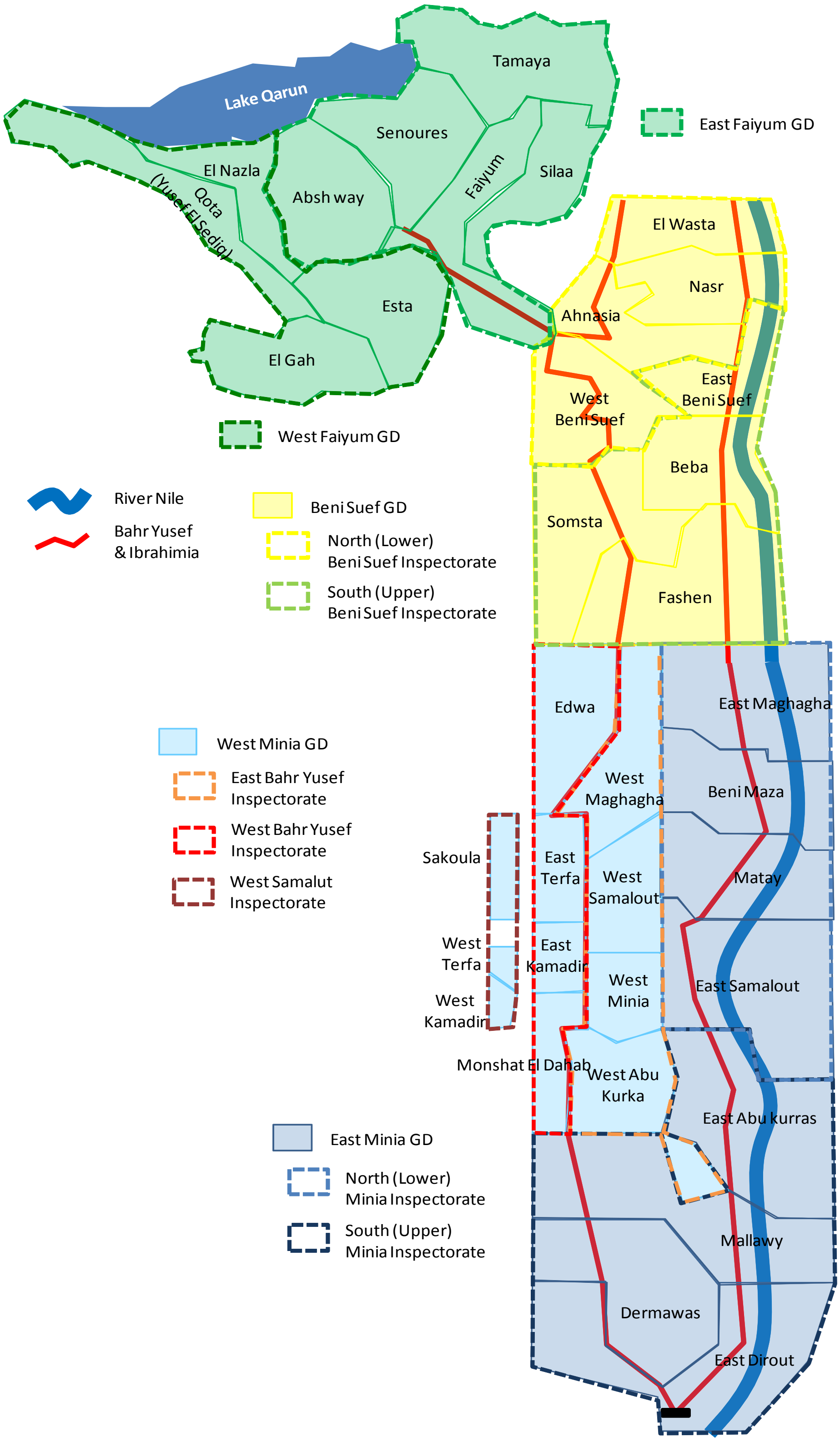
Figure 2.9 Structure of Local Offices

There are Inspectorates and Irrigation Districts (IDs) below GD. Table 2.8 shows all offices covering three canals. Names and locations of local offices in Upper Egypt are shown in Figure 2.10. There are many offices in three governorates. Bahr Yusef and Ibrahimia canals stretch across several IDs, Inspectorates, GDs and CDs

Table 2.8 Irrigation Districts of Target Area

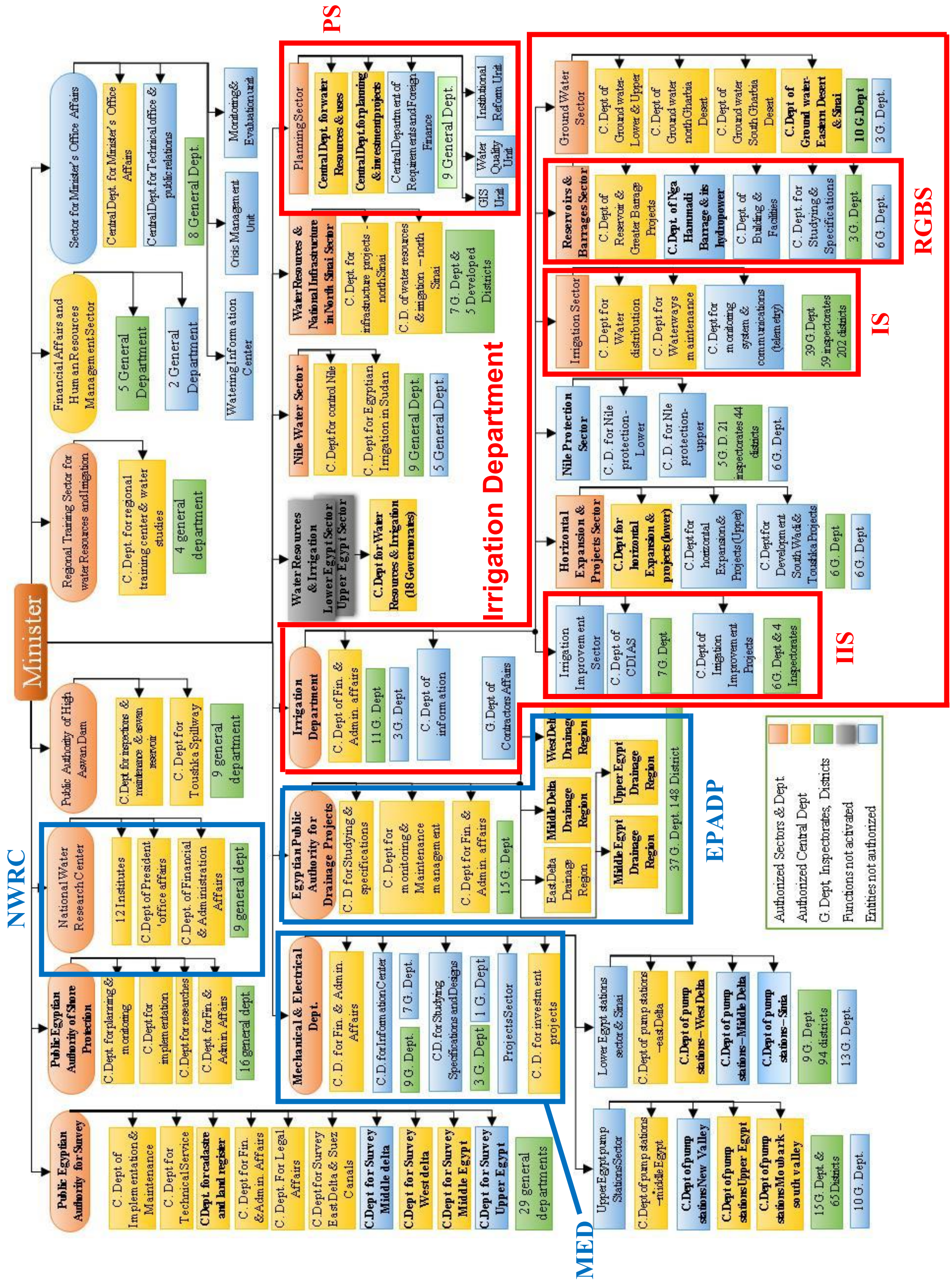
Governorate	CD	GD	Inspectorate	ID	Area(feddan)
Minya	Minya	East Minya	South	East Dirout	22,300
				Dermawas	40,668
				Mallawy	18,783
				East Abu kurras	69,110
			North	East Samalout	49,720
				Matay	32,818
				Beni Maza	43,345
				East Maghagha	49,045
		West Minya	East Bahr Yusef	West Abu Kurka	35,957
				West Minya	27,291
				West Samalout	28,671
				West Maghagha	32,442
			West Bahr Yusef	Monshat El Dahab	19,030
				East Kamadir	22,960
				East Terfa	21,410
				Edwa	37,535
			West Samalout	West Kamadir	12,450
				West Terfa	19,550
				Sakoula	12,000
Beni Suef	Beni Suef	Beni Suef	South	Fashen	51,970
				Somsta	47,679
				Beba	43,778
				East Beni Suef	27,760
			North	West Beni Suef	45,389
				Ahnasia	38,639
				Nasr	38,328
				El Wasta	45,027
Faiyum	Faiyum	Faiyum	East Faiyum	Faiyum	35,291
				Silaa	33,363
				Tamaya	47,015
				Senoures	53,279
				Absh way	56,444
			West Faiyum	Esta	46,425
				El Gah	32,762
				Qota	26,500
				El Nazla	35,634
Gharbia	Gharbia	Gharbia		Tanta	69,415
				Qotour	

*Area include not only Bahr Yusef and Ibrahimia but also other canal's command area.
Source: JICA Survey Team made by lists of from each ID.



Source: JICA Survey Team

Figure 2.10 Diagram of Irrigation Local Offices



Source: Information from JICA expert who has been dispatched to Planning Sector in MWRI

Figure 2.11 Organizational Chart of MWRI

2.4.4 Water User Organizations

As previously mentioned, water user organizations (WUOs) are developed into three categories of WUA for the meska level, BCWUA for the branch canal level, and regional DWB for a group of branch canals. Management at the meska level has a long history of cooperative water use activities, which were organized territorially before the Aswan Dam was constructed. At present, organizations for meska were reformed and modernized by the establishment of the Irrigation and Drainage Law (No. 12/1984) and WUA Legalization Law No. 213 (1994). Although DWB exists formally, there are no substantial activities yet. Table 2.9 is an organization outline on WUA, BCWUA and DWB.

Table 2.9 General Information of Water User Organizations

	WUA	BCWUA	DWB
Legal basis	Irrigation and Drainage Law, and WUA legalization law (Laws No.12/Law 213)	MWRI Ministerial ordinance 977	Nothing particular
Organization size	～1,000 feddan	1,000～5,000 feddan	5,000～50,000 feddan
Organizational structure	1. General Assembly: It consists of all beneficiary farmers. 2. Board of Directors: Operating organization of WUA	1. Base unit: organized by region. 2. Representative Meeting: BCWUA's decision making organization 3. Board of Directors: Operating organization of BCWUA	1. Council consisting of representatives of BCWUAs and the administration 2. DWB will be set up after the BCWUAs in the area is set up.
Main Activity	-Regular holding of general meetings and Board of Directors meetings -Participation in Irrigation Improvement Project -Operation and maintenance of facilities and collection of levies for that -Administration of WUA organization -Establishment of rules and formulation of the action plan, budget management -Dispute resolution and resolution between members -Taking necessary training and transferring technology and knowledge to members -Maintain close relationships with government agencies and implement water management in cooperation with other WUAs -The burden of irrigation/ drainage project cost for WUA management part	-Hosting a base unit conference (twice a year) -Council meeting (appointment/dismissal of officers, establishment of a special committee, data collection support by the board of directors, deliberation of issues proposed from each base unit, revision of regulations, decision of annual activity plan and approval of reporting on operational situation, approval of financial planning, approval of key projects that BCWUA is working on, inspection by the Board of Directors) (twice a year) -Board meeting activities (management of functions and activities of BCWUA, coordination among members, negotiation and agreement of contract, compliance with regulations and related laws and ordinances, employment of staff, resolution of disputes concerning water management, negotiation, implementation of the annual plan)	- Adjustment and management of water distribution among BCWUAs

Source: Prepared by JICA Survey Team based on reports of SWMT.

Table 2.10 shows the establishment of irrigation associations by region.

Table 2.10 Type of WUO and Number of Established Number by Them as of April 2017

WUO categories	WUA			BCWUA			DWB		
Scale of WUO	～1,000 feddan			1,000～5,000 feddan			5,000～50,000 feddan		
Jurisdictions* /Item	Established	Target	Established ratio	Established	Target	Established ratio	Established	Target	Established ratio
East Delta	88	-	-	741	741	100%	0	0	0
Middle Delta	1,021	-	-	440	1,002**	43.9%	2	45	4.4%
West Delta	672	-	-	162	482	33.6%	6	7	85.7%
North Valley	24	-	-	159	323	49.2%	2	2	100%
Beni Suef	48	-	-	19	165	11.5%	0	0	0
Middle Valley	435	-	-	70	370	18.9%	1	1	100%
South Valley	75	-	-	427	1,127	37.9%	0	33	0
Total	2,363	-	-***	2,018	4,210	47.9%	11	85	12.9%

*: These jurisdictions are in accordance with the CDIAS's ones which were revised in April 2017.
**: It has been revised as it is, the previous number was at 620 as of December 2016.
***: Though the responsible organization (IIS) has not declared the target number of the WUA establishment, the current established ratio is estimated at around 5% taking the fact that there are about 10-15 meskas in a branch canal in average. In addition, the total target number of the WUA establishment is assumed at around 70,000 in entire Egypt.
Source: JICA Survey Team

The establishment ratio of WUOs varies largely by region. The differences may depend on whether regions had been a target area of donor-funded projects that had focused on the establishment of WUOs.

2.5 Environmental and Social Considerations

2.5.1 Legislative System Related to Environmental and Social Considerations in Egypt

(1) Fundamental Laws and Regulations

The Egyptian laws and regulations related to environmental and social considerations are shown in Table 2.11. Among these, Law No. 4/1990 is the principal law on the environment, while "Guidelines of Principles and Procedures for Environmental Impact Assessment (2nd edition)" regulates the EIA principle and procedure.

Table 2.11 List of Fundamental Laws and Regulations on Environmental and Social Considerations and Water-Related in Egypt

Law No.		Name
Overall		
The Constitution, 2014 Article 44: The State shall protect the River Nile, preserve Egypt's historical rights thereto, rationalize and maximize its use, and refrain from wasting or polluting its water. The State shall also protect groundwater; adopt necessary means for ensuring water security; and support scientific research in that regard. Article 45: The State shall protect its seas, shores, lakes, waterways, and natural protectorates. Article 46: Environment protection is a national duty. The State shall take necessary measures to protect and ensure not to harm the environment.		
EIA Guidelines		
Guidelines for Principles and Procedures for Environmental Impact Assessment 2nd Edition, EEAA (January/2009)		
Natural Environment Aspects		
Law No.	31/1976	Public cleanliness (control of solid waste management, amendment of Law No. 38/1967)
Law No.	27/1978	Public water sources (drinking and domestic purposes)
Law No.	137/1981	Control of workplace safety and the environment.
Law No.	48/1982	Protection of Nile and its waterways
Law No.	12/1984	Irrigation and Drainage (Amended in some parts by Law No. 213/1994, Legalizes WUAs)
Law No.	102/1983	Natural protection
Law No.	4/1994	Environment Law, amended by 105/2015 (Amended of some parts by Law No. 9/2009)
Law No.	66/1973	Transport Air Pollution

Law No.		Name
Law No.	93/1962	Wastewater and Drainage (control of wastewater discharges and drainage to public sewers and specifies standards for waste disposal to sewers and for use in irrigation)
Law No.	53/1966	Agriculture law
Law No.	58/1937	Criminal and penal law on loud voices and noises during the night (Amended by Law No. 50/2014)
Law No.	124/1983	Fisheries law
Social Aspects		
Law No.	577/1954	Expropriation of the real estate for public interest or for improvement (Amended of some parts by Law No. 252/1960)
Law No.	27/1956	Expropriation of real estate for public interests and its procedure (Amended in some parts by Law No. 10/1990)
Law No.	140/1956	No work can be conducted on public roads without a license from the competent authority.
Law No.	100/1964	On lease of state-owned property
Law No.	59/1979	Setting up for the new urban communities
Law No.	3/1980	Urban planning law
Law No.	4/1996	Applying the provision of the Civil Code to places not previously leased, and places with expired or expiring lease contracts without anyone having the rights to remain in them.
Law No.	12/2003	Labor Code
Law No.	94/2003	Establishing the National Council for Human Rights
Archaeological Aspects		
Law No.	117/1983	Cultural heritage

Source: Prepared by JICA Survey Team

(2) International Conventions

Egypt has signed various multilateral environmental agreements as shown in the table below.

Table 2.12 International Conventions List regarding Environment

Name of Convention	Date of Signature	Date of Ratification	Date of Entry into Force
Nile Basin Initiative			
An intergovernmental partnership of 10 Nile Basin countries formed in February 1999			
Climate Change			
UN Framework convention on Climate change (UNFCCC)	6/9/1992	12/5/1994	3/5/1995
Kyoto Protocol	3/15/1999	1/12/2005	4/12/2005
Vienna Convention on the protection of the ozone layer	3/22/1985	5/9/1988	
Montreal Protocol on substances that deplete the ozone layer	9/16/1987	8/2/1988	
Paris Agreement	4/22/2016		
Hazardous Substances and Wastes			
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal		1/8/1993	
Stockholm Convention on Persistent Organic Pollutants	5/17/2002	5/2/2003	
Convention on the Ban of the Import into Africa and The control of Transboundary Movement and Management of Hazardous Wastes within Africa (Bamako Convention)	1/30/1991	5/18/2004	
Marine Pollution			
Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (Jeddah Convention)		5/31/1990	8/20/1985
Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean	2/16/1976	8/24/1978	7/9/2004
Nature Conservation			
United Nations Convention on Biological Diversity (UNCBD)	6/9/1992	6/2/1994	
Cartagena Protocol on Biosafety to the Convention on Biological Diversity	12/20/2000	12/23/2003	3/21/2004
Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization	1/25/2012	10/28/2013	
Ramsar Convention on Conservation and Wise Use of Wetlands			9/9/1988
Agreement on the Conservation of Cetaceans of the Black Sea, the Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)		4/19/2010	7/1/2010
Convention on the Conservation of Migratory Species of Wild Animals (CMS), Bonn Convention			11/1/1983
Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)	8/20/1997	11/1/1999	11/1/1983

Source: Prepared by JICA Survey Team based on EEAA web page

(3) Relevant Authorities Concerned with Environmental and Social Consideration

The table below lists the relevant authorities concerned with environmental and social consideration in the irrigation sector.

Table 2.13 Authorities in the Irrigation Sector Concerned on Environmental and Social Considerations

Authority	Mandate/Relation
Ministry of Water Resources and Irrigation (MWRI)	Possible Project Proponent
Egyptian Environmental Affairs Agency (EEAA)	Authority of EIA Approval
Ministry of Agriculture and Land Reclamation	Authority regarding agriculture
Ministry of Housing Utilities, and Urban Communities	Authority regarding drainage
Ministry of Health and Population	Authority regarding water quality
Egyptian General Authority for Land Survey	Authority for Assessment of resettlement
Minya Governorate and MWRI General Directorate	Possible Local government authority in the project area
Beni Suef Governorate and MWRI General Directorate	Possible Local government authority in the project area
Faiyum Governorate and MWRI General Directorate	Possible Local government authority in the project area
Garbia Governorate and MWRI General Directorate	Possible Local government authority in the project area

Compiled: JST

2.5.2 The Egyptian EIA System

(1) Organization of EEAA and Its Structure

EEAA is the responsible organization for EIA designated by Law No. 4 of 1994. The figure below shows the EEAA Organization Structure.

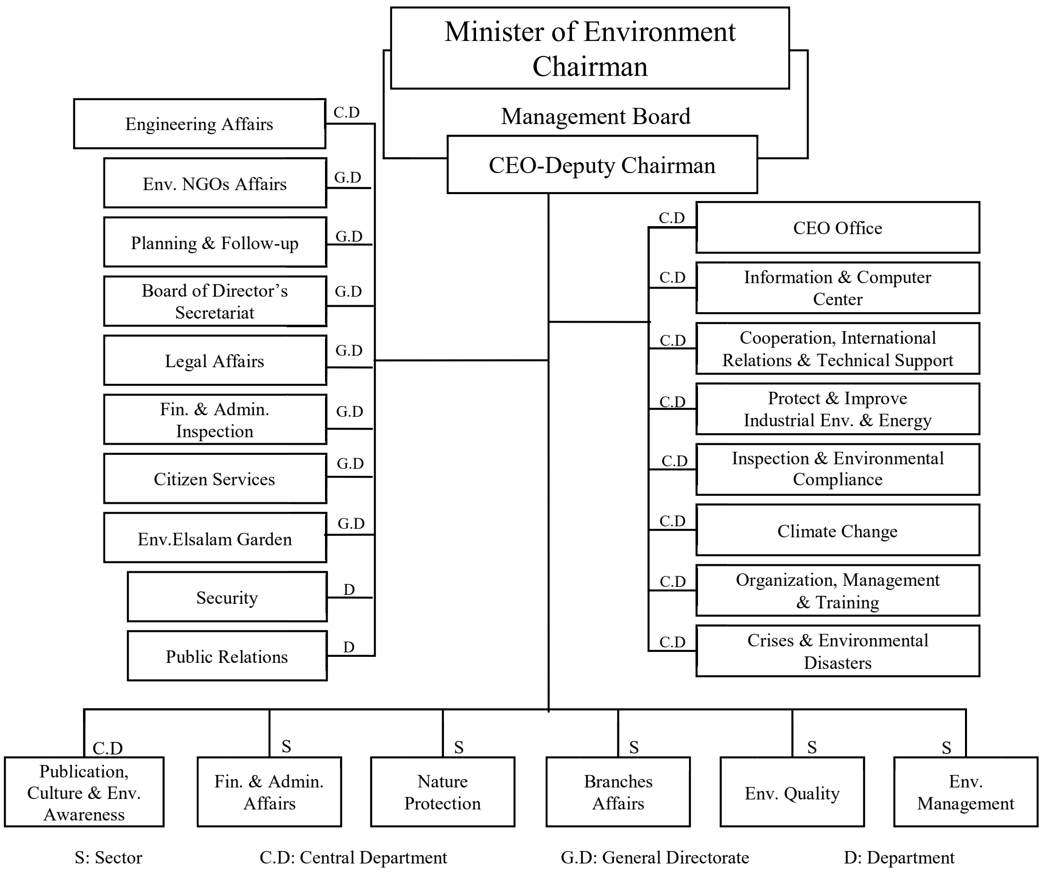


Figure 2.12 Organization Structure of EEAA

(2) Categorization of Projects

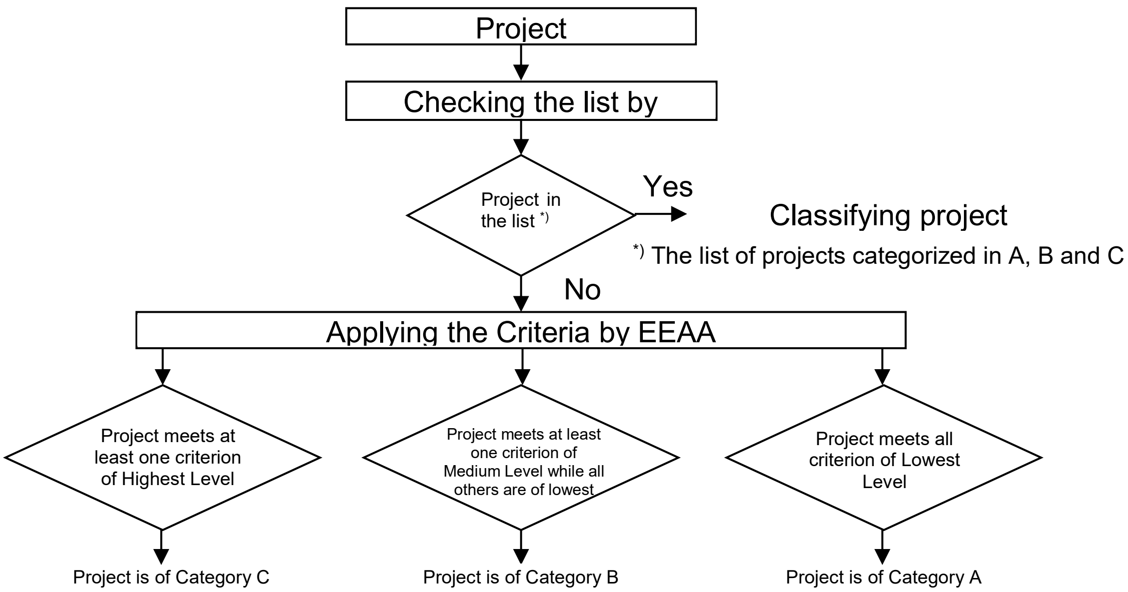
The ERs (Executive Regulations) of Law No. 4/1994 identify projects, which should be subjected to an EIA based on the following main principles: i) Type of activity undertaken by the establishment, ii) The extent of natural resources exploitation, iii) Location of the establishment and iv) Type of energy used to operate the establishment.

The EIA system classifies the projects into three categories based on different levels of EIA requirements according to the severity of possible environmental impacts and location of the establishment and its proximity to residential settlements:

Table 2.14 Categorization of a Project

Category	Contents
A	Projects with minimum environmental impacts. These are required to complete an environmental impact assessment **form A**.
B	Projects with potential adverse environmental impacts yet less adverse than category C. These are required to complete an environmental impact assessment **form B**.
C	Projects that have highly adverse impacts. These are required to prepare a full **EIA study.**

Category A projects defined by the JICA Guidelines generally include i) vital sectors which may cause significant impact, such as agriculture with large-scale irrigation, ii) projects which may cause large-scale involuntary resettlement, or iii) projects located in/around sensitive areas. On the other hand, according to the Egyptian guidelines, medium-sized irrigation and drainage projects are categorized in Category B, and large-scale irrigation and drainage projects, dams and barrages are listed in Category C that needs full-scale EIA. Figure 2.13 shows a flow that summarizes the above decision rules.



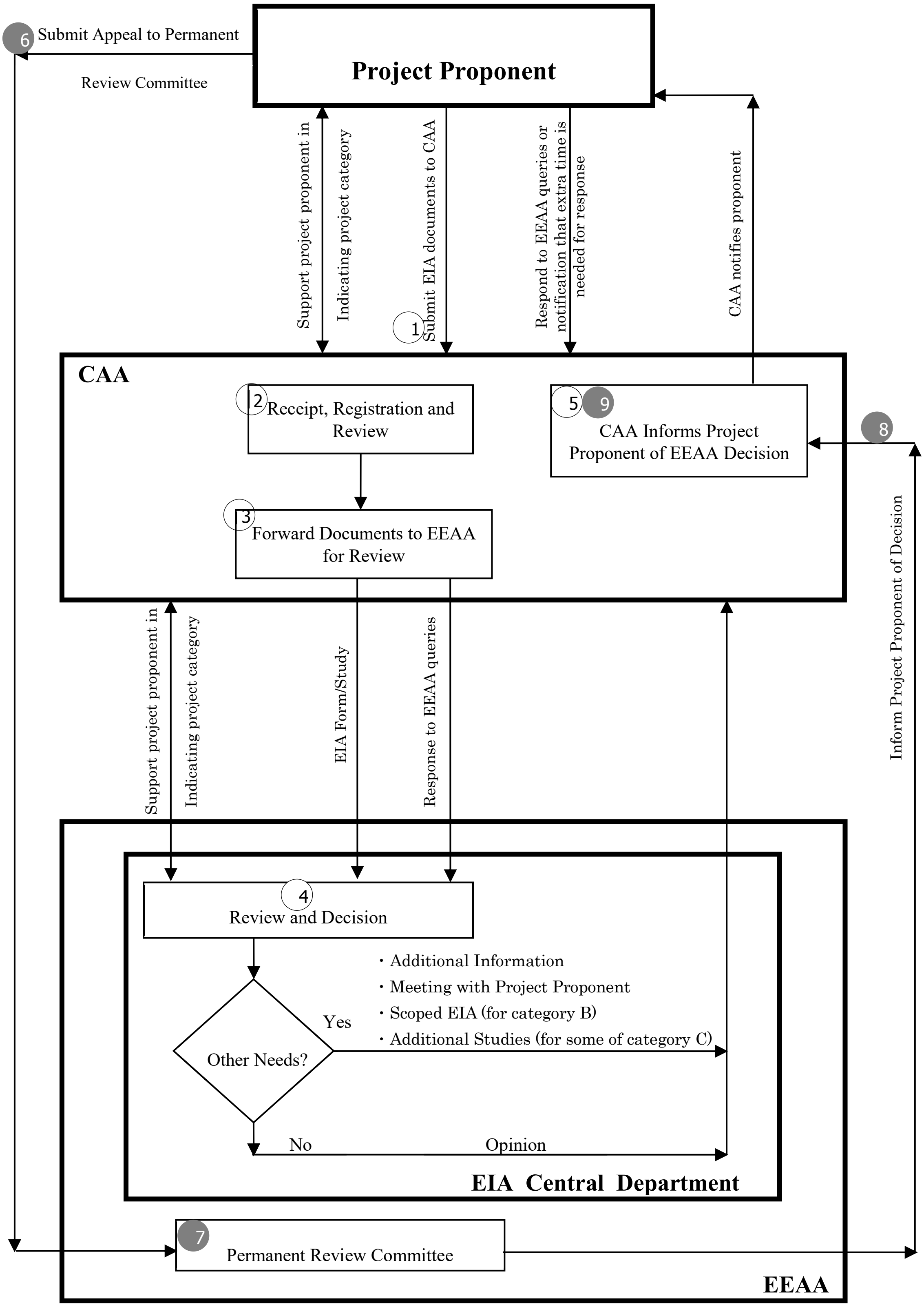
Source: Prepared by JICA Survey Team based on the Egyptian EIA guideline

Figure 2.13 EIA Project Classification Process for Projects

(3) EIA Procedure

Each of the three categories has specific requirements for impact assessment, but there are similar processing procedures as follows. The EIA scheme procedure flow is shown below.

1. The Competent Administrative Authority (CAA) directs the project proponent to the correct project category and explains the related requirements. EEAA should make the final decision regarding the classification and should provide the proponent with its opinion in writing via the CAA.
2. The project proponent applies to the CAA, before any construction work is initiated, with a letter of intent and attaches the required EIA documents (forms/study report).
3. The CAA evaluates the EIA documents by examining the forms/study report to ensure that the selected category is correct and that the project is compatible with the general plans for the CAA. The submitted information is also examined in terms of compliance with the requirements and its completeness. If the project is not correctly categorized, the CAA directs the proponent to the right category and requests the resubmittal of the required documentation.
4. The CAA formally forwards the documents to EEAA for review and evaluation. Such forwarding of the EIA documents is considered as a non-objection to the project according to criteria other than environmental ones.
5. EEAA reviews and evaluates the documents and provides its remarks and conditions needed for mitigation and minimization of negative impacts.
6. EEAA notifies the CAA of its decision (approval, objection, or information requests, etc.) within 30 days of EEAA's receipt of completed documents, or else it is considered an implicit approval.
7. For projects deemed having high-level impacts by EEAA, an independent advisory entity will be considered by EEAA for additional advice. The review could require site inspection or meetings with the proponent to discuss specific points of the study.
8. EEAA registers the documents, its opinion, and recommendations in the EIA register at EEAA and notifies the CAA of its decision.
9. The CAA officially notifies the project proponent of the results via a registered letter with an acknowledgment of receipt and shares the results of the review. The results may be:
   (a) An approval of the EIA form/study report, while containing information on the environmental requirements (specified in the approval) with which the project proponent should comply.
   (b) An objection of the EIA and a recommendation to refuse the project. It includes the reasons for the objection that usually relate to environmental issues concerning the maximum carrying capacity for pollution in the project area or the planned project area.
   (c) Further requests from the proponent.
   - Additional information or clarifications could be requested from the project proponent. The date of the receipt of the needed information to EEAA via the CAA is considered as a new review process with a 30-day period.
   - For some of the category B projects, EEAA might request a scoped EIA study for certain components, impacts, or processes of the project in accordance with the Terms of Reference
   - In the case of some of the category C projects, EEAA could request additional studies such as risk assessment or cumulative pollution load (information to be provided through EEAA) to ensure compliance with allowable limits.
   - The CAA follows up and ensures the implementation of EEAA decisions and related conditions.



Source: Egyptian EIA guideline
Note: ① ~ ⑨ are the order of procedure. If there is any doubt about the decision of EEAA, request retrial in ⑥.

Figure 2.14 EIA Procedure

(4) Role of Competent Administrative Authorities (CAAs) in the EIA System

The CAAs are the entities responsible for issuing a license for project construction and operation. The EIA is considered one of the requirements for a license. The CAAs are thus responsible for receiving the EIA forms or study reports, checking the information included in the documents concerning the location, suitability of the location to the project activity and ensuring that the activities and the location do not contradict the surrounding activities and related ministerial decrees. The CAA forwards the documents to EEAA for review. Members of CAA are shown in the table below.

Table 2.15 Member of Competent Administrative Authorities (CAA)

Authority	Type of Projects
Ministry of Health and Population	Hospitals and medical centers
Ministry of Agriculture and Land Reclamation (MALR)	Agricultural and land reclamation projects
Ministry of Water Resources and Irrigation (MWRI)	Irrigation, agricultural drainage, barrages and dams
Ministry of Transportation	Large transport projects such as roads, airports, railways and large transportation systems as well as marine transportation including ports and marine platforms
Ministry of Housing, Utilities & Urban Development (MOH)	Urban development projects, residential complexes, water treatment plants, domestic wastewater treatment plants on the city level as well as tourism cities affiliated to the Ministry
The Ministry of Electricity and Renewable Energy	Power generation projects and electricity grids
Ministry of Petroleum and affiliated petroleum/gas entities	Projects related to petroleum, gas, and petrochemicals.
Industrial City Councils	Projects within industrial cities
Tourism Development Agency (TDA)	Tourism projects in lands affiliated to the TDA
General Authority for Investment and Free Zones	Projects that are within the free or investment zones or projects established according to the Law of Investment, 8/1997
General Authority of Industrial Development affiliated to the Ministry of Industry	Development of industrial estates
Nature Protection Sector in EEAA	Projects within the boundaries of the natural protectorates

Source: Prepared by JICA Survey Team based on the Egyptian EIA guideline

(5) Public Consultation

The involvement of the public and concerned entities in the EIA planning and implementation phases is mandatory for Category C projects through the public consultation process with concerned parties. Public consultations follow the EIA process and thus deal with mainly environmental and social aspects related to the project. Consultation activities are undertaken twice during the EIA process. The first consultation takes place in the phase of identifying the scope of EIA and the second will be after the preparation of the draft EIA.

2.5.3 Environmental Standards

Major environmental standards that must be considered for an irrigation project are summarized as follows:

(1) Air Quality

Law No. 4/1994 provides the maximum allowable limits for ambient air pollutants as shown in Table 2.16.

Table 2.16 Maximum Limits of Outdoor Air Pollutants

Pollutant	Area	Maximum Concentration (Microgram/m^3)			
		Hour	8 Hours	24 Hours	Year
Sulfur dioxide	Urban areas	300	-	125	50
	Industrial areas	350	-	150	60
Carbon monoxide	Urban areas	30 mg/m^3	10 mg/m^3	-	-
	Industrial areas	30 mg/m^3	10 mg/m^3	-	-

Pollutant	Area	Maximum Concentration (Microgram/m^3)			
		Hour	8 Hours	24 Hours	Year
Nitrogen dioxide	Urban areas Industrial areas	300 300	- -	150 150	60 80
Ozone	Urban areas Industrial areas	180 180	120 120	- -	- -
Total suspended solid particles	Urban areas Industrial areas	- -	- -	230 230	125 125
Solid particles less than 10 micrometer	Urban areas Industrial areas	- -	- -	150 150	70 70
Solid particles less than 2.5 micrometer	Urban areas Industrial areas	- -	- -	80 80	50 50
Solid particles measured as smoke	Urban areas Industrial areas	- -	- -	150 150	60 60
Lead	Urban areas Industrial areas	- -	- -	- -	0.5 1
Ammonia	Urban areas Industrial areas	- -	- -	120 120	- -

Source: Law No.4/1994

(2) Agricultural Drainage

Decree No. 402/2009 on the protection of the Nile River and Canals (amendment of Law No. 48/1982) sets the water quality standards for agricultural drainage as shown in the table below.

Table 2.17 Water Quality Standards for Agricultural Drainage

Description	Standard and Specifications (Milligram/Liter Unless otherwise mentioned)	Description	Standard and Specifications (Milligram/Liter Unless otherwise mentioned)
Total dissolved solids	Not more than 1000	Copper	Not more than 1
Temperature	Not more than 3 degrees above the receiving waterway	Zinc	Not more than 2
Dissolved oxygen	Not less than 5	Phenol	Not more than 0.05
Hydrogen exponent	Not less than 6.5, and not more than 8.5	Arsenic	Not more than 0.01
BOD	Not more than 30	Cadmium	Not more than 0.03
COD	Not more than 50	Chromium	Not more than 0.05
TN as N	15	Cyanide	Not more than 0.01
TP as P	3	Lead	Not more than 0.01
Oil and grease	Not more than 3	Nickel	0.1
Mercury	Not more than 0.001	Selenium	0.01
Iron	Not more than 3	Probable enumeration for the colonic group 100 cm^3	5000
Manganese	Not more than 2		
Pesticides which include:			
Aldrin and dieldrin	Not more than 0.003	Chlordane	Not more than 0.002
Alachlor	Not more than 0.2	2, 4-dichloroprop	Not more than 0.3
Aldicarb	Not more than 0.1	Fenoprop	Not more than 0.09
Atrazine	Not more than 0.02	Mecoprop	Not more than 0.1
Bentazone	Not more than 0.3	2, 4, 5-T	Not more than 0.09
Carbofuran	Not more than 0.07		

Source: Decree No. 402/2009

(3) Noise

Law No. 4/1994 sets the maximum allowable limits for ambient noise intensity as shown below.

Table 2.18 The Maximum Permissible Limit for Noise Intensity in the Different Areas

Type of area		Permissible limit of the equivalent noise level (A) LAeq in Decibels	
		At day and evening (from 7 am to 10 pm)	At night (from 10 pm to 7 am)
1)	Areas sensitive to exposure to noise*	50	40
2)	Residential suburbs with weak movement and limited service activities	55	45
3)	Residential communities in towns with commercial activities	60	50
4)	Residential communities located on roads less than 12 meters, wherein there are some workshops, commercial activities, administrative activities, recreational activities or amusement parks	65	55
5)	Areas located on roads the width of which is 12 meters or more, or industrial zones with light industries and some other activities	70	60
6)	Industrial zone with heavy industries	70	70

Source: Law No. 4/1994

Day: from 7 a.m. to 6 p.m.
Evening: from 6 p.m. to 10 p.m.
Night: from 10 p.m. to 7 a.m.

(4) Other Standards

In addition to the above environmental quality standards, Law No. 4/1994 also regulates the emission standards for sources of air pollution such as factories and vehicles, as well as effluent standards for wastewater discharge from industries. It also presents standard provisions for intermittent noise generated from heavy hammers, workplace standards on air and noise conditions, etc.

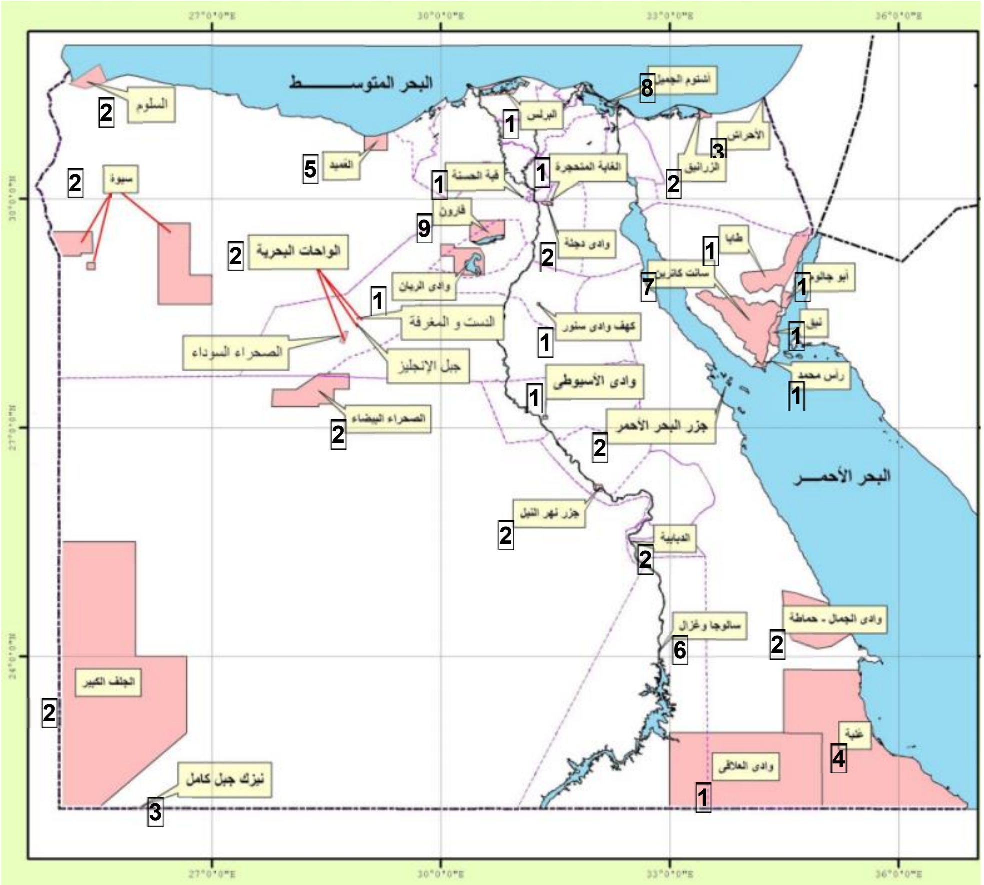
2.5.4 Basic Environmental Situation

(1) Natural Protectorates

The natural protectorates and the important wild bird habitats in Egypt defined by Law No. 102/1983 for Natural Protectorates are shown in Figure 2.15 and Figure 2.16. Among the natural protectorates, No. 2, 9, 10, and 19 are for wetlands registered in the Ramsar convention. Lake Qarun of No. 9 and Wadi El Rayan of No. 10 are located downstream of the Faiyum Governorate as shown in Figure 2.17. Both lakes are designated as Egyptian Natural Protectorates, important wild bird habitats[9], and Ramsar Convention wetlands. They are both salt lakes. Lake Qarun is located 25 km northwest, whereas Wadi El Rayan is located 35 km west of Faiyum city center. Both lakes and their buffer zones are designated as nature protectorates, but they do not overlap the project site.

Lake Qarun is the third largest lake in Egypt, and the source of water is drainage from two large drains (El Bats and El Wadi) in the Faiyum district. It has an area of 240 km^2, an altitude of -45 m and a water depth of 4 to 8 m. The water level is strictly controlled by the drainage agency (EPADP) so as not to influence the aquifer in Faiyum district, and if it rises, the water is drained to the adjacent Wadi El Rayan.

9 IBAs: Important Bird and Biodiversity Area, managed by international nature conservation partnership Bird Life

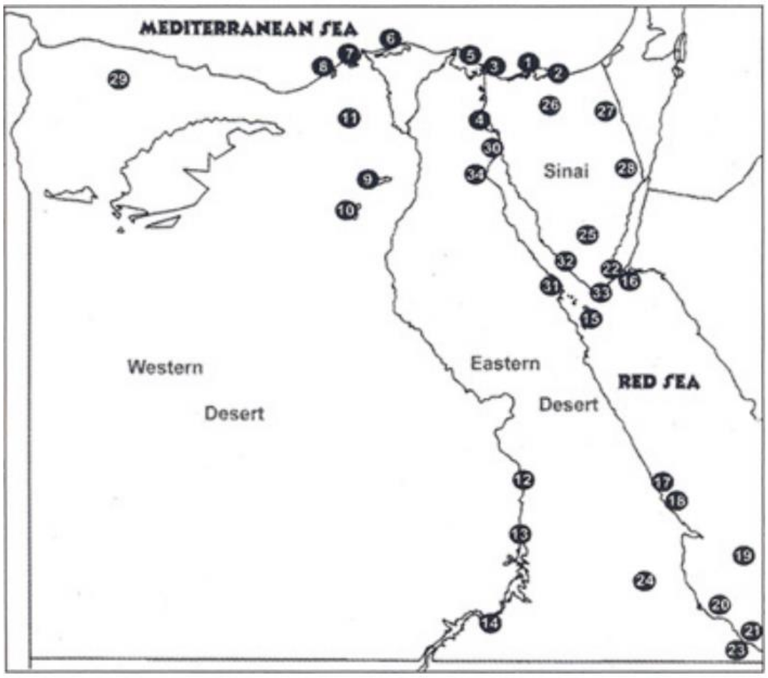


Source: Prepared by JICA Survey Team based on EEAA web page

No.	Protectorates Names	Area km²	Governorate	No.	Protectorates Names	Area km²	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 Progectorate	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 Faiyum	24	Wadi El-Gemal/Hamata	7,450	Red Sea
10	Wadi El Rayan Protectorate*	1,225	El Faiyum	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	-	New Valley

Source: Prepared by JICA Survey Team based on EEAA web page. *: No. 2, 9, 10, and 19 are registered in the Ramsar site.

Figure 2.15 Egyptian Natural Protectorates



1- Lake Bardawil	10- Wadi El Rayan	19- Zabargad Island	27- Quseima
2- Zaranik	11- Wadi El Naturn	20- Siyal Islands	28- Wadi Gerafi
3- El Malaha	12- Upper Nile	21- Rawabel Islands	29- El Qasr Desert
4- Bitter Lakes	13- Aswan Reservoir	22- Nabaq	30- Suez
5- Lake Manzalla	14-Lake Nasser	23- Gabel Elba	31- Gabel El Zeit
6- Lake Burullus	15-Hurghada Archipelago	24- The Abraq Area	32- El Qa Plain
7- Lake Idku	16- Tiran Island	25- St. Katherine	33- Ras Mohammed
8- Lake Maryut	17- Wadi Gimal Island	26- Gabel Maghara	34- Ain Sukhna
9- Lake Qarun	18- Qulan Island		

Source: Prepared by JST based on EEAA web page

Figure 2.16 Distribution of IBAs in Egypt

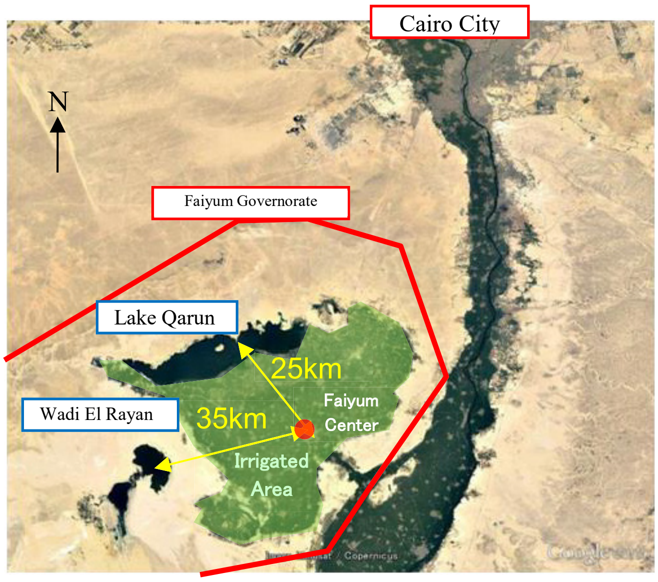


Figure 2.17 Location of Lake Qarun and Wadi El Rayan

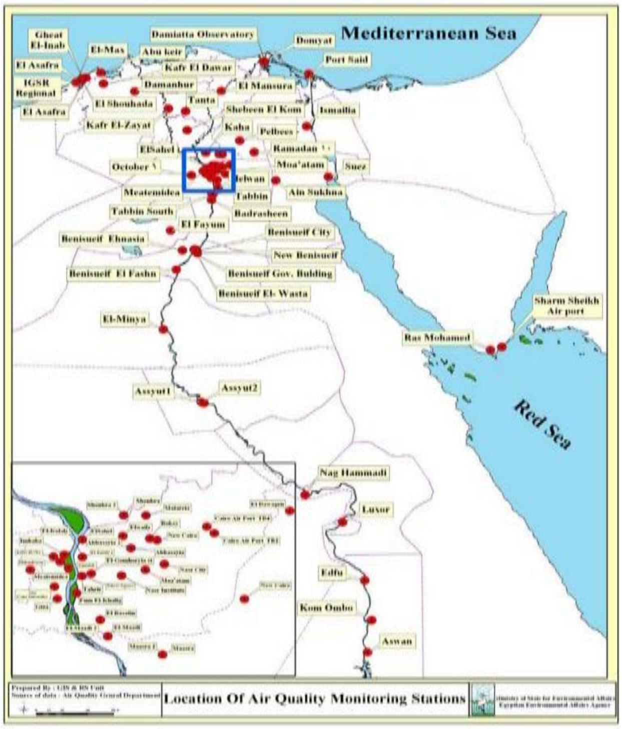
(2) Air Pollution

A national monitoring network for air pollutants consists of stations of six classifications: (1) Industrial areas, (2) Urban areas, (3) Residential areas, (4) Traffic areas, (5) Remote Reference zones, and (6) Areas with nature overlapping the activities. Monitoring takes place at 87 stations distributed all over the different regions of Egypt as shown in Table 2.19 and Figure 2.18.

Table 2.19 Geographical Distribution of Air Monitoring Stations Affiliated to MSEA during 2012

Station / Type	Greater Cairo	Alexandria	Delta	Upper Egypt	Sinai and Canal Cities	Total
Industrial	8	3	4	3	1	19
Urban	9	1	4	7	-	21
Residential	5	2	2	2	-	11
Traffic	10	-	-	1	-	11
Remote	4	1	1	1	2	9
Mixed	12	1	2	1	-	16
Total	48	8	14	15	3	87

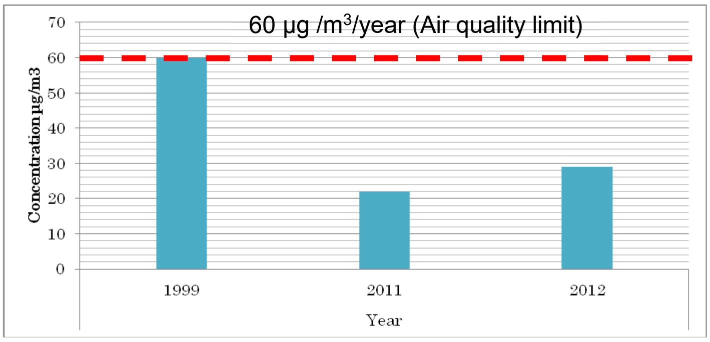
Source: Egypt State of Environment Report 2012, issued 2015, EEAA



Source: Egypt State of Environment Report 2012, issued 2015, EEAA

Figure 2.18 Distribution of Air Monitoring Stations in Egypt

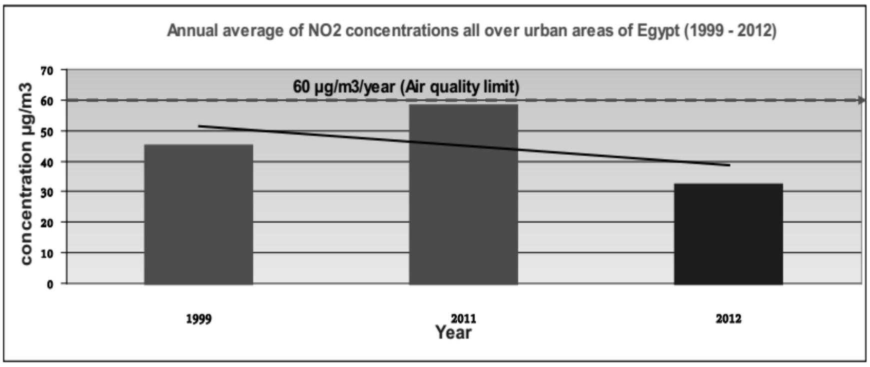
According to the results of sulfur dioxide concentration in all monitoring stations of the Republic in 2012, none of the annual average concentrations exceeded the annual permissible limit (60 μg/m^3) in 2011 and 2012.



Source: Prepared by JST based on Egypt State of Environment Report 2012, issued 2015, EEAA

Figure 2.19 Annual Average of Sulfur Dioxide Concentration in Egypt during 1999-2012

The results of the annual average nitrogen dioxide concentrations, which were monitored at air quality monitoring sites in urban areas nationwide, are shown in the figure below. The estimated annual average concentration in 2012 (32 µg/m^3) was lower than the maximum allowed by law (60 µg/m^3 in the air as an annual average in urban areas (shown in Table 2.16).

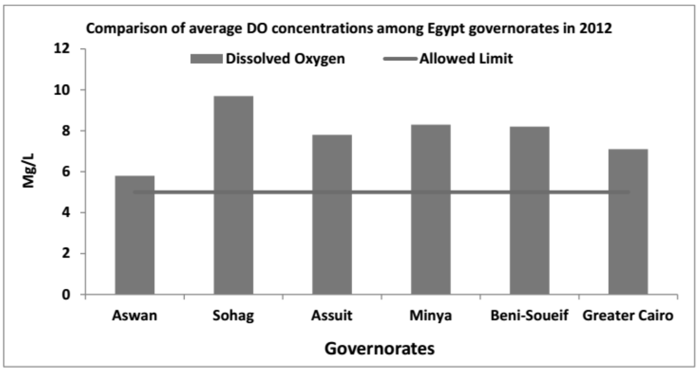


Source: Egypt State of Environment Report 2012, issued 2015, EEAA

Figure 2.20 Annual Average of Nitrogen Dioxide Concentrations All Over Urban Areas of Egypt (1999-2012)

(3) Water Quality

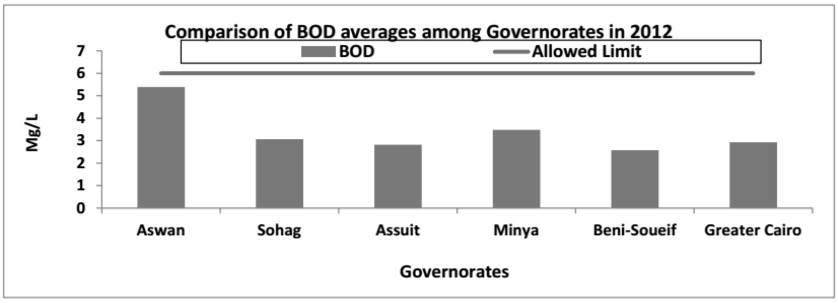
Monitoring results of the Nile River's water quality in different governorates from Aswan to Greater Cairo during 2012 show gradual improvements that imply that the River Nile has the ability of self-purification. PH average values range between 7.15 and 8.61, which indicate that the water tends to be slightly alkaline but within tolerable limits. The average concentration of dissolved oxygen (DO) in all governorates from Aswan to Greater Cairo exceeds the minimum allowed concentration for water quality (5mg /L), with a range of (5.83 - 9.71 mg/L) and an overall average of (7.81mg /L). Comparison between average concentrations of DO is shown in Figure 2.21.



Source: Egypt State of Environment Report 2012, issued 2015, EEAA

Figure 2.21 Comparison between Average Concentrations of Dissolved Oxygen among Governorates of Egypt during 2012

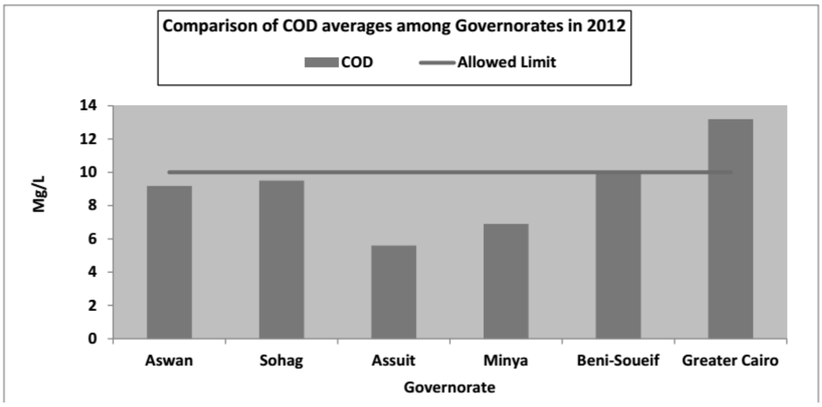
The average concentration of organic matters represented in biological oxygen demand (BOD) is below the allowed limit (6 mg/L) for water quality for the River Nile in all governorates from Aswan to Greater Cairo. It ranges between (2.57 - 5.38 mg/L) with an overall average of (3.37 mg/L) as clarified in Figure 2.22.



Source: Egypt State of Environment Report 2012, issued 2015, EEAA

Figure 2.22 Governorates Average Concentrations of BOD in Egypt in 2012

Average values of chemical oxygen demand COD are less than the allowed limit (10 mg/L) in most governorates overlooking the Nile River, except for greater Cairo, where COD concentrations tend to be higher than the permissible limit due to industrial effluents within the governorate (13.20 mg/L). The remaining recorded values range between (5.64 - 9.9 mg/L). Nevertheless, the overall average value for COD throughout the system is (9.03 mg/L), which is still under the allowable limits specified by law. The figure below compares the average values of COD in different governorates in 2012.



Source: Egypt State of Environment Report 2012, issued 2015, EEAA

Figure 2.23 Governorates Average Concentrations of COD in Egypt in 2012

2.5.5 Land Acquisition and Involuntary Resettlement

(1) Institutional Arrangements

Property expropriation and compensation in Egypt are initiated and executed at central, local and stakeholder levels. On the central level, the governmental agency in charge of the implementation of the expropriation acts issued for the public interest is the Egyptian General Authority for Land Survey (ESA), except for projects handled by other entities pursuant to a law to be issued in this respect. ESA is charged with the formation of the expropriation and compensation committees. Usually, the executing entity will be the concerned Ministry or Governorate. Accordingly, this executing entity would be responsible for paying the compensation to affected groups through ESA or under its supervision, offering alternative resettlement options, and implementing the resettlement project. On the local level, several local departments and directorates are involved in the resettlement program as shown in Table 2.20. On the stakeholder level, the relevant NGOs, Community Based Organizations (CBOs) and elected councils together with PAPs play crucial roles in ensuring that the participatory decision-making, planning, implementation, and monitoring process are inclusive and transparent.

Table 2.20 Local Departments and Directorates Concerning the Resettlement Program

Authority	Responsibility
Directorate of Housing and Infrastructure	To set the alternative resettlement options for the affected group, to participate in all operational procedures that concern defining compensation, and to set improvement actions within informal settlements.
Department of Physical Planning	To prepare the detailed plans for areas subjected to resettlement and provide all detailed maps and documents required to define the affected groups (e.g., roads right-of-ways, Setbacks.)
Department of Amlak (property)	To provide all required documents for ownership or tenure status within the affected areas with all attached historical documents for those properties that show the different transactions of the properties.
Department of Land Surveying	To define the size, area, and locations of different ownership to be affected by the resettlement. It is also responsible for defining the compensation mechanisms and values, in cooperation with ESA and other relevant local bodies.
Department of Social Affairs	To conduct all field surveys required to identify the affected groups, their socioeconomic status, their affordability level, and their preference against different resettlement options and compensations mechanisms. To mitigate the negative impact of resettlement whether during or after resettlement, through the preparation of rehabilitation programs for those affected groups and monitoring of the impact of the process
Department of Legal Affairs	To deal with legal issues related to tenure and ownership and resolve a dispute between different involved parties
Head of Local Governorate Units (LGUs)	To manage the overall project where the resettlement is involved
Agricultural Associations,	Representing the Ministry of Agriculture on the village level, to assess the compensation values related to the temporary or permanent acquisition of agriculture land and the compensation for crops and trees.

Source: JICA Survey Team

(2) Fundamental Laws and Regulations on Land Acquisition and Involuntary Resettlement

The relevant regulations on land acquisition and resettlement are given in Table 2.21.

Table 2.21 Laws and Regulations on Land Acquisition and Involuntary Resettlement

Law No.	Remarks
The Constitution /2014	Article 33: The State shall protect ownership of its three types: the public, the private, and the cooperative. Article 35: Private properties shall be protected, and the right to inheritance thereto is secured. Expropriation shall be allowed only in the public interest and for its benefit, and against fair compensation to be paid in advance according to the Law.
Law No. 577/1954	Expropriation of the real estate property for public benefit and improvement (amended by Law 252/1960 and Law 13/1962)
Law No. 27/1956	Expropriation of districts for re-planning, upgrading, and improvement
Law No. 10/1990	Expropriation of real estate for public interest and its procedure (Amendment of Law No. 27/1956) Public interest includes: − Construction of roads, streets, squares, or their broadening, modification, paving, or the constructing of entirely new districts. − Sanitary drainage and water projects − Irrigation and drainage projects − Electricity/power projects − Construction of bridges and the surface paths (slides, lower passages, or modifying them) − Transportation projects − Urban/rural planning and improvement of infrastructure − All activities that are considered to be of public benefit as per any other law − Other public benefit activities may be added as per Cabinet of Ministries Decree(s) − The decision ruling public benefit activities shall be in accordance with a Presidential decree and shall have a memorandum of the project enclosed. The law also defines that the owners are eligible to be compensated for loss due to land acquisition.
Law No. 140/1956	On public road occupation. No work can be conducted on public roads without a license from the competent authority.

Law No.		Remarks
Law No.	59/1979	Setting up for the new urban communities
Law No.	3/1982	Physical planning law Article 40: prohibits commencing resettlement before one month from official notice. Article 47: authorizes the concerned Governor to formulate compensation committee.
Law No.	4/1996	Applying the provision of the Civil Code to places not previously leased, and places with expired or expiring lease contracts without anyone having the rights to remain in them. (Amended by the Law No. 137/2006)
Law No.	94/2003	Establishing the National Council for Human Rights
Law No.	100/1964	On lease of state-owned property

Source: JICA Survey Team

(3) Land Ownership and Related Laws for Land and Structure Expropriation

There are three main forms of land ownership in Egypt:

(a) Public or State land (in Arabic *Amlak Amiriya*), which is divided into the State's public domain that cannot be assigned and the State's private domain, which can be assigned generally through sale, lease, *Takhssiss* (i.e., transfer of ownership conditional on meeting certain criteria, such as keeping the land use unchanged and paying the remaining installments of the land price) or through *Haq Intifaa*, (usufruct)

(b) Private land (in Arabic *Mulk horr*), which may be assigned/transferred freely, and

(c) *Waqf* land (land held as a trust/endowment for religious or charitable purposes), which is often subject to covenants on transfer or use, and which is typically transferred through leasehold or usufruct.

In addition, there are some areas in Sinai and on the northern coast with implicitly recognized **customary rights** to land to the benefit of Bedouins. In these areas, someone wishing to acquire land often has to make two payments, first to the Bedouin claimant(s) for the right of use and then to the State to regularize and register their land tenure/ownership and be able to obtain services.

It is important to note that the Civil Code (No. 131 of 1948) recognizes Hiyaza (i.e., possession of immovable/movable property without ownership, e.g., informal or squatter settlements) as a legitimate channel to acquire ownership of the property in question through adverse possession, provided that the Hiyaza has been "peaceful, unchallenged and uninterrupted" for a period of 15 years. By law, ownership through adverse possession does not, however, apply to State lands.

(4) Procedure for Land Acquisition and Resettlement

According to the Law No. 10/1990, the expropriation procedures involve the following:

(a) Declaration of public interest pursuant to a Presidential Decree accompanied with a memorandum on the required project and a complete plan for the project and its buildings (Law 59/1979 and Law 3/1982 provide that the Prime Minister issues the decree) and,

(b) The Decree and the accompanying memorandum must be published in the Official Gazette. A copy for the public is placed in the main offices of the concerned local government unit. Based on these procedures, the operational steps go as follows:

1) The entity requesting the expropriation of the ownership of a real property for public interest ("Expropriating Entity") submits a memorandum with the request to the President or the Prime Minister (if a delegation of authority by the President is granted). ESA has been defined as the Expropriation Entity, except for projects handled by other entities pursuant to a law to be issued in this respect.
2) The President or the Prime Minister would issue the required decree declaring the property in question appropriated in the public interest and authorizing taking the property pursuant to direct enforcement procedures by the Expropriating Entity.
3) The Expropriating Entity is authorized to enter into the property in question in the case of long-term projects and after giving notice of its intention to do so for other projects. The objective of such immediate authorization is to conduct necessary technical and survey operations, position landmarks, and obtain information on the property.
4) The Expropriating Entity shall communicate the authorizing decree to ESA, together with the information on the

project to be executed and a drawing of the full project and the real property needed in order to take procedures for expropriating the property in question.

5) A **committee** will be formed to determine the properties required for the public interest. The committee is to be composed of:

i) A representative of ESA,

ii) A representative of the local government unit within which jurisdiction the project is located,

iii) The treasurer of the local area in question.

(c) The committee shall declare its activities to the public 15 days prior to the commencement of its works.

(d) The land survey department shall verify the information collected by the committee by comparing such information with that found in the official records.

(e) The General Department of Appraisal within ESA shall inspect the property of the project in question, examine, and complete the appraisal maps and lists of transactions concerning the property within the area of the project. It shall also prepare a consultative report with an estimated compensation document, for consideration by the Committee within ESA.

(f) After depositing the compensation amount by the Expropriating Entity within ESA - the concerned local office - lists of all real properties and facilities being identified shall be prepared, including details of those areas, location, description, names of their owners, and holders of property rights therein, their addresses, and the compensation determined by the Committee.

(g) ESA shall thereafter officially notify the property owners, other concerned parties and the Expropriating Entity with the dates on which the lists prepared shall be presented to them, at least 1 week prior to such presentation. These lists will be posted for a period of 1 month in the offices of the concerned local government unit and shall be published in the Official Gazette and two widespread daily newspapers.

(h) Owners of the properties and holders of rights therein shall be officially notified of an evacuation request within a period not to exceed 5 months from the date of their notification.

(i) The holders of rights include: owners of beneficiary rights, using rights, housing rights, mortgaging rights, concession rights, hekr (ground rent) right holders

(j) Court of Cassation decisions has resolved that rights holders are those who hold rights on the tenement. Accordingly, the holders of leasing rights are regarded as right holders since they are holders of personal rights.

(5) Gaps between Egyptian Regulations and World Bank Policies

The gaps between Egyptian regulations and World Bank policies are summarized in Table 2.22.

Table 2.22 Gaps between Egyptian Regulations and World Bank Policies

	Topic	Egyptian Legislation	World Bank Policy	For Operation Stage
1	Calculation of Compensation	According to prevailing prices in the affected area and assessed by a specialized committee for that purpose	Full replacement cost	This issue is crucial since all previous Egyptian practices of valuation have been substantially below the market rate due to: lack of valuation experience in ESA; no real market rate defined due to taxes; and fees charged on properties.
2	Squatters	The targets for compensation are the property owners. There are no definite plans for compensation for illegal occupants.	Resettlement assistance should be provided (but no compensation for land)	This has to be clearly considered in any resettlement action. Affected people should be offered options for either alternative shelters or fair compensation that enables them to find another shelter.
3	Resettlement	Affected occupants who are physically displaced are to be provided with another residential housing. They do not have the rights to object to the location of the resettlement, but only the housing suitability in terms of area, design, or relevant issues. Their objection is submitted within 15 days after receiving the notification of the new housing, to a dedicated committee for that purpose, which should respond within one month.	Affected people who are physically displaced are to be provided with residential housing, or housing sites, or, as required, agricultural sites at least equivalent to the old site. Preference is to be given to land-based resettlement for Project Affected Persons whose livelihoods are land-based. The resettlement would be based on RAP in case the affected people is 200 or more, while ARAP would be conducted for less than 200.	Affected people should be offered various options for resettlements (not only one option) at least equivalent to the old property or site.

	Topic	Egyptian Legislation	World Bank Policy	For Operation Stage
4	Resettlement assistance	Not included	Affected people are to be offered support after displacement, for a transition period.	This assistance should be included in any resettlement project.
5	Vulnerable Groups	Not included	Particular attention to be paid to vulnerable groups, especially those below the poverty line, the landless, the elderly, women and children, indigenous peoples, ethnic minorities.	Considerable attention should be paid to those groups and give priority in selections for resettlement and financial support to them.
6	Information and Consultation	Not consulted on resettlement options. Not able to participate in planning, implementing and monitoring resettlement.	Project Affected Persons and their communities are provided timely with relevant information, consulted on resettlement options, and offered opportunities to participate in planning, implementing, and monitoring resettlement.	Affected groups should get access to full information about the resettlement process and options for compensation. Participatory planning and decision-making should be applied in resettlement options and compensation.
7	Grievances	Specialized committees for that purpose and time. One month to object to the decision of resettlement. Four months to object to the compensation value	Appropriate and accessible grievance mechanisms to be established.	There is a need for ensuring that affected groups are offered the direct channel for grievance and receive redress in proper time prior to resettlement. The receiving of full compensation should be prior to resettlement.

Source: Prepared by JICA Survey Team based on Resettlement Policy Frameworks for Greater Cairo Natural Gas Connections Project, November 2007

Chapter 3 Policies in the Irrigation Sector and the Direction of Donor Support

In this chapter, the future direction of the policy for the irrigation sector including water resources management in Egypt is confirmed. In addition, past and current cooperation in this sector by development partners are reviewed, and the direction of support for the irrigation sector in the Survey's target area is summarized. Hence, the possibility of the contents and areas of Japan's future cooperation is stated.

3.1 Development Plan Related to the Irrigation Sector

The development plans related to the irrigation sector including water resources are looked at through the review of Egypt Vision 2030 for the general economic and social development of Egypt, NWRP for the water resources sector and SADS2030 for the agricultural sector. In addition, the future direction of the policy for the irrigation sector in Egypt is confirmed.

3.1.1 Egypt Vision 2030

Sustainable Development Strategy: Egypt Vision 2030 aims to outline the direction of development in Egypt, after the movements following the Arab Spring. The strategy was formed from 2014 to 2015 by an approach participated in by various stakeholders in a wide range of sectors, and with arrangements organized by the Ministry of Planning, Monitoring and Administrative Reform. It shows the 15-year nationwide course to achieve sustainable development that Egypt is targeting, and a way for policies to be externally applied at three stages, namely the revision-, recovery- and advanced-stage.

Egypt Vision 2030, in its introductory section, explicitly expresses its concern on securing water resources from the viewpoint of Egypt's national security, and states the importance of securing water resources that are limitedly available. In addition to the external measures, it urges a way to secure the water by enhanced-reform programs towards efficient water management, as well as by conducting sustainable projects and functioning mechanisms in Egypt.

Egypt Vision 2030 identifies elements to realize sustainable development to form the country in terms of natural resources, human resources, and mechanisms of implementation and sets ten pillars under three dimensions: economic, social and environmental (See Table 3.1). The "Economic development", which is one of the pillars of the vision, aims to achieve the following eight major objectives: 1. Stability of the macroeconomic environment, 2. Achieve sustainable inclusive growth, 3. Increase competitiveness, diversification, and knowledge, 4. Maximize added value, 5. Become an active player in the global economy capable of adjusting to international developments, 6. Create decent and productive job opportunities, 7. Increase per capita GDP up to the level of high-middle income countries, and 8. Integrate informal sectors into the country's economic activities, which are the highest number of the major objectives. Among these major objectives, the irrigation sector has direct relationships with the sector of "water and irrigation". This sector is positioned in one of the elements, which support "stability of the macroeconomic environment", which is broken into nine sectors: 1. Industry, 2.

Table 3.1 Framework of Egypt Vision 2030

Dimension	Pillar
1. Economic	**1. Economic Development**
	2. Energy
	3. Knowledge, Innovation, and Scientific Research
	4. Transparency and Efficiency of Government Institutions
2. Social	5. Social Justice
	6. Education and Training
	7. Health
	8. Culture
3. Environmental	9. Environment
	10. Urban Development

Source: JICA Survey Team based on Egypt Vision 2030

Foreign trade, 3. ICT, 4. Agriculture, 5. Water and irrigation, 6. Tourism, 7. Supply and internal trade, 8. Housing and public utilities, and 9. Transportation. The sector of "water and irrigation" is positioned as one of the important elements to support economic development together with other sectors. The "Economic development" has quantitative indicators as GDP, to measure the progress in achieving the objectives. Especially, the objective "stability of the macroeconomic environment" defines decreasing the public debt down to the GDP ratio, reduce the proportion of the total deficit to GDP, and maintain price stability. Challenges, important policies, and corresponding programs/projects are indicated in each sector. The challenges and policies of the sector of "water and irrigation" are shown in Table 3.2. The programs and projects are shown in Table 3.3.

Table 3.2 Challenges and Policies in Water-and-Irrigation Sector of Egypt Vision 2030

Item	Contents
Challenge	1. Continuous population growth resulting in an increase in potable water services with limited availability to meet this demand 2. Deterioration of water quality due to pollution 3. **Spatial and temporal distribution of limited water resources** 4. Lack of funding and targeted investments to provide water services at the domestic level
Policy	1. **Develop and manage water resources and rationalize the use of water in all fields.** 2. Complete and rehabilitate the national infrastructure for water systems and horizontal expansion. 3. **Develop an integrated water resources management system.** 4. Strengthen relations between Egypt and the Nile Basin countries. 5. **Develop methods for groundwater, rainwater, and flood harvesting.** 6. Desalinate seawater and brackish water. 7. **Construct and rehabilitate pump stations.** 8. Maintain the quality and efficiency of the High Dam and Aswan Reservoir, and protect the Nile River, its subsidiaries, and Lake Nasser. 9. **Rehabilitate canals, drains networks, and all irrigation facilities.** 10. Execute studies and scientific research about technical and scientific applications in agriculture, using up to date databases and electronic government facilities.

Source: JICA Survey Team based on Egypt Vision 2030

Table 3.3 Programs and Projects in Water-and-Irrigation Sector of Egypt Vision 2030

Programs and Projects	Contents
1. Establish new communities to achieve inclusive development	This project includes the development and reclamation of 1.5 million acres (the new Egyptian countryside), the project to complete the national infrastructure for the development of the Northern Sinai on 400,000 acres (Al Salam Canal), and the project to complete the Sheikh Zayed Canal in the South Valley on 540,000 acres (Toshka).
2. Rationalize water use	This project aims to switch from flood irrigation to modern irrigation systems and develop the efficiency of canals while reducing the cultivation of rice.
3. Strengthen and rehabilitate main canals and lift stations	This project aims to achieve optimum control of water flows and improve irrigation through the implementation of the protection of the High Dam and reinforcement of the Aswan reservoir, establishment and strengthening of barrages, and improving irrigation facilities and lift stations.
4. Address climate change and coast and facilities protection	This would develop the inlets of the Northern Lakes, develop, and protect the coasts and beaches from the risks of erosion and sea level rise. It would also introduce the use of solar power to operate lift pumps and wells to reduce greenhouse gas emissions.
5. Water resources development	Develop new ways to reuse treated agricultural wastes and wastewater according to modern specifications, and expand the use of groundwater and rainwater collection.
6. Improve water quality	Preserving the environment and protecting public health is one of the top priorities in the government program. It intends to cover the waterways into residential blocks and implement programs for monitoring and following-up the water resource system of Lake Nasser and the Nile with its two branches, canals, and drains, and groundwater along with sewage treatment on the waterways.
7. Expand the sustainable development programs for Nubian sandstone and brackish water reservoirs	Increase the efficiency of surface irrigation of increased agricultural production in developed irrigation areas by about 30%. Develop a strict system to prosecute unlicensed good users and issue a water law to ensure efficiency of use. The draft law stipulates punishment for whoever causes pollution of water, as well as non-compliance with the requirements for obtaining licenses.
8. Develop groundwater and combat violations	Develop the management of groundwater systems and periodically monitor underground reservoirs in quantity and quality. Implement groundwater treatment plants.

Programs and Projects	Contents
9. Develop a covered drainage network program	Increase area for covered drainage networks by 100,000 acres through construction and replacement projects. Increase the area of the covered draining system by 480,000 acres by 2017- 2018. Other planned implementation of projects such as the expansion of drainage cross section

Source: JICA Survey Team based on Egypt Vision 2030

Especially, the subjects concerning the irrigation systems of three canal systems, which are included in the Survey's target area in Table 3.2, are as follows. The challenge facing the subject is "spatial and temporal distribution of limited water resources". The policies are "Develop and manage water resources and rationalize the use of water in all fields", "Develop an integrated water resources management system", "Develop methods for groundwater, rainwater, and flood harvesting", "Construct and rehabilitate pump stations" and "Rehabilitate canal and drain networks and all irrigation facilities". Programs and projects of the subject are "Rationalize water use", "Strengthen and rehabilitate main canals and lift stations", "Water resources development", "Improve water quality", "Develop groundwater and combat violations" and "Develop a covered drainage network program". As observed above, it is recognized that a wide variety of programs and projects to improve irrigation systems of the target area are defined as being at the public policy level.

3.1.2 National Water Resources Plan

NWRP is a core plan for the water resources sector under the MWRI. According to the end of the term explained by the second national water resources plan (NWRP2017: planning period: 1997 to 2017), the third national water resources plan (NWRP2037: planning period: 2017 to 2037) is currently being developed.

NWRP2017 sets four pillars to utilize the limited amount of water resources based on integrated water resource management. It shows 49 measures that are described as the use of water resources, including the irrigation sector, which uses the most water (See Table 3.4).

Table 3.4 Second National Water Resources Plan (NWRP2017) (excerpt)

Pillar	Typical Measures as Example
1. Developing additional resources	4 types of sources: Nile water, groundwater, rainfall and flush flood harvesting, and desalinization in coastal areas
2. Making efficient use of the existing resources	In irrigation: **Horizontal expansion, improvement of irrigation efficiency (including apply canal lining in canal stretches where leakage is large), improve drainage conditions, and drainage water reuse** In **improving water allocation and distribution of Nile water: continue set up of water use associations at meska level, improve physical infrastructure for water distribution such as discharge regulators at intakes of branch canals, weirs/cross regulators**, etc.
3. Protecting health and environment	Prevention of industrial and agricultural and pollution packages, treatment of urban and industrial wastewater package, the definition of functions of waterways and introduce water quality standards based on receiving water, and issues on water quality (e.g. monitoring and information dissemination)
4. Institutional and financial measures	Institutional reform, cost-sharing, and private sector participation, enhancement of capacity on planning and cooperation (e.g. data exchange, coordination between de-central and national level), etc.

Source: JICA Survey Team based on NWRP2017

NWRP2017 has been positioned as a basis to plan cooperation activities in the sector of water resources by supporting countries. It is an essential plan to consider the future cooperation of the irrigation sector. Especially, irrigation systems have a direct association with the following measures: "Horizontal expansion", "Improvement of irrigation efficiency (including betterment of lining of canals whose leakage is large)", "Improve drainage conditions and drainage water reuse", "Improving water allocation and distribution of Nile water", "Continue set up of water-user associations at meska level" and "Improvement of physical infrastructure for water distribution such as discharge regulators at intakes of branch canals, weirs/cross regulators". These measures are under the second pillar of NWRP2017, "Realization of efficient use of the existing resources".

NWRP2037 is a plan formulated for the next term, reflecting the current challenges. Despite the delay during its formulation process, important elements and major subjects for planning were introduced in the donor meeting on water resources held in March 2017 (See Table 3.5).

Table 3.5 Framework of Third NWRP (2037) and Corresponding Pillar of NWRP2017 (as of March 2017)

Main objective	Governmental priority	Corresponding Pillar of NWRP2017
Enhance availability of freshwater resources	Desalination Sustainable use of groundwater Use of brackish groundwater Rainwater and flash flood harvesting	1. Developing additional resources
Improve the water quality	More wastewater treatment plants Low-cost drainage water treatment (e.g. in-stream/off-stream wetland) Solid waste management	3. Protecting health and environment
Enhance the efficiency of water use	Reduce cultivated areas of water consuming crops Promote low water consuming crops **Apply modern irrigation techniques** **Reuse of drainage water and treated wastewater** Rationalize use and decrease losses in the municipal water network **Maintain, rehabilitate and improve irrigation and drainage infrastructure**	**2. Making efficient use of the existing resources**
Improve enabling an environment for IWRM, Planning, and implementation	Raise awareness about water issues **Enhance institutional and human resources capacity** Enhance and improve the legal framework Enhance and improve the institutional framework	4. Institutional and financial measures

Source: JICA Survey Team based on a subcommittee of the donors

The challenges (problems to be tackled) indicated as the direction of NWRP2037 reflects the situation where the expansion of available water resources is restricted. Accordingly, NWRP2037 emphasizes certain focal points on drainage water reuse, expansion of water saving in water use, and other issues for more efficient water use. However, it is rather consistent with the contents of Egypt Vision 2030, and NWRP2037 has similar compositions to those that appeared in NWRP2017 as a whole.

Especially, it is expected that NWRP2037 will continue to tackle issues listed in the second pillar "Realization of efficient use of existing resources" in NWRP2017, such as "Horizontal expansion", "Improvement of irrigation efficiency (including apply canal lining in canal stretches where leakage is large)", "improve drainage conditions, drainage water reuse", "improving water allocation and distribution of Nile water", "continue to set up water use associations at meska level" and "improve physical infrastructure for water distribution such as discharge regulators at intakes of branch canals, weirs/cross regulators". These issues will be addressed as the main objectives in NWRP2037: "Enhance the efficiency of water use" and "Improve the enabling environment for IWRM, planning, and implementation".

In addition, the EU is supporting the formulation of NWRP2037 under the framework of Water Sector Reform Programme - Phase II (WSRP-II). GWRP, which is the governorate-level version of NWRP2037, will be formulated in the five targeted governorates and eventually in all the governorates.

3.1.3 Sustainable Agricultural Development Strategy towards 2030[10]

SADS2030 was formulated by the MALR as a long-term plan for the field of agricultural development. It was created in 2009 as a successor to three strategies: the agricultural development strategy 2017, the 1980s agricultural development strategy and the 1990s agricultural development strategy. The

[10] This content is referred to as the Final report, Project for the Master Plan Study for Rural Development through Improving Marketing of Agricultural Produce for Small-Scale Farmers in Upper Egypt, JICA, Aug. 2012, and Summary of Sustainable Agricultural Development Strategy towards 2030, Arab Republic of Egypt 2009, etc.

year 2009 was before the target year of the agricultural development strategy 2017. It aims to deal with the current challenges based on the experience of the previous plans. In the opening sentence of SADS2030, the future direction of SADS2030 based on previous strategies was stated. Especially, as for policies of the irrigation sector, i) decentralization of water management, ii) establishment of a mechanism to recover part of the cost of irrigation services and the maintenance of irrigation facilities, iii) water management including activities by water user associations to improve the use of agricultural natural resources, were focused on. The composition of SADS2030 is shown in Table 3.6.

Table 3.6 Structure of Sustainable Agricultural Development Strategy 2030

Item	Contents
Vision	To achieve a comprehensive economic and social development based on a dynamic agricultural sector capable of sustained and rapid growth, while paying a special attention to helping the underprivileged social groups and reducing rural poverty
Mission	Modernizing Egyptian agriculture based on achieving food security and improving the livelihood of the rural inhabitants, through the efficient use of development resources, the utilization of the geopolitical and environmental advantages, and the comparative advantages of the different agro-ecological regions
Strategic Objectives	**1. Sustainable Use of Agricultural Natural Resources** 2. Improving Agricultural Productivity 3. Increasing Competitiveness of the Agricultural Products in Local and Foreign Markets 4. Achieving Higher Rates of Food Security in Strategic Goods 5. Improving Opportunities for Agricultural Investment 6. Improving Livelihood of Rural Inhabitants

Source: JICA Survey Team based on SADS2030

The strategic objective: "1. Sustainable Use of Agricultural Natural Resources" is related to the irrigation sector. This objective outlines the enhancement of water-use efficiency in the irrigated agricultural areas to use the limited water resources effectively. Especially, due to high water losses, water conveyance efficiency is estimated at 70%, and the mean efficiency of field irrigation systems is estimated at only 50%. Hence, it aims for gradual improvements in the efficiency of O&M for field irrigation systems to achieve 80% by 2030. In addition, improvement of on-farm irrigation systems as measures for these issues under MALR's jurisdiction and needs for the introduction of improved on-farm irrigation systems are stated.

3.1.4 Summary of Future Direction of Policy for Irrigation Sector

In Egypt Vision 2030, a wide variety of programs and projects to improve irrigation systems in irrigation areas including the Survey's target area are defined. These programs and projects include "Rationalize water use", "Strengthen and rehabilitate main canals and lift stations", "Water resources development", "Improve water quality", "Develop groundwater and combat violations" and "Develop a covered drainage network program", etc. Also, in NWRP, it is expected that NWRP2037 will continue to tackle the issues listed in the second pillar "Realization of efficient use of existing resources" in NWRP2017, such as "Horizontal expansion", "Improvement of irrigation efficiency (which includes canal-lining in canals where large leakage is found) " , "improve drainage conditions, drainage water reuse", "improving water allocation and distribution of Nile water", "continue to set up water-user associations at meska level" and "improve physical infrastructure for water distribution such as discharge regulators at intakes of branch canals, weirs/cross regulators". In addition, in SADS2030, a long-term plan for the field of agricultural development, it states the need to rationalize water-use efficiency through improvement of an irrigation system with the aim of enhancing water-use efficiency in irrigated lands.

A wide variety of programs, projects and typical measures stated above includes projects for hard components such as improvement of facilities for water use under the irrigation systems, with projects for soft components such as organization reinforcement and improvement of irrigation water management. These projects for soft components associated with these projects for hard components boost effectiveness. Though it is a basic premise to formulate the project in accordance with the related policies, it is considered necessary to select and formulate projects that would not only boost effectiveness for both hard and soft components, but also achieve mutual effects. In this way, the individual programs, projects and typical measures in the irrigation sector will boost their effectiveness.

3.2 Cooperation in Irrigation Sector by Development Partners apart from Japan

3.2.1 Overview of Cooperation in Irrigation Sector

In the irrigation sector of Egypt, after the completion of the construction of the High Aswan Dam, many development partners supported various efforts for irrigation and drainage facilities composed of huge systems and for activities to utilize a limited amount of water efficiently in various areas.

Firstly, as for cooperation at the policy-making level, UNDP and the World Bank supported the formulation of NWRP in the initial stage and the Netherlands was one of those who supported the formulation of NWRP2017. In addition, the EU has been supporting the formulation of NWRP2037 under the framework of Water Sector Reform Programme - Phase II (WSRP-II).

Secondly, cooperation for irrigation facilities to use water resources is implemented at various levels of the rehabilitation of large-scale barrages in the Nile River to principal/terminal facilities composing the irrigation system. These cooperation projects are implemented as a combination of soft and hard components. Each type of major project conducted by development partners apart from Japan is as follows.

3.2.2 Repair Work on Large-scale Barrages and Megaproject

Repair work on large-scale barrages are the projects to renew or improve the head works to take water from the Nile River before distributing the water to respective areas through irrigation facilities. Large-scale barrages were constructed a long ago and repair work has been sequentially implemented. Recent repair work on large-scale barrages is shown in Table 3.7.

Table 3.7 Repair Work on Large-Scale Barrages in Nile River

Project	Development Partner	Budget (Million €)	Completion	Remark
Esna Barrage	Italy, Rumania, Austria	325	1994	Foreign loan & National budget
Naga Hammadi Barrage	European Investment Bank (EIB), Germany Development Bank (KfW)	320	2008	
Asiout Barrage	KfW	430	2017 (Plan)	

Source: JICA Survey Team, mainly based on Final Report, the Preparatory Survey for the Rehabilitation and Improvement of Dirout Group of Regulators, JICA, Oct. 2010

In addition, AfDB conducted a feasibility study of the Zefta barrage in 2009. Also, the projects implemented in new development areas which are regarded as mega-projects, described in the water and irrigation sector of Egypt Vision 2030 - the Toshka project that takes water from Lake Nasser and the Northern Sinai development project, are supported by the United Arab Emirates, and by Kuwait and Saudi Arabia, respectively[11].

3.2.3 Cooperation for Irrigation Facilities from Principal Canal to Terminal Canal

Many donors cooperate for irrigation facilities from the principal canal to terminal canals after the water is taken from the mainstream and tributary of the Nile River. These cooperation projects cover a various range of scales and structures as both hard and soft components from principal/main facilities to terminal facilities in a part of the irrigation system in Egypt and are implemented as

[11] Reuters, 2014 December 6, Abu Dhabi/Cairo, Ahramonline, 2016 June 4, ttps://www.kuwait-fund.org/en/web/kfund/

follows[12]. These cooperation projects include those that concern soft components.

There are irrigation projects including canal facility improvement projects such as the El Mahmoudia Canal Project (KfW, US$30 million), the El Bohia Canal Project (OPEC, US$10 million), and the Irrigation Improvement Projects (WB and KfW, US$152 million).

Furthermore, there are other types of irrigation projects that focus on terminal facilities such as meska as a unit of improvement, as well as on water management aiming at improving water use through the establishment of water-user-driven WUAs and strengthening of their activities. Examples of such projects are given in Table 3.8.

Table 3.8 Examples of Irrigation Projects for Terminal Facilities and Water Management

No.	Project	Partner	Outline
1	Regional Irrigation Improvement Project	USAID[13]	Budget (million US$): - Period: 1985 – 1988 Outcome: Detail design of Cerry Canal, establishment of WUAs, establishment of IAS etc.
2	Irrigation Improvement Project (IIP) (the extension period of Regional Irrigation Improvement Project)	USAID	Budget (million US$): - Period: 1989 – 1996 Outcome: Strengthen the institutional capacity of Ministry of Public Works and Water Resources in Minya and delta, Develop a rational interdisciplinary approach in planning, designing and implementing the renovation of canal, Develop an IAS to transfer water management technical information and technical assistance to WUAs, Establish policies and procedures for the recovery of an appropriate portion of O&M costs etc.
3	Faiyum Water Management Project	Netherland	Budget (million US$): - Period: 1993 - 2006 Outcome: Strengthen of establishment of WUAs in Faiyum, training for governmental officers etc.
4	Irrigation Improvement Project (IIP)	World Bank	Budget (million US$): 80.00 Period: 1994 - 2006 Outcome: Improvement of the irrigation system in Delta, Strengthen of establishment of WUAs etc.
5	Livelihood and Income from the Environment (LIFE) Integrated Water Resource Management Project (LIFE/IWRM project)	USAID	Budget (million US$): 33.00 Period: 2004 - 2008 Outcome: Strengthen of establishment of IWMD and BCWUAs in some parts of central delta and Upper Egypt (Out of target area of the Survey), capacity building for MWRI officers (training in the graduate school of USA) etc.
6	Integrated Irrigation Improvement and Management Project (IIIMP)	World Bank, KfW, Netherland	Budget (million US$): 303.00 Period: 2005 - 2016 Outcome: Promotion of integrated water management in the delta, improvement of water management on filed, establishment of BCWUAs and DWB etc.
7	Faiyum Water Users Organization Project (FaWUOP) (Succeeding project of Faiyum Water Management Project)	Netherland	Budget (million US$): 3.50 Period: 2007 – 2010 Outcome: Strengthen and establishment of BCWUAs and DWB in Faiyum, Review, and assistance for implementation of the institution/organization structure/function, capacity building for officers etc.
8	Integrated Water Resources Management II (IWRM II)	USAID	Budget (million US$): - Period: 2009 - 2012 Outcome: Formation and development of Integrated Water Management Districts in some parts of central delta and Upper Egypt (Out of target area of the Survey), formation and development of BCWUAs, equitable allocation of water resource, improvement of maintaining and renewal of the water management equipment, environmental services for improvement of water quality management, improvement of Wastewater reuse, Capacity building of MWRI personnel etc.
9	Farm Level Irrigation Project (during preparation)	AfDB	Budget (million US$): 105.00 Period: 2017 - Intervention area: Nile Delta (EI Beheira governorate government)

[12] Prepared by JICA Survey Team based on Final report, the Preparatory Survey for the Rehabilitation and Improvement of Dirout Group of Regulators, JICA, Oct. 2010, Integrated Water Resources Management Practices in Egypt, A Critical Review and Analysis, Fourteenth International Water Technology Conference (IWTC 14 2010, Cairo, Egypt), Water resources management in modern Egypt (Wikipedia), World Bank Web site, etc.

[13] United States Agency for International Development

No.	Project	Partner	Outline
			Outcome: Modernization of irrigation system（including terminal canal）, Improvement of agricultural techniques（Irrigation, agricultural management）etc.

Source: Compiled by JICA Survey Team mainly based on: Participatory Irrigation Water Management in Egypt: Review and Analysis (Allam M.N.,2004), Preparatory Survey Report of Water Management Improvement Project 2 in Egypt (JICA), Evaluation of the Irrigation Improvement Project-Component of the Irrigation Management Systems (USAID, 1993.11), Final Performance Management Report (Livelihood and Income from the Environment in Sinai) (USAID, 2012.4), Mid-Term Evaluation Report (Integrated Water Resources Management II) (USAID, 2011.5), Designing Local Framework For Integrated Water Resources Management Project Technical Report(1) (National Water Research Center (NWRC), Water Management Research Institute (WMRI), 2013.4), AfDB Website (https://www.afdb.org/en/projects-and-operations/project-portfolio/p-eg-aac-016/, 2017.10.2 Access)

In addition, although the Water Management Reform Program by GIZ was planned to promote the establishment of BCWUAs, it was not actually carried out.

As observed above, the establishment of WUAs, which are in charge of terminal water management, and the establishment of IWMD and BCWUAs for the decentralization of water management by MWRI were actively carried out. In particular, through the LIFE/IWRM project and IWRM II, institutional reform of MWRI such as the establishment of IWMD as the decentralizing force of water resource management and the establishment of BCWUAs, aiming at going forward with IWRM in NWRP2017, are implemented. On the other hand, based on an interview with related persons in MWRI, it is noted that the institutional reform of MWRI might cause confusion among rural- and central-level institutions and result in reluctance to implement rural-level activities. It was also pointed out that the capacity building of BCWUAs was insufficient even though the capacity building was implemented for IWMD. In addition, most of the past projects had been implemented in the Nile Delta.

3.2.4 Direction of Support by World Bank

To reveal the trend of support in the irrigation sector of Egypt, WB projects were examined. As WB has continuously financed projects in cooperation with donor countries and supported cooperation in the water resources sector of Egypt, its policies were looked at through its funding projects.

The support that initially began in the 1970s, showed a tendency to implement many projects that aimed to maintain and newly establish drainage systems and to rehabilitate and newly establish pump stations for water reuse managed by MED. From the mid-1980s, development projects were started targeting irrigation facilities. In particular, since 2000, there were many projects targeting terminal facilities and water management focusing on facility management transfer from the government to farmers' groups (See Table 3.9).

Table 3.9 Examples of Irrigation Projects Financed by World Bank

No.	Project Title	Outline	Evaluation Results
1	Nile Delta Drainage Project	Approval year: 1970 Closure year: 1980 Committed amount(million US$): 26.00 Intervention area: Nile Delta Objective: Prevent further farmland to be damaged by waterlogging and soil salinization and to reverse the deterioration of land already affected Outcome: Construction of pumping stations on the main drains, remodeling of open drains, installing subsurface field drains and collectors in the delta	◆ Well coping with the facing problem. Highly successful project in terms of its impact on the economy and many beneficiaries. ◆ On the other hand, 4years delays in execution have lowered the value of benefits in total over the project. (June 1982)
2	Upper Egypt Drainage	Approval year: 1973 Closure year: 1981 Committed amount (million US$): 36.00 Intervention area: Upper Egypt Objective: Improve drainage in Upper Egypt Outcome: Excavation of new open drains, remodeling of existing open drains, construction of pumping stations, expansion of existing pumping station, reclamation of saline land	◆ Drainage is essential in most of the irrigated area in Egypt and there can be no doubt that World Bank made the right choice in selecting drainage in the agricultural sector. ◆ Main issue is improper project implementation. (June 1984)
3	Upper Egypt Drainage (2)	Approval year: 1976 Closure year: 1985	◆ The project was successful with economic rates of return through

No.	Project Title	Outline	Evaluation Results
		Committed amount (million US$): 50.00 Intervention area: Upper Egypt Objective: Increase agricultural productivity in the irrigated agriculture subsector Outcome: Excavation of new open drains, remodeling existing open drains, installation of field drainage, construction of new pumping station, reclamation of saline land	start-up and execution of the project were delayed considerably. ◆ Sustainability of the civil works constructed under the project depends on the efficiency of O&M which is problematic in a monitoring system of drain performance. (June 1988)
4	Nile Delta Drainage Project (2)	Approval year: 1977 Closure year: 1985 Committed amount (million US$): 66.00 Intervention area: Nile Delta Objective: Increase agricultural productivity in the irrigated agriculture subsector Outcome: Remodeling of existing open drains, installation of field drainage, construction of new pumping stations, rehabilitation of pumping stations	◆ Same as above.
5	Irrigation Pumping Stations Rehabilitation Project	Approval year: 1983 Closure year: 1992 Committed amount(million US$): 41.50 Intervention area: Upper and Lower Egypt Objective: Rehabilitate and improve O&M of irrigation and drainage pumping stations, strengthening the O&M capacity of MED Outcome: Replacement of pump units, spare parts, and equipment to rehabilitate pump stations, establishing and equipping workshops and electrical laboratories for maintenance, construction of houses for pump operators and workshop staff, institutional improvements for maintenance, accounting and store inventory system by MED etc.	◆ Highly satisfactory for the project which given especially the unexpectedly greater amount of rehabilitation that was achieved. ◆ Very satisfactory economic rate of return. ◆ On the other hand, there are some institutional weaknesses, which need further attention. ◆ Regarding sustainability, there are motivated staffs at the pumping stations, but more needs to be done to improve the related maintenance system. (June 1994)
6	Drainage Project (5)	Approval year: 1985 Closure year: 1994 Committed amount (million US$): 68.00 Intervention area: Whole Egypt Objective: Increase agricultural productivity by providing adequate drainage infrastructure, evacuate excess water and salt out of the production areas and hence reverse the deterioration of the land resource base, strengthen the EPADP for design, construction supervision and management of drainage activities with particular emphasis on improvement of monitoring and evaluation and maintenance of the improved drainage facilities Outcome: Remodeling of open drains, treatment with subsurface drains	◆ Highly satisfactory in the achievement of most of its objectives and successfully completed drainage works construction activities immediately. ◆ Contributed significantly to the staff of EPADP. Then the maintenance equipment and facilities procured by EPADP under the project has contributed to the long-term sustainability of the drainage works. (April 1995)
7	Channel Maintenance Project	Approval year: 1986 Closure year: 1993 Committed amount (million US$): 70.00 Intervention area: Whole Egypt Objective: Increase agricultural production by improving the operational efficiency of irrigation and drainage channels, minimize the need for major investments for the rehabilitation of these channels, contain and reduce maintenance costs, strengthen the institutional capacity of the agencies of Ministry of Public Works and Water Resources concerned with the implementation of the project, improve and increase the productivity of the staff and equipment of Public Excavation Companies involved in channel maintenance work Outcome: Procurement of specialized weed-mowing equipment to be sold to contracting companies, field and laboratory equipment for the related institution of Ministry of public works and water resources, imports of selective herbicides for the control of weeds in irrigation and drainage canals	◆ The outcome of the project has been unsatisfactory. Regarding channel maintenance, the channel continues to be damaged etc. ◆ The equipment purchased through the project did not include channel maintenance specialized equipment and was only useful for excavation works. ◆ After the appraisal, project contents were changed and the new project contents did not contribute to the achievement of project objectives. (June 1995)
8	Pumping Stations Rehabilitation Project （02）	Approval year: 1990 Closure year: 1998 Committed amount (million US$): 31.00 Intervention area: Mainly Delta, Nile Valley Objective: Avoid loss of agricultural productivity through rehabilitation of pumping equipment, Reduce the O&M cost of the pumping plant, Strengthen the institutional capability of the MED Outcome: Rehabilitate pumping stations, provide	◆ Although rehabilitated pumping stations exceeded its objective, there is little evidence that MED has improved its way of working. ◆ As observed above, the outcome of the project is rated moderately unsatisfactory. (February 2004)

No.	Project Title	Outline	Evaluation Results
		workshops/laboratories/miscellaneous equipment, institutional support through technical assistance for management information system/electrical laboratories/water quality monitoring	
9	National Drainage Project	Approval year: 1991 Closure year: 2000 Committed amount (million US$): 120.00 Intervention area: Whole Egypt Objective: Improve the capacity of Egyptian Public Authority for Drainage projects under MWRI to implement drainage in areas where waterlogging and salinity are constraints to maintaining and increasing land productivity Outcome: Install and renew subsurface drainages, remodel surface drains, institutional support such as technical support and equipment supply to Egyptian Public Authority for Drainage projects under MWRI/the Drainage research institute/the Research Institute for groundwater, pumping equipment for MED etc.	◆ All its objectives with few shortcomings and its outcome are rated satisfactory. ◆ Institutional support makes the capacity building not only within the government but also among private sector contractors. ◆ A viable monitoring and evaluation system was established and it's important outcome. (February 2004)
10	Irrigation Improvement Project（IIP） （Contents partly overlapped Table 3.8）	Approval year: 1994 Closure year: 2006 Committed amount(million US$): 80.00 Intervention area: Delta Objective: Increasing agricultural production and farm incomes by improving irrigation infrastructure, facilitating a more equitable distribution of water and improving on-farm irrigation management. Improving the long-term sustainability of irrigation through take-over of O&M responsibility for the tertiary level irrigation system by farmers etc. Strengthening the irrigation sector institutional planning and implementation capacity of the Ministry of public works and water resources Outcome: Irrigation improvements thorough canal rehabilitation and installation of facilities etc... Establishment of IAS through training and assistance to WUAs, institutional support for supervision of design and construction, monitoring, and evaluation. Strengthening staff capacity and development of guidelines for environmental assessment and management. On-farm irrigation-management demonstration program.	◆ There were several design deficiencies of the project and there were no completed detailed designs for irrigation works, contributing to the project's very long implementation period. ◆ Engineering achievements and development of WUAs were eventually considerable performance, and project's potential impact has not yet been fully realized. ◆ As observed above, the outcome of the project is rated moderately satisfactory. (September 2007)
11	Pumping Stations Rehabilitation III	Approval year: 1998 Closure year: 2007 Committed amount (million US$): 120.00 Intervention area: Whole Egypt Objective: Improve the efficiency of O&M of the pumping stations and thereby save public expenditures on O&M, improve the efficiency and reliability of delivery of irrigation water and evacuation of drainage water, strengthen further the planning and O&M capability of the MED Outcome: Rehabilitation of pumping stations, strengthening workshop and electrical laboratories, capacity building for MED	◆ The project exceeded its original targets for rehabilitation of pumping stations. ◆ It did not successfully complete the construction of new pumping stations. ◆ Institutional support and capacity building outputs were substantially achieved. ◆ Notable shortcomings with regard to the development of monitoring and evaluation, and management information system. ◆ As observed above, project outcome is rated as moderately satisfactory. (May 2008)
12	The Second National Drainage Project	Approval year: 2000 Closure year: 2015 Committed amount (million US$): 50.00 Intervention area: Whole Egypt Objective: Increase the efficiency of drainage, increase the agricultural productivity and improve rural income, identify and oversee the resolution of environmental issues resulting from the discharge into the open drains of untreated industrial and domestic wastewater in the project area Outcome: the provision of subsurface drainage, deepening and remodeling of open surface drains, institutional Support for the EPADP	◆ The total area covered by the project exceeded the initial target area. However, there were notable weaknesses in institutional reforms. ◆ The project contributed to higher farmer's incomes in project areas. However, there was no information on the increase in agricultural production. ◆ The project faced challenges in achieving its targets on environmental issues. ◆ As observed above, project outcome is rated as moderately satisfactory. (June 2016)
13	Integrated Irrigation Improvement and	Approval year: 2005 Closure year: 2016	◆ The relevance of the project objective is rated high. The

No.	Project Title	Outline	Evaluation Results
	Management Project (IIIMP) (Contents partly overlapped Table 3.8)	Committed amount (million US$): 120.00 Intervention area: Delta Objective: improving the management of irrigation and drainage in the project area in order to increase the efficiency of irrigated agriculture water use and services Outcome: Integrated water management, improved on-farm water management, institutional development, and capacity building for related institutions and WUAs, project management, environmental mainstreaming	project contributed to not only agricultural productivity/poverty reduction but also reduction of flood damage. ◆ The relevance of the project design/implementation/equitability is rated substantial. ◆ Regarding the overall outcome rating, the project is rated as moderately satisfactory. ◆ The project gets a poor evaluation of the higher cost of meska rehabilitation compared with the appraisal estimate and from the two-year delay in implementation. ◆ Regarding the involvement of the government and implementation agency, it is evaluated as moderately satisfactory. (December 2016)
14	West Delta Water Conservation and Irrigation Rehabilitation Project	Approval year: 2008 Closure year: 2011 Committed amount (million US$): 145.00 Intervention area: Western Delta Objective : Improve the livelihood and increase the income of people in the project area through mitigating further environmental degradation caused by the excessive drawdown of the groundwater resources, and establishing a framework for the financial sustainability of irrigation infrastructure in the use of water resources Outcome: Design, construction, the operation of surface-water-irrigation system and water use plan. Market-driven technical support to small and medium scale farmers. Support for institutional development and capacity building of the project management unit, regulatory office, and water users council	◆ The relevance of objectives is evaluated as substantial. ◆ Relevance of project design is evaluated as modest. ◆ The results chain linking project activities to expected livelihoods and income outcomes were complete and logical. ◆ The capacity-building activities for the Ministry and water user's council were relevant. ◆ The project design overlooked a number of critical activities that were necessary for the private operator to secure its revenue stream. ◆ Interagency cooperation is limited. (January 2013)
15	EG - National Drainage II Add. Financing	Approval year: 2010 Closure year: 2017 Committed amount (million US$): 30.00 Objective: Increase the efficiency of additional drainage, increase agricultural production and improve rural income, to identify and oversee the resolution of environmental issues resulting from the discharge into the open drains of untreated industrial and domestic waste water in the project area. Outcome: construction of drainage for scaling up of the intervention area of the on-going project, the procurement of much-needed machinery, institutional support for related persons through technical support	◆ (Completion Report is available only on Arabic, February 2012)
16	Participatory Farm-level Irrigation Modernization	Approval year: 2010 Closure year: 2016 Committed amount (million US$): 3.00 Intervention area: Delta Objective: pilot more participatory approaches for modernizing farm-level irrigation and cropping practices Outcome: Increasing farmer knowledge on participatory approaches for modernizing farm-level irrigation, improved irrigation system, and cropping practices. Monitoring and evaluation. Dissemination of lessons learned	◆ The project target area has not been reached as planned, but, additional areas could be carried out have been identified. ◆ Dissemination of technique is implemented as planned. ◆ The government agreed that when the project completes, dissemination of technique would be approved as official dissemination program. (May 2016)
17	EGYPT-Farm-level Irrigation Modernization	Approval year: 2010 Closure year: 2017 Committed amount (million US$): 100.00 Intervention area: Mainly Delta Objective: Increase access to improved irrigation systems in the project areas Outcome: Marwa and farm-level irrigation improvements, Farm-level technology modernization	◆ Contract supervision has been enhanced through expert consultants, and contract implementation issues are being swiftly resolved. ◆ Arrangements are being put in place to accelerate remaining works in light of the approaching closing date of the project. (July 2017)
18	EG-Enhanced Water Resources Management	Approval year: 2012 Closure year: 2016 Committed amount (million US$): 6.68	◆ It is highly evaluated that contribution of the project to policy of government and World Bank,

No.	Project Title	Outline	Evaluation Results
		Intervention area: Delta Objective: Pilot IWRM and enhance the knowledge and capacity of water sector institutions for IWRM in the recipient's territory Outcome: Dissemination of system of rice intensification approach for reducing water consumption per year, improvement of water supply to the pilot area, capacity building of related institution, improvement of research methodology through introduction of remote sensing and GIS etc., awareness campaign for water user to pay fees to service providers	and environmental issues. ◆ Regarding the project design, there are logical causal links between the project activities, their outputs, and outcomes. ◆ The pilot project implementation was rated as substantial as all outcomes were either realized or exceeded. ◆ The capacity building was rated as substantial. However, it is difficult to determine the extent to which the project activities contributed. (July 2017)
19	Regional Coordination for Improved Water Resources Mgt. & Capacity	Approval year: 2012 Closure year: 2017 (ongoing) Committed amount (million US$): 1.05 Intervention area: Whole Egypt Objective: Improve fragile water resources and agricultural management affected by climate change etc. Outcome: Improved local water resources and agricultural management, Capacity building and project management, Regional Integration and Cooperation	◆ The overall project run smoothly in general. ◆ Toward the project end, the outcome could be shared to the beneficiary. (May 2017)

Source：Prepared by JICA Survey Team mainly based on: World Bank Web site, Project Performance Audit Report on Nile Delta Drainage Project I (Feb.1982), Project Performance Audit Report on Upper Egypt Drainage I Project (June 1984), Project Performance Audit Report on Upper Egypt Drainage II Project and Nile Delta Drainage II Project (June 1988), Performance Audit Report on Irrigation Pumping Stations Rehabilitation Project (June 1994), Implementation Completion Report on Drainage V Project (Apr. 1995), Implementation Completion Report on Channel Maintenance Project (June 1995), Project Performance Assessment Report on Second Pumping Stations Rehabilitation Project (Feb. 2004), Project Performance Assessment Report on the National Drainage Project (Feb. 2004), Implementation Completion Report Review on Egypt Irrigation Improvement Project (Sep. 2007), Implementation Completion Report Review on Pumping Stations Rehabilitation III (May. 2008), Implementation Completion Report Review on The Second National Drainage Project (June 2016), Implementation Completion Report Review on EGYPT-Integrated Irrigation Improvement and Management Project (Dec. 2016), Implementation Completion Report Review on West Delta Water Conservation and Irrigation Rehabilitation Project (Jan. 2013), Implementation Completion Report Review on EG – Sanitation (Apr. 2017), Project Paper on Proposed Additional Loan in the Amount of US$30 million to the Arab Republic of Egypt for an Additional Financing for the Second National Drainage Project (Feb. 2010), Implementation Status & Results Report on Participatory Farm-level Irrigation Modernization (May. 2016), Implementation Status & Results Report on EGYPT-Farm-level Irrigation Modernization (Jul. 2017), Implementation Completion Report Review on EG-Enhanced Water Resources Management (Jul. 2017), Implementation Status &Results Report on Regional Coordination for Improved Water Resources Mgt. & Capacity (May. 2017), Project Appraisal Document on A Proposed Grant on Regional Coordination for Improved Water Resources Mgt. & Capacity (June 2012), Project Paper on an proposed additional Loan in the amount of US$30 million to the Arab Republic of Egypt for an Additional Financing for the second national drainage project (Feb. 2017).

Many projects were evaluated as “satisfactory” in each project period. However, as explained above, the capacity of MWRI and BCWUA/WUA, in terms of organizational management, remained “insufficient” and the handover to MWRI after the project was incomplete. Therefore, those activities should be strengthened for the sustainability of BCWUA/WUA and ensured the development by MWRI. Moreover, that many projects have been implemented mainly in the areas of the Nile Delta was pointed out.

3.2.5 Summary of Cooperation by Development Partners apart from Japan

As observed above, outcomes of the projects by development partners apart from Japan are summarized below.

(a) A set of cooperation for plan formulation at a policy level regarding formulation of NWRP and granting BCWUAs legal status
(b) Repair work on large-scale barrages, such as Esna Barrage, Naga Hammadi Barrage, and Asiout Regulator, in the Nile River, which is the upstream part of the irrigation system
(c) Introduction of large irrigation system in new development area, known as a mega project
(d) Rehabilitation of meska as terminal canals in the downstream area and support for establishment of WUAs as described in Table 3.8
(e) Organizational reinforcement of MWRI, such as IWMD, as recipient of water management work implemented in the LIFE/IWRM I project and IWRM II

On the other hand, challenges facing development partners apart from Japan are summarized below.

(a) Influence of the promotion of institutional reform of MWRI, which is implemented in the LIFE/IWRM I project and IWRM II, on the current organizational structure
(b) Lack of capacity building of BCWUAs and WUAs after the support for their establishment as described in Table 3.8

There are several outcomes that have significant effects on policy-level and the irrigation sector, such as large-scale projects. Outcomes also include organizational reinforcement of WCAs close to terminal-level and establishment and reinforcement as water management recipients on MWRI's side. On the other hand, promotion of structural reform of MWRI caused some confusion within the organizations. This has prevented the effect of the project from being successfully continued. Although the establishment of the organization as a receiver made progress, their capacity did not strengthen sufficiently after establishment, and consequently the organizations are vulnerable. It can be said that in order to secure sustainability, it is important to support capacity strengthening in MWRI and BCWUA/WUA, which are responsible for O&M of the irrigation system, in terms of organizational and technical aspects.

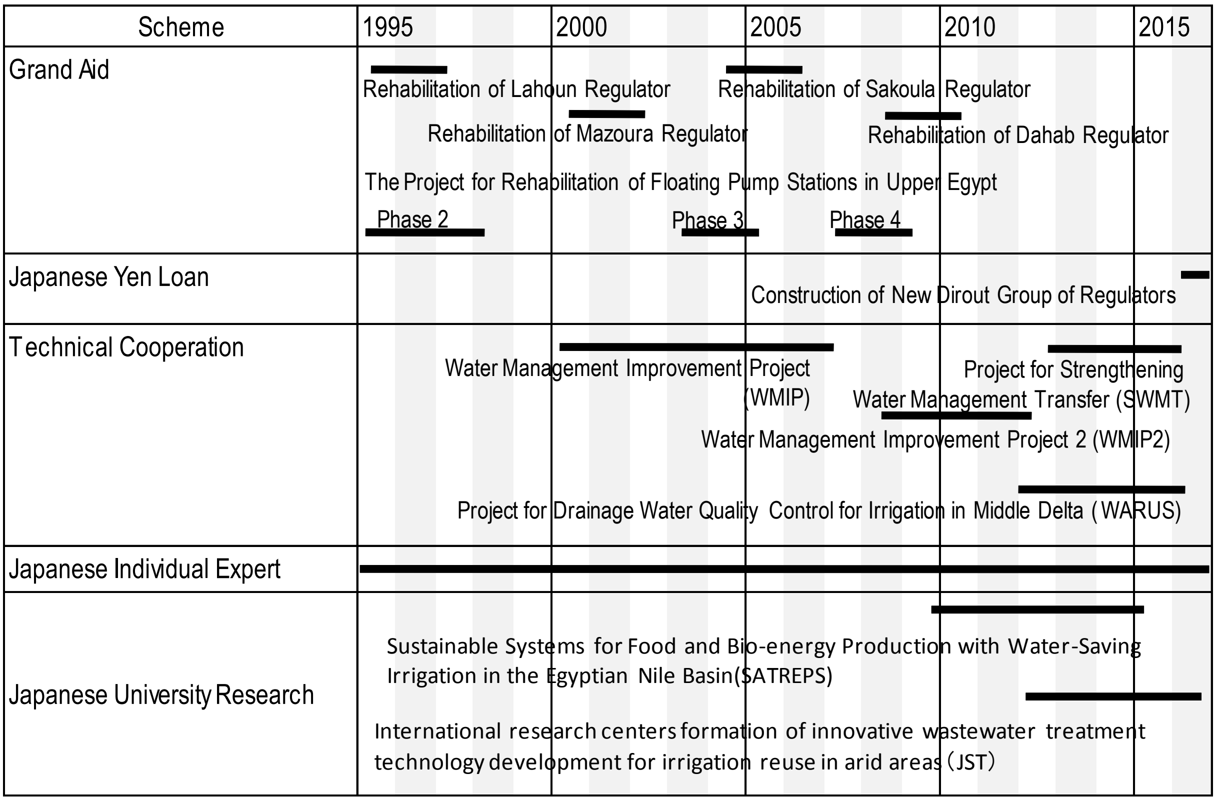
3.3 Japan's Cooperation and Achievement of Individual Project

3.3.1 Summary of Japan's Cooperation in Irrigation Sector

As mentioned, cooperation for the irrigation sectors has been actively implemented in Egypt by donors after the completion of the Aswan High Dam in 1970. Japan concluded a technical cooperation agreement in 1983 and then conducted the survey for irrigation development in the Bahr Yusef area. Based on this, Japan has been supporting the rehabilitation of irrigation facilities through Japanese yen loan projects from 1997 and supporting the water management sector through technical assistance projects from 2000.

In addition, a detailed design study to construct the new Dirout Group of Regulators (regulator for Ibrahimia and Bahr Yusef canals targeted by the Survey) by Japanese yen loan projects has been conducted since 2015.

In recent years, cooperation in research such as sustainable food production and wastewater treatment technology for reuse of irrigation water has been carried out (See Figure 3.1).



Years are the calendar year.
Source: JICA Survey Team

Figure 3.1 Summary of Japan's Previous Cooperation in Irrigation Sector

Japan's cooperation in the Egyptian irrigation sector has been mainly carried out in the field that contributes to "Realization of efficient use of the existing resources", which is the second pillar of the four pillars of NWRP2017. The cooperation includes improvement of facilities through grant aid cooperation and support for water management through technical cooperation, together with the dispatch of individual irrigation experts. This support is in line with the content of NWRP2017 and is considered as "appropriate" based on the needs of Egypt.

Reviewing Japan's cooperation in the irrigation sector, challenges and achievements are summarized based on documents such as the project evaluation report of each project as below.

3.3.2 Rehabilitation of Four Regulators on Bahr Yusef Principal Canal

(1) Overview

Four regulators, namely Lahoun, Mazoura, Sakoula and Dahab, installed in the Bahr Yusef Principal Canal in the midstream area of the Nile River, had shown deterioration in their functions. As measures against such situations, projects through Japanese grant aid were conducted, and these facilities were rehabilitated from 1997. The project outlines of each regulator are shown in Table 3.10.

Table 3.10 Project for Rehabilitation Work of Regulators in Bahr Yusef

Project	Basic Information	Ex-post Evaluation
Lahoun Regulator Construction year: late 1800s, History of rehabilitation:	Completion: 1997/3/12 Cost: 2.39 Billion Yen Facility: Lahoun Regulator Target: service area; 223,000 ha, No.	**<Relevance>** The project is consistent with Policies such as Egypt's five-year plan, local needs, and the project. **<Effectiveness>** Although the direct effect of the project is uncertain, target beneficiary area increased by 6%, irrigated area increased by 10%, planting area increased by 10%, cropping rate increased by 4%, crop yield increased by 3 to 46%, and agricultural production increased by 31% in winter and 16% in summer crop, and diversification was recognized. **<Impact>** A positive impact such as a reduction in the accumulation of floating

Project	Basic Information	Ex-post Evaluation
1988	of beneficiaries; 214,550	garbage on the environmental aspect, a smoothing of traffic due to the widening of the bridge, a decrease in the conflict about water use, and a contribution to the increase in the income of the poor are recognized. **<Status of maintenance>** Gate operation became easier, and maintenance and management expense were reduced by about 60%. <**Lessons learned and Recommendation**>Introduction of remote control of the gate, improvement of irrigation efficiency at the field level, improvement of regulators of upstream, necessity of comprehensive water management are expected.
Mazoura Regulator Construction year: 1902, History of rehabilitation: 1963 and 1965	Completion: 2002/3/14 Cost: 2.14 Billion Yen Facility: Mazoura Regulator Target: service area; 22,000 ha, No. of beneficiaries; 13,675	**<Relevance>** The project is consistent with Japan's aid policy to Egypt, policy such as Egypt's section five-year plan, local needs, so overall evaluation is A. **<Appropriateness and efficiency of facilities/equipment>** As facilities and equipment are managed and used appropriately, the overall evaluation is A. **<Status of the effect (Effectiveness)>** Increased planted area by 8%, cropping rate increased by 2%. The increase of more than 10% of the benefited area, increase by 3 to 38% on yield, agricultural production amount more than 2.5 times compared with before project implementation. The overall evaluation is A. **<Impact>** Because of the maintenance of the bridge, traffic became smooth, the traffic restriction was raised to 30 tons, and the traveling expenses and running time of the vehicle were saved. Income of landless farmers (about 20% of beneficiaries) was improved. The overall evaluation is A. **<Sustainability>**While management efforts such as asphalt pavement by the Egyptian side are recognized, dissatisfaction with water shortage was also heard due to lack of absolute water resources, and overall evaluation is B. Not everything can be solved by facility rehabilitation higher water use efficiency is required. **<Public relations effect>** The attendance of the Minister to the completion ceremony, picking up by the media, establishing the nameplate, the overall evaluation is A. The evaluation of the Egyptian side is also high. **<Lessons learned and Recommendation>** An appropriate combination of hardware and software is effective, cooperation with other donors is important.
Sakoula Regulator Construction year: 1902, History of rehabilitation: 1988	Completion: 2006/6/11 Cost: 2.10 Billion Yen Facility: Sakoula Regulator Target: service area; 34,700 ha, No. of beneficiary households; 97,000	**<Relevance>** It is consistent with policies and development needs such as Japan's Country Assistance Program, Egypt's Five Year Plan, and the rating is high. **<Efficiency>** Implementation of the facility development as planned, the project cost, the implementation period within the plan, and the rating is high. **< Effectiveness>** The intake volume before the project was 189.1 MCM, short of 5% to the necessary volume of 198.2 MCM, while the volume after the project increased to 273.5 MCM, 38% plus to the necessary volume. Although the water shortage is being solved as a whole, the water shortage trend appears in July of the peak in the peak, and 80% of the respondents said that the water supply after the project decreased, and the rating is "moderate". There is a possibility that there may be problems with the aging of small-scale irrigation facilities and the lack of maintenance and management. **<Impact>** On gravity irrigation area branch line, While farmers that agricultural productivity and yield per unit area were increased were 20 to 45%, the farmers in the branch canals downstream who answered those were decreased were 45 to 60% is reduced. There were also some positive impacts such as improvement of the convenience of the local residents due to the rehabilitation of the bridge, but there was a decline in agricultural productivity, especially in the downstream of the branch canal because of the water shortage caused mainly by the aged small-scale structure etc. The rating is "moderate". **<Sustainability>** The number of persons who directly manage regulators has decreased from 8 to 6 people. Regarding maintenance, the operational situation of regulator and flow control situation have minor problems; the rating is "moderate". **<Conclusion>** Based on the above, the evaluation of this project is "high". **<Lessons learned and Recommendation>** Rehabilitation of small-scale irrigation facilities, implementation of IIP, and proper water distribution are necessary.
Dahab Regulator Construction year: 1900, History of rehabilitation: 1917 and 1952	Completion: 2010/7/18 Cost: 2.14 Billion Yen Facility: Dahab Regulator (77.6 km from Bahr Yusef Intake, Upper Egypt) Target: service area; 37,000 ha, No. of beneficiaries; 656,352	**<Relevance>** The project is consistent with Japan's Country Assistance Program, policies and such as Egypt's Five Year Plan etc., development needs, and the rating is "high". **<Efficiency>** Implementation of the facility development as planned, the project cost, the implementation period within the plan, the rating is high. **<Effectiveness, Impact>** Although the water distribution volume did not reach the target value (489.6 MCM), the actual value (465.8 MCM) increased 9% from the standard value (427.4 MCM). The standby time was decreased from 5 to 0 minutes by the maintenance of the bridge. The effect of the project is estimated to be limited, but agricultural production has improved by 27% in 2014 compared by 2005, the rating is "moderate". Unachieved water distribution may have problems irrigation water demand in downstream and aging of the upstream Dirout Group of Regulator Improvement in agricultural production can be attributed to other factors

Project	Basic Information	Ex-post Evaluation
		such as improvement of agricultural technology. On the other hand, it contributed to the improvement of operation efficiency of surrounding pumps and improvement of the sanitary environment around the regulator. **<Impact>** Although it can be said that there is no direct relationship with the project, 64% of farmers are not satisfied with the project due to the shortage of water in the terminal canals. They do not feel the improvement of the standard of living by the project; it is considered that this is due to the occurrence of water flow obstruction due to the dumping of the dust in the terminal canal. 28% of the farmers who answered very satisfactorily and satisfied were cultivating upstream of the secondary canal. Regarding the level of living standards by the project, 96% answered "not changing" and almost did not feel it. The negative impact is not recognized, The rating is "moderate". **<Sustainability>** Labor costs increased by 25%, and operating costs increased by 11%.The maintenance and management of this project have no problems in terms of structure, technology, and financial situation, and the sustainability of the effect expressed by this project is "high". **<Conclusion>** Based on the above, the evaluation of this project is "very high". **<Lessons learned and Recommendation>** Local office of MWRI should cooperate with municipalities to build, and rehabilitation of the Dirout Group of Regulators is expected. Combination of software support is effective.

Source: Post Evaluation Report for Rehabilitation of Lahoun Regulators, Post Evaluation Report of Rehabilitation of Mazoura Regulator on Bahr Yusef Canal, Post Evaluation Report for Rehabilitation of Sakoula Regulator on Bahr Yusef Canal, Post Evaluation Report of Rehabilitation of Monshat El Dahab Regulator on Bahr Yusef Canal

(2) Achievements and Challenges through Cooperation

1) Achievements through Cooperation

The following achievements were confirmed according to the above ex-post evaluations of each project.

a) It was confirmed that the irrigation water reaches the fields due to efficient water distribution. Hence, the planting area increased by 8 to 10% and the rate of farm utilization increased by 2 to 4%. In addition, due to the promotion of efficiency, the effect of increasing the irrigation area by using surplus water was observed. Furthermore, the water was distributed in a timely manner and unit yield increased by 3 to 46%, and revenue for farmers increased.

b) The size of the bridge beside the regulator was reconsidered as part of the rehabilitation of the regulator. In addition, the effect of logistics improvement was observed.

2) Challenges Facing Cooperation

Likewise, from the post-evaluation report, common challenges were mentioned as follows:

a) In order to use limited water resources effectively, it is necessary to centrally manage not only the rehabilitated regulators but also the whole basin including all canal levels and to introduce new ideas and systems for a more efficient water-distribution approach.

b) There are also many small-scale irrigation facilities from principal canals to terminal canals located downstream of the rehabilitated regulators that require urgent remodeling. Refurbishment of medium-sized regulators alone is insufficient to improve the water management capacity of the whole irrigation system, including facilities from principal canals to terminal canals. Hence, it is necessary to rehabilitate small-scale irrigation facilities from principal canals to terminal canals that require urgent remodeling.

c) In the beneficiary area at the terminal level of the irrigation system, water shortages have occurred and water conflicts have continued. In order to solve the problem, it is crucial to have an MWRI system for more efficient water management, to conduct distribution management reflecting the situation at the field, to establish irrigation associations, and to conduct training to improve water management capacity.

d) The necessary amount of water based on the present cropping pattern has not been identified and the water distribution cannot refer to its demands. Hence, a system needs to be established to find the necessary amount of irrigation water considering the present cropping pattern and to deliver an appropriate amount of irrigation water in response to its demands.

(3) Summary of Cooperation

For the hard component, medium-sized regulators of the upper and middle stream of Bahr Yusef Principal Canal were rehabilitated. This cooperation enhanced water use efficiency and increased the irrigation area, unit yield, and income in the targeted area. On the other hand, based on the above challenges, it is considered that the following cooperation is effective for further achievement.

(a) Introducing a plan for efficient water distribution with centralized control of the whole basin. The plan should align with the pillar, "Develop an integrated water resources management system", defined as Water and Irrigation Sector's policy of Egypt Vision 2030 (hard component: introduction of the system, soft component: practice of management)

(b) Rehabilitation of small-scale irrigation facilities at each canal level from principal canals to terminal canals. This puts into practice the "improvement of irrigation efficiency (including apply canal lining in canal stretches where leakage is large)" and "improvement of physical infrastructure for water distribution, such as discharge regulators at intakes of branch canals, weirs/cross regulators", defined as concrete measures of the second pillar "Making efficient use of the existing resources" of NWRP2017 (hard component)

(c) Promotion of establishment of WUAs to resolve terminal issues and BCWUAs to resolve the issues at the upper level. Moreover, capacity building in terms of organization and water management, and strengthening of collaboration between MWRI and BCWUAs should be conducted (soft component)

(d) Introduction of system of identifying demand of the amount of irrigation water based on present cropping plans and delivering structure corresponding to the demand (soft and hard components)

Indeed, it is significant to conduct cooperation for the soft component as well as the hard component. Through the combination of both components, further achievements can be expected than merely conducting rehabilitation of four medium-sized regulators.

3.3.3 Rehabilitation of Lifting Pumps in Upper Egypt

(1) Overview

With regards to the floating pumps mostly located along the Nile River in Upper Egypt, 34 dilapidated irrigation facilities that needed urgent maintenance had been replaced by grant aid over 15 years since 1991 over four phases. The outline of each project is shown in Table 3.11.

Table 3.11 Summary of Rehabilitation of Lifting Pumps in Upper Egypt

Project	Basic Information	Ex-post Evaluation
Phase I	Completion : 1993 Cost: 1.30 Billion Yen Facility: 10 floating pump stations Target: service area; 3,165 ha	No available data
Phase II	Completion : 1998 Cost: 1.40 Billion Yen Facility: 11 floating pump stations Target: service area; 2,604 ha, No. of beneficiaries; 23,000	No available data

Project	Basic Information	Ex-post Evaluation
Phase III	Completion : 2004, March Cost: 0.87 Billion Yen Facility: 5 floating pump stations, 1 maintenance boat Target: service area; 4,368 ha, No. of beneficiaries; 5,628	**<Relevance>** The project is consistent with Japan's aid policy to Egypt, policies such as the five-year plan of Egypt, local needs, are evaluated as excellent from the point of view of poverty reduction. Therefore, the overall assessment is A. **<Appropriateness and efficiency of facilities/equipment>** Management, use, selection of facilities and equipment, and scale of costs are appropriate. The project was also able to reduce 35% management personnel. Therefore, the general assessment is A. **<Status of the effect (Effectiveness)>** Although it was not able to confirm the reduction of administrative expenses because of the delay of status of the effect by the difficulty in site negotiations etc., the irrigation area increased 34%, the agricultural production value expected to increase by 45%, and the overall evaluation is A. **<Impact>** In the target area, the cultivation area increased 4% on average, the agricultural production value expected to increase by 45%, and the number of farmers increased 18%, and it was evaluated that there was a certain contribution to poverty reduction. So the overall evaluation is A. Agricultural exports increased from 1.5 billion pounds (about 30 billion yen) to 5 billion Egypt (about 100 billion yen) during the planning period of Egypt's Fourth Socio - Economic Five - Year Plan (2003 - 2007). Although it is difficult to measure the degree of the impact of this project directly on the agriculture with the whole country or Egypt. In the planned target area, because both cultivation area and agricultural production amount are increasing, positive influence is given. **<Sustainability>** Since the facilities were properly operated and maintained at the time of the ex-post evaluation, the overall evaluation is A. **<Lessons learned and Recommendation>** One pump has not been used for two years. Follow-up after the implementation is required.
Phase IV	Completion : 2009, March Cost: 0.67 Billion Yen Facility: 8 floating pump stations Target: service area; 947 ha, No. of beneficiaries; 15,300	**<Relevance>** The project is consistent with Japan's aid policy to Egypt, Egypt's long-term socio-economic development plan and policy, and its relevance is high. **<Effectiveness/Impact>** Water supply volume increased by 40% compared to 2006, improvement of pump efficiency improved from 30-40% (2006) to 77% (2012). Increase by 25% of crop yield in the target area, and reduction of maintenance cost per unit pump water supply listed as the project purpose was generally achieved. Increasing the number of domestic animals used by farmers was 21%, and the negative impact was not recognized, so the effectiveness/impact is high. **<Efficiency>** The project cost was within the plan (91%), but the project period slightly exceeded the plan (112%), so the efficiency is moderate. **<Sustainability>** There is no problem in the organizational aspects, technical aspects, financial aspects, maintenance, and management situations of the executing agency, and the sustainability of the effect produced by this project is high. **<Comprehensive evaluation**> Considering the above, the overall rating is very high. **<Lessons learned and Recommendation>** Since it was difficult to collect data in the ex-post evaluation, it is required to create a database.

Source: Project for Rehabilitation of Floating Irrigation Pump Stations in Upper Egypt Phase III, Project for Rehabilitation of Floating Irrigation Pump Stations in Upper Egypt Phase IV

(2) Summary of Cooperation Achievements and Challenges

1) Summary of Cooperation Achievements

From the ex-post evaluations above, the following achievements were confirmed.

a) It is evaluated that the third phase of the project increased the pumping capacity from 7.1 m^3/s to 8.1 m^3/s after its implementation, and the fourth phase improved the pump efficiency from

30 to 40% in 2006 to 77% in 2012. This cooperation is the replacement of floating irrigation pump stations in the Nile River and it is rated highly in terms of its direct indicator: the increase of pumping capacity.

b) As for the operation, maintenance and management of facilities, it was evaluated as appropriate or no problem at the time of evaluation. Even for the interview of this survey at MED, it was reported that all the stations that were able to be confirmed (25 stations among all the 34 stations) were operational.

c) The expansion of irrigation areas is confirmed in each phase as shown in Table 3.12.

Table 3.12 Increase in Irrigated Area (Unit: feddan (ha))

Phase	Before Rehabilitation	After Rehabilitation	Increase Rate
1st	7,535 (3,165)	No data	
2nd	4,040 (1,697)	6,870 (2,885)	70.0%
3rd	7,620 (3,200)	10,400 (4,368)	36.5%
4th	1,804 (758)	2,255 (947)	25.0%

Source: Compiled by JICA Survey Team from the documents of JICA expert at MWRI, Ex-post Evaluation of the Project for Rehabilitation of Floating Irrigation Pump Stations in Upper Egypt Phase III (2007, Ministry of Foreign Affiar), and Ex-post Evaluation of the Project for Rehabilitation of Floating Irrigation Pump Stations in Upper Egypt Phase IV (2012, JICA)

2) Summary of Cooperation Challenges

Although the operations of 25 stations were confirmed, they need replacement work within a period of 20 years, taking into account that 22 to 24 years have passed since the first grant.

(3) Summary of Cooperation

Through the irrigation rehabilitation plan in Upper Egypt (hard components), increases in the pumping capacity and current operations of all stations were confirmed. In addition, the irrigation area expanded in the direct beneficiary area, and highly sustainable and effective cooperation were determined. However, the effects have not spread out of the target area. Moreover, considering the necessary replacements of pumps and motors, it is planned to rehabilitate nine stations in phase V through a loan by Kuwait. It is expected that each development partner will continue their cooperation.

3.3.4 Features of Construction of New Dirout Group of Regulators

(1) Overview

Currently, the detailed design study of the new Dirout Group of Regulators by a Japanese yen loan project is conducted. The Dirout Group of Regulators is the intake of Bahr Yusef Principal Canal and it is one of the oldest operational regulators. In addition to repairing work, several observation points for water level (13 regulators and 41 water intakes) will be allocated in the irrigation system. It will enable confirmation of the flow status of the whole irrigation system from the central management office and to change the opening of water gates corresponding to the demand. The summary of the project is shown in Table 3.13.

Table 3.13 Summary of Construction of New Dirout Group of Regulators

<table>
<tr><th>Project</th><th>Basic Information</th><th>The Plan of the Evaluation</th></tr>
<tr>
<td>The new Dirout Group of Regulators

Construction year: 1872
History of rehabilitation: 1900~1907, 1962, 2001</td>
<td>Schedule: planed from March 2015 to October 2021.
Budget: 6.288 billion (5.854 billion of it is the Japanese yen loan and special terms for economic partnership (STEP))
Responsible organization: reservoir of MWRI and grand barrages sector (RGBS))
Target area: Dirout City in Asiout and the surrounding areas (Giza, Beni Suef, and Faiyum)
Activities: 1.Construction of regulators (establishment of 5 regulators, introduction of gate facilities, preparation for surroundings and temporary shutoff construction), 2. Introduction of materials and equipment of communication for integrated water resource management (installation of systems and central management facilities), 3.Consulting services (support for bid and construction management)
Target service area: 0.6 million ha
Beneficiaries: 2 million</td>
<td>Expected outcomes of the project are as bellow.
1. Quantitative outcomes
(1) Operation and effect indicators
<table>
<tr><th>Indicators</th><th>Standard Value (actual value in 2013)</th><th>Target Value (2025) 3 years after completion</th></tr>
<tr><td>Inflow to the intake of branch canal (million m^3)</td><td>No available data</td><td>Realization of measurement and water management based on the water requirement</td></tr>
<tr><td>Inflow to Bahr Yusef Principal Canal (million m^3)</td><td>Summer: 2,100
Winter: 1,700</td><td>Summer: about 2,300 (10% up)
Winter: about 1,800 (6% up)</td></tr>
<tr><td>Yield of wheat (million tons/year)</td><td>1.7</td><td>1.74</td></tr>
<tr><td>Yield of maize (million tons/year)</td><td>2.20</td><td>2.29</td></tr>
</table>
(2) Internal Rate of Return
Based on the following premise, economic internal rate of return is estimated at 21.2% but financial internal rate of return is not estimated.
【Economic internal rate of return】
Cost: project expenses (tax excluded), administration and management expenses
Benefit: increase of yield of crops by stabilization of water distribution
Project life: 50 years

2. Qualitative outcomes
The increase of agricultural productivity by realization of the efficient water distribution

As the indicators of future evaluation, “inflow to the intake of branch canal (million m^3) ”, “ Inflow to Bahr Yusef Principal Canal (million m^3) ”, “yield of wheat (million tons/year)”, and “yield of maize (million tons/year)” are assumed.</td>
</tr>
</table>

Source: Prepared by JICA Survey Team from the Ex-ante Evaluation of New Dirout Group of Regulators and the Documents of the Orientation for the Detailed Design Study of the New Dirout Group of Regulators

(2) Features of Cooperation

It is difficult to determine the achievements and challenges since the new Dirout Group of Regulators are still under construction. However, the following features were identified, according to the above ex-ante evaluation and documents.

(a) The rehabilitation of four medium-sized regulators of Bahr Yusef Principal Canal has gradually recovered the water-distribution functions at the canal, which accounts for 52% of the irrigation water of the existing Dirout Group of Regulators. This cooperation completes the reinforcement of the water-distribution function. It also contributes greatly to IWRM including the rehabilitation of the four medium-sized regulators.

(b) As well as each water intake of branch canals, it is possible to increase and stabilize the inflow to the Bahr Yusef Principal Canal. The Bahr Yusef Principal Canal is a target canal for the project for rehabilitation work of regulators in Bahr Yusef.

(c) Contribution is expected to stabilize irrigated agriculture over 0.6 million/ha and for 2 million beneficiaries and to increase the yield of wheat and maize.

3.3.5 Technical Cooperation Project for Water Management and Maintenance of Irrigation Facilities by WUAs

(1) Overview

Cooperation projects have been carried out on water management through capacity development of WUAs and the maintenance and management of irrigation facilities. A series of cooperation projects, namely WMIP, WMIP2, and SWMT Project, were implemented. The summary of each project is shown in Table 3.14.

Table 3.14 List of Technical Cooperation Projects on Water Management and Maintenance and Management of Irrigation Facilities

Project	Basic Information	Ex-post Evaluation of Project
Water Management Improvement Project (WMIP)	Duration: 2000/3 - 2007/2 Cost: 580 Million Yen Area: 1 site (Kafr El-Sheikh, Middle Delta) Activity: Demonstration of Improvement Method of IIP Project by Farmer Participation Output: 1. Improvement methods of irrigation facilities, 2. WUAs establishment method, 3. Appropriate water management at the field level, 4. Information sharing to government officials	**<Relevance>** The project has been consistent with policies such as five-year plan of Egypt, country assistance program of Japan, and needs of the beneficiary farmers, and thus its relevance is high. **<Effectiveness>** According to the questionnaire to beneficiary farmers, 96% are satisfied, the achievement degree of each outcome is also satisfactory level. The effectiveness is high. Output 1: Irrigation facility construction work was completed at 65 meska, 92% farmers responded that they are functioning well on Mescal level water management. Output 2: 66 WUAs was established and registered, and 5 kinds of training texts were created. Water charge was collected at all WUAs (64 WUAs), and 67% of WUAs collected pump renewal fee as part of water charge. **<Efficiency>** The inputs of both countries and the management of the project were done properly, so it is a satisfactory level. **<Impact>** A lot of impacts, such as the spread of improvement method to other projects fair water distribution, reduction of irrigation time and cost, increased yield, reducing the water conflict, use as a farm road of the old meska, etc. are seen. **<Sustainability>** There is room for improvement in terms of policy and there is a prospect of securing funds, organizational aspects need to cope with inadequacies of the legal system, there is no major technical problem. **<Lessons learned and Recommendation>** Efforts to improve the efficiency of water usage in branch / main canals, and appropriate follow-up to project target area is required. Careful response to farmers by awareness reform of staff, appropriate evaluation / orbital correction during the project was effective.

Project	Basic Information	Ex-post Evaluation of Project
Water Management Improvement Project Phase 2 (WMIP 2)	Duration: 2008/6 - 2012/4 Cost: 175 Million Yen Area: 6 sites (Beheira in West Delta, Kafr Shiek, Dakahlia in Middle Delta, Faiyum, Minya, Qena in Upper Egypt) Goal: To improve the capacity of CDIAS to support WUO establishment and strengthen activities throughout the country Outcomes: 1. Clarification of roles and functions of WUO at various levels, 2. Measures for establishment of WUO and strengthen of activities, 3. Formulation of a system of national government agencies for outcome 2:	**<Relevance>** The project has been consistent with policies such as five-year plan of Egypt, country assistance program of Japan, and thus its relevance is high. **<Effectiveness>** The achievement of outcome 3 is low but the impact is limited, and the goal is expected to be achieved, so the effectiveness is moderate. The canal management plan was implemented with a degree of satisfaction of 70% to 80% (target 80%) for each district. Maintenance fee is collected from 80 to 100% (target value: 90%) for each district by meska level, and 20 to 50% at the branch level. 60 to 80% of action plan were started (target value: 50%), and 50 to 80% has been completed (target value: 25%). **<Efficiency>** Both countries of the input are properly made, and the JRW (Joint Repair Work) is the technique of high-cost efficiency, so efficiency is high. **<Impact>** Some succeeded in collecting maintenance expenses, and the positive impact was seen, such as technical exchanges with other JICA projects are expected to contribute to the establishment of infrastructure for conflict prevention in Nile basin countries, and as a whole impact is moderate. **<Sustainability>** Although C/P has begun to utilize introduction technology, technical sustainability is relatively high, but sustainability is somewhat weak due to unstable position of C/P institution, uncertain financial outlook, and successive removal of C/P etc. **<Lessons learned and Recommendation>** It is necessary to follow financial and organizational aspects by MWRI, legal position such as BCWUAs, the creation of plain guidebook for IMT, utilization of Japanese knowledge in water management, high effectiveness of JRW.
Project for Strengthening Water Management Transfer (SWMT)	Period: 2012/11 - 2016/3, Budget: 221 Million Yen, Target Area: 4 area (Gharbia and Beheira at Middle Delta, Faiyum at Upper Egypt), Goal: implementation system maintenance necessary in order to carry out water management transfer at the national level Results: 1. Methodology of WMT for BCWUAs, 2. Maintenance of system for sustainable training. 3. Approval of roadmap for implementation of water management transfer	**<Relevance>** It is consistent with policies such as Egypt's five-year plan, Japan's country assistance plan, and target group's needs, and the advantage of Japanese technology has been recognized and the relevance is "excellent". **<Effectiveness>** All achievements and goals are expected to be achieved, the effectiveness is "good". Collaboration between the expert team and stakeholders was a promotion factor, but frequent replacement of C/Ps is an impediment factor. The understanding degree of 80% of TOT participants was more than 90%, and the understanding degree of 80% of staff training participants was more than 80%. TOT: 8 courses, staff training: 11 courses, WUAs training: 7 courses were implemented. **<Efficiency**> The inputs of both countries were adequate, training was highly appreciated, but some C/Ps was concurrently conferring on other activities and there were restrictions on activities, so efficiency is "good". **<Impact>** Since various activities contribute to the achievement of the overall goal and no negative impact has been reported, the impact is positive as a whole. **<Sustainability>** Continuation can be expected from the policy side and the role/capacity of the C/Ps organization, but the financial aspect becomes a matter of concern and the sustainability can be expected to some extent. **<Lessons learned and Recommendation>** Approval of the roadmap, development, and implementation of necessary processes for promotion, procurement of equipment with a time margin, and flexible project period setting so as to be able to cope with unexpected events.

Source: Terminal Evaluation Report of WMIP1, Terminal Evaluation Report of WMIP2, Minutes of Meeting for the Terminal Evaluation for the Project for Strengthening Water Management Transfer in the Arab Republic of Egypt

(2) Summary of Cooperation Achievements and Challenges

1) Summary of Cooperation Achievements

The following achievements were confirmed according to the terminal evaluations of each project.

a) In terms of water management, a mechanism was created to ensure participation of farmers/irrigation associations, and methods were introduced that enabled farmers, who are beneficiaries of water use, to analyze problems for themselves. Moreover, it completed the setting of manuals (for WMT, water quality inspection, GIS, water distribution, environment, training, etc.) for ministry and agency staff to guide farmers. Furthermore, curriculums for developing trainers within ministries and agencies were completed. Consequently, a system of training farmers by ministry staff members was established.

b) For the maintenance and management of irrigation facilities, the idea of JRW was introduced and the beneficiaries repaired the branch canals themselves. The practice of JRW succeeded in reducing construction expenses by 20% compared to the cost of repair work done by full subcontractors. Some BCWUAs have started collecting fees toward the implementation of such work.

c) Based on the investigation results of current water management issues, water management facilities were established and repaired, illegal cropping of rice was eliminated, and new rules of rotation were set and adhered to. This enabled more equitable water distribution and alleviated terminal shortages.

d) The cooperation projects summarized their achievements and presented policy recommendations to ministries and agencies. The roadmap to expand WMT to a national-scale was created and officially adopted. This roadmap showed the direction of WMT as MWRI, clarified the roles of each stakeholder, and divided them into five stages according to BCWUA's abilities. As of 2025, the number of organizations for each stage is set as the goal to strive for capacity building.

2) Summary of Cooperation Challenges

From the terminal evaluations and this Survey, the following challenges and recommendations are given.

a) Since water management needs funding, it is recommended to give farmer-initiated WUAs, especially BCWUAs, legal status and conduct training to legally manage activity funds. Meanwhile, the bill to give legal status to BCWUA is currently under preparation by the Congress through the Cabinet.

b) Securing human resources and budget for training lecturers of CDIAS and GDIAS under the Irrigation Advisory Service (IAS) is a matter of concern in order to monitor and evaluate the proper introduction of the roadmap.

(3) Summary of Cooperation

To begin with, WMIP developed technical methods of irrigation water management available to farmers, and WMIP2 made progress in applying the methods on a larger scale. Furthermore, the SWMT project prepared manuals through practical activities and developed a roadmap to forward water management transfer. The achievements of this series of cooperation projects are huge, in that water management and maintenance of irrigation facilities from branch canals to terminal canals were conducted and manuals for these contents were prepared. At the time as this survey in 2016, the progress of the roadmap seemed “satisfactory” according to the interview with MWRI. Based on the above challenges, the underlying assumptions for further achievements are that the status of BCWUA has legal grounds initiated by MWRI. Regarding the bill, it is being prepared by Congress, and MWRI is willing to promote WMT when established. In addition, based on the experience of conducting water management and maintenance below the branch canals, in order to expand WMT to other areas, it is necessary to strengthen the capacity of WUA, which is in charge of water management at meska, and both BCWUA and IAS, which play their roles in water management at branch canals. In doing so, it is important to utilize various manuals, human resource development systems, knowledge on JRW practice, etc., created by previous support programs.

3.3.6 Technical Cooperation Project on Water Reuse

(1) Overview

As a technical cooperation project to cope with the restricted supply of water resources and deterioration of water quality, technical cooperation was provided in the Delta region to expand water reuse for irrigation. The summary of the project is shown in Table 3.15.

Table 3.15 Technical Cooperation Project on Water Reuse

Project	Basic Information	Summary of Final Report
Project for Drainage Water Quality Control for Irrigation in Middle Delta (WARUS)	Period: 2012/2 - 2016/3, Budget: 430 Million Yen, Target Area: 1 governorate (Kafr El-Sheikh at Middle Delta), Outcome: Formulation of drainage reuse plan, C/P's capacity development for project plan formulation and improvement of the project. implementation capacity Activity: Research, reuse water plan (draft), implementation of pilot projects, finalization of water reuse plan	**<Formulation of wastewater reuse plan>** Overall, it is proposed to consider the countermeasures for issues of water quality conservation and wastewater reuse facilities for both wide and narrow areas. Monitoring of water quality that should be maintained would be implemented. The details are as follows. For the narrow area, local residents are encouraged to make efforts for themselves. Their focus area will be set to the range that polluters of wastewater and users can identified. To ensure participations of local governments (local units), the activities at village levels are combined into a package called "irrigation complex" (which is composed of 1) colony wastewater treatment facility, 2) direct purification facility, 3) wastewater reuse pump, 4) composting facility, 5) organization of residents, 6) environmental campaign, and 7) vegetation purification). The package will be set at the point where the canal and the drain are close below branch canal. For the wide area, it is also necessary to apply contamination countermeasures at the upstream to bring benefits in the downstream. Measures to act on a wide area by looking at the entire upstream and downstream of the water system (water quality conservation of Gharbia drainage, construction of a large scale water reuse pump, and underwater drainage) shall be developed in the water system of the main drainage canal level. In addition, as "technology development and foundation improvement" to promote wastewater reuse effectively, projects were proposed to strengthen the utilization of water quality monitoring as well as to develop and disseminate farming improvement skills. These projects are the contents of the water reuse plan. **<Pilot Project>**Five districts were selected for the pilot project. One district where irrigation complexes were set up and developed in all areas. The drainage reuse pumps were set up in four districts, and environmental awareness activities were conducted in all five districts. Regarding these activities, a garbage transport vehicle was supplied. It was confirmed that the pilot project was implemented by a system that centered on DAS (Drainage Advisory Service) of the drainage agency and GDIAS (General Director for Irrigation Advisory Service) of the irrigation department. Lessons learned include thorough improvement of the implementation system, utilization of public lands, and construction plans that can afford more time to spare. **<Recommendation>** The following recommendations are made to implement the wastewater reuse plan.

Project	Basic Information	Summary of Final Report	
		Item	Contents
		Promotion of project in harmony with conventional MWRI plan	Some projects have already been implemented by MWRI. In order to smoothly develop the plan, priorities should be given to areas where projects are currently operated and components with less cost burden so that it would be easier for MWRI to set the budget.
		Implementation in cooperation with other ministries and development partners	In the irrigation complex, it is difficult for MWRI alone to set up a facility for village wastewater treatment. Hence, collaboration with MOHUU is required.
		Involvement of stakeholders from central level to village level	At the central level, cooperation is made with MOHUU and departments within MWRI. As for environmental education activities at the village level, collaborations with the local unit, the Ministry of Religion, Ministry of Youth and Sports, Ministry of Education are made. For future developments, cooperation system between stakeholders is necessary.
		Regionally project development and collaboration between regional upstream and downstream	Efforts from upstream to downstream is required to bring about desirable effects, and thus MWRI IS and EPADP should prepare a coordination system of the local unit and BCWUA.
		Maintenance system with stakeholder consideration	This system would improve the sanitation environment of the residents at the drainage sources, and increase the amount of available water for the beneficiary farmers at the downstream who receive reused water. Therefore, participations of both stakeholders could be expected for operation and maintenance.
		Cooperation of relevant departments in farmer organization	Regarding the establishment of the drainage pump committee and the strengthening of organizational capacity, not only IS and EPADP, but also GDIAS with experience of supporting BCWUA/WUA are required to be directly involved.
		Clarification of official position of drainage pump committee	Since the drainage pump committee has no legal basis, it is important to provide a public position officially by the Ministerial Ordinance from IS of prefecture.
		Continuation of environmental education activities	The environmental education activities require continuous efforts and involvement of EPADP and the IS.
		Gender consideration	It is important to involve women in environmental education activities because it is their role to dispose household garbage.

Source: WARUS Final Report

(2) Summary of Cooperation Achievements and Challenges

1) Summary of Cooperation Achievements

The following achievements were confirmed according to the final report and interviews in the different fields.

a) It was confirmed that irrigation efficiency improved by reusing wastewater and that purification at simple quality control facilities met the water quality standards for reuse. This was reflected in the wastewater reuse plan.

b) It was confirmed that accumulation and transportation activities of garbage for water quality improvement at the pilot sites continued after the project ended. (This encourages secondary use of transport vehicles.)

2) Summary of Cooperation Challenges

In the final report, the following challenges and recommendations were proposed.

a) Although the master plan including activities of soft and hard components at branch and main drainage levels was created, it has not expanded horizontally into the areas of the Delta including the targeted area. For implementation of activities of soft and hard components in line with the master plan, it is necessary to collaborate with stakeholders such as departments within MWRI, MOH, and local units, etc.

b) It is assumed that simplified purification facilities that target branch drainage cannot cope with the deterioration of water quality in the upstream area and the increase of drainage from villages. Hence, these facilities can have advantages in areas where extreme deterioration in water quality does not occur. However, it is considered that a careful survey of water quality is required before use.

(3) Summary of Cooperation

It was confirmed that the reuse of drainage water increases irrigation efficiency and the water quality meets the standards for reuse by setting up simplified purification facilities in the targeted area. In addition, a successful example of measures concerning garbage was given. On the other hand, considering that collaboration among stakeholders is needed and selection of target areas at the branch drainage level is limited, it may take time to develop the plan for a wastewater reuse plan.

3.3.7 Other Support

In addition to the cooperation projects explained above, cooperation projects in research are under way. They mostly contribute to the field of effective utilization of the finite water resources of Egypt. The summary of each project is shown in Table 3.16.

Table 3.16 Outline of Research Cooperation for Efficient Water Use

Project	Basic Information	Ex-post Evaluation of Project
Sustainable systems for food and bioenergy production under water-saving irrigation in the Egyptian Nile basin	Period: 2009/6 - 2015/3 Budget: 430 million Yen (Science and Technology Research Partnership for Sustainable Development: SATREPS), Target Area: Nile delta, Goal: To develop a strategy to implement efficiency and sustainability of agricultural production, while also increasing water use in the agricultural sector in the Nile Delta region to manage the rapid population increase Research contents: 1. Various conditions relating to the balance of water and salt under various conditions of Nile Delta are clarified 2. Presentation of measures for rationalization of water distribution and water management at the canal level, 3. Presentation of measures to prevent salt damage in the field level, 4. Presentation of methods for improving field level irrigation methods by proper crop selection.	**<Relevance>** The project is consistent with policies such as Egypt's five-year plan, Japan's aid policy, and its relevance is high. **<Effectiveness>** The effectiveness is high since all outcomes and target have been achieved. It is predicted that the amount of water required for agriculture in the Nile basin can be reduced by a maximum of 20 to 30%. As academic papers, 10 editions (9 out of which are in English) have been published, and 5 more will be published. The research results were disseminated to the outside (10 journals, 6 conference presentations, 49 oral presentations, 12 poster presentations were conducted) **<Efficiency>** The input by the Japanese side was appropriate mostly, there was a period of interruption due to political unrest in Egypt, the Great East Japan Earthquake in Japan, but extended the response. Although existing data could be used efficiently, stealing equipment, frequent changing of C/P, and coordinate among research institutions were difficult. Therefore, efficiency is moderate. **<Impact>** Policies and research recommendations based on research results will be formulated and submitted, and research results are widely disseminated, positive impacts are recognized and the impact is generally high. **<Sustainability>** Policy persistence is high, but the organizational, financial and technical sustainability is moderate. **<Lessons learned and Recommendation>** Recommendations include formulation, submission of policies and research recommendations, a reflection of MWRI on policy aspects, a continuation of related research, dissemination of outcomes, and collaboration between research institutes in Egypt and Japan. Lessons learned are the difficulty of coordination by 3 research institutes, and the effectiveness of collaboration between universities and relevant ministries and agencies.

<table>
<tr><th>Project</th><th>Basic Information</th><th>Ex-post Evaluation of Project</th></tr>
<tr>
<td>Establishment of international core of excellence for innovative technology development on sewage treatment for reuse of irrigation water in arid area</td>
<td>Research Period: Japanese Fiscal Year (JFY) 2011 - JFY2016,
Budget: maximum 50 Million Yen per year funded by Japan Science and Technology Agency (JST),
Target Area: Arid area,
Activities: Creation of the applicable new sewage treatment technology in developing countries, transfer and diffusion of technology
Results: Construction of laboratory sewage treatment facility, understanding of processing mechanism and development effect of development technology, database construction for conducting contamination situation and list evaluation on irrigation water, establishment of a network of research centers including Kenya</td>
<td>
<table>
<tr><th>Comprehensive evaluation</th><th>Target achievement level</th><th>Results</th><th>Relevance of plan/method</th><th>Sustainability</th><th>Reflecting the mid-term evaluation</th></tr>
<tr><td>S</td><td>s</td><td>s</td><td>s</td><td>a</td><td>a</td></tr>
</table>
Overall evaluation: S (efforts beyond the intended plan are being conducted)
It was highly evaluated for their social implementations that made breakthroughs in progress and achievements. This includes flexible response to delay due to political instability, deployment based on E-JUST (Egypt-Japan University for Science and Technology), application of the Down flow Hanging Sponge (DHS) plant by the Egyptian government, and the commencement of the construction of demonstration No. 1 in irrigated areas funded by the Egyptian government.
<Target achievement level> The initial plan was greatly achieved before the end of the project, such as the start of construction of first unit 1.
<Results> Implementations of pilot demonstration test of plant (a processing capacity of about 2,000 people, 200 tons/day) in the local Egypt, elucidation of the processing mechanism of DHS, survey on the actual situation of utilization of irrigation water, establishment of research base, and awareness raising activity were steady and made achievements. The developed wastewater treatment system is about 1/10 of the running cost of general activated sludge method, and the filtration material (sponge for treating sewage) almost requires no maintenance because it is unnecessary to exchange it for 10 years.
<Relevance of plan/method> The project I highly evaluated for properly responding to the delay of political unrest.
<Sustainability> To promote the dissemination and deployment of the system, MoA (Memorandum of Agreement) was concluded among the four members of Tohoku University, E - JUST, Egyptian government agencies ASRT, private industry association ASRT (Academy of Scientific Research and Technology, and AOI (Arab Organization for Industrialization). Toward the construction of demonstration No. 1(at Zakem village, about 4,000 residents), the detail design was planned to start. In the future, the same sewage treatment plant in 7,000 villages is planned to be installed.
<Reflecting the mid-term evaluation> The issues pointed out in the mid-term evaluation such as strengthening cooperation with related organizations, promoting educational activities, etc., were improved in the last half of the project.
</td>
</tr>
</table>

Source: Summary of Terminal Evaluation Results of Sustainable Systems for Food and Bio-energy Production under Water-saving Irrigation in the Egyptian Nile Basin Project, Ex-post Evaluation Report of Establishment of International Core

These research projects contribute to reduce the amount of irrigation water per unit and to improve water quality in water reuse. Both outcomes of the research are expected to increase the amount of water resources, which is an issue to be addressed in Egypt. On the other hand, it is difficult to utilize the experience of the research directly because the pilot projects are limited to the terminal canal level. However, knowledge of water management organized in the above can be utilized for this survey.

3.3.8 Summary of Japan's Cooperation

Based on the achievements and challenges of Japan's previous cooperation, cooperation regarding the hard component, i.e., rehabilitation of four medium-sized regulators and rehabilitation of lifting pumps in Upper Egypt, have managed to be effective in the direct beneficiary areas that surround the facilities. However, it has been insufficient for producing a widespread effect. The rehabilitation of four medium-sized regulators could contribute to realizing a comprehensive irrigation system through the completion of construction of the new Dirout Group of Regulators. Toward more cooperation achievements regarding the hard component, rehabilitation of small-scale irrigation facilities from principal canals to terminal canals is needed as the hard component to secure horizontal and vertical expansion. In addition, promotion of establishment of WUA and BCWUA, and capacity building in the organization structure are essential as soft components.

On the other hand, regarding capacity building as soft components, technical cooperation projects are conducted for water management and maintenance of irrigation facilities by WUAs, and these activities are put into practice from branch canals to terminal canals. Extension of these activities by MWRI is expected.

The technical cooperation project and the research cooperation project on the reuse of drainage water realized achievements to a certain extent. On the other hand, there are many difficulties to be tackled such as collaboration among ministries and agencies, and the time required to formulate the implementation structure. Hence, it could be acknowledged that the application of this approach has certain limits for conducting future expansion and horizontal/vertical expansion.

3.4 Summary of Past Cooperation by Other Donors and Japan and Direction of Future Cooperation of Irrigation Sector

3.4.1 Summary of Cooperation by Other Donors and Japan

(1) Summary of Cooperation Contents

Although each donor, including Japan, has implemented point-based projects for facility developments of each canal level as hard components, they have not been carried out downstream of the targeted area of each project. Hence, as mentioned in the challenges facing the rehabilitation of the medium-sized regulators with Japan's cooperation, improvement in the water management capacity of the whole irrigation system is inadequate. Concerning the cooperation targeting small-scale irrigation systems downstream from main-canals, for instance, the Regional Irrigation Improvement Project, which was conducted by USAID, targets the Serry canal system, which is the main canal of the Bahr Yusef Principal Canal. However, this project has not expanded greatly as a cooperative form of irrigation systems in Egypt.

As for cooperation regarding soft components, donors including Japan have carried cooperation projects targeting WUAs at the meska level. While other donors have focused on rapid organizational establishment and reorganizations in MWRI, Japan has contributed to construct mechanisms that ensure sustainability after establishment of WUAs. A series of technical cooperation projects in the past has formulated a roadmap, showing the pathway of transferring irrigation facilities to WUAs. Continuation of the activities by the Egyptian government is expected in the present state.

To enhance the effectiveness of cooperation of hard components and promote its expansion, it is significant to efficiently integrate soft components established through Japan's cooperation that contribute to constructing a mechanism that ensured the sustainability of the organizations.

(2) Summary of Target Areas of Cooperation

Japan's cooperation has been conducted mainly in Upper Egypt in terms of facility development as well as in the Delta in terms of mechanism building. Other donors have targeted a wider project area, but especially focusing on the Delta, for facility development and capacity enhancement for terminal water management.

3.4.2 Future Direction of Japan’s Cooperation

Among Japan's previous cooperation projects, “rehabilitation of four regulators on the Bahr Yusef Principal Canal”, “rehabilitation of lifting pumps in Upper Egypt (floating pumps)”, and “technical cooperation projects on water management by WUAs and maintenance and management of irrigation facilities”, these were very useful for future cooperation and were regarded as the second pillar of

NWRP2017: making efficient use of the existing resources. In NWRP2037, “enhance the efficiency of water use” is also set as the main objective. It is considered that future cooperation should be aimed at “efficient water use” to maximize the effects of achievements made in the past.

Comparing Japanese cooperation with that of other donors, it has an advantage in water management, which enables equitable water distribution below the branch-canal level, and it can be applied to the levels of main and principal canals. In order to deliver enough water to the terminal, equitable water distribution should be started from the upper stream (principal canal level).

To consider the direction of future cooperation by Japan, a comprehensive cooperation project should be highlighted that covers activities previously mentioned. Moreover, several cooperation schemes should be effectively linked together, particularly regarding irrigation facility development for hard components and development of sustainable organizations for soft components.

Chapter 4 Situation in the Target Area

4.1 Overview of the Target Area

4.1.1 Social and Economic Situation

(1) Administrative Structure

The administrative set up of target areas including the governorates of Minya, Beni Suef, and Faiyum in Upper Egypt, and Gharbia governorate in Middle Delta is as shown in Figure 4.1. The concentration of most of the people living in Upper Egypt is confined to the Nile Valley and Faiyum basin; the western desert occupies most of the area.

Table 4.1 shows the basic information about the governorates. According to the table, the total population of Egypt has increased by 25% as per the estimated value of 2016 compared to the census in 2006. The population growth in Gharbia is lower than the national average, while one of the three governorates in Upper Egypt is higher than the national average. The average household size indicates a similar tendency. The illiteracy rate also shows the same tendency and the differences among governorates are particularly noticeable. The ratio of the rural population in all the target governorates is higher than the national average; in particular, the ratio in the three governorates in Upper Egypt is about 80%, which is far higher than the national average of 57%.

Source: JICA Survey Team made by UN map

Figure 4.1 Governorates of Target Area

Table 4.1 Basic Information on Target Four Governorates

Item	Nation	Minya	Beni Suef	Faiyum	Gharbia	Source
Estimated Population in 2016	90,086,267	5,309,254	2,943,740	3,280,103	4,852,968	Statistical Yearbook 2016
Population in 2006	72,349,119	4,150,397	2,286,368	2,505,725	4,001,199	"
Population Growth (%)	125	128	129	131	121	Calculated
Area (km^2)	1,009,450	32,279	10,954	6,068	1,948	Dirout Report (JICA, 2010)
Inhabited Area (km^2)	78,990	2,412	1,369	1,856	1,948	"
Population Density (pop./km^2)	1,140	2,201	2,150	1,767	2,491	Calculated
Average Size of Household (person)	4.2	4.6	4.6	4.5	4.0	Population Census 2006
Illiteracy Rate (%)	29.6	41.3	40.5	40.9	25.9	"
Rate of Urban Population (%)	43	19	23	22	30	"
Rate of Rural Population (%)	57	81	77	78	70	"

Source: Population Census 2006

(2) Population

Table 4.2 summarizes the Population Forecast of 2014 in the target area (by gender/governorates).

Table 4.2 Population by Gender and Governorate

Unit: 000 Pop.

Governorate	Gender proportion*	%	Sum	Female	Male
Cairo	102.5	10.6	9,184	4,536	4,648
Gharbia	102.7	5.4	4,697	2,317	2,380
Beni Suef	103.6	3.2	2,812	1,381	1,431
Faiyum	106.6	3.6	3,118	1,509	1,609
Minya	104.0	5.8	5,077	2,489	2,588
All Egypt	104.2	100	86,814	42,509	44,305

*Gender proportion: No.of male/100 female population
Source: JICA Survey Team made from Central Agency for Public Mobilization & Statistics (CAPMAS) web site

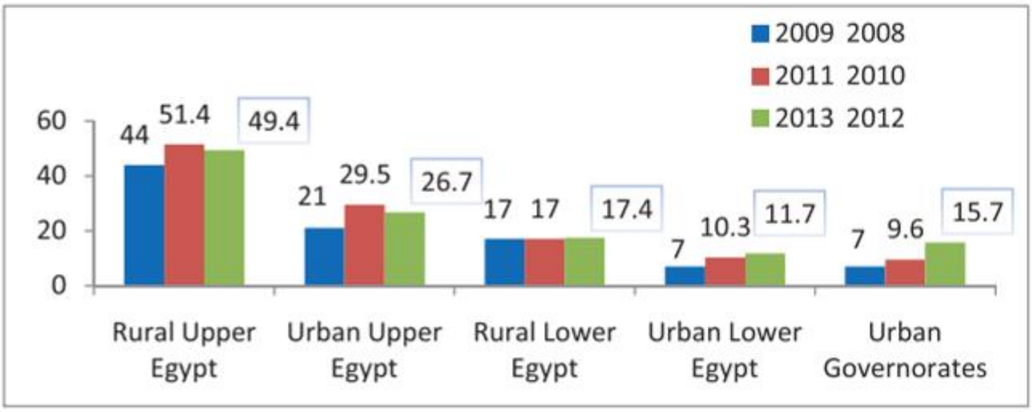
The ratio of the number of farmers to employed people in all the four target governorates is shown in Table 4.3. The percentage of Minya, Beni Suef, and Faiyum ranges from 32 to 45%, above the national average (26%), while the Gharbia stood at 22 %, lower than the national average.

Table 4.3 Ratio of Farmers to be Employed in Target Governorates

Item	Sex	Minya	Beni Suef	Faiyum	Gharbia	Sub Total	Egypt
No.of farmer	Male	474,900	224,400	225,000	197,400	1,121,700	4,426,600
	Female	186,400	170,600	63,300	105,500	525,800	2,051,200
	Total	661,300	395,000	288,300	302,900	1,647,500	6,477,800
Enrolled Pop.	Male	1,135,000	633,000	745,900	1,050,200	3,564,100	19,986,100
	Female	340,800	258,400	143,100	322,300	1,064,600	5,345,000
	Total	1,475,800	891,400	889,000	1,372,500	4,628,700	25,331,100
Rate (%)	Male	42	35	30	19	31	22
	Female	55	66	44	33	49	38
	Total	45	44	32	22	36	26

Source: Statistical Yearbook 2017

On the other hand, the proportion of the poor is shown in Figure 4.2, which indicates that about half the rural population of Upper Egypt is poor.



Source: Central Agency for Public Mobilisation and Statistics (CAPMAS), Household Income, Expenditure, and Concumption Survey (various years)

Note: The definition of poverty rate is; the poverty rate = the number of the poor / the total population, the national standards in Egypt is applied to the number of the poor. The poverty line is defined as expenses for acquiring basic goods and services for individuals/families, 3,100 EGP in 2010/11 and 3,900 EGP in 2012/13.
Source: Egypt's Progress towards Millennium Development Goals, UNDP & Ministry of Planning, Monitoring and Administrative Reform, 2015

Figure 4.2 Rate of the Poor People by Region

The proportion of poor farmers is inferred as 41% × 49% = 20% in Upper Egypt, calculated from the proportion of farmers to the proportion of the poor. For Gharbia in Rural Lower Egypt, it can be inferred as 22% × 17% = 4%.

4.1.2 Agriculture in Target Area

Within the target areas of Upper Egypt, farming is mainly done as irrigated agriculture using Bahr Yusef and the Ibrahimia main canal. In the governorate of Gharbia, which is located in the central delta, irrigated agriculture using the Kased canal is the main farming practice. Here, an overview of general information on irrigated agriculture such as cultivated area, cropping area, production volume, and yield in the target four governorates is presented.

(1) Cultivated and Cropping Area

Trends in the total cultivated area of the four governorates from 2008/09 to 2014/15 and its breakdown (old land / new land[14]) are presented in Table 4.4. In the cultivated area of Gharbia, there is no increase in the new land, and it is believed that agriculture is practiced only on the old land. The new land in the other three governorates has repeatedly increased/decreased after it declined in 2009/10. Old land tends to increase in Faiyum, but there was no change in Beni Suef and Minya. The total of old land cultivation in the four governorates accounts for about 23% to that of Egypt and the total for new land cultivation also accounts for about 4% to that of Egypt as a whole, which accounts for about 17% of the total cultivated area of Egypt.

Table 4.4 Trends of Total Cultivated Area (Old and New Land) in Target Governorate (From 2008/09 to 2014/15)

Unit: feddan

Governorate	Land	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
Gharbia	Old Land	373,860	368,114	361,781	361,224	367,735	354,744	359,364
	New Land	0	0	0	0	0	0	0
	Total	373,860	368,114	361,781	361,224	367,735	354,744	359,364
Beni Suef	Old Land	247,027	259,172	259,957	250,006	258,468	254,322	246,925
	New Land	42,877	37,128	37,052	36,358	39,198	37,266	47,110
	Total	289,904	296,300	297,009	286,364	297,666	291,588	294,035
Faiyum	Old Land	395,287	398,855	400,115	398,713	405,606	406,172	418,628
	New Land	49,924	23,563	30,424	22,554	15,721	15,405	20,800
	Total	445,211	422,418	430,539	421,267	421,327	421,577	439,428
Minya	Old Land	425,931	422,792	426,999	410,650	409,403	423,610	418,881
	New Land	78,318	49,979	43,697	44,911	39,914	42,150	57,716
	Total	504,249	472,771	470,696	455,561	449,317	465,760	476,597
Total	Old Land	1,442,105	1,448,933	1,448,852	1,420,593	1,441,212	1,438,848	1,443,798
	New Land	171,119	110,670	111,173	103,823	94,833	94,821	125,626
	Total	1,613,224	1,559,603	1,560,025	1,524,416	1,536,045	1,533,669	1,569,424
National	Old Land	6,156,531	6,117,723	6,071,219	6,019,395	6,182,507	6,082,176	6,155,756
	New Land	2,626,683	2,623,399	2,548,208	2,780,044	2,771,816	2,834,289	2,939,949
	Total	8,783,214	8,741,122	8,619,427	8,799,439	8,954,323	8,916,465	9,095,705
Share to National	Old Land	23%	24%	24%	24%	23%	24%	23%
	New Land	7%	4%	4%	4%	3%	3%	4%
	Total	18%	18%	18%	17%	17%	17%	17%

Source: Bulletin of the Agricultural Statistics 2008/09~2014/15

In addition, the proportion of the old land to new land was calculated using the data of Table 4.4. The results are shown in Table 4.5. In Gharbia, 100% of the cultivated area is the old land. The proportion occupied by the old land in the other three governorates is also much higher than the national average,

[14] The old land is pioneered cultivated land spreading in the Nile delta and the Nile Valley, and the new land is said to be new cultivated land in the desert, etc., since the Land Reform Program in 1952. In the survey area, Kamadir, Terfa, Sakoula and Mazoura sub-regions are new land, but they have been irrigated with water from the Bahr Yusef Principal Canal for a long time, and there is no significant change in the target area total, which does not adversely affect water demand.

so one can say that agriculture in the four governorates is practiced mainly on the old land.

Table 4.5 Rate of Old and New Land in Target Governorates (from 2008/09 to 2014/15)

Unit: %

Governorate	Land	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	Average
Gharbia	Old Land	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	New Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beni Suef	Old Land	85.2	87.5	87.5	87.3	86.8	87.2	84.0	86.5
	New Land	14.8	12.5	12.5	12.7	13.2	12.8	16.0	13.5
Faiyum	Old Land	88.8	94.4	92.9	94.6	96.3	96.3	95.3	94.1
	New Land	11.2	5.6	7.1	5.4	3.7	3.7	4.7	5.9
Minya	Old Land	84.5	89.4	90.7	90.1	91.1	91.0	87.9	89.2
	New Land	15.5	10.6	9.3	9.9	8.9	9.0	12.1	10.8
Total	Old Land	89.4	92.9	92.9	93.2	93.8	93.8	92.0	92.6
	New Land	10.6	7.1	7.1	6.8	6.2	6.2	8.0	7.4
National	Old Land	70.1	70.0	70.4	68.4	69.0	68.2	67.7	69.1
	New Land	29.9	30.0	29.6	31.6	31.0	31.8	32.3	30.9

Source: Prepared by JICA Survey Team from values of the cropped area

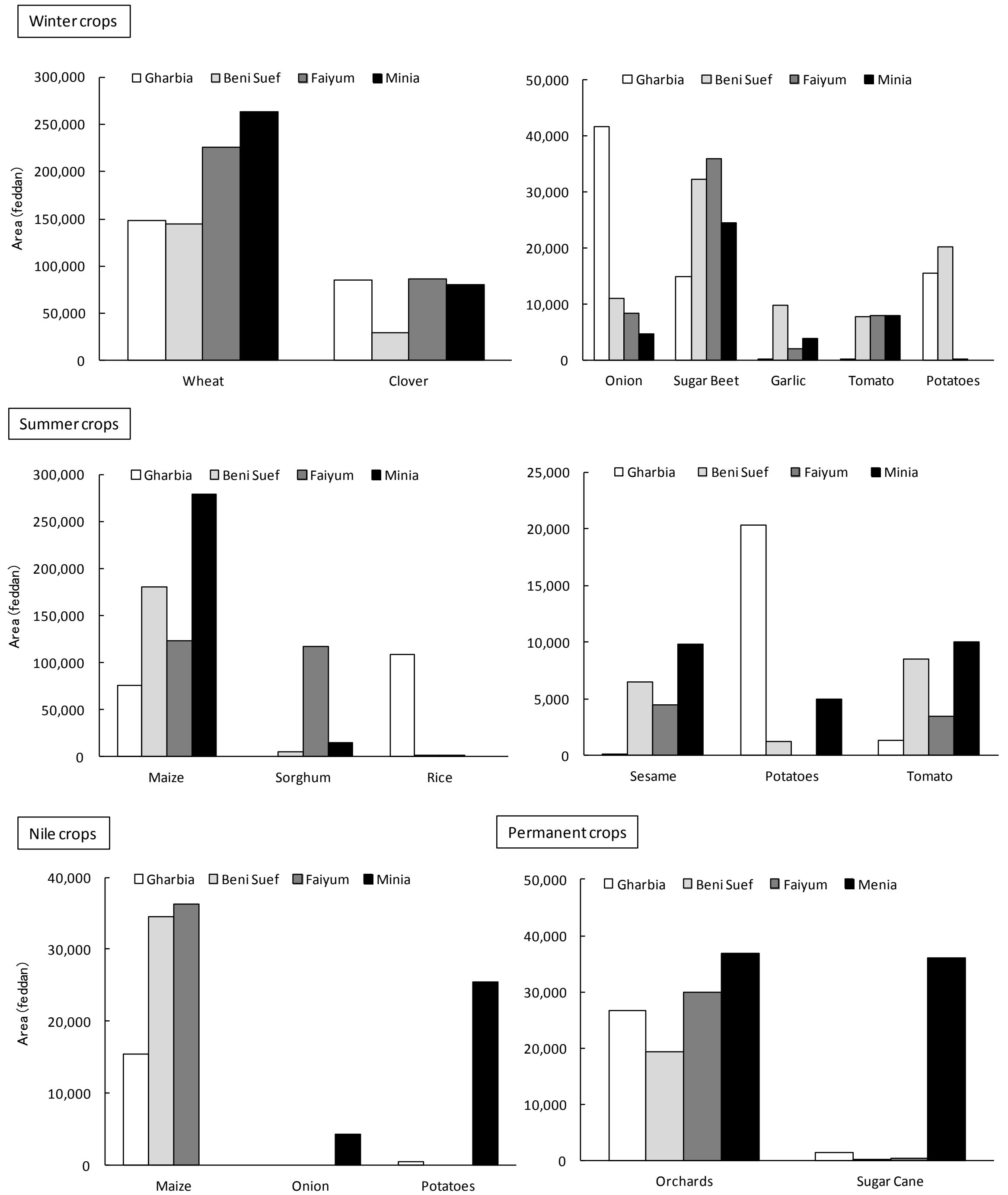
The cropped area and cropping intensity for each cropping season (winter, summer, Nile, permanent) in the four governorates for 2014/15 are shown in Table 4.6. As a feature, the cropping intensity during winter in the four governorates is higher than the national average. The intensity of summer crops is also higher than the national average except for Faiyum. On the other hand, the intensity of the permanent crops is lower than the national average in the four governorates. The total intensity is extremely high at 201% in Gharbia, followed by Beni Suef (193%), Minya (185%), and Faiyum (180%), i.e., they are all higher than the national average (172%).

Table 4.6 The Cropped Area and Cropped Intensity of Survey Target Governorate (2014/15) (Unit: feddan)

	Cultivated Area	Winter Crops Area and Intensity		Summer Crops Area and Intensity		Permanent Crops Area and Intensity		Nile Crops Area and Intensity		Total Intensity (%)
		Total Area	Intensity (%)	Total Area	Intensity (%)	Total Area	Intensity (%)	Total Area	Intensity (%)	
Gharbia	359,364	330,927	92	326,620	91	28,437	8	36,701	10	201
Beni Suef	294,035	274,040	93	232,117	79	19,995	7	41,170	14	193
Faiyum	439,428	407,806	93	294,699	67	31,622	7	57,528	13	180
Minya	476,597	401,816	84	373,807	78	74,781	16	29,868	6	185
National	9,095,705	6,895,131	76	6078,066	67	2,200,574	24	463,323	5	172

Source: Bulletin of The Agricultural Statistics 2014/15

Figure 4.3 shows the cropped area of major crops cultivated in winter, summer, Nile, and permanent in the four governorates.



Source: Bulletin of the Agricultural Statistics 2014/15

Figure 4.3 Cropped Area of Major Crops for Each Cropping Season (2014/15)

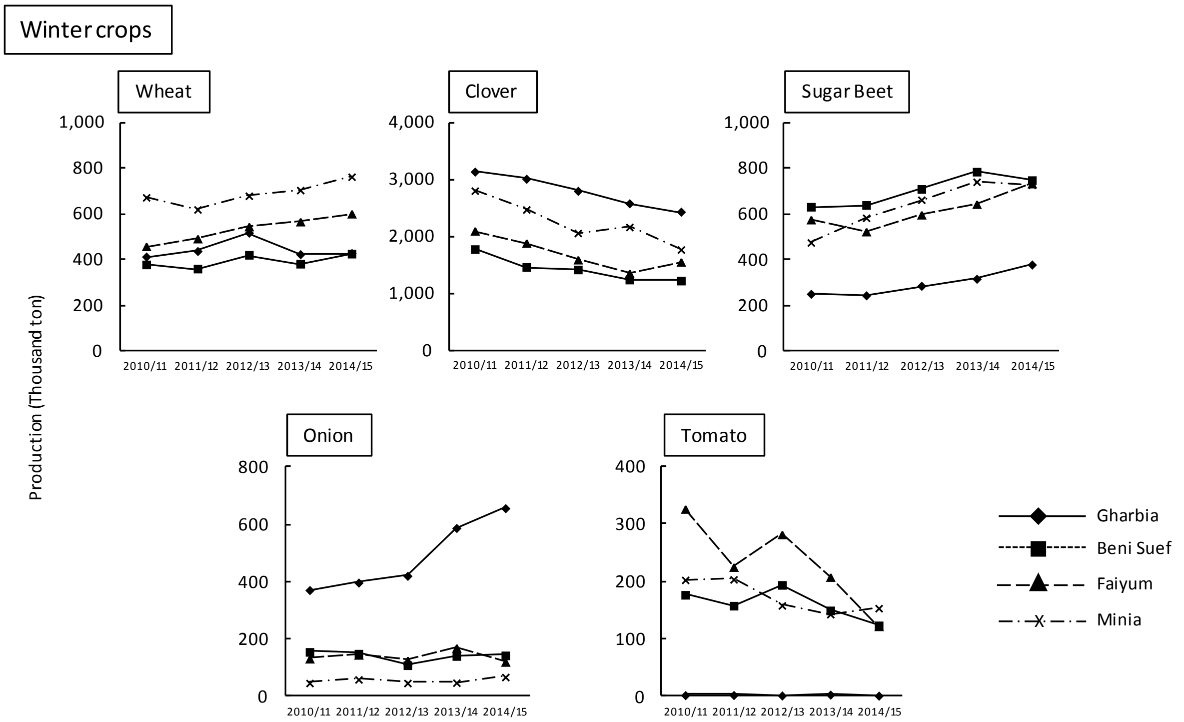
The features of cultivated crops of the four governorates interpreted from Figure 4.3 are summarized in Table 4.7.

Table 4.7 Features of Cultivated Crops of four Governorates

Governorate	Feature of Cultivated Crops
Gharbia	・In winter, onion is the major crop, while tomato holds quite a little share. ・Rice is much cultivated in addition to maize in summer. ・Potato is much cultivated in winter and summer.
Beni Suef	・Clover is cultivated a little in winter. Sugar beet, garlic, and potato are much cultivated in winter. ・Maize is much cultivated in summer. Sesame and tomato are also cultivated in summer.
Faiyum	・Wheat and sugar beet are much cultivated in winter. ・Sorghum is much cultivated in addition to maize in summer. ・Maize is most cultivated among four governorates in Nile season.
Minya	・Wheat is most cultivated in four governorates in winter. ・Maize is mostly cultivated in four governorates in summer. ・Onion and potato are cultivated in Nile season instead of maize. ・Sugarcane is much cultivated in addition to orchard grass as permanent crops.

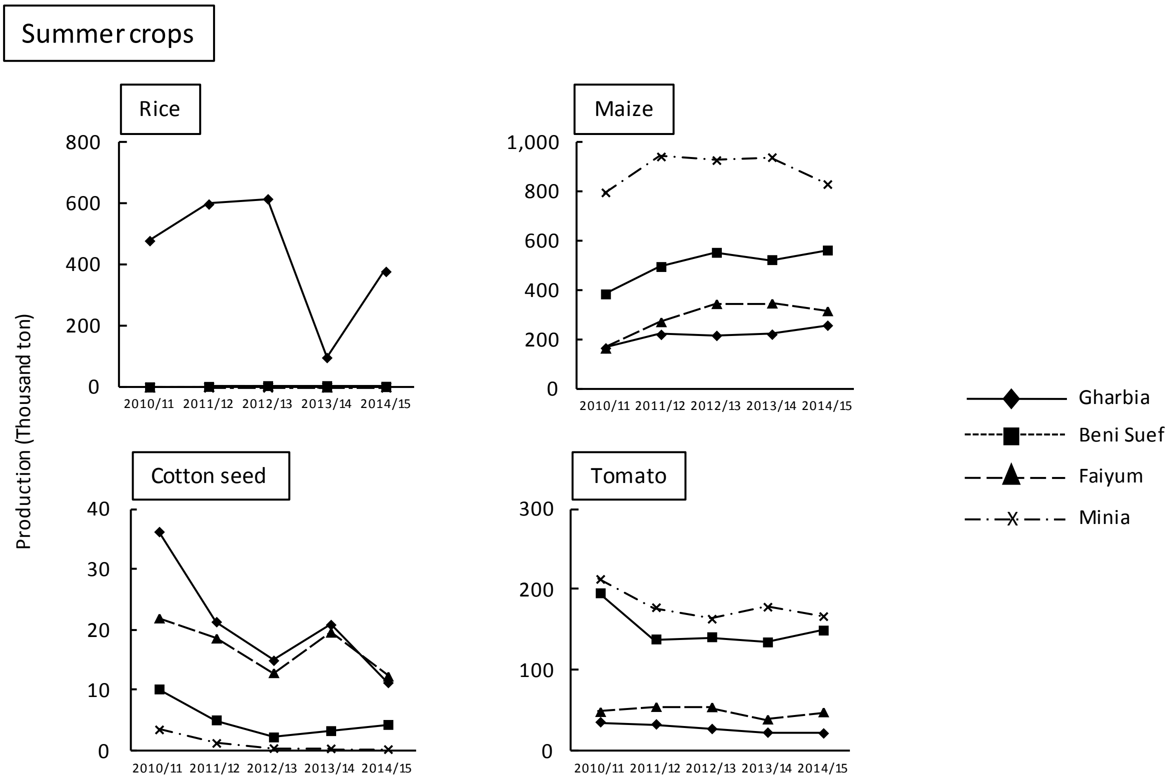
(2) Major Crop Production Trend in the Target Governorates

The major crop production trend for each cropping season for the past five years is shown below.



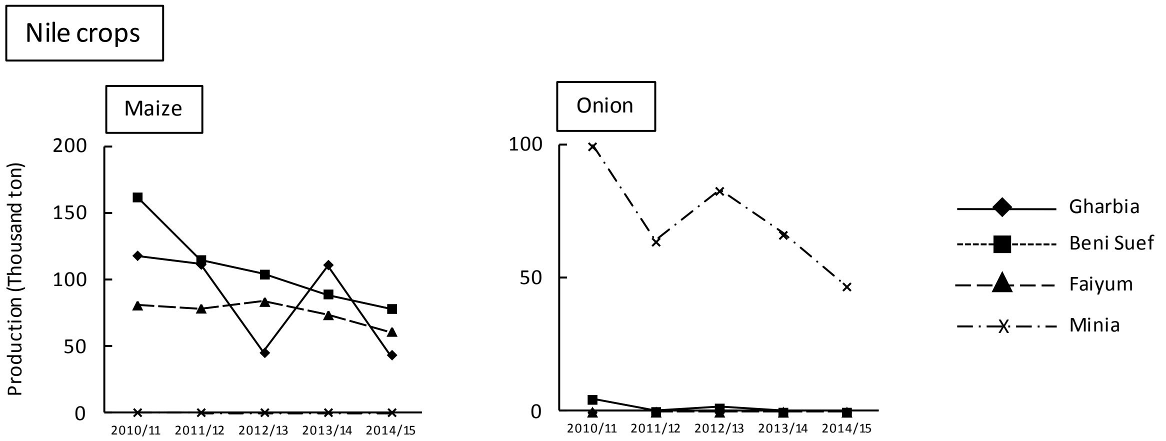
Source: Bulletin of the Agricultural Statistics 2010/11~2014/15

Figure 4.4 Major Crop Production Trend in Winter (2010/11~2014/15)



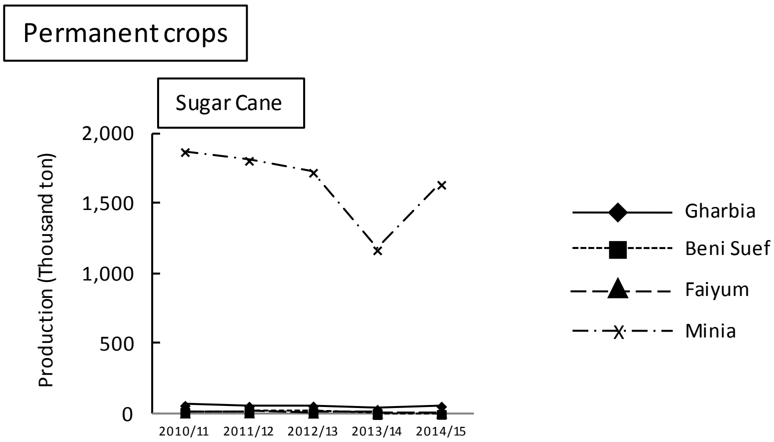
Source: Bulletin of the Agricultural Statistics 2010/11~2014/15

Figure 4.5 Major Crop Production Trend in Summer (2010/11~2014/15)



Source: Bulletin of the Agricultural Statistics 2010/11~2014/15

Figure 4.6 Major Crop Production Trend in Nile Season (2010/11~2014/15)



Source: Bulletin of the Agricultural Statistics 2010/11~2014/15

Figure 4.7 Major Crop Production Trend of Permanent Crops (2010/11~2014/15)

Crop production in the target governorates inferred from Figure 4.5, Figure 4.6 and Figure 4.7 is summarized in Table 4.8.

Table 4.8 Feature of Crop Production of four Governorates

Governorate	Feature
Common in all governorates	・Wheat and sugar beet tend to increase, while clover tends to decrease in winter. ・Maize tends to increase slightly, while cottonseed tends to decrease in summer.
Gharbia	・Onion production has increased sharply in recent two years (2013/14, 2014/15). ・Rice production was decreased significantly in 2013/14, because of the cropping area of rice was decreased enormously (the factor is unknown).
Beni Suef	・Maize production tends to decrease in Nile season.
Faiyum	・Tomato production tends to decrease in winter.
Minya	・Onion production trends to decrease in Nile season. ・Sugarcane production was much decreased in 2013/14, but recovered in 2014/15.

(3) Yield of Major Crops

The yield of major crops in the four governorates for each cropping season in 2014/15 is shown in Table 4.9.

Table 4.9 Yield of Major Crops for Each Cropping Season (2014/15)

Winter crops (Unit: Ton/feddan)

Governorate	Wheat	Clover	Sugar beet	Onion	Garlic	Tomato	Potato
Gharbia	2.890	28.489	25.356	15.731	7.349	9.301	9.360
Beni Suef	2.995	40.972	23.076	12.948	10.121	15.771	10.853
Faiyum	2.658	17.916	20.407	14.357	7.620	15.153	9.000
Minya	2.898	22.079	29.744	14.381	9.680	19.326	-
National	2.770	30.103	21.593	14.637	9.231	17.680	11.180

Summer crops

Governorate	Maize	Rice	Sesame	Tomato	Potato
Gharbia	3.397	3.490	0.457	15.705	13.186
Beni Suef	3.131	4.200	0.522	17.405	11.277
Faiyum	2.576	3.501	0.480	13.633	-
Minya	2.983	-	0.654	16.623	8.438
National	3.123	3.963	0.571	15.906	12.339

Nile crops

Governorate	Maize	Onion	Potato
Gharbia	2.792	-	5.109
Beni Suef	2.251	-	-
Faiyum	1.672	-	-
Minya	-	11.183	8.191
National	2.808	13.741	8.903

Permanent crops

Governorate	Sugar Cane
Gharbia	41.136
Beni Suef	31.915
Faiyum	26.052
Minya	45.525
National	48.469

Source: Bulletin of the Agricultural Statistics 2014/15

4.1.3 Setting Inventory of Irrigation Facilities in GIS

The Survey conducted outlining the irrigation facilities of the main canal, sample areas, and model areas to grasp an outline of the target area. The Survey results are transformed into an inventory of irrigation facilities (Annex 3). Such results and information based on existing materials were set in GIS, making it possible to visually understand the whole irrigation system, boundaries, and distribution of sub-regions.

(1) Preparation of GIS Data

The table below shows GIS data prepared by the Survey. It consists of satellite images, boundary data and water canal data of the sub-regions, and irrigation facility data obtained through the on-site survey.

Table 4.10 Contents of GIS Data

Item	Data Title	Data Type	Contents
Data based on satellite images	Boundary data of the sub-regions	Polygon	Outlined polygon data of boundaries of the sub-regions. Investigation and renewal are necessary for detailed information.
	Water canal data	Line	Line data possess attributes obtained from existing materials and irrigation system. Location of principal canals, main canals, irrigation canals, drainage, rivers, and lakes are obtained from satellite images.
Data from the on-site survey	Irrigation facility data	Point	Point data of irrigation facilities, which consist of location data and attribute information obtained through the on-site survey.

1) Preparation of Data from Satellite Images

The Survey prepared boundary data and irrigation canal data of the sub-regions based on satellite images and existing materials. These data were mainly obtained by conducting a close inspection of satellite images. Where it is difficult to decipher satellite images, an on-site survey of the model areas and inference about the other areas from existing materials were used to fill in the gaps. Attribute information (benefitted area, name of canals, length of canals, etc.) was input using the existing materials. Figure 4.8 shows the preparation flow of irrigation canal data.

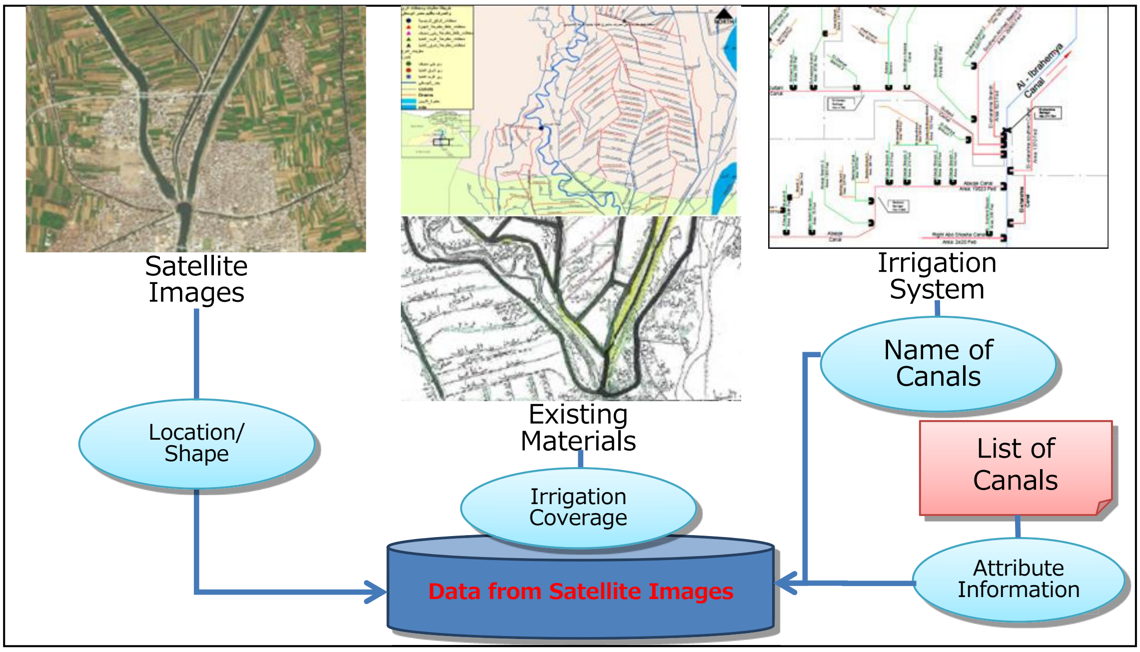


Figure 4.8 Flowchart of Data Preparation from Satellite Images

The data cover the target areas of the Survey. In addition to the irrigation systems of Bahr Yusef canal, Ibrahimia canal, and Kased canal, the data include the irrigation systems of the Faiyum canal that are located downstream of the Bahr Yusef canal.

2) Preparation of Irrigation Facility Data

Individual data of particular irrigation facilities (point data), were combined with coordinates, attribute information, and formed as GIS data. This process is based on the results of an inventory survey by a local contractor, irrigation facility survey, and the on-site survey of the model areas. Satellite images were applied to check and adjust the coordinates collected by hand-held GNSS devices. Attribute information was prepared through the on-site survey and interviews accompanied by those who were in charge of irrigation areas, and through crosschecking of existing materials. Figure 4.9 and Figure 4.10 show the preparation flow of irrigation facility data and data coverage, respectively.

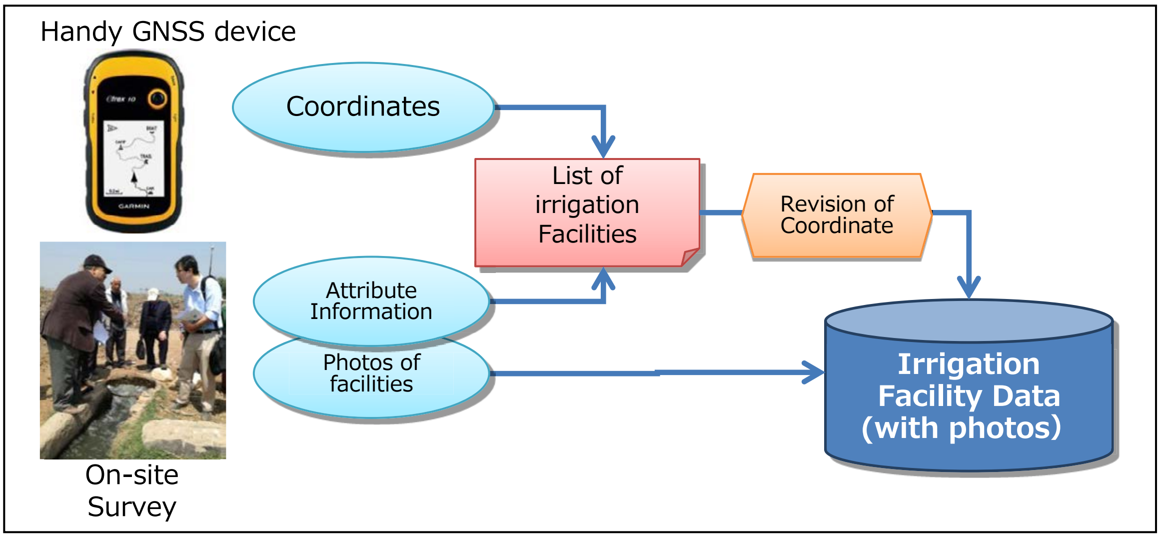


Figure 4.9 Flowchart of Preparation of Irrigation Facility Data

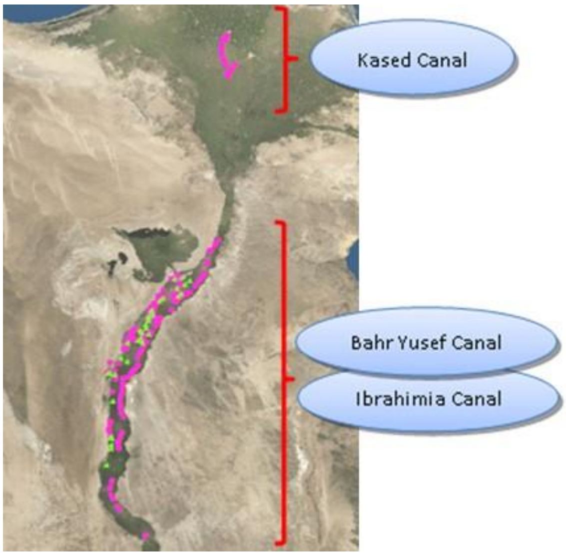


Figure 4.10 Coverage of Irrigation Facility Data

3) Specifications for GIS Data

The GIS data, the Survey prepared, followed the coordinate systems as shown below.

Table 4.11 Coordinate Systems

Item	Contents
Projection	UTM (Universal Transverse Mercator) Zone 36N
Reference Ellipsoid	WGS84(World Geodetic System 84)
False Easting	500,000 m
False Northing	0 m
Central Meridian	33° 00′ 00″
Map Correction Factor	0.9996

The following table shows a sample of the definition of attributes of the GIS data the Survey prepared.

Table 4.12 Sample of Definition of Attributes of GIS Data

GIS Database Structure Field Definition

2017/5/19

FILE NAME	Pumps.shp	LAYER	Pumps
FILE TYPE	Shape Format	DATE TYPE	Point

No	Field Name	Contents	Length	Data Type	Note
1	Number_	ID_Number	-	Long	
2	Irr_Unit	Irrigation Unit Name	254	Text	
3	Irr_Dist	Irrigation District	254	Text	
4	Location	Location of Pump	254	Text	
5	Name	Name of Facility	254	Text	
6	Type_	Type of Facility	254	Text	
7	Gate_Num	Number of Gates	-	Long	
8	Gate_Width	Gate Width	-	Double	
9	N	Latitude of Facility	-	Double	WGS84 (Degree)
10	E	Longitude of Facility	-	Double	WGS84 (Degree)
11	Const_Year	Construction year	-	Long	
12	Feddan	Irrigation Area	-	Long	Feddan
13	Canal_Leng	Canal Length	-	Double	Kilometer
14	Pump_Num1	Number of Pump (1)	-	Long	
15	Discharge1	Discharge (1)	-	Double	m^3/S
16	Pump_pow1	Power of Pump (1)	-	Double	KW
18	Pump_Num2	Number of Pump (2)	-	Long	
19	Discharge2	Discharge (2)	-	Double	m^3/S
20	Pump_pow2	Power of Pump (2)	-	Double	KW
21	Reha_Year	Year of Rehabilitation (2)	-	Long	
22	Remark	Necessary work	254	Text	
23	Rank	Condition Rank	254	Text	
24	Filepath	Picture File Path	254	Text	

** All data: From Field Investigation*

Following the above-mentioned definitions, the Project formed the GIS data from the result of surveys such as an irrigation facility survey.

(2) Usage of GIS Data

The Survey has utilized the GIS data not only for the integration of the survey results, but also for the consideration of further cooperation programs. The Survey, using an open-GIS software called "QGIS", has also created a project file that is capable of showing coordinates and attributes of irrigation facilities and searching for them, to propel data usage. The project file makes it possible to display photos of facilities on the GIS screen by linking the point data of irrigation facilities and the photos taken during the field survey.

Although MWRI's irrigation division and drainage division have separately prepared databases to date, these databases should be integrated to rationalize the maintenance of facilities in the future. If such database were used for maintenance, it should be renewed every year and can continue to maintain its quality for several years. The establishment of a system that enables governorate officials to utilize and renew the database is also preferable. Displaying both irrigation-facility data and photos simultaneously, can simplify the checking of irrigation systems of each canal. Adding detailed irrigation-facility data to the database prepared by the Survey and periodical renewal of it will enable the facilitation of its usage for maintenance of irrigation facilities, storage of survey results, and future project planning.

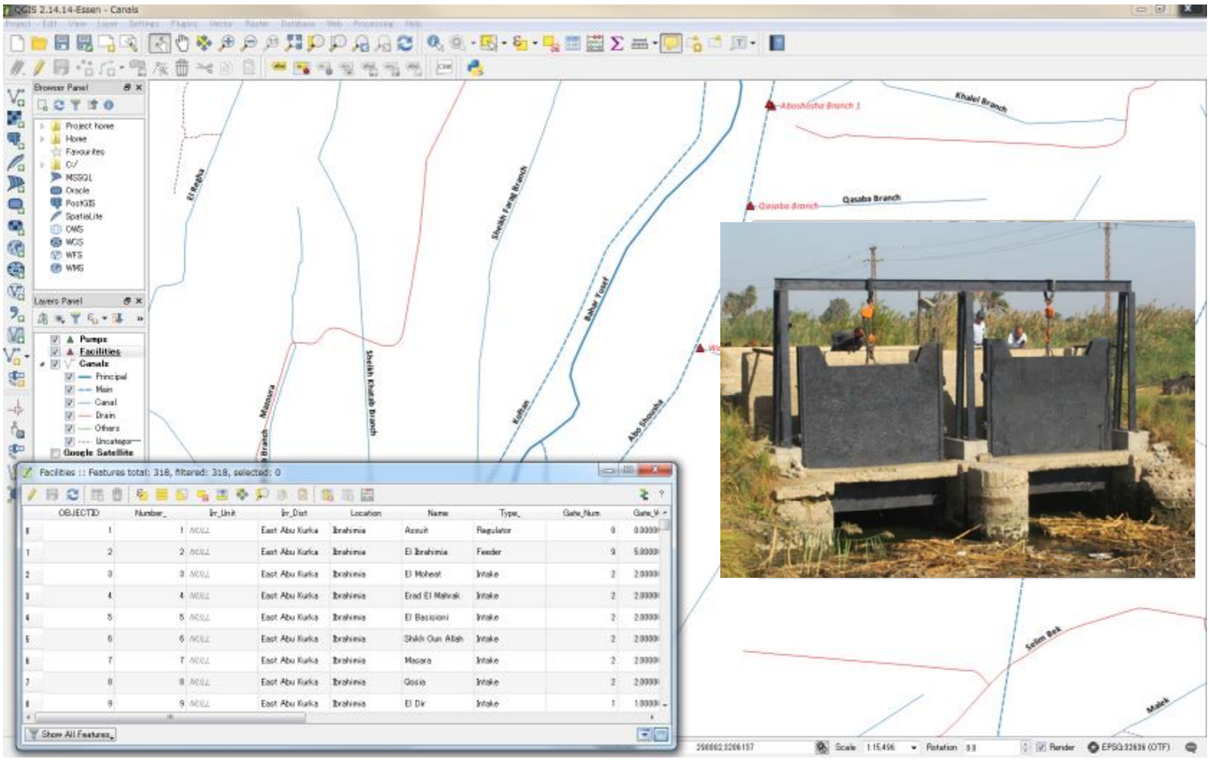
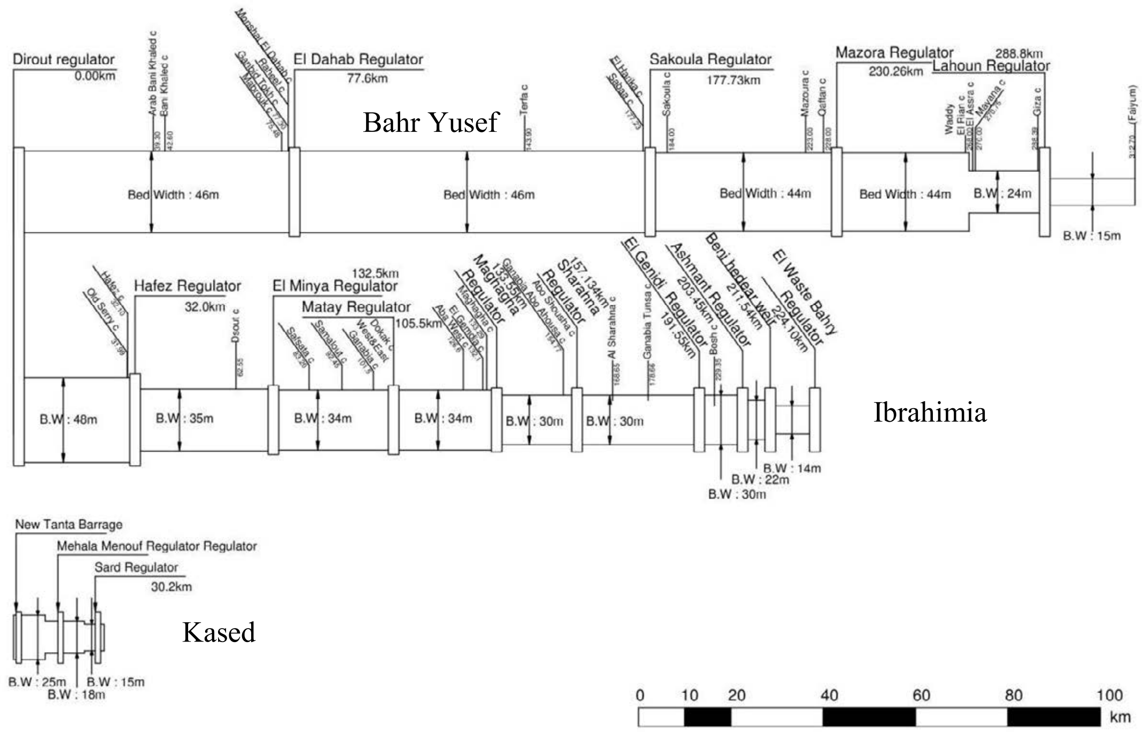


Figure 4.11 Sample Display of QGIS

4.1.4 The Irrigation Systems

(1) Overall View of the Three Target Canals

Schematic drawings of the three target canals, namely, Bahr Yusef, Ibrahimia and Kased Canal, are presented below to grasp the features of the conveyance system. The Bahr Yusef Principal Canal is a naturally made meandering canal system without forming much change in its (canal) width that conveys water up to Faiyum city (downstream) and which covers 60% of the cultivated land envisaged in the canal system. Although Bahr Yusef and Ibrahimia start and end at approximately the same location (longitudinally), the former is much longer due to many curves. On the other hand, the Ibrahimia Principal Canal is an artificially made canal systematically constructed such that the canal cross-section becomes smaller as it goes downstream. Compared to Bahr Yusef and Ibrahimia Principal Canal, the size of the Kased Main Canal is very small.



Source: JICA Survey Team, made from field survey.

Figure 4.12 Schematic Canal System of the Three Canal

Table 4.13 shows the length and number of canal systems by their types (such as main canal and branch canal) of the three target canals. Between the main canal and branch canals, there is another level of canals, which are termed in this report as "sub main" canals.

Comparing the number and the total length of the canal of the two principal canals, Ibrahimia has 1.2 times more canals, but is 60% shorter in length than the Bahr Yusef canal. It means that the Ibrahimia Canal has more shorter canals than Bahr Yusef does.

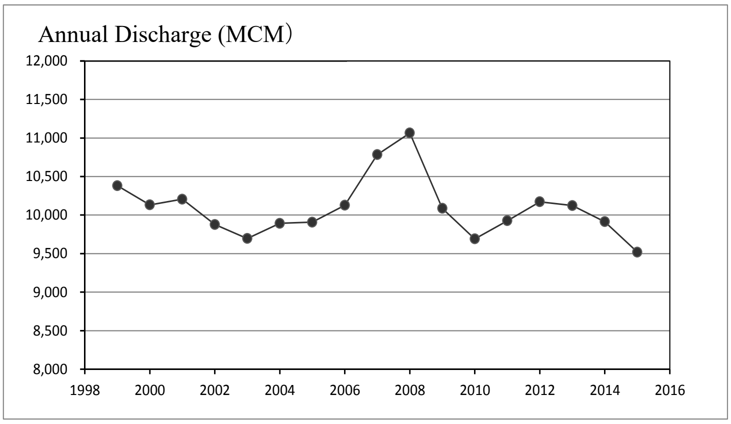
Table 4.13 Type and Number of Canals and Total Length of Target Three Canals

Canal System		Sum	Main Canal	Sub Main Canal	Branch Canal
Bahr Yusef	Number	768	55	92	621
	Length (km)	5,328	596	755	3,977
Ibrahimia	Number	889	77	165	647
	Length (km)	3,400	630	823	1,947
Kased	Number	35	1	0	34
	Length (km)	230	42	0	188

Source: Prepared by JICA Survey Team based on collected data from MWRI

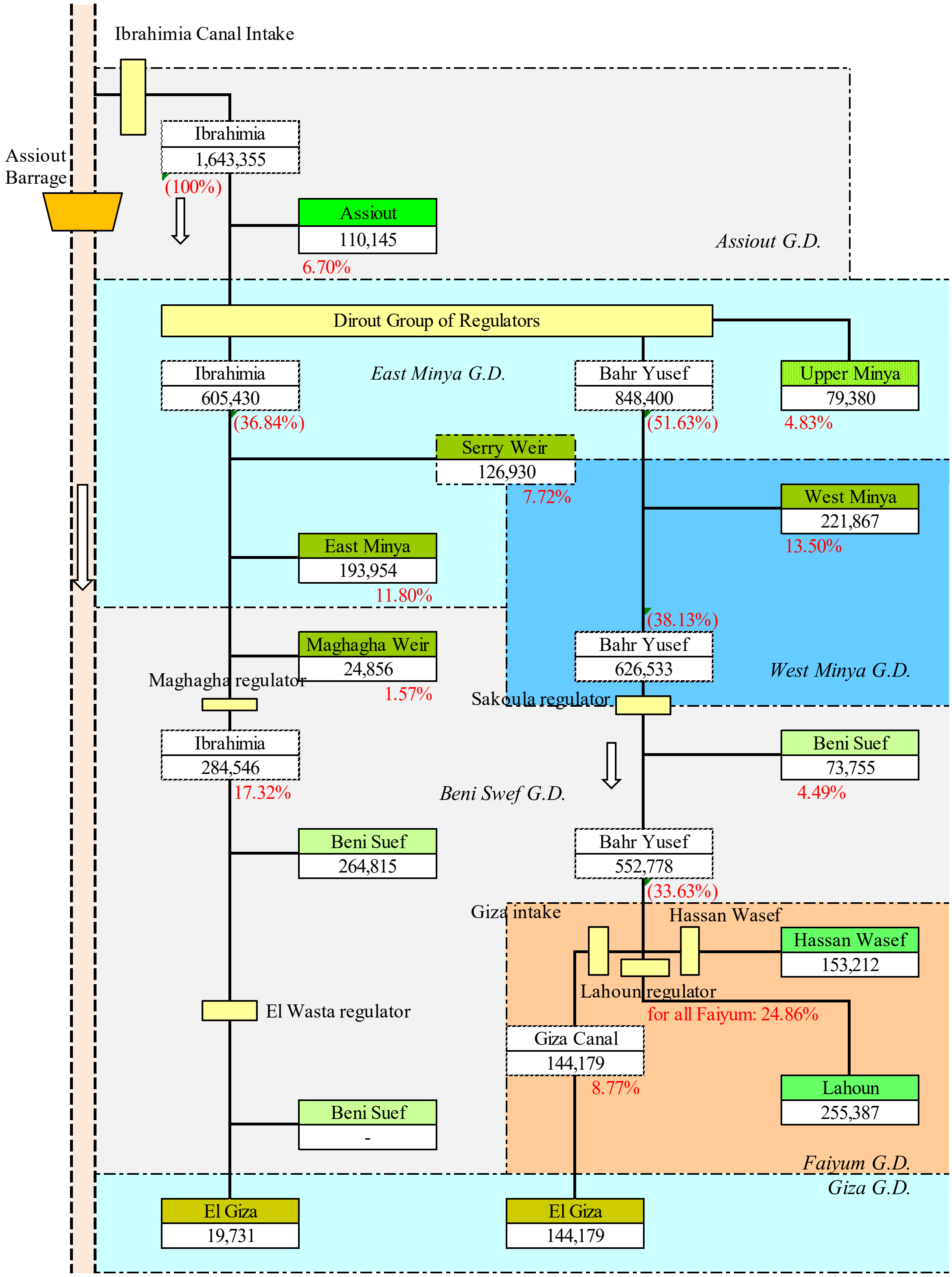
(2) Upper Egypt

The discharge of the original Ibrahimia canal (60 km span ranging from the Asiout intake to Dirout Group of Regulators) at the Ibrahimia Canal Intake, fluctuates year by year, even though release water is not less than 9.6 billion m^3 per year. It is assumed that the fluctuation of annual discharges is a reflection of reserved water quantity in the High Aswan Dam reservoir. However, the seasonal pattern of water distribution in a year seems similar. The flowchart of water distribution under the Ibrahimia Canal Intake is shown in the following diagram.



Source: MWRI

Figure 4.13 Trend of Annual Discharge at the Ibrahimia Canal Intake

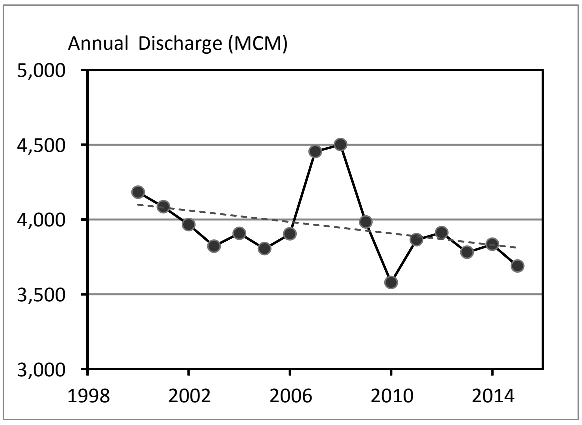


Legend:
Intake or Regulator
Command Area by relevant GDs
Figures in the columns are command area at the unit of fedden.
Red figures of % are the official apportionmants of discharge diverted from Assiout Intake
Source: MWRI

Figure 4.14 Diagram of Water Distribution under Asiout Intake

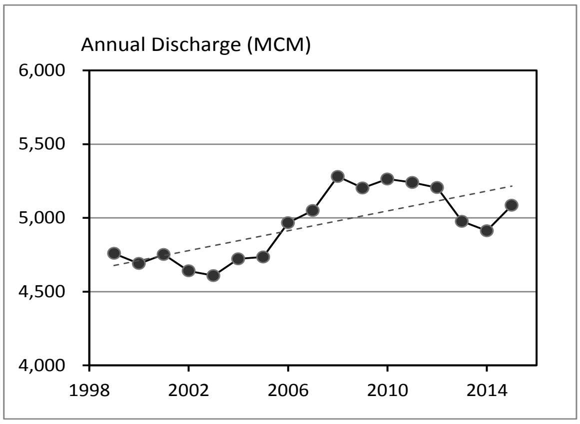
The apportionment ratios of discharge of the Ibrahimia Principal Canal and the Bahr Yusef Principal Canal are recorded at 36.84% and 51.63%, respectively. Furthermore, water distribution ratio of all other canals is also specified. Even though water distribution ratio is fixed, the real state of water distribution is not simply the same. The actual distribution of water must take into account the real situation of the beneficiaries of the water supply.

Figure 4.15 and Figure 4.16 show the trends of annual discharges at the Ibrahimia Principal Canal and Bahr Yusef Principal Canal, respectively.



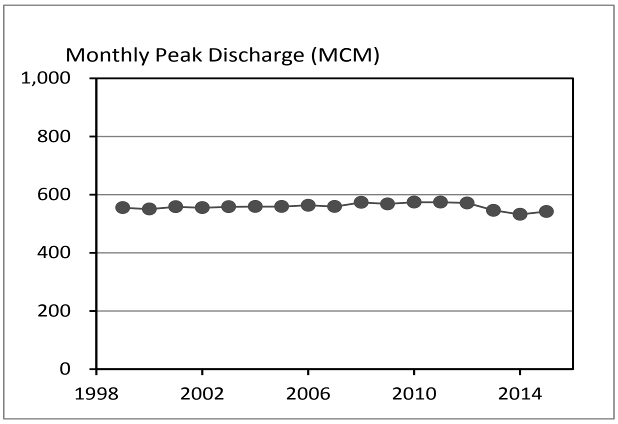
Source: MWRI

Figure 4.15 Trends of Annual Discharges at Ibrahimia Principal Canal



Source: MWRI

Figure 4.16 Trend of Annual Discharges at Bahr Yusef Principal Canal



Source: MWRI

Figure 4.17 Time Series of the Peak Monthly Discharge of Bahr Yusef Canal

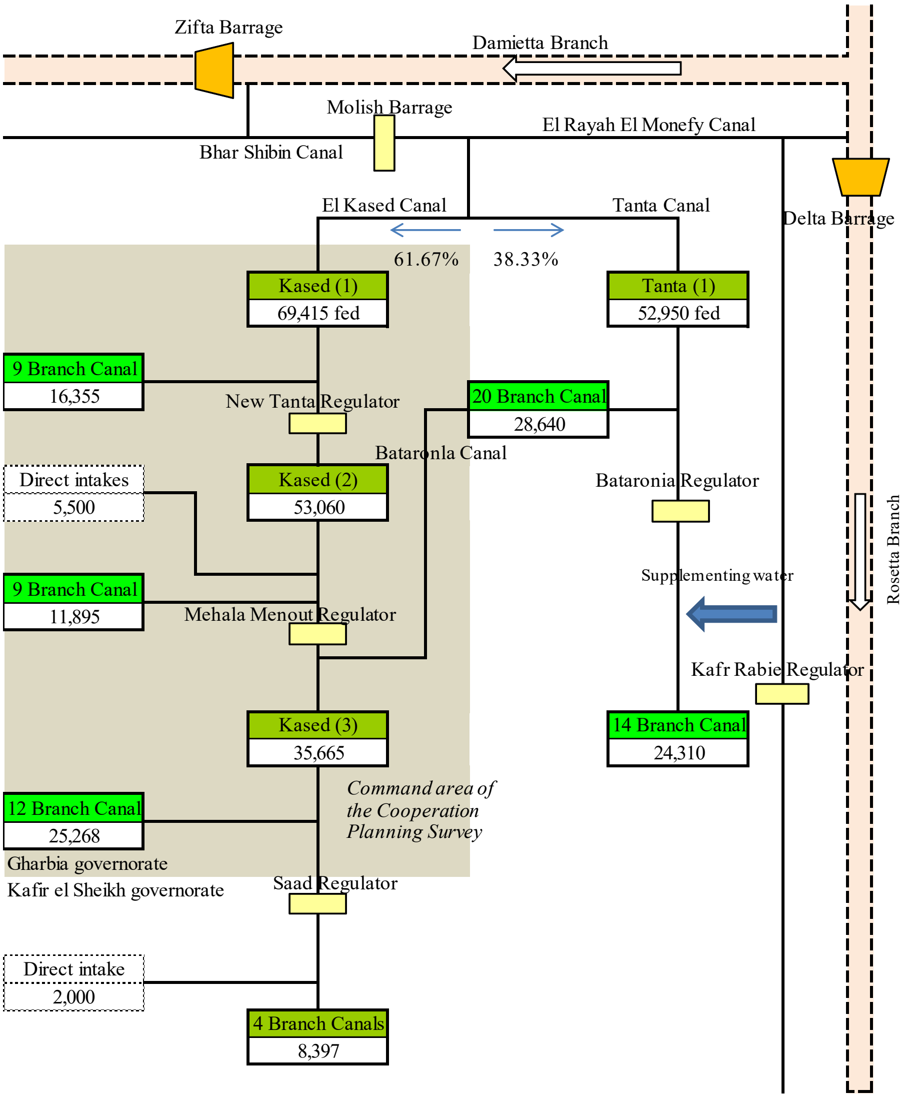
Figure 4.15 and Figure 4.16, the discharge of the Bahr Yusef Principal Canal has tended to increase annually, while discharge of the Ibrahimia Principal Canal has been apt to decrease annually.

Furthermore, Figure 4.17 shows the comparison of the amount of peak monthly-water-release volume to both benefited areas as water, and it shows almost the same for every month. Given that the total annual discharge is increasing in an upward trend as mentioned above, it is suggested that there could be a limitation in the ability of the Bahr Yusef Principal Canal to convey water and that the amount gauged here might have reached the upper limit.

(3) Middle Delta (Kased Canal System)

The Kased canal is a middle-scale canal irrigation system located in the middle delta running from south to north through the governorates of Gharbia and Kafr El-Sheikh (in the Survey, relates to the portion of the canal only in Gharbia). Water in the canal originates from the Delta Barrage, which is located in the Rosetta Branch of the Nile River. Diverted water at the Delta Barrage flows into the El Rayah El Money canal, and branches of the Tanta canal. The Tanta canal turns off to the Kased canal around 10 km downstream from its starting point. The diagram of water distribution of the Kased canal is shown in the figure below.

As diverting water to the Kased canal is controlled by the Bataronia Regulator located 7 km downstream, the apportionment ratio of discharge is accorded at 38.33% and 61.67% for the Tanta canal and Kased canal, respectively.

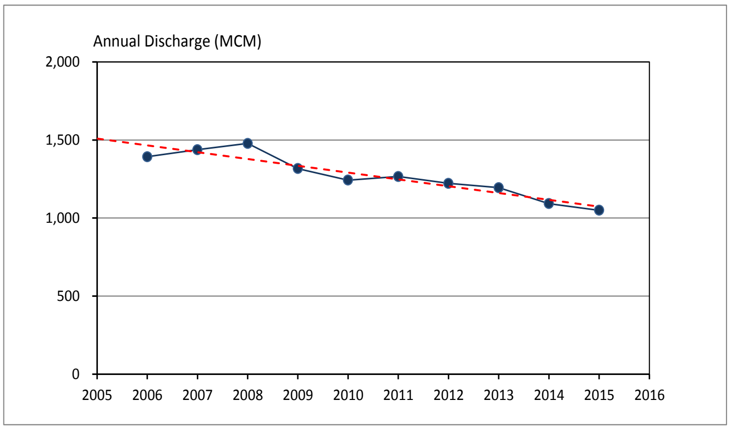


Source: MWRI

Figure 4.18 Diagram of Water Distribution of Kased Canal

Though observed discharge data are available for the Tanta canal, the discharge of the Kased canal can be estimated from the data of the Tanta canal by using a linear interpolation, because of the absence of artificial regulations between both. Figure 4.19 shows the time series of the monthly discharge of the Tanta canal by years. The discharges are not constant.

In the figure above, a decreasing trend can be recognized from the discharge sequences of the Tanta canal. A yearly discharge decrease tendency was observed even in Upper Egypt, and such a decreasing water tendency is similar throughout Egypt.



Source: MWRI

Figure 4.19 Time Series of Monthly Discharge of Tanta Canal

4.1.5 Situation of Irrigation Water Use

Here, the current situation is explained through 1. Calculation of the designed irrigation requirement based on the cropping areas and patterns, 2. Objective analysis by using satellite images to look at the whole target area, and 3. Review of the water quality and water reuse considering water use at the terminal.

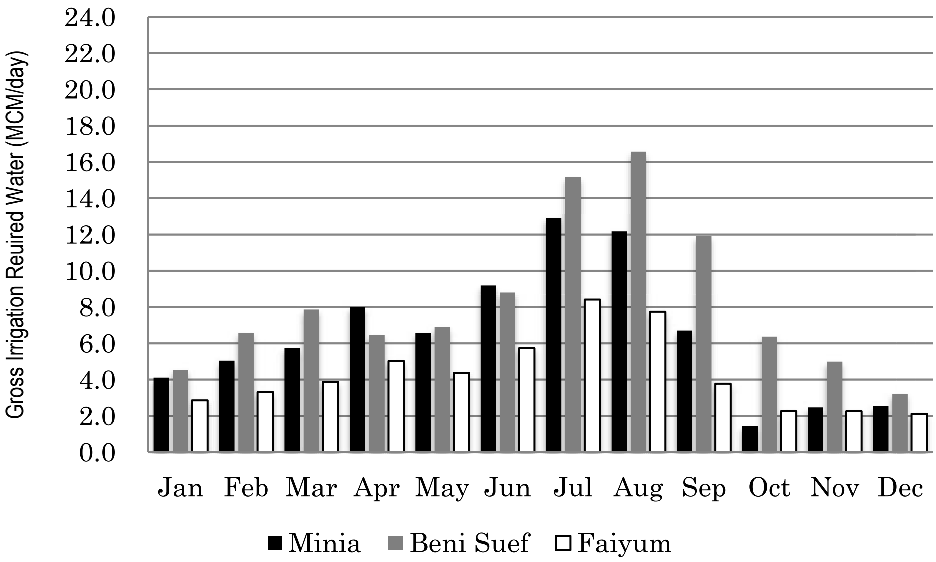
(1) Comparison between Designed Irrigation Requirement and Irrigation Water Supply

In order to verify the status of excess and deficiency of irrigation water volume in the Bahr Yusef canal system and Ibrahimia canal system, the comparison between the designed irrigation requirement and actual irrigation water volume was examined.

1) Calculation of Designed Irrigation Requirement

Since the cropping area and pattern in Minya, Beni Suef, and Faiyum mentioned in Chapter 2 confirmed that no major change has been made in recent years to the design-cropped area (2016), the decision regarding the design water requirement followed the cropping pattern of the Dirout Report (2010).

The irrigation requirement is calculated by considering the irrigation efficiency necessary for the crop water requirement. The designed irrigation requirement of each governorate, which is calculated by the current irrigation efficiency of 0.605[15] of previous data, is shown in Figure 4.20.



Source: JICA Survey Team

Figure 4.20 Monthly Designed Irrigation Requirement of Each Governorate

The monthly designed irrigation requirement peak in July-August and the cropped area design in summer decreases in the order of Minya, Faiyum and Beni Suef, but since the cropping system is different, the required water volume increases in the order of Beni Suef, Minya, and Faiyum. It is suggested that the design cropped area of Beni Suef needs more irrigation water volume and crops with low water consumption are cultivated in Faiyum.

[15] The Final Report, the Preparatory Survey for the Rehabilitation and Improvement of Dirout Group of Regulators, JICA, 2010

The designed cropping system and cropped area of each governorate used for calculating the required water volume are shown in Table 4.14.

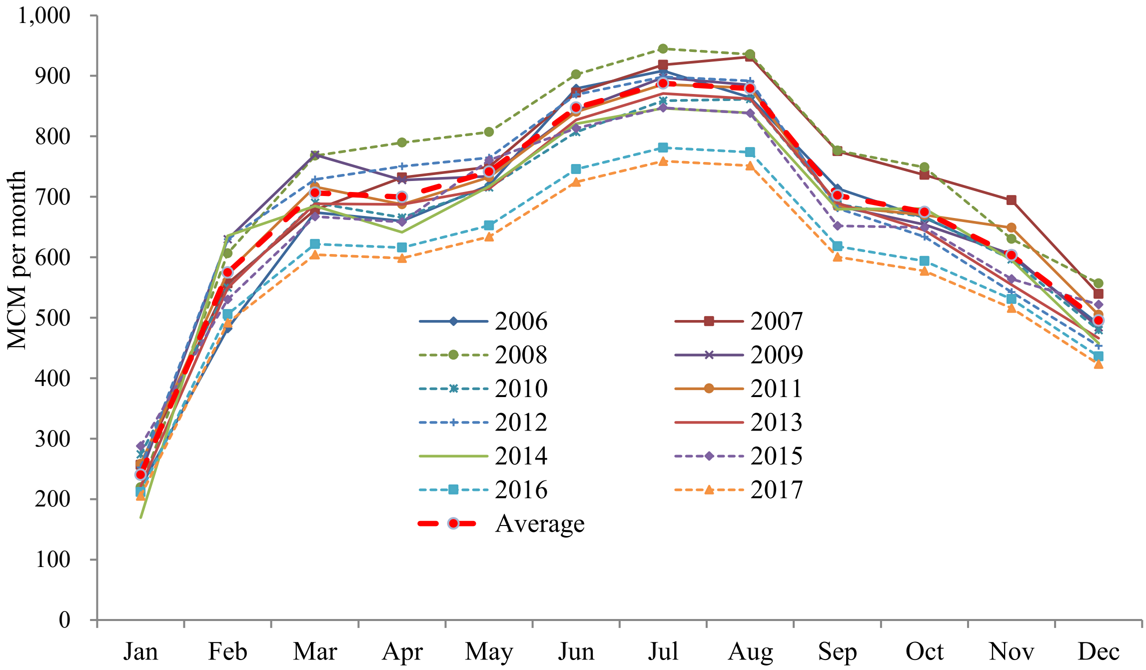
Table 4.14 Cropping Percentage by Representative Crops of Each Governorate

Season	Crops	Beni Suef		Faiyum		Minya	
		Area (ha)	Share (%)	Area (ha)	Share (%)	Area (ha)	Share (%)
Winter	Wheat	60,476	25.4%	94,816	28.5%	110,436	29.9%
	Beseem	12,496	5.2%	36,276	10.9%	33,550	9.1%
	Vegetables	22,522	9.5%	10,512	3.2%	8,524	2.3%
	Others(majoram)	19,603	8.2%	29,674	8.9%	16,252	4.4%
	total	115,097	48.3%	171,278	51.5%	168,762	45.6%
Summer	Maize	73,332	30.8%	47,944	14.4%	96,489	26.1%
	Sorghum	2,105	0.9%	49,413	14.9%	6,110	1.7%
	Oil Crop (Peanuts)	5,453	2.3%	2,524	0.8%	18,890	5.1%
	Vegetables	16,598	7.0%	23,893	7.2%	35,510	9.6%
	total	97,488	40.9%	123,774	37.2%	156,999	42.5%
Nile	Maize	14,476	6.1%	15,212	4.6%	0	0.0%
	Vegetables	2,815	1.2%	8,950	2.7%	12,545	3.4%
	total	17,291	7.3%	24,162	7.3%	12,545	3.4%
Perenial	Suger cane	45	0.0%	195	0.1%	15,161	4.1%
	Fruit trees	8,084	3.4%	12,597	3.8%	15,497	4.2%
	Date	143	0.1%	486	0.1%	750	0.2%
	total	8,272	3.5%	13,278	4.0%	31,408	8.5%
Total		238,148	100.0%	332,492	100.0%	369,714	100.0%
Winter vegetables		Onion		Tomato		Tomato	
Summer vegetales		Tomato		Tomato		Tomato	
Nile vegetables		Tomato		Tomato		Potatoes	
Fruit trees		Citrus		Citrus		Grape	

Source: Compiled by JICA Survey Team based on existing data

2) Irrigation Water Supply

The irrigation water volume performance was determined using the monthly average discharge of the Bahr Yusef and Ibrahimia Principal Canal during the last 12 years from 2006 to 2017. The monthly discharge during this period with its average discharge is presented in the figure below. The trend has shown that the volume of water conveyed to the target area has been reduced, especially during 2016 and 2017.



Source: Compiled by JICA Survey Team based on MWRI's data

Figure 4.21 Monthly Discharge of Water for the Period between 2006 and 2017 with Its Average

The irrigation water volume for each governorate, which is calculated by proportionally distributing the total average discharge volume in the principal canals according to the cropped area of each governorate, is shown in Table 4.15.

Table 4.15 Irrigation Water Supply of Each Governorate

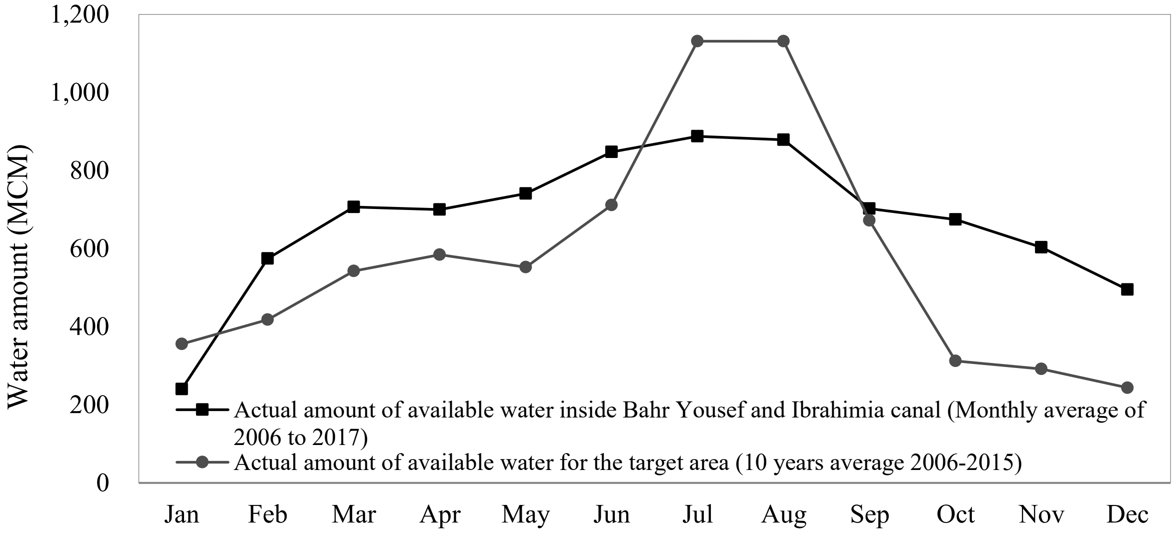
Unit: MCM

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Total average	240	575	707	700	741	847	888	879	702	675	603	495	8,052
Minya	88	212	260	258	273	312	327	324	259	249	222	182	2,965
Beni Suef	81	194	239	236	250	286	300	297	237	228	204	167	2,720
Faiyum	71	169	208	206	218	249	261	258	206	198	177	146	2,367

Source: Compiled by JICA Survey Team based on MWRI's data

3) Comparison of Irrigation Water Supply and Required Water Volume

Using the cropping calendar of the target area collected from MoA, the required volume of water per month is calculated. Figure 4.22 shows the relationship between the performance of irrigation water and the required water for the whole system. Under the current situation, it is confirmed that there is a shortage of irrigation water at the peak period from July to August and it is speculated that the volume of irrigation water is particularly tight at the same time.



Source: Prepared by JICA Survey Team based on MWRI data

Figure 4.22 Comparison of Irrigation Water Supply and Required Water Volume

(2) Evaluation of Productivity in Upper Egypt Irrigation Area by Time-series Data

Here, the distribution of water shortages is estimated by conducting productivity evaluations of the Upper Egypt irrigation area using time-series-satellite images. Since satellite-image-analysis is suitable for grasping the situation in a wider area qualitatively and extensively, it was carried out in order to understand the general situation of Upper Egypt. The Kased Main Canal was excluded from the analysis because it occupies a small part of the Nile Delta.

1) Analysis Method

The analysis of 1. Crop Frequency, 2. Blooming Season, and 3. Growing Condition has been performed with MODIS time-series data[16]. The data was provided by the Rural Planning for Win-Win Laboratory, Graduate School of Agricultural Science, Kobe University. The analysis period is 16 years, from 2000 to 2015, and the detail of the analysis method is based on Kotera et al., 2015[17].

<Vegetation Index>

Growing conditions of crops can be evaluated by a vegetation index, which indicates the flourish condition of plants. In this Survey, Enhanced Vegetation Index (EVI) is used as the vegetation index. Written mathematically as:

$$EVI = G \times \frac{NIR\text{-}RED}{NIR + C_1 \cdot RED\text{-}C_2 \cdot BLUE + L}$$

Where NIR, RED, BLUE are surface reflectance, and G, C_1, C_2, L are the coefficients.

[16] Data observed by MODIS (Moderate Resolution Imaging Spectroradiometer) incorporated in NASA Observation Satellite TERRA/AQUA, resolution: 250m

[17] Kotera, A., Nagano, T., Berberoglu, S., and Cullu, M.A. 2015. A global dataset of noiseless time-series vegetation and water indices for farmland analysis. Proceedings of Fourth International Conference on Agro-geoinformatics 2015. Istanbul, Turkey. 20-23 Jul. 2015.

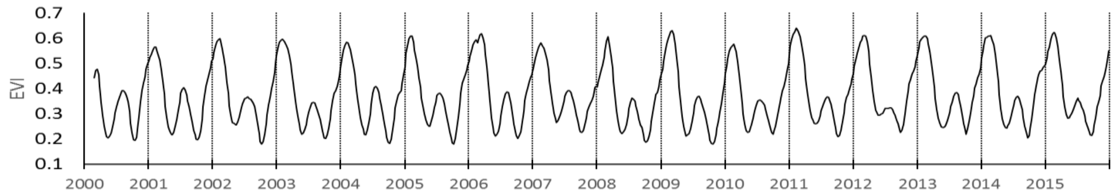
<Analysis of Cultivation Condition＞

In general, vegetation index in cultivated land shows a lower value in the seeding season, increases along with the growth and shows a peak value before/after blooming. Figure 4.23 indicates the time series changes of EVI at a study point in the target area from 2000 to 2015. This point has double cultivation per year, and the blooming seasons are around February and July every year.

Crop Frequency is detected by counting the time-series EVI peak. In the case where the value of EVI is less than 0.2[18], it is eliminated as another plant. Crop Frequency per year is the sum of the peak in the period of May to the following April.

Blooming Season is the date when the peak is detected. For mapping, the result is divided into quarters (every three months) so that all the different blooming seasons are presented.

Growing Condition is based on the average value of EVI per quarter as its index.



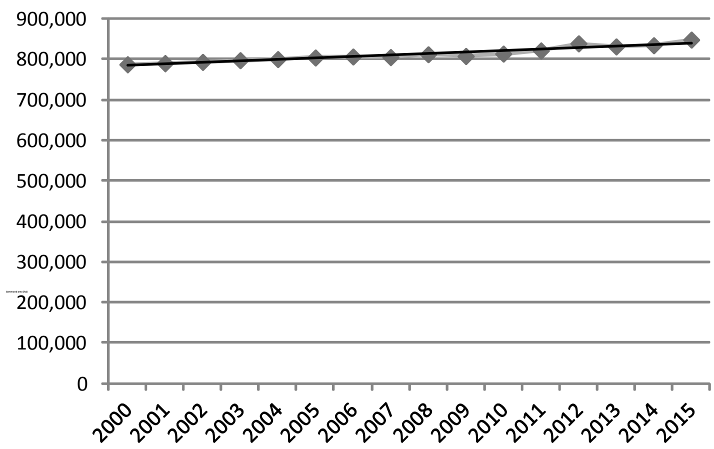
Source: Data is provided by Kobe University

Figure 4.23 Time-series Data of De-noised Enhanced Vegetation Index (EVI) from 2000 to 2015 at 29.00 N-30.95E.

2) Analysis Results

i) Annual Change of Cultivated Area

The area where EVI shows more than 0.2 in the map product is determined as cultivated area. Figure 4.24 shows the annual change of cultivated area in Upper Egypt. The area tends to be overestimated in the satellite-image analysis because the area of this analysis covers from the point of the Dirout group of Regulators to the beginning of the Nile Delta region, including the area around the Asyut regulator and along the Nile River. Hence, the whole cultivated area in the figure is larger than the statistics as previously mentioned. According to Figure 4.25, the cultivated area (EVI>0.2) tends to increase year by year. Such tendency for increasing is found mainly along the western edge of Upper Egypt.



Source: JICA Survey Team made from data that provided by Kobe University

Figure 4.24 Annual Change of Cultivated Area

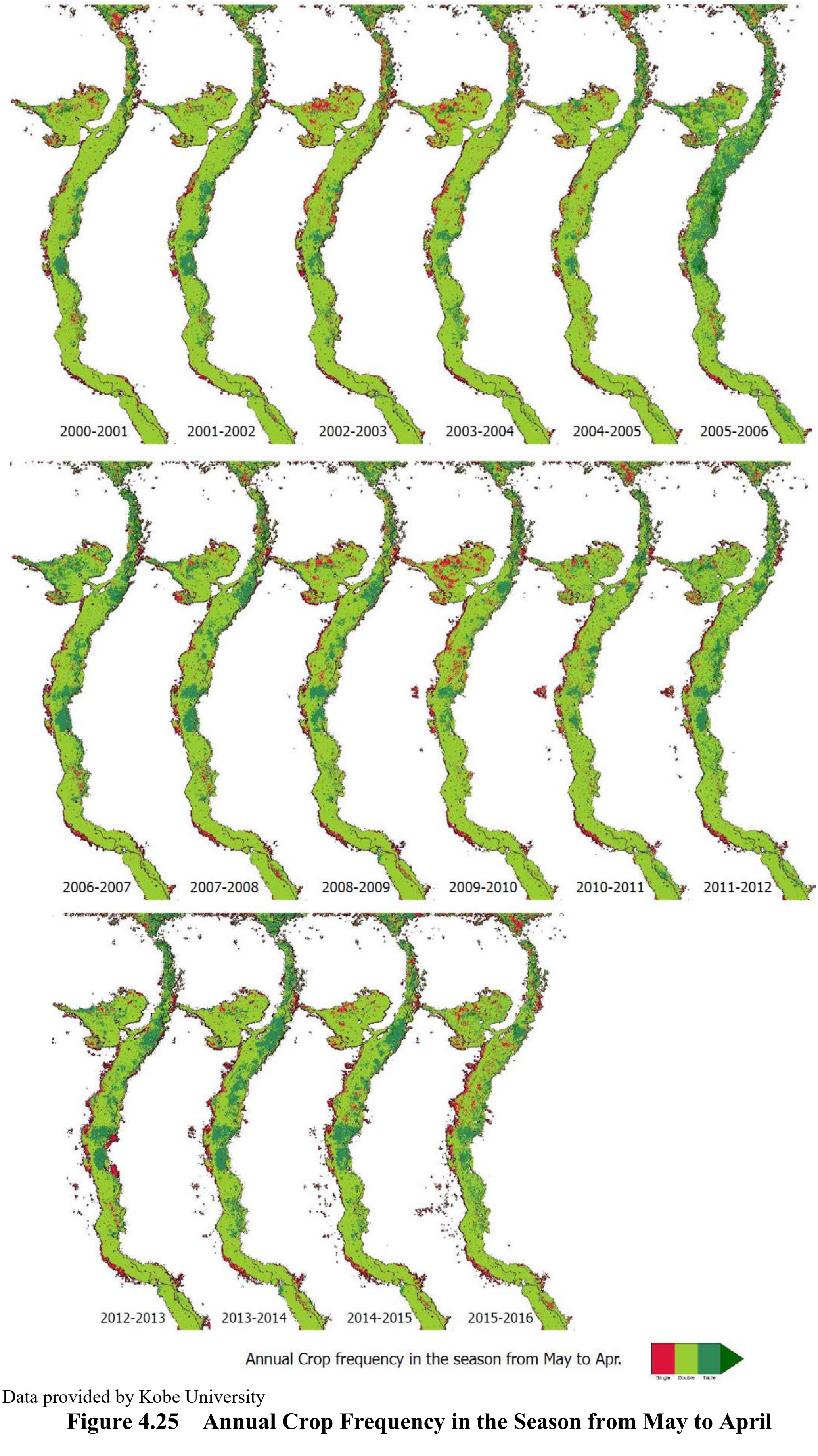
18 EVI threshold: For determination of the presence of vegetation, the EVI threshold=0.2 is commonly used. It was confirmed that the area of EVI less than 0.2 through the year is a desert from the image data, the area of EVI>0.2 was determined to be an area with vegetation such as cultivated land.

ii) Crop Frequency and Insufficiency of Irrigation Water

Figure 4.26 shows the annual Crop Frequency of each of the 5 years. In the most irrigated area in the Upper Nile region, double cropping, (yellow area in the figure below), has been practiced. The triple-cropping area, (green area in the figure), has a distribution in North Minya and along the Nile River in Giza, where the EVI peak is detected three times due to the difference of the blooming season of vegetables and grass. Judging from the cropping pattern in the field, this does not mean that three croppings were done annually, but it is believed this is because the peak of the vegetation index was detected three times by different vegetation with different flowering seasons, and they were mixed in the analysis area (250 m × 250 m). On the other hand, the red area in the figure indicates a single cropping area, where winter crops are cultivated according to the analysis of the blooming season (the blooming season is January to March). Many of the single cropping areas are in the east/west edge of Upper Egypt, and single cropping increased in the newly expanded area in the period from 2011 to 2015 compared with that from 2001 to 2005. In addition, according to Figure 4.25, it is found that single cropping is frequently practiced in Faiyum.

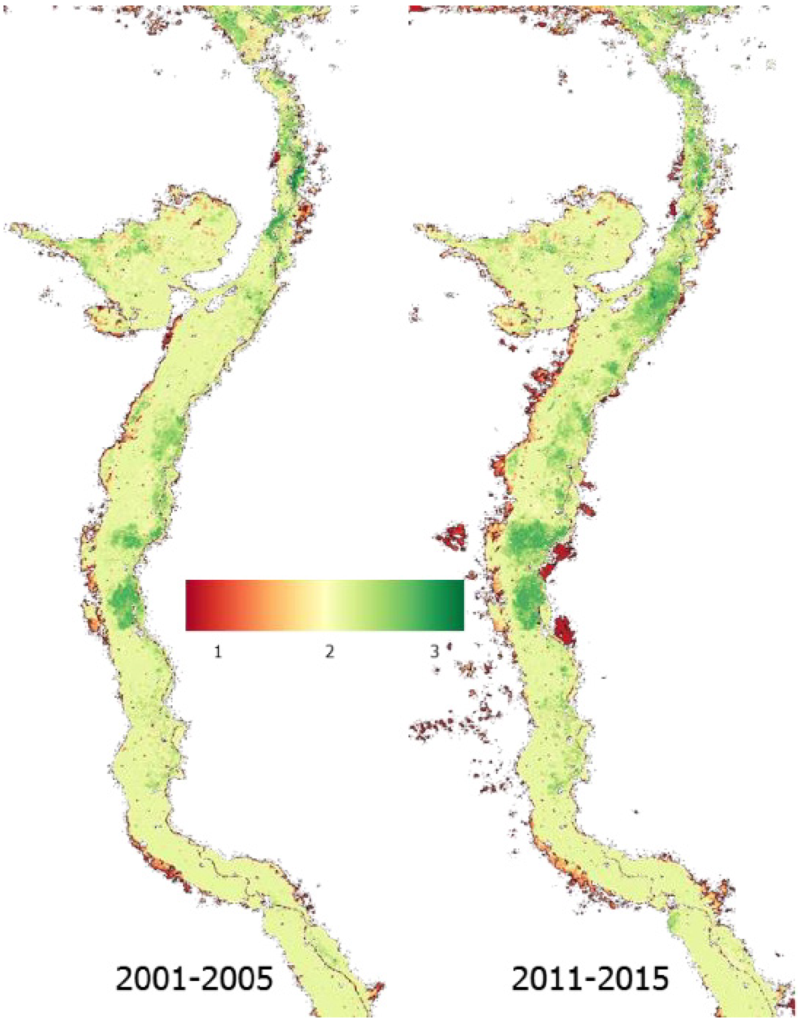
From the analysis result of the cropping frequency number, the area where the peak of the vegetation index appeared only once in a wide area can be judged to be the area where the single cropping was done probably due to water scarcity, since it is common in the east-west periphery area and Faiyum governorate.

The image analysis results of 2005 to 2006 showed that the area where the peak was detected three times was widely spread, but this factor was not observed by the field survey.



Source: Data provided by Kobe University

Figure 4.25 Annual Crop Frequency in the Season from May to April



Source: Data provided by Kobe University

Figure 4.26 5 Years Average of Crop Frequency (Left: 2001-2005, Right: 2011-2015)

In the fruit-growing area included in the area of woods and forests, trees have leaves throughout the year. Hence, EVI peak, which affects Crop Frequency, can appear differently from that of another cultivation area. In the case of Faiyum governorate, fruit trees and miscellaneous areas identified from satellite images and the land use situation of single cropping areas were confirmed.

Figure 4.27, Figure 4.28, and Figure 4.29 show verification results of satellite images and analysis results. Figure 4.27 shows a cropping frequency and fruit-growing areas are framed in the yellow line. Figure 4.28 shows the comparison between field and fruit trees and miscellaneous areas and the enlarged figure of each area is shown in Figure 4.29. As a result, most of the single cropping (red area in Figure 4.27) is in the cultivation area; on the other hand, only multiple cropping (green area in Figure 4.27) is seen in the fruit-growing area. From the above, it can be seen that many of the areas indicated as single cropping belong to the upland fields.

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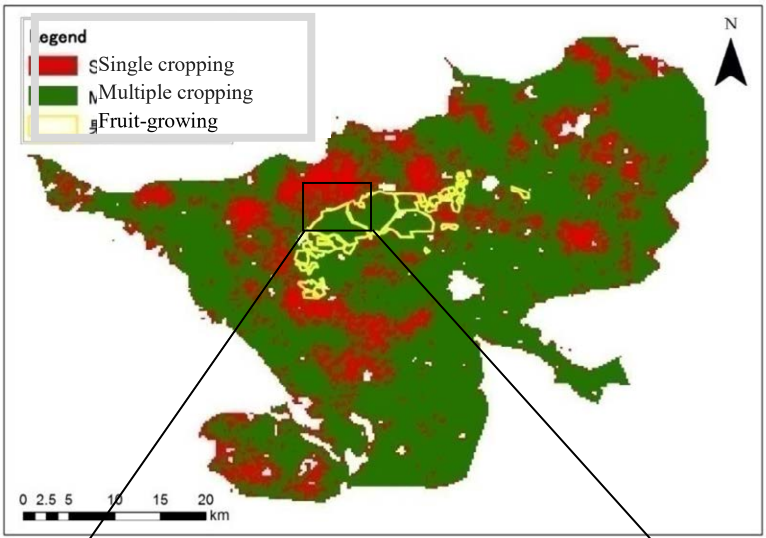


Source: JICA Survey Team made by data that provided by Kobe University

Figure 4.27 Crop Frequency in Faiyum in 2009

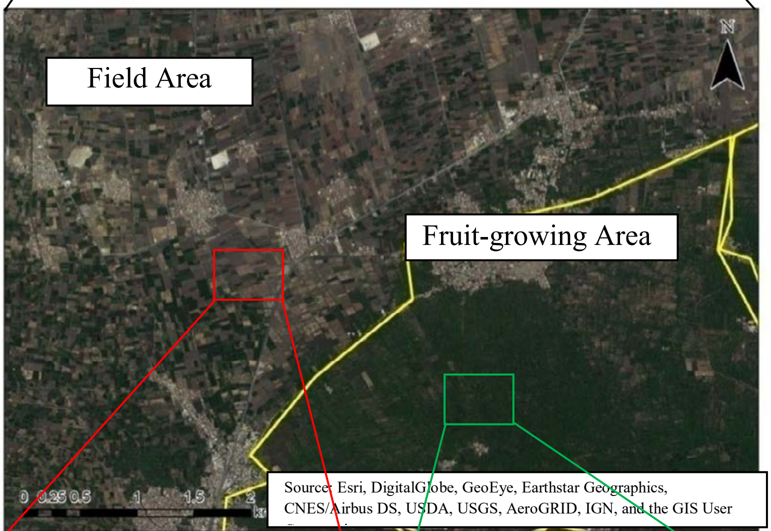


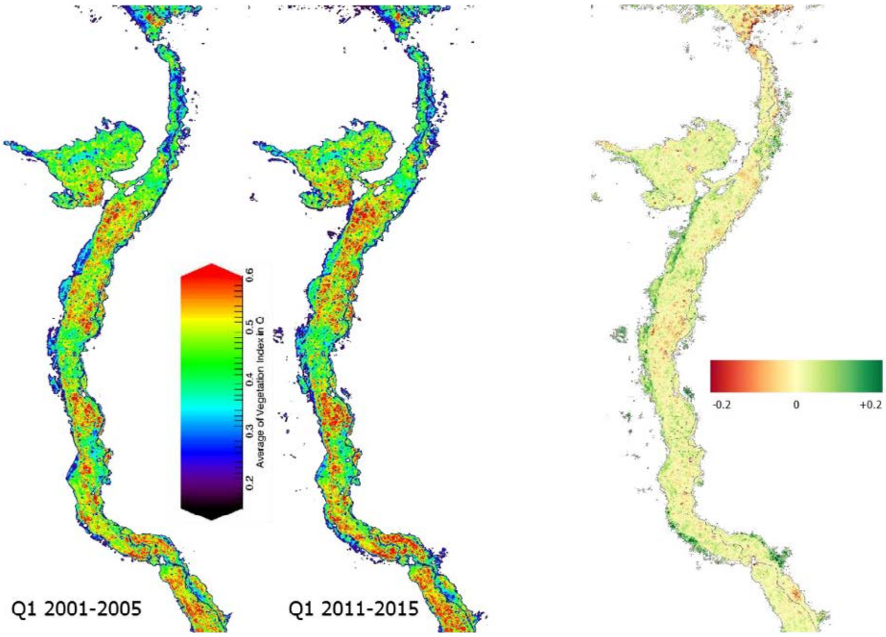
Figure 4.28 Comparison between Cultivation Area and Fruit-growing Area in Satellite Image

Source: JICA Survey Team

Figure 4.29 Partial Enlarged View (Right: Cultivation Area, Left: Fruit-growing Area)

3) Growth and Irrigation Deficit Area

Figure 4.30 shows the average EVI of the first quarter (January to March) of five years. The red area in the left figure indicates good growing conditions, while the blue area indicates not good conditions in the winter season. The right figure in Figure 4.30 shows the 5-year average difference between 2001 to 2005 and 2011 to 2015. Collating the Crop Frequency results as mentioned above, the Growing Condition in winter in the east/west edge of Upper Egypt tends to be lower than that in the double cropping area located in the middle. Water demand is relatively satisfied in summer and winter in the area where double cropping is established at present. However, in the lower part of the area, irrigation water is seemingly not enough to satisfy water requirements even in winter due to insufficient water resources.

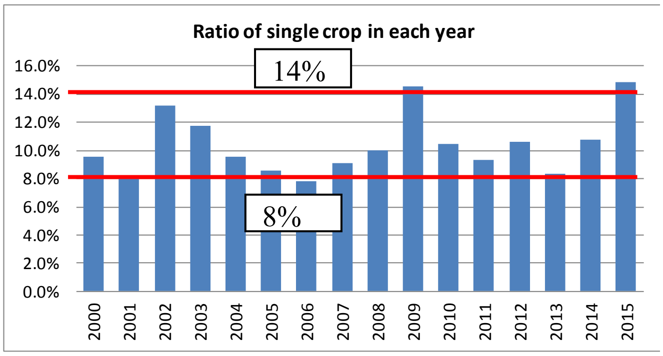


Source: Data provided by Kobe University

Figure 4.30 5 Year Average of Growing Condition (Left: 2001-2005, Right: 2011-2015) and the Difference

4) Improvement in Irrigation Efficiency

Figure 4.31 shows the ratio of single cropping areas to the whole cultivated area in each year from 2000 to 2015. The ratio varies from 8% to 14%, and it is affected by the amount of water intake, water distribution in the principal canal and the difference of crop types. At the Dirout Group of Regulators, however, there is no obvious correlation between the ratio and the amount of water intake, and it is mainly affected by water distribution in the irrigation system and the cropping types. The ratio of single cropping is expected to rise to about 8% through improvement of irrigation efficiency.



Source: JICA Survey Team made by data that provided by Kobe University

Figure 4.31 Ratio of Single Crop in Each Year

(3) Water Quality of Irrigation and Drainage Systems (Irrigation Water and Reuse Water)

Egypt's drainage system was at first established with the aim of addressing the draining of salt accumulation caused by irrigation. Therefore, the irrigation system is generally separated from the drainage system. Regarding the irrigation-drainage system in the survey area, the water introduced from the Nile River has separated along the canal and is distinctly used for irrigation or drainage. Irrigation water used in the agricultural fields consequently flows out to the drains. The quantity of drainage water generally deteriorates and pollutants may increase during its use. Since sewage from urban areas and drain from used water by irrigation usually flows into drainage canals, water quality in the irrigation-drainage system has generally deteriorated more in drains than in canals.

Water quality is directly affected not only by the Nile River as a water source, but also by the water distribution at intakes when the water runs through the system and by its utilization process. Water quality for irrigation and drainage systems are shown in Table 4.16, referring to salt concentration, which is the major indicator to determine the polluting load (area source load).

Table 4.16 Water Quality Measured at Canals of Target Areas

Canal Name	Location	Date	Water Temperature (°C)	pH	EC (µS/cm)
Bahr Yusef	Arab Beni Pump Station	2016.12.1	19.2	8.0	368
	Beni Khalid Pump Station	2016.12.1	18.7	8.0	378
Ibrahimia	Old Hafez Regulator	2016.12.1	19.3	8.1	360
		2017.1.3	14.7	7.9	377
Kased	Old Tanta Regulator	2016.12.4	18.7	8.2	498
	Mehala Menou Regulator	2016.12.4	18.7	7.9	502

Source: JICA Survey Team

Electric conductivity (EC), an indicator of salt concentration, ranges between 360 to 380 µS/cm in the principal canal in the upstream part of Upper Egypt of the Survey area. In the Kased Main Canal, located in the Nile Delta, which is the downstream part of the Survey area, EC is recorded at 500 µS/cm. Therefore, a cumulative increase of EC is seen downstream of the canal system. Although the salt concentration is relatively higher than the value shown in section '2.1.2(2) Water quality', it is still lower than 700 µS/cm of the EC where "FAO Irrigation & Drainage Paper No. 29" stated the reductions of crop yields (vulnerable to salt damage) might occur for irrigation water.

In the Upper Egypt region of the Survey area, GD does not implement water quality monitoring of irrigation facilities believing that there is usually no challenge to the water quality of irrigation water. Water quality is not observed at a fixed point or on a regular basis, but the Ministry of Health conducts water quality inspections in the canals and factories (where water is drained). The Ministry would report to the GD in charge of each canal, under the conditions of Law 48/1982: Protection of Nile from Pollution. Whenever challenges to water quality are detected, the Ministry of Health would ask for GD to implement improvement measures.

In the Nile Delta region, the preceding JICA Survey[19] stressed that water reuse for irrigation should pay careful attention to water quality, as well as water quantity. It is assumed that in the Nile Delta region, which is a densely populated area, water drained into canals contains other substances that cause contamination, in addition to cumulative progression of salinization by farmland drainage.

To address these challenges facing the Nile Delta, in the area of the Kased Main Canal, one of the survey areas located in the Central Delta region, the Gharbia GD responsible for the district is taking action to maintain good water quality. In the area of the Kased Main Canal, since there are water intakes at water treatment facilities on the left bank of the

[19] Project for Drainage Water Quality Control for Irrigation in Middle Delta、JICA, March 2016

canal, drainage has not been introduced to the main canal part, and thus water quality is considered not to be degraded due to drainage.

Through these efforts, the water quality of irrigation water in the Survey area has generally been well maintained.

Table 4.17 Drinking Water Facilities of Kased Canal (Tanta Region)

Name	Station Distance
Elgalaa Station	5.00 km
Elmarshaha Station	7.700 km
Elestad Mobile Station	10.50 km
Met Sudan Mobile Station	14.700 km
Abo Gendy Mobile Station	21.500 km
Shobra Nabas Mobile Station	25.00 km

Source: JICA Survey Team

As for reuse of water from drainage, after the introduction of drain water into the Bahr Yusef Principal Canal and Ibrahimia Principal Canal, no notable challenges concerning the irrigation water quality have been reported on both principal canals. Moreover, in order to make up for the water shortage in sub-regions, a reuse pump station, which relies on water resources from nearby drainage canals mainly at the branch canal level, is installed following a decision of MWRI. It will be implemented when the water quality is good enough to use as irrigation water after drained water is mixed. In particular, the Gharbia GD undertakes reuse of drainage water in many districts in the Nile Delta region, based on the results of water quality inspections conducted twice a year.

Table 4.18 shows the EC of the drainage at the inflow point of the Samatai drainage canal of the Mahallat Menouf drainage canal. The Mahallat Menouf drainage canal is designed to use the drainage at the branch canal of the Kased Main Canal.

Table 4.18 Inspected Water Quality at Drainage Canal

Canal Name	Location	Date	Water Temperature (℃)	pH	EC (μS/cm)
Mahallat Menouf drainage canal	point of interflow at the Samatai drainage canal	2017.1.5	14.2	7.7	1,210
			15.2	8.0	1,260

Source: JICA Survey Team

4.2 Current Condition of Irrigation Facility

In this section, the current situation of irrigation facilities confirmed from the results of a sample survey, the model area survey and the inventory survey of irrigation facilities is explained. (See Chapter 1, 1.2 for the definition of various types of surveys and areas.)

The JICA Survey team conducted a field survey in order to grasp the current condition and challenges facing irrigation canals and irrigation facilities at each irrigation system, i.e., the Bahr Yusef Principal Canal system, Ibrahimia Principal Canal system, and Kased Main Canal system in the target area. The Survey was conducted in the following two stages: in the first stage, an inventory survey was made of the canal and appurtenant facilities of the principal canal and main canal of the sample survey area. In the second stage, the survey was made of an identified model survey area covering the entire canal system up to the terminal level. Moreover, a hearing survey of stakeholders such as MWRI and GD or ID was done. Analyses of collected data and field surveys were made for understanding the current condition and challenges over the whole area in the target area. Additionally, a cross-section survey on the Bahr Yusef Principal Canal was conducted from the Dirout Group of Regulators to the Lahoun Regulator to update the current condition of the cross-section of the canal and determine the capacity of the existing canal system to convey the design discharge released from the Dirout Group of Regulators.

During the selection of a sample survey area, selection criteria were set through discussions with MWRI and GD. Accordingly, it was agreed that the sample area should:

- have as many types of irrigation structures as possible (e.g., intake, regulator, road crossing, pump station, etc.)

- have a small to medium-size command area: which means the command area shall not be too small and not too large. The tentative range of scale can be in between 10,000 feddan and 60,000 feddan. In addition, the site shall be under normal irrigated conditions
- have better access to the site for the survey
- have a better surrounding condition for the survey (e.g., tertiary-level traffic conditions, the cooperation of the community for the survey)
- be around the main canal (not branch canal) taking water from the principal canal
- be chosen according to given priority by related GDs and inspectorates

Furthermore, selection criteria for model areas were set in accordance with the M/D made on 9th March 2017 between JICA and MWRI. Accordingly, the selected area should:

- target the improvement of water management covering the whole area from the main canal to the terminal area
- include a critical challenge in terms of the efficient use of water recourses for further proposals
- be of appropriate scale for model-area surveys considering the limited survey schedule from April to the beginning of May.

Through the above-mentioned survey (inventory survey on principal and sample area, and model-area survey), the current conditions were observed related to the irrigation facility in each target area and were used to summarize the situation as a whole.

4.2.1 Principal Canal Level

Based on the result of the inventory survey, the result of the cross-section survey on Bahr Yusef, a field investigation and information gathered from all levels of the counterparts (from the MWRI, East & West Minya and Beni Suef GD), the existing conditions of the principal canals are described below.

(1) Bahr Yusef Principal Canal System

The Bahr Yusef Principal Canal is one of the longest irrigation canals in Egypt and diverts water from the Ibrahimia Canal at the Dirout Group of Regulators and runs downstream up to Faiyum, stretching over 313 km. The canal is allocated about 5 billion m^3 of water per year, which is equivalent to 9% of the annual available water source of 55.5 billion m^3 based on the Nile Agreement. The command area of Bahr Yusef is about 848,400 feddan (= about 356,000 ha, 2016 MWRI). The maximum estimated discharge that should be conveyed in the canal is about 234 m^3/sec (Source: "Feasibility Study for Rehabilitation and Improvement of Delivery Water System on Bahr Yusef Canal" (1992)).

Along with the Bahr Yusef Principal Canal, there are four major water-controlling barrages (regulators), which were constructed and rehabilitated by a Japanese grant aid project between the years 1997 and 2010. In addition, the Dirout Group of Regulators, which is located at the beginning of the Principal canal, is planned to undergo rehabilitation work financed by a Japanese loan.

The canal is characterized as a meandering earth-canal with very gentle slope ranging between 1/14,000 and 1/20,000, having some 200 critical curves along the canal. There are also numerous villages and residential areas in addition to irrigated land along the canal.

The water level along the Bahr Yusef Principal Canal is controlled by the four regulators set along the canal and the required volume of water is divided from each intake canal and in turn to each branch and meska to cultivate vast irrigated farmland. In addition, in some cases, a pump station is set up to pump the water directly from the Bahr Yusef Principal Canal to the main canal and is distributed to each branch and meska. Table 4.19 shows the general design dimensions of the Bahr Yusef Principal Canal, (report of 1992; source MWRI).

Table 4.19 General Specification of Bahr Yusef Principal Canal

Section	Distance(km) ※	Bed width(m)	Side Slope	Canal Slope
Dahab Regulator	77.600	46.0	1:1.5	1/14,000
Sakoula Regulator	177.730	46.0	1:1.5	1/15,400
Mazoura Regulator	230.260	44.0	1:1.5	1/14,300
Lahoun Regulator	288.700	24.0	1:1.5	1/20,000
END	312.700	15.0	1:1.5	1/20,000

※Distance from Dirout Group of Regulators(km)

Source: Prepared by JICA Survey Team from documents of MWRI

Regarding the capacity, it has been pointed out that canal cross-section studies were conducted in the "Feasibility Study for Rehabilitation and Improvement of Delivery Water System on Bahr Yusef Canal (1992) ", and it was concluded that the water conveyance capacity of the Bahr Yusef Principal Canal is found to be insufficient. As a result, lowering the bed level of the Bahr Yusef canal by 0.70 m was proposed in the same document. Considering this proposal, the construction of four regulators constructed by Japanese Grant aid was set according to the proposal of 1992.

(2) Bahr Yusef Principal Canal

The current condition and challenges facing the Bahr Yusef Principal Canal can be summarized in the following two points: 1) there are hydrological bottlenecks that are unable to convey the designed discharge due to insufficient cross-section, 2) there are many hydrological critical curves that affect the canal in terms of water use and structural stability.

1) Insufficient Function of Principal Canal

The deformation of the canal cross-section and sedimentation over time is unavoidable because the Bahr Yusef Principal Canal is characterized as a meandering and natural canal made of earth canals. In addition, the longitudinal slopes of the principal canal are very gentle, ranging from 1/14,000 to 1/20,000, and the average velocity is not more than 0.8 m/s at the time of maximum discharge. The continuous deposition in one side and scouring on the other side of the canal bed has resulted in the deformations of the canal's cross-section and it caused a reduction in the water flow capacity of the canal.

With regard to the deformation of the canal's cross-section, the current condition was confirmed through the cross-section survey conducted during the Survey (Figure 4.33). Moreover, according to the review of the result of cross-sectional survey in the Bahr Yusef Principal Canal (see Figure 6.2), it was observed that some portion of the canal-bed is higher than the designed level and in another section, the canal bed has been deeply cut compared to the design level.

The maintenance of principal canals such as dredging of sedimentation in some parts of the canal and cleaning up of waterweeds and garbage are conducted once and four times per year, respectively, by the concerned GD, namely West Minya, East Minya, and Beni Suef. However, the extent of the maintenance activities is limited and not sufficient to maintain the cross-section for conveyance judging from the dredging plan (canal cross-section) that has been submitted to the MWRI from GD during the annual budget request made for maintenance.

As evidence for the insufficiency of the cross-section of the canal for conveying the required flow (especially during peak demand), the following information was confirmed through an interview made with a related officer from MWRI, i.e., the water distribution technician of Dirout Group of Regulators and General Director of each GD.

- The amount of water released to the Bahr Yusef Canal must be limited due to the risk of overflow in some portions of the canal. In an area such as Delhans Bridge village, about 220 km downstream of the Dirout Group of Regulators, water overflows the embankment of the principal canal due to an insufficient cross-section especially during the summer season when more water is required to satisfy the water demand downstream. This assessment is supported by the personnel in the sites (general directorates of the area and engineers responsible for water distribution at the Dirout Group of Regulators) who informed the team about that the amount of maximum water released to Bahr Yusef so that it does not create any challenge downstream

- The management of water distribution to each canal is determined and adjusted following the official water distribution ratio. However, the actual water distribution is determined and adjusted depending on the actual situation in the sites. Every year during the peak water requirement period of the farmers along the Bahr Yusef canal, operation of water distribution systems to the canal is hectic and risky work. The engineers at each Irrigation District are ordered to fully open each and every intake gate and regulator along the Bahr Yusef Principal Canal at a time when the peak flow reaches close to 200~214m^3/sec.

Furthermore, a flow calculation based on the result of the cross-section survey of this study was implemented. It was done using non-uniform flow considering a non-uniform cross-section and the backwater effect. The result of the water level profile in relation to the bank of the canal is presented in the figure below. The result shows that on many portions of the canal, especially above the Dahab Regulator, the calculated water level using the present cross-section is above the bank of the canal, which indicates that the flow capacity of the Bahr Yusef canal is much less than that required according to the design flow.

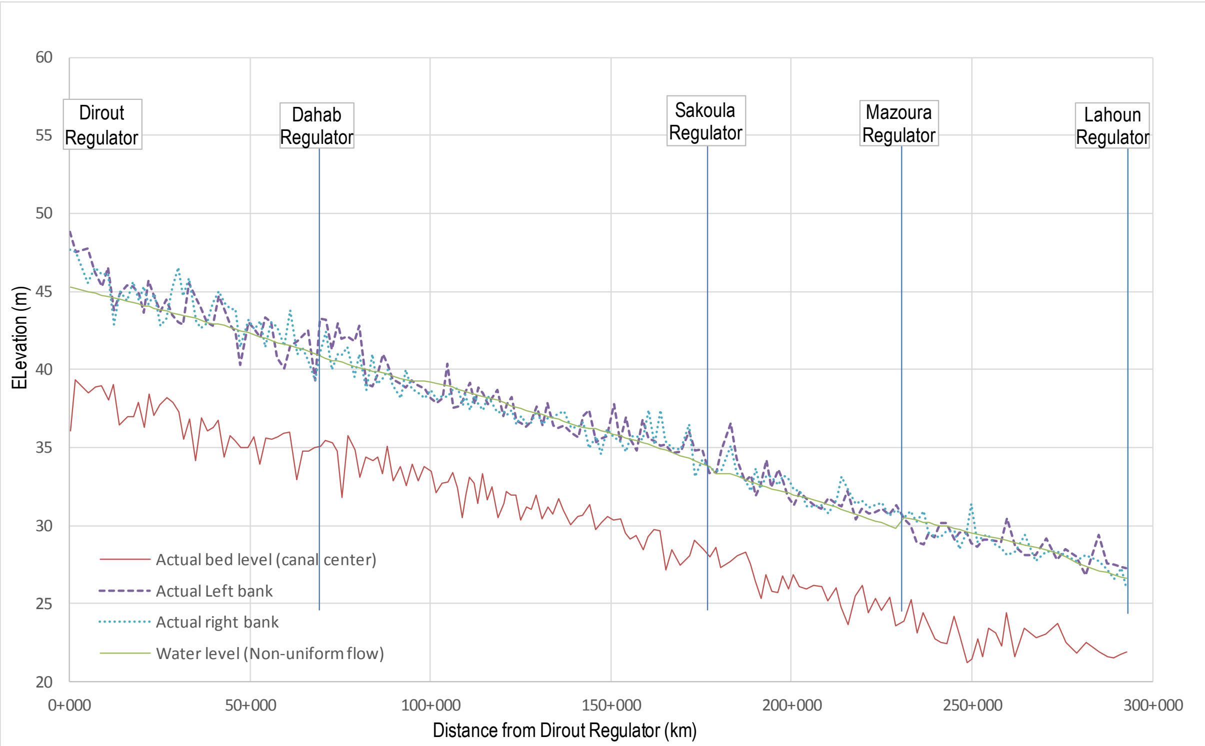


Figure 4.32 The Result of Water Flow Capacity of Current Cross-section in Bahr Yusef Principal Canal (Hydraulic Profile)

Source: Prepared by JICA Survey team based on the data of cross-section survey in Bahr Yusef Principal Canal. (The detail of hydraulic calculation is attached in Annex 7)

On the other hand, a discharge calculation was also made for the design parameter of the canal. Table 4.20 shows the comparison between the design discharge and the estimated canal capacity at a different section of the canal using the design parameter of the canal. The result indicates that the design canal dimension seems capable of conveying the planned discharge if n = 0.025, which is generally applied for clean earth canals. However, from the actual situation of the canal, and according to the 1992 report prepared by JICA, the roughness coefficient should be used as n = 0.03, which is applied for weed-filled and unclean earth canals. Therefore, the calculated discharge using n = 0.03 is close to the actual canal condition of Bahr Yusef, which is much less than the design discharge.

Table 4.20 Comparison of Calculated Discharge and Design Discharge under the Initial Cross-section of Bahr Yusef Principal Canal

Section	Station	Bed width (m)	Side slope	Canal slope	Calculated water depth(m)	Calculated discharge (m^3/s)	Design discharge (m^3/s)
Dirout Group of Regulators	000+100	46	1.5	1/14,000	4.90	188.93	226.50
Dahab Regulator	077+600	46	1.5	1/14,000	4.90	188.93	210.15
Sakoula Regulator	177+730	46	1.5	1/15,400	4.85	177.01	193.64
Mazoura Regulator	230+260	44	1.5	1/14,300	4.55	157.83	187.79
Lahoun Regulator	298+700	24	1.5	1/20,000	4.80	83.31	80.07

Source: Prepared by JICA Survey team based on the data from East Minya GD and "Preparatory Survey Report for Irrigation Plan in Bahr Yusef Irrigation Area, 1992"

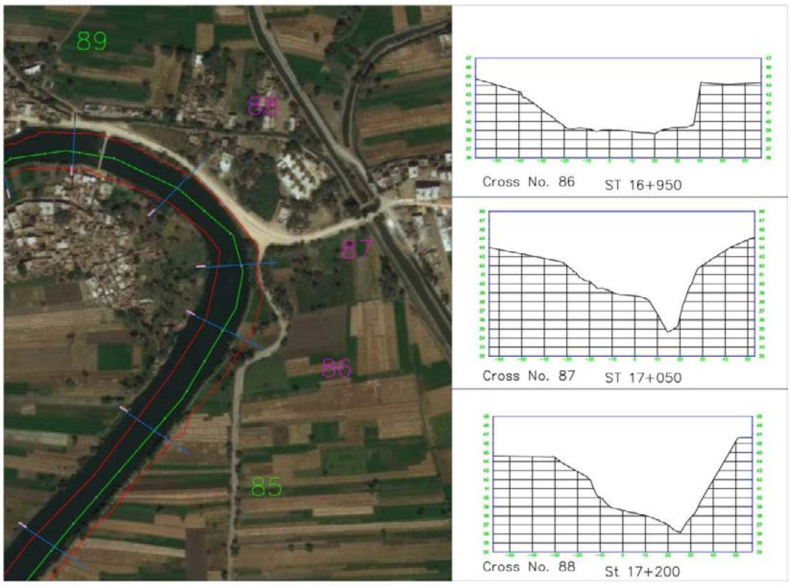
As indicated in the table above for the design discharge of 226.50 m^3/sec, the capacity of the canal is about 189 m^3/sec. As a conclusion, the Bahr Yusef Principal Canal faces a crucial challenge in that it cannot convey sufficient water to the main and branch canals to irrigate the large beneficiary area on time due to an insufficient canal cross-section as well as deformed canal shape.

2) Critical Curve Challenge

The canal has a serious meandering portion with over 200 curves along the entire length between the Dirout Group of Regulators and the Lahoun regulator. Part of these curves is called "critical curves" where the radius of the curves is too small to convey water safely (sharp bend), so they are faced with structural and hydraulic challenges.

In areas considered as "critical curves", the continuous scouring on the outside bank causes damage to agricultural land, residential area, and road the behind the bank. In the meantime, deposition of sediment in front of the inside bank is observed, and it has induced insufficient hydraulic performance of the canal (means relative roughness coefficient decrease due to the growth of water grass caused by the low velocity of water and prolonging of the canal at the curve).

Figure 4.33 shows a typical cross-section at one of the "critical curves" obtained from the canal cross-section survey implemented in the Survey. (17 km from Dirout Group of Regulators)



Source: JICA Survey Team
Satellite image: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 4.33 Typical Cross-section at Canal Curve (Floor and Cross-section Plan)

The specific challenges arising at the portion of critical curves obtained from GD as well as from the result of a survey by the JICA Survey Team are summarized as follows:

- There are several places with dangerous situations such as overflow of water from the bank during peak flow season. (Figure 4.34 shows a critical curve around Delhans Bridge village, which has experienced an overflow of water during peak flow on the outside of the curve.)
- In the vicinity of El Soltan Hasan village (about 70 km from the Dirout Group of Regulators), sand sedimentation was observed in the Bahr Yusef canal due to the erosion of the bank of the canal. The transported sediment could also accumulate at consecutive curves, resulting in insufficient hydraulic performance of the canal and required additional maintenance (Figure 4.35).

Overflow portion(Around Dlhans Bridge village)

Sand sedimentation into the canal induced by destruction of the canal bank

Source: JICA Survey Team

Figure 4.34 Example of Critical Curve (Point of over Flowed at Peak Flow)

Figure 4.35 Example of Erosion at the Sand Hill (around El Soltan Village)

In some sites where emergency countermeasures were needed, the Ministry had made efforts to protect the curves by applying riprap technology (such as at El Gafadon village as shown in Figure 4.36 below). However, in some places, these protections had been washed away probably due to the lack of durability, as shown in Figure 4.36 (right side); hence, a different method of protecting such curves is expected to be implemented.

Protection work constructed by MWRI. (Around El Gafadon village)

Protection work washed out at peak of flow rate. (Dlhans Bridge village)

Source: JICA Survey Team

Figure 4.36 Example of Protection Works Implemented by MWRI along Bahr Yusef Canal

On this matter, each GD of the area has identified the critical curves and prepared a list of them that need urgent protection by MWRI. Table 4.21 lists the names and length of each critical curve identified.

Table 4.21 Lists of Critical Curve Chosen by Each GD

No.	GD	Curve Position (km from Dirout)	Neighbor Village	Length of curve (m)
1	East Minya	6.10	Dahroug	350
2		6.80	El Sheikh Mogherah	400
3		7.30	Bani Haram	400
4		8.90	North Bani Haram	400
5		10.10	Abo El Hadr	300
6		12.20	North Abo El Hadr	350
7		14.10	Ezbet Abo El Makarem	400
8		14.85	Ezbet Abo El Makarem	250
9		16.50	Awlad Sarhan	350
10		18.10	Awlad Sarhan	250
11		22.80	El Sheik Shebekah	400
12		23.50	El Sheik Shebekah	350
13		48.90	North Abo Kaltah	300
14		50.70	Inside Bani Khalid	300
15	E/W Minya*	60.80	South of Kafr Lbas	400
16	E/W Minya	61.60	Inside Kafr Lbas	500
17	West Minya	64.50	El Kesery	250
18		71.05	El Soltan Hasan	500
19		72.75	Bani Saed	300
20		75.40	Ezbet El souq	300
21		76.10	Ezbet El souq	400
22		79.05	North of Ebeed	300
23		85.50	Bani Shebah	450
24		87.40	Towa abo Shenaf	350
25		89.79	Towa water treatment plant	350
26		105.00	Hehya	300
27		108.00	Aseer	350
28		136.70	El Sheik Teladah	200
29		163.70	Kalyamoun	250
30		164.50	Elsnakoreyah	250
31	Beni Suef	210.00	Izbet Megahed – El Konissa	100
32		211.50	Izbet Masood	200
33		213.00	Menssaba	200
34		214.50	Menssaba	400
35		215.50	Menssaba	160
36		216.50	Menssaba	200
37		217.00	Dlhans bridge	400
38		218.20	Dlhans bridge	300
39		219.00	Dlhans bridge	200
40		219.50	Dlhans bridge	300
41		221.00	Izbet Boshra	300
42		222.00	Izbet Fadl Alla	50
43		224.00	Marco	200
44		225.00	Kamoon	400

No.	GD	Curve Position (km from Dirout)	Neighbor Village	Length of curve (m)
45		231.00	Izbet Nasr Alla	250
			Total	13,910

* E/W Minya stands for East Minya and West Minya, and sub-region locates in both GD.

Source: Prepared by JICA Survey Team based on information from GD

As mentioned above, many critical curves face several challenges, such as sediment accumulation in the canal, erosion on the bank, overflow into agricultural land and residences, and so on. In particular, this condition makes it hydrologically difficult for the necessary amount of water to flow down during the peak irrigation period, and from a structural stability point of view, the critical curves have threatened the safety of agricultural and residential land around them.

(3) Irrigation Facilities on Bahr Yusef Principal Canal

The Dirout Group of Regulators is located at the initial portion of the Bahr Yusef Principal Canal and its renovation is under way under the Japanese Loan Project. On the other hand, the four major regulators, namely, Dahab, Sakoula, Mazoura, and Lahoun have been renovated by a Japanese grant aid project. These regulators faced no functional or structural challenges at the time of the Survey.

Along the Bahr Yusef Principal Canal, there are a number of main canals serving large- and medium-scale irrigation areas, and branch canals with small-scale irrigation areas, which are directly branched-off from the principal canal. In addition, there are feeder/link canals connecting the principal canal to main and guide canals connecting Bahr Yusef to a pump station.

Intake gates are established at the entrance of all the canals (main, branch, feeder/link and guide canal). On the guide canal, there are relatively large-scale pump stations that lift water to the newly developed area. In addition, small-scale pump stations are also set on the principal canal feeding water to small branch canals. Other than these water facilities, many bridges also exist as crossing structures. Table 4.22 shows the structures found within the survey area between the Dirout Group of Regulators and Lahoun regulator.

Table 4.22 List of Main Structures on Bahr Yusef Principal Canal

Survey Zone between Regulators		Regulators	Canal Intakes/ Others	Pump Stations (Irrigation)	Pump Stations (Reuse)	Sub-Total	Bridges	Total
From	To							
Dirout	Dahab	1	9	2	3	15	20	35
Dahab	Sakoula	1	8	2	1	12	20	32
Sakoula	Mazoura	1	7	6	1	15	12	27
Mazoura	Lahoun	1	22	4	4	31	14	45
Total		4	46	14	9	73	66	139

Source: JICA Survey Team, based on the result of the inventory survey.

Diversion facilities such as intake and pump stations play important roles in conveying water from the Bahr Yusef Principal Canal and distributing it to the main canal and branch canals as per the required amount when needed under the operational command of main four structures. However, these facilities are aging rapidly, and face structural instability, insufficient operability of gates, degraded suction performance of pump units, and so on.

The description below is the summary of the challenges facing intake and pump stations obtained from an inventory survey, sample survey, and model-area survey and from information collected from GD of irrigation districts.

1) Intake

- Of the existing sixteen (16) intake gates identified, it is confirmed that all the gates are unable to operate or are extremely difficult to operate due to aging from wear and tear. Among these intake facilities, if the body of the structure is built of bricks, it is necessary to renovate the entire body including the gate because of the difficulty to repair them. In the case of structures made of reinforced concrete, they could be repaired depending on the situation of the structure
- Although most of the bodies of the intakes are made of reinforced concrete or brick, the situation requires some kinds of repair due to a very old installation period. In the case of reinforced concrete, the structure is cracked or peeling off. In the case of a brick structure, the bricks are falling down due to the peeling of mortar.
- Deterioration phenomenon of gate facilities is categorized as deformation of the doors, abrasion, perforation (large holes), deformation of gate grooves, and being unable to operate due to deformation of the spindles. Small defects or damage can be repaired, but the deformation of the doors and piercing requires the total replacement of the gate.
- The intakes that are installed on branch canals are not causing big challenges in the distribution of water, but they are aging. However, because of the lowering of the water level in the Bahr Yusef canal, especially during winter, it is unable to divert water by gravity and unable to sufficiently distribute water to branch canals. These are the eight small-scale water intakes that are installed upstream of the Dahab Regulator (all about 1.0 m wide).
- Most of the intakes located around settlement areas are covered with garbage at the entrance and it is hard to operate the gates.

The degree of deterioration of each intake facility is evaluated into five categories. In evaluating the degree of deterioration, judgment was made by considering the facts like the construction year, information obtained from visual inspection and hearing from ID and field investigations. The result is summarized as follows:

Table 4.23 Evaluation Standard of Deterioration Degree at Intake

Category	Condition of structure	Remarks
A	The gate does not work, and the structure of the body is considerably damaged.	Consideration of needs for replacement of the entire facility (Structures made by bricks need entire renovation).
B	The body of the structure is stable; however, gate does not work or has considerable damage.	Consideration of replacement of gate
C	There is large-scale cracking on body (Gate does not have a challenge or small-scale damage).	Consideration of the repair of the body of the structure (Gate is able to be reused).
D	There is small-scale cracking on body (Gate does not have a challenge).	Need for small repair (Gate is able to be reused).
E	There is no challenge.	Regular maintenance

Source: JICA Survey Team

The following table shows the summary of the number of intakes according to the result of the evaluation standard mentioned above.

Table 4.24 Summary of Intake Deterioration Condition (Facility on Bahr Yusef Principal Canal)

Section(Regulator)	A	B	C	D	E
Dirout ~Dahab	-	1	2	6	-
~Sakoula	-	-	8	-	-
~Mazoura	-	2	2	3	-
~Lahoun	8	5	1	8	-
Total	8	8	13	17	-

Source: JICA Survey Team based on the result of inventory Survey.

2) Pump Station (Irrigation Pump or Water Reuse Pump)

Out of the 23 pump stations found along Bahr Yusef (14 irrigation pumps and 9 reuse pumps) about 17 pump stations have been confirmed as being a facility-related challenge; 10 of these are pump stations for irrigation water and the other 7 stations are reuse pump stations. The reuse pump stations along the Bahr Yusef Canal pump water from the drainage canal end of the catchment and return it to the Bahr Yusef Principal Canal. They are relatively large scale and controlled by MED.

The main challenges clarified by the Survey are summarized below.

The Terfa Main Canal is a canal fed by the Terfa Pumping Station set 100 m from the left bank of the Bahr Yusef Principal Canal and is provided with a guide canal. The canal irrigates a command area covering over 32,600 feddan (about 13,700 ha; including illegally irrigated areas) in the newly expanded area. At this station, there are 2 pump stations (old and new) with 10 pump units (with a total discharge of 3.5 m^3/s). However, due to the insufficient suction head of the pump, the required amount of water cannot be pumped into the main canal. This water shortage is remarkable especially in the winter season because of the low water level in the Bahr Yusef Principal Canal. Furthermore, during the summer season, only 3 pumps out of 10 pumps can work because of the insufficient water head in the guide canal.

The Arab Beni Khalid pump station (located about 39 km downstream from the Dirout Group of Regulators) and Beni Khalid pump station (located 43 km downstream) (with an irrigated area of about 2,100 to 2,200 feddan, pumping rate of 1.2 m^3/s), is set to convey water to the main canal from Bahr Yusef during winter irrigation. However, the pump units are very old and the discharge capacity of the pumps has declined. Similar to the Terfa pump station, the suction head is insufficient when the water level in Bahr Yusef gets lower during the winter season. In such situation, the required amount of water cannot be pumped into the canal. The lack of suction head was also confirmed at other pump stations, such as Abo Rahib pump station.

Other common challenges in terms of facilities include capacity reduction due to aging of the pumps and motors, malfunction of pump units and leakage from delivery pipes due to deterioration. Besides challenges such as the lack of suction pools or screens on the suction pipe, the breakage of screen-hoisting devices and the absence of pump houses are prevalent in some of the pump stations.

Regarding reuse pump stations, most of the pump facilities are very old, but there is no station that needs total renovation. However, there are pump stations in three places where diesel pump stations frequently suffer from operational challenges and pumping of drain water is not sufficient. Farmers complain about such situation and demand electrically operated motor pumps. In another area, there are breakages of control panels, operational difficulties with manual cranes, leakage from pipe facilities and garbage clogging due to the fault of the screen at the intake pipes.

Regarding the degree of challenges facing pump stations, they were organized based on the evaluation criteria into the following five categories (A to E). The table below shows the categories according to the deterioration situation of the facility and functional status.

Table 4.25 Evaluation Criteria of Degradation Level in Pump Stations

Category	Condition of Pump Stations	Remarks
A	Pump capacity is insufficient and water demand is not satisfied	Considering improvement of pump functions
B	Weak function of the pump facility due to aging	Considering full renovation (renewal) of pump stations
C	Part of the pump equipment becomes obsolete and its original capacity is not attained	Considering replacement of all or part of pump facilities (including partial repair of construction facilities)
D	No particular challenge with pump facilities, but there are some challenges with the accessory structures	Rehabilitation of suction pool, installation of the screen, crane and so on
E	There is no particular challenge at present	Support for periodic maintenance

Source: JICA Survey Team

The pump stations along the Bahr Yusef Principal Canal are organized according to the situation of deterioration using the above evaluation criteria and are summarized in the following table.

Table 4.26 Synoptical Table of Deterioration Situation in Pump Stations (Facilities in Bahr Yusef Principal Canal)

Pump Station	A (Places)	B (Places)	C (Places)	D (Places)	E (Places)
Pump station for irrigation water	-	3	5	2	4
Pump station for drainage water reuse	-	-	6	1	2
Total	-	3	11	3	6

Source: JICA Survey Team based on the inventory survey

(4) Ibrahimia Principal Canal System

The Ibrahimia Principal Canal starts from the Asiout Barrage located on the River Nile. The total length of the canal is 316 km. After running for about 60 km, the canal meets the Dirout Group of Regulators where the water is divided into 7 canals. The canal flows northward between the Nile River and the Bahr Yusef Canal.

The target area of the canal for this Survey ranges between the Dirout Group of Regulators and Wasta Regulator covering about 224 km. Although the amount of inflow into the Ibrahimia Principal Canal in the Dirout Group of Regulators has been decreasing slightly in recent years, it is about 4 billion cubic meters (average of 2006 to 2015) a year and it is large scale. The irrigation command area is about 605,000 feddan (= about 254,000 ha; MWRI in 2016). The design flow of the Ibrahimia Principal Canal is 161.62 m^3/sec (from Dirout Report 2010)[20], and the maximum inflow is about 183 m^3 / sec (July 2008; MWRI).

The Ibrahimia Principal Canal has nine regulators and two weirs, and each regulator functions to control the division of water into the main canal and branch canal. Among these is the Serry Main Canal, which is located upstream of the Ibrahimia Principal Canal and is divided from the Hafez Regulator, which has a large irrigation command area about 127,000 feddan (2016 MWRI data), and is included in the rehabilitation project that has been implemented with recent aid by USAID 1984, and major irrigation structures are in place.

Table 4.27 shows general specifications of the Ibrahimia Principal Canal (initial design provided by MWRI).

[20] The Preparatory Survey for the Rehabilitation and Improvement of Dirout Group of Regulators in the Arab Republic of Egypt, Final Report, JICA, October 2010

Table 4.27 General Specifications of Ibrahimia Principal Canal

Section up to	Station (km)*	Bed Width (m)	Side Slope	Canal Slope
Hafez Regulator	32.80	48	1:1.5	1/14,300
El Minya Regulator	71.75	35	1:1.5	1/14,300
Mataya Regulator	105.60	34	1:1.5	1/15,400
Maghagha Regulator	133.65	34	1:1.5	1/9,100~1/20,000
Maghagha Weir	134.60	32	1:1.5	1/20,000
El Sharahna Regulator	157.23	30	1:2	1/12,500
El Genidi Regulator	191.56	30	1:2	1/12,500
Ashmant Regulator	203.85	22	1:2	1/12,500
Beni Hedear weir	211.64	22	1:2	1/20,000
El Wasta Kebi Regulator	220.30	16	1:2	1/16,700
El Wasta Bali Regulator	224.20	14	1:2	1/16,700
End	316.00	14	1:2	1/16,700

Distance from Dirout Group of Regulators (km)
Source: Prepared by JICA Survey Team from documents of MWRI

(5) Ibrahimia Principal Canal

Since the Ibrahim Principal Canal is an earth canal, deformation of the cross-section caused by erosion and sedimentation is common. However, it is necessary to carry out periodic maintenance work such as grass removal and sediment dredging. The cross-section of canals is generally maintained except in some portions of the canal where it crosses urban areas. This is confirmed by the hearing survey made on the relevant GD and from the results of an inventory survey.

However, since the canal is flanked by a railway line on the right side and a main road on left the bank, it is inevitable that the canal will pass through a major urban area. Hence, particularly in such sections of the canal, various challenges arise that impede the function of the canal to allow necessary irrigation water to flow downstream safely.

The current situation and challenges in terms of facilities along the Ibrahimia Principal Canal are 1) the difficulty of maintaining part of the canal crossing urban areas and subsequent deterioration of the canal system, 2) the existence of a structure obstructing the smooth flow of water downstream and 3) the decrease in the canal capacity due to accumulation of garbage dumped from the city.

1) Challenge of Canal Reach Crossing Urban Areas

The Ibrahimia Principal Canal’s reach that passes through Minya City, in between 62 km and 72 km downstream of the Dirout Group of Regulators, has the following challenges related to flow obstruction and inability to conduct maintenance work:

- In this reach of the canal, there are numerous structures such as road crossing structures, water supply pipes, railway bridges, regulators and intake facilities. The pillars of these crossing structures affect the flow of water especially when rubbish and aquatic weeds are accumulated around the piers. This phenomenon results in the difficulty of the canal to perform its function properly such as water division at intakes facilities and smooth flow water downstream.

- In addition, in the canal reach where it becomes narrow due to sedimentation, the water level increases, which results in progressive erosion on the banks of the canal’s freeboard. Especially, in the canal reach between the El Mansour bridge and the Minya regulator, since some residential buildings have moved further into the canal, thus narrowing the canal width, the levee part is damaged by running water. The extent of damage to the canal bank is visible in the failure of the railway line and exposure of the foundations of the nearby houses (see Figure 4.37).

Destroyed railway line along the bank of the canal

Progressive erosion on the foundation of the house

Source: JICA Survey Team

Figure 4.37 Example of Canal Erosion Reach (Ibrahimia Principal Canal)

- Usually, maintenance work by backhoes such as dredging and removal of water grass/dumped garbage is carried out from pontoons. However, in the Minya urban area, many facilities such as bridges, regulator, main roads, railroads, and houses are crossing over, making maintenance work of the canal difficult. Actually, in the 4-km section of the station, i.e., from 63 km to 67 km, it is impossible for a backhoe access the area for dredging, and impossible to secure a temporary working place for excavated sand. Therefore, maintenance work is extremely difficult and becomes a big challenge.
- According to the study made in 2013/14 by the Channel Maintenance Research Institute of the National Water Research Center, Egypt on this reach, about 80% of the sediment is concentrated in the 4.25-km reach of the target 10-km section and only 64% of the design discharge can pass through this section.

Based on the above points, it is concluded that between 3 to 5 km sections of the canal passing Minya City adversely affect the water-supply efficiency and the function of the canal. It hinders the main purpose of the principal canal, such as properly distributing water to the irrigation area.

2) Obstruction of Water Flow from Existing Structure

Among the structures along the Principal Canal, two of the old regulators (Old Hafez and Old Minya regulators) are not serving as water-control structures, but are used for light vehicle or pedestrian traffic. However, in spite of the absence of gates (fully open or removed), these structures cause a hydraulic loss when a large flow rate passes through it. The results of field surveys investigating the influence of these old regulators on the water flow is explained below.

- The Old Hafez regulator, located 32 km downstream of the Dirout Group of Regulators, creates a huge hydraulic loss. The presence of this old barrage results in water losses and is making it difficult to control water passing through the main canals upstream (East and West Hafez canal). According to hearing information from East Minya GD, especially during peak flow, the old barrage forces too much water to flow into this main canal creating an overflow in the main canal and reducing the amount of water flowing downstream (hearing from East Minya GD).

Source: JICA Survey Team

Figure 4.38 Situation of Old Hafez Regulator (Upstream Side)

- A rough estimate of the head loss at the old Hafez regulator during peak flow is predicted to cause a water level rise of about 45 cm in the case where all the flow is assumed to pass through it. This value drops to about 28 cm in the case where the planned amount of water is diverted to the Serry main canal. This result suggests that if an unexpectedly large amount of water flows in the canal, it may overflow around the old regulator, which is almost consistent with the hearing result from the farmers and GD.

(Calculation example) $\Delta h_1 = fe \cdot v^2/2g = 0.5 \times 4.18^2 / 19.6 = 0.45$ m (Peak flow amount; Q1)

$\Delta h_2 = 0.5 \times 3.31^2 / 19.6 = 0.28$ m(Planned flow rate of Serry main canal; Q2)

($V = Q/A$, $Q1 = 183 m^3/s$, $Q2 = 145 m^3/s$, $A = 2.5m \times 2.5m \times 7 = 43.75m^2$)

- Under such circumstances, East Minya GD requests the removal of the old Hafez regulator and the construction (replacement) of a bridge.
- On the other hand, the condition of the old Minya regulator (located about 66 km downstream of the Dirout Group of Regulators) is hydraulically similar, but due to the large flow area of the gates, the head loss at this point is small and the challenge is not much compared to the old Hafez regulator.

As described above, the existence of the old Hafez regulator causes a hydraulic loss in the Ibrahimia principal canal, making it difficult to adjust the water intake to the main canal immediately upstream of the regulator, and restricting the smooth flow of water downstream in the principal canal.

3) Decline in Canal Capacity due to Dumping of Garbage

Since the Ibrahim Principal Canal passes through the urban area and many residential villages, dumping of garbage into the canal can be seen in many places. The field survey and interview revealed this is one of the factors that inhibit the smooth flowing of water in the canal, affect the operation of intake gates and deteriorate the quality of water.

(6) Irrigation Facilities on Ibrahimia Principal Canal

The lists of structures in the target section of the Ibrahimia Principal Canal are shown in Table 4.28 below. (The table does not include the old Hafez regulator and old Minya regulator that do not perform a hydraulic function). Out of the total of 196 structures in the canal, there are 99 irrigation structures such as regulators, weirs, and intakes; 97 bridges account for nearly 50% of the total.

Table 4.28 List of Major Structures along Ibrahimia Principal Canal

Survey Zone between Regulators		Barrages /Regulator	Canal Intakes/ Others	Weirs	Siphons	Spillways / Culverts	Pump Stations (Re-use)	Sub-Total	Bridges	Total
From	To									
Dirout	New Minya	2	6	0	0	1	0	9	33	42
New Minya	Maghagha Weir	2	32	1	0	1	0	36	31	67
Maghagha Weir	El Wasta Beli	5	40	1	3	2	3	54	33	87
Total		9	78	2	3	4	3	99	97	196

Source: Prepared by JICA Survey Team based on the inventory survey (Target section is from Dirout Group of Reg. to El Wasta Reg.)

Based on the inventory survey of the major structures such as regulators and intake structures and from the results of a hearing survey with stakeholders in each GD, the current conditions of the structures are summarized as below.

1) Regulator / Weir

Nine regulators and two weirs are currently functioning properly. These facilities include those constructed before 1940 and constructed a few years ago (New Minya regulator: 2013). Although there is no serious challenge facing the soundness and functional aspects of concrete structures and gate facilities, some facilities face the following challenges.

- Maghagha, El Sharahna and El Wasta Kebi regulators have no great challenges with the gate facilities but routine maintenance and repair of those structures are necessary since some of the concrete or brick structure (mortar finish) is deteriorated and damaged.
- Maghagha weir is partially damaged in the concrete structure of the main body and both sidewalls on the downstream side (the brick structure with mortar finish) are unstable, therefore, repair of this parts is necessary.
- At Beni Hedear weir, it seems the accumulation of a huge amount of garbage is usual, which adversely affects the control of the water level by the weir. Also at the regulator downstream of this weir, (El Wasta El Bahria regulator), accumulation of garbage and the flourishing of aquatic plants seriously obstruct the gate for adjusting the water level.
- On the other hand, there is some difficulty in terms of performing water-control activities within the required time and limited labor for the operation of each gate facility. This is because the opening-and-closing regulators along Ibrahimia are manually performed. Since the emergency operation is not required in contrast to flood-prevent operations, it is considered that there are no particular challenges in terms of function at present. However, GD has requested to replace the manual gate operation system with a motorized operation system to attain good responsiveness (East Minya GD), especially for the new Minya regulator, since it plays an important role in water level control in the Ibrahimia Principal Canal.

2) Intake

From the inventory survey result, about 78 intakes are confirmed along the Ibrahimia Principal Canal. Although there is a lot of wear and tear on the gates and intake-bodies due to aging, the condition of the gate structure itself is still good, and only a few intakes need urgent repair work in terms of stability and functions of the structure. However, most of these structures are in need of routine maintenance.

The following is a summary of intakes that need repair or replacement work.

- The East Hafez Intake, which is located immediately upstream of the old Hafez regulator and channels water into the East Hafez main canal has two gates, both 2.5 m wide. One of the gates is not working because it is very old and deteriorated. Since the body of the structure is built with bricks, it is difficult to rehabilitate it partially. Therefore, full renovation of the gate is necessary. Since the intake structure crosses the railway line, careful consideration including construction method is necessary in the case of rehabilitation.

- The Fesheta intake located immediately upstream of the Maghagha regulator channels water in the left bank. It is equipped with three gates (each 2 m wide); however, only one gate is operational and the other two are malfunctioning due to deterioration. Therefore, replacement of the gates is required. From the investigations, it is confirmed that the body structure can be corrected by partial repair. In addition, the El Zaytoun Intake (about 202 km downstream from the Dirout Group of Regulators), equipped with one gate (1.2 m width), does not work effectively enough and does not completely close. It is impossible to stop water completely due to the intensive wear of the gate-door body. Therefore, it is necessary to replace the gate.
- It is confirmed that there are large cracks in the bodies of the intakes on five facilities and that they threaten the structural stability. Although these gates need some repair, the structure itself can be reused.

All intakes existing on the Ibrahimia Principal Canal are summarized as shown in Table 4.29 according to the degree of deterioration. (For evaluation criteria, see the Bahr Yusef Principal Canal)

Table 4.29 Summary Table about Deterioration Status of Intake (Facilities on Ibrahimia Principal Canal)

Section(Weir)	A Grade (No. of structures)	B Grade (No. of structures)	C Grade (No. of structures)	D Grade (No. of structures)	Total
Dirout ~New Minya	1	-	1	4	6
~Maghagha Weir	-	1	-	31	32
~El Wasta Beli	-	1	4	35	40
Total	1	2	5	70	78

Source; Prepared by JICA Study Team based on the result of inventory survey

3) Other Structures

As for irrigation facilities along the Ibrahimia Principal Canal other than weirs and intakes, siphons, spillways and pump stations (drainage reuse) crossing the principal canal were confirmed as presented in the list of main structures in Table 4.28.

- Three siphons crossing just under the Ibrahimia Principal Canal were confirmed. One of them (El Saida siphon) suffered damage and rehabilitation is needed. No particular structural challenge has been confirmed in the other two siphons.
- It is confirmed that four spillways are used as facilities for discharging excess water from the Ibrahimia Principal Canal directly to the Nile River. Three spillways are equipped with a gate and the other one has a culvert structure. There is no particular challenge in the functional and structural aspects of the conditions of those facilities.
- There are three pumps serving to mix drainage water into irrigation water. They play a role in mixing excess water from a drainage canal in the area into the Ibrahimia Principal Canal. Unlike the case of the Bahr Yusef Canal, these pump stations are managed under IS. The capacity of the pump station is medium size with 4.0 - 5.0 m^3/s. The discharge from each pump unit is about 1.0 m^3/s per unit and four to five units of each pump are present in each station. The facility requires minor repairs and parts replacement for both structures of the pump house and urgent repair is not required at present.

4.2.2 Main and Branch Level Canal

(1) Main and Branch Canal and Structures in Bahr Yusef Principal Canal System

There are about 768 canals, (main and branch canals), within the Bahr Yusef Principal Canal system. Among them, 55 are main canals and the remaining are branch and sub-branch canals. Most of the main canals are earth canals; however, concrete pavements, masonry/stone pitching, and concrete culvert structures are used in very small parts of the canal system. Especially, in newly developed areas, concrete canals are common to convey water to these parts to a limited degree due to the soil type (sandy soil). Canals, such as the Dahab main canal and Koftan main canal, flow parallel to the Bahr Yusef Principal Canal and both canals are connected to the Bahr Yusef Canal by a feeder canal. The purpose of this feeder canal is to supply irrigation water from Bahr Yusef to the canal and reverse excess water from the canal to the Bahr Yusef Canal.

In order to understand the current state of irrigation facilities in the main canal, the three target areas (hereinafter "sample area") were selected and facility-surveys were conducted on the main canal and branch canal.

The summary of the area where a sample survey is conducted is presented below.

Table 4.30 Outline of Target Main Canal of Sampling Survey (Bahr Yusef Principal Canal System)

No.	Main canal name	Station (km)	Length (km)	Command Area (feddan)	Number of Structures	
					Irrigation	Bridge
1	Terfa Canal	144	14.06	19,550	15	3
2	Saba Canal	177	23.00	16,300	18	12
3	Koftan Canal	229	17.14	19,134	13	4

Source: Prepared by JICA Survey Team based on the sampling survey for irrigation facilities

From the sample survey of the irrigation facilities, the following challenges are identified.

1) Deterioration of the function of the main canal due to deformation of the cross-section

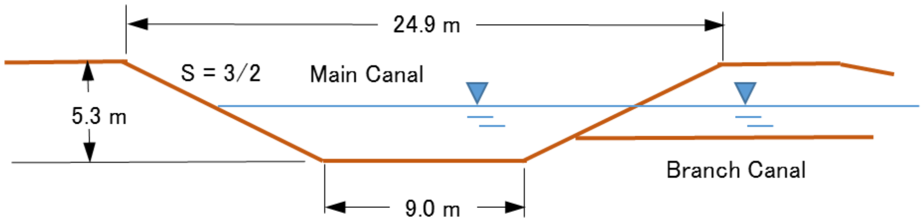
2) Malfunction due to the aging of water control facilities

3) The blocking of water supply/water control due to garbage accumulation

1) Decrease of Water Flow to Branch Canal due to Canal Deformation

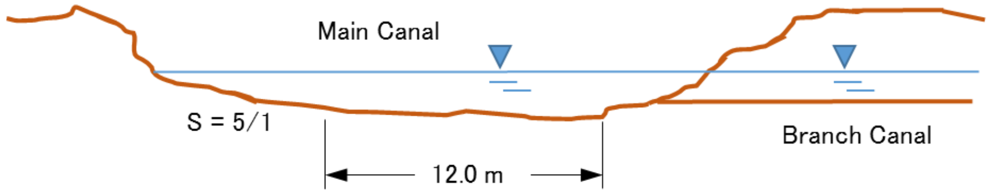
Most of the unlined canals reveal deformations in their cross-sections such as widening, collapsed slopes, shallow bottoms caused by scouring and silting by water flows, as well as excessive excavation of canal slopes during long-term facility maintenance work such as weeding and sediment removal. Accordingly, the shapes of the canal cross-sections become significantly different from their original design shape. An example is shown in a Saba canal case presented in Figure 4.39 and Figure 4.40 below. It is also observed that most of the branch canals have higher bed-elevation than the bottom level of the main canal.

Furthermore, the soil dredged during maintenance work had been left on canal banks and it had repeatedly fallen back into the canal. This event worsened the situation in which the canals cannot sustain the original design cross-sections.



Source:JICA Survey Team

Figure 4.39 Originally Designed Cross-section (e.g.: Saba Main Canal at 6 km point)



Source:JICA Survey Team

Figure 4.40 Current (Enlarged) Cross-section (e.g.: Saba Main Canal at 6 km point)

The field survey has identified the malfunctioning of the widened canal in terms of water-use due to the deformation of the canal's cross-sections. This issue becomes a common challenge throughout all the sample areas as mentioned in the following:

- Since water levels in the main canals are lower than the design water levels, their branch canals cannot attain the necessary water levels at each intake.
- As a result, it causes water shortages at the terminal portions after the branch canals, which receive insufficient distribution to meet irrigation demand.

To confirm these situations as an example (a case of the Saba irrigation system), to describe changes in various discharges into branch canals responding to respective discharges under uniform flows in a main canal, the following formula is presented

$$Q = CA\sqrt{2gh}$$

Where,

C: orifice constant, C = 0.61

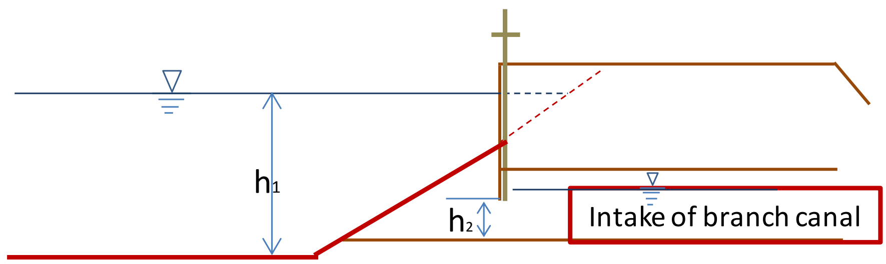
g: gravitational acceleration, g = 9.8 m/s^2

h: head in front of opening, then $h = h_1 - h_2$

h_1: height of water in the main canal

h_2: height of orifice opening (assumed at h_2 = 0.2 m in this case)

A: orifice area, A = h_2b (b: width at orifice opening assumed at b = 1.0 m in this case)



Source:JICA Survey Team

Figure 4.41 Layout of Intake Point for Orifice Equation

As a result of calculations, it is estimated that the inflow to the branch canals decreases by less than 15%. Therefore, the main canal needs rehabilitating against one of the challenges, namely, that its water level of uniform flows lowers due to progressive deterioration (mainly canal widening) in continued operations. This then creates a lack of discharge from the branch canals to secure effective water distribution. This markedly impairs efficient utilization of available water resources.

For the above calculation of the case of the Saba irrigation system, flow reductions will indicate almost a constant rate in the wide range of discharges in the branch canal under the deformed main canal. This probably means that water distribution seriously affected the cases that occurred in downstream areas that receive a smaller amount of water (greater impact may appear in smaller differences of water levels), and during low discharges in drought periods (water may frequently not reach the required level).

2) Malfunction of Water Regulating Facilities Due to Aging

The regulators and intakes that play the role of controlling the water level and of taking water from the main canal to the branch canal (including parts of the branch canal) are extremely important irrigation facilities for distributing water to irrigation areas. Although most of these structures are required to have a reliable opening-closing function when executing rotational irrigation, in the sample survey area conducted in the Survey, it is recognized that most of these facilities are malfunctioning. In addition, it was confirmed by the hearing survey that the tail-ends of this irrigation area face a shortage of water.

Structures areas along the main canal that are surveyed as the sample survey are listed in Table 4.31.

Table 4.31 List of Structures that Exist along the Main Canal in the Sample Survey Area (Bahr Yusef Principal Canal System)

Canal	Barrages /Regulator	Canal Intakes / Feeders	Pump	Other	Bridge	Total
Terfa Canal	0	7	7	1	3	18
Saba Canal	1	11	1	5	12	30
Koftan Canal	1	11	0	1	4	17
Total	2	29	8	7	19	65

Source: JICA Survey Team based on the sampling survey.

The major irrigation facilities are regulators and intakes that control the water level in the canal and help divert water to the branch canal. Most of these irrigation facilities are structurally unstable due to the aging of structures (mainly bricks) and have gate facilities that have insufficient operability due to the wear and tear of the gate (expired within its economic lifetime). Other irrigation structures include under drainage (road crossing), siphons, aqueduct bridges, and reuse pump facilities.

The list below indicates the major challenges of the irrigation facilities from the sample survey area.

- In the Terfa main canal system, there is a challenge regarding the lack of a suction head at the main pump station (mentioned above). However, the other two relay-pump stations require minor repairs and there is no urgent challenge. No particular challenges are present at the five of seven intake facilities, but in two places, the gate equipment has deteriorated considerably and is difficult to operate.
- The Turfa main canal system distributes water to each branch canal (many of them are lined) after raising the water level using the relay pump station, but the water does not reach most ends of the canal due to illegal pumping undertaken in the area. There is also the destruction of the lined canal bottom due to illegal pump installation.
- There are many intakes on the Saba main canal. Most of these intakes are difficult to operate or inoperable due to degradation of gate equipment, and irrigation water is not distributed to

branch canals equally. In addition, old intakes on the branch canal do not work and are left opened. According to the hearing, the planned rotation of the water delivery has not been fulfilled.

- There is a reuse pump station at the end of the Saba main canal. However, because the irrigation water does not reach the end, it is not possible to mix water from the drainage canal. Rather, the drain water is being used directly to irrigate the area.
- Two of the three gates of the Koftan intake set at the entrance of the Koftan main canal are immobile (remain fully closed), and the third gate has deteriorated, resulting in a big hole being formed and always being found in an open state. In addition, the gate of the Deshasha regulator, (found 12 km downstream from the Koftan intake), was not working effectively and cannot be moved from its closed position. Water cannot pass downstream, hence more water flows into the branch intake creating overflowing (flooding) from the canal.
- Similar to the condition of the Saba canal, most of the intakes to branch canals are malfunctioning and water cannot be distributed to each branch canal equally due to deformation of the main canal.

Table 4.32 shows the lists of water controlling facilities organized according to evaluation criteria described in the previous section (Evaluation standard is as shown in Table 4.23).

Table 4.32 Summary of Deterioration Condition of Intake and Regulator (Sample Area of Bahr Yusef Principal Canal System)

Sample Area	A	B	C	D
Terfa	-	2	-	5
Saba	-	8	1	3
Koftan	1	5	3	3
Total	1	15	4	11

Source: JICA Survey Team based on the sampling survey.

As can be seen from the sorting results of the sample survey area in the table above, water control facilities (mainly intakes) have defects related to the equipment gate in many facilities. Malfunctioning of the intakes that dominate the total number of structures in one irrigation area becomes a bottleneck-related challenge in maintaining stable irrigated agriculture in the canal system. For this reason, restoration of the functions of these facilities is extremely important.

3) Malfunction of the Flow and Control of Water Caused by Garbage

There are many challenges related to garbage accumulation inside the irrigation facilities in the main and branch canals. Especially at intake facilities, the accumulation of garbage inhibits the entrance of water into the intake-gates and damages the mechanical part of the gate during operation. Sometimes, depending on the location, net-trash facilities have been installed in front of intakes to prevent the inflowing of garbage. However, that net is not functioning adequately because of insufficient maintenance (Bahnasa intake located 6 km downstream of the Saba main intake).

In addition, part of the main and branch canals that passes through the residential area is covered by concrete slabs to prevent dumping by residents. However, garbage and sediment deposits flowing from upstream of the canal closes the entrance to the closed-type canal (passage facility). Mostly, it is difficult to access the inside of the closed-type canal, so removal of the garbage becomes a big challenge.

(2) Main/Branch Canal and Irrigation Structures of Ibrahimia Principal Canal

There are about 889 canals, which include 77 main canals, within the Ibrahimia Principal Canal system. Three main canals out of 77 are selected as the sample survey canals that help understand the present condition of the main canals in the Ibrahimia Principal Canal system. The list and general condition of the selected canals are presented in the table below.

Table 4.33 Overview of Main Canal Surveyed as Sample (Ibrahimia Principal Canal)

No.	Main Canal Name	Station(km)from Dirout	Length (km)	Command Area(feddan)	Number of Structures	
					Irrigation	Bridge
1	West Hafez Canal	32.800	14.70	23,246	9	8
2	El Gendia Canal	132.800	14.75	12,240	10	10
3	Tunsa-Kella Canal	179.030	20.45	24,820	21	14

Source: JICA Survey Team based on the result of Sample survey

Similar to the sample survey of the Bahr Yusef Principal Canal, challenges confirmed by the results are: 1) degradation of water flow capacity due to deformation of the canal's cross-section, 2) malfunction of water-control facilities due to deterioration and 3) malfunction of flow and control of water induced by the accumulated garbage.

1) Degradation of Water-Flow Capacity in the Main Canals

Similar to the main canals in the Bahr Yusef Canal system, the main/branch canals in the Ibrahimia Principal Canal system are made of earth (only 2.7 km at the beginning of the Tunsa-Kella canal is lined). Most of the cross-section of the main/branch canals is deformed (widened) due to (i) repeated erosion and (ii) inappropriate maintenance work, such as dredging of sediment deposition, weeding, etc. Since the necessary water level in the main canal cannot be secured due to a decreasing water level, there is a significant challenge related to securing the necessary amount of water in the branch canals.

This is a common challenge in the entire sample-surveyed area. It causes a shortage of water at the terminal of the irrigation area, and results in insufficient irrigation efficiency throughout the entire irrigation system and impairs the efficient use of irrigation water throughout the entire canal system.

2) Malfunction of Water Control Facility due to Deterioration

The number and type of structures surveyed in the sample survey area are listed below.

Table 4.34 List of Structures in Main Canal Surveyed (Ibrahimia Principal Canal System)

Canal	Barrages /Regulator	Canal Intakes / Feeders	Pump	Other	Bridge	Total
West Hafez Canal	2	5	0	2	8	17
El Gendia Canal	1	6	0	3	10	20
Tunsa-Kella Canal	3	15	2	1	14	35

Source: JICA Survey Team based on the result of Sample survey

The main irrigation facilities are regulators and intakes. Many of these irrigation facilities include unstable structures due to aging and facilities that cannot work fully. Other irrigation structures are under drainage (road crossing), siphons, aqueducts, and reuse pump facilities.

The main challenges revealed by the sample survey are summarized below.

- There are two regulators in the West Hafez main canal. The El Mahras regulator is not functioning due to the serious aging of the equipment. The gates of this regulator always remain open. In terms of intake, two intakes need repair and the other requires minor maintenance.

- There are many covered-type canals along the West Hafez main canal system because it crosses many residential areas. Similar to most of the main canals, since a covered-type canal has a gentle gradient, sedimentation tends to occur. However, internal maintenance is somewhat difficult due to the structure of the canals.
- Only one regulator along the El Gendia main canal had no challenges during the Survey. However, one of the six intakes along the main canal is not functioning because of the serious breakage of the entire facility. In addition, two intakes have no gates that necessitate installation. The remaining structures show slight deterioration that can be handled with routine maintenance.
- In this canal, there are also many covered-type structures (culvert, siphon) which cross the residential area. Similar to above, it is difficult to clean sediment and garbage deposited upstream from the structure because of the gentle gradient and low internal-flow velocity.
- A gate is not functioning at one of the three regulators along Tunsa-Kella main canal. The other two regulators need repair because of deformation of gate grooves. There are also many intakes in this irrigation system that need repair or replacement due to aging.
- In the upstream area of Tunsa-Kella main canal (around 2.7 km), an aqueduct (composed of four steel pipes) has been used to cross the drainage canal. However, the aqueduct has many holes due to corrosion of steel pipes, and this brings about a large amount of water to be lost by leakage (Figure 4.42).
- There is one reuse-pump station along the main canal and five reuse-pump stations along branch canals. One of these stations ceased working 4 years ago due to submergence of the equipment. The other pump station also needs replacement or repair of equipment because of deterioration. In addition, according to the information from Beni Suef GD, because of this status, the irrigation system is not operating as planned; it has not been able to compensate for the shortage of water at branch canals from the reuse pump.

The field survey confirmed that most of the irrigation facilities in branch canals distributed from main canals located in these three-sample survey areas are very old and need some kind of rehabilitation work.

Source：JICA Survey Team

Figure 4.42 Aged Irrigation Facilities(Regulator and Aqueduct)

The table below shows the number of structures in the sample area, organized according to the degree of deterioration (Evaluation standard is as shown in Table 4.23). Similar to the challenge in the Bahr Yusef Principal Canal system, important irrigation facilities such as water intake facilities and regulators become very old, and the water supply for the downstream area is clearly not sufficient.

Table 4.35 Summary of Deterioration Condition of Intake and Regulator (Sample Area of Ibrahimia Principal Canal System)

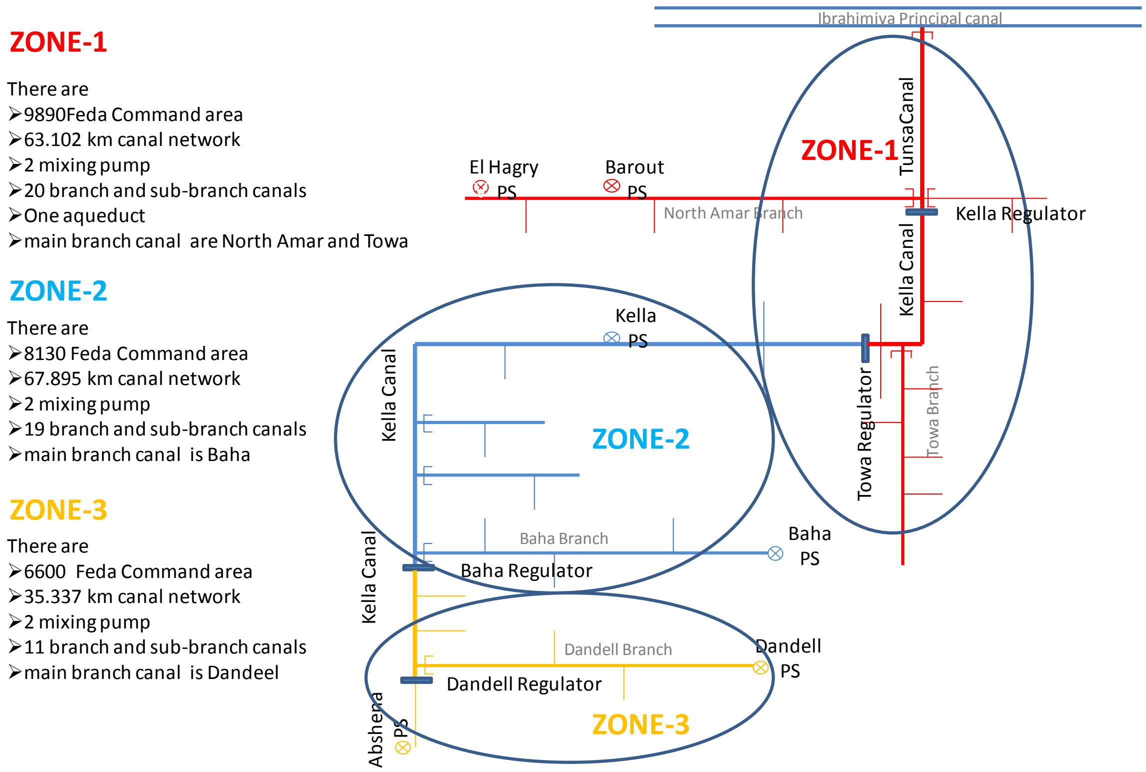
Sample area	A	B	C	D
West Hafez	1	-	2	4
El Gandia	1	2	1	3
Tunsa-Kella	3	3	8	4
Total	5	5	11	11

Source: JICA Survey Team based on the result of Sample survey

3) Case Study on Model Area (Tunsa-Kella Sub-region)

The result of a field investigation on the Model Survey area shows that the irrigation facilities in the irrigation system are not functioning properly in delivering the required amount of irrigation water to each branch canal even after applying irrigation rotation (The detailed results of the survey are shown in Annex 4). Under this condition, a simple hydraulic analysis was made in the Tunsa-Kella sub-region to determine the effect of (a) deformed canal shape, (b) malfunctioning facilities and (c) insufficient water management on the distribution needed in the system. The sub-regions are divided into three zones according to the existing irrigation rotation. Each zone is expected to receive irrigation water every 10 days.

A system diagram of the irrigation system is shown in Figure 4.43.



Source: JICA Survey Team

Figure 4.43 Image Map of Water Distribution on Rotation Irrigation in Tunsa-Kella Area

Due to the lack of detailed information, certain assumptions are used in the hydraulic analysis as presented below.

i) Assumptions for Calculation

The following assumptions are considered in this hydraulic analysis.

- In this Survey, the irrigation efficiency in a sub-region is estimated, because the improvement of water use efficiency and projects to achieve it are considered for each sub-region. The irrigation efficiency is calculated by <used water amount / supplied water amount> in a certain area. Since the unused water and seepage are regarded as losses, the irrigation efficiency in a sub-region is relatively small. Considering the water balance in a broad area, such losses are reused downstream and the available water amount increases, so the irrigation efficiency also rises.
- The overall irrigation efficiency (Ep) of 60.5% presented in the previous reports (feasibility report on Bahr Yusef Canal, 1992) is used as the originally designed overall irrigation efficiency of the system. For reference only, the Tunsa-Kella Sub-region is situated in the Ibrahimia Canal system, but the last report in 2010 treated it under the assumption of 60.5% of irrigation efficiency. The report explains that the irrigation efficiency is calculated as below by the quantity proportion of the consumed water against the supplied water.

  <Irrigation efficiency = Consumed water quantity / Supplied water quantity>

  Here, the consumed water quantity and supplied water quantity include the following:

  Consumption: Required amount: unit crop consumption x cultivated land
  Required amount at newly developed land: pumped amount at 4 lifting pump stations
  Domestic water: consumption by people and livestock

  Supply: Intake amount: intake amount at Dirout Group of Regulators to Bahr Yusef Canal
  Reused amount: pumped amount at 9 reuse pump stations
  Reused amount by farmers: farmers pump drained water amount for duration of water shortages between June and September
  Other reuse: gravity water-reuse from drained water

- The present overall irrigation efficiency of the system is determined using the efficiency formula (Ep = Ec x Ea, where Ep = Overall Irrigation Efficiency, Ec = conveyance efficiency, Ea = filed application efficiency).
- The original conveyance efficiency (Ec) of the irrigation system is assumed as 80%, which would be applied to earth canals (Clay) (based on the guideline by FAO; refer to the table below).

Table 4.36 Irrigation Efficiencies

Indicated Values of the Conveyance Efficiency (Ec)

	Earthen Canal			Lined Canals
Canal Length	**Sand**	**Loam**	**Clay**	
Long (> 2,000 m)	60%	70%	80%	95%
Medium (200- 2,000 m)	70%	75%	85%	
Short (< 200 m)	80%	85%	90%	

Indicated Values of the Field Application Efficiency (Ea)

Surface irrigation (border, furrow, basin)	60%
Sprinkler	75%
Drip Irrigation	90%

Source: FAO Irrigation Water Management: Irrigation Scheduling (1989), ANNEX I

- Since Tunsa-Kella has three rotations, the analysis is made separately for each rotation. The result of the distribution efficiencies for the three rotations are averaged to determine the distribution efficiency of the whole irrigation system.
- The required discharge for each rotation is determined through the relationship between the command area and water duty which has been adopted by MWRI and is as follows:

$$q = f \times q_i \times A$$

Where: q = required discharge in lit/sec
f = safety factor = 1.25, equivalent to 20% of loss at terminal (80% efficiency = 1/1.25)
q_i = water duty = 0.84 lit/sec/fed
A= area in feddan

Accordingly, the discharge during each rotation is calculated as follows:

Table 4.37 Required Discharge by Each Rotation

Rotation	Area covered in the sub-region	Area (feddan)	Discharge (m^3/sec)	Main branch canal
Rotation1	From intake to Towa Regulator	9,890	10.385	North Amar, Towa
Rotation2	From Towa to Baha Regulator	8,130	8.536	Baha
Rotation3	From Baha regulator to the end	6,600	6.930	Dandeel

Source: JICA Survey Team

- The design flow from the main canal to each branch canal during each rotation is determined using the following formula (refer to 4.2.2 (1) 1))

$$Q = CA\sqrt{2gh} \quad (m^3/s)$$

- The original dimension of orifice-opening to each branch canal is determined from the required discharge and the height of water in the main canal, which is calculated using Manning's Formula.
- The new conveyance efficiency is calculated by dividing the water reached at each branch canal (to the field) by the water diverted from the source (the required water for the command area served by the canal).

ii) Analysis of the Present Condition of the Canal System

Initially, flow through the main canal and discharge to each intake structure along the main canal was determined. As discussed before, the present condition of the Tunsa-Kella sub-region is characterized as having malfunctioning irrigation facilities and a deformed canal section with insufficient water management.

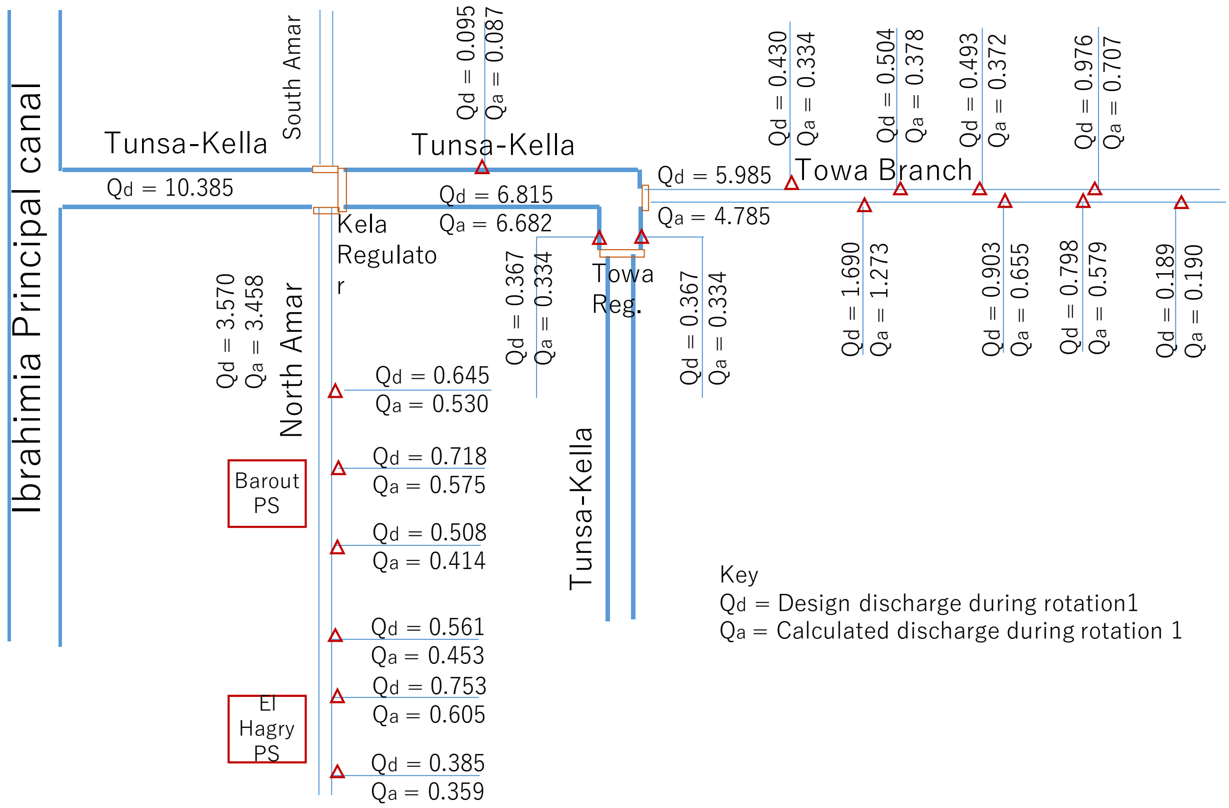
In this analysis, initially, the distribution of the design-discharge on the main canal, sub-main and every branch canal is calculated. The discharge on the canal system is determined next taking into account (i) the deformed canal shape and (ii) the malfunctioning facilities such as the broken regulators and intake gates.

Finally, the distribution efficiency during Rotation 1 on the main canal, North Amar canal, and Towa canal is calculated by dividing the determined discharge with the design discharge in each branch canal and the value is averaged to determine the average distribution efficiency during Rotation 1. The result of discharge on each canal system for the case of Rotation-1 is depicted in Table 4.38 and Figure 4.43. The detailed calculations are shown in Annex 6 as “Fig. Flow of Tunsa-Kella Irrigation System in its present condition for Rotations 1, 2 and 3”.

Table 4.38 Required Discharge and Water Reached at Inlet of Branch Canal during Rotation-1 with the Existing Condition of the System

Branch Canal Name along main canal	Command area (Fed)	Required Discharge (m^3/sec)	Water Reached at Each Canal (m^3/sec)
North Amar	3,400	3.570+0.500	2.935
Kella 1 branch	90	0.095	0.087
Towa Canal	5,700	5.985	4.488
Old kella left Genebia	350	0.368	0.334
Old kella right Genebia	350	0.367	0.334
Total (Area and discharge)	**9,890**	**10.385+0.500**	**8.178**
Conveyance Efficiency	8.178/(10.385+0.500) x 100 = 75%		

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.44 The Design and Actual Distribution of Water in Tunsa-Kella Sub-region during Rotation 1

In a similar way, the water distributions of the system during Rotations 2 and 3 were determined and the efficiencies are calculated accordingly (see table below). Compared to the originally assumed distribution efficiency of the system, the present conveyance efficiency has been reduced as low as 55% during Rotation 3.

Table 4.39 Result of Present Conveyance Efficiency (Tunsa-Kella Irrigation System)

Tunsa - Kella Sub-region	Rotation		
	R1	R2	R3
Each Rotation Area	75%	68%	55%
System Average	66.7%		

Source: JICA Survey Team

As indicated in the table above, the average conveyance efficiency of the system in its present state is 75% in the upstream (R1), 68% in the mid-stream (R2), 55% in the downstream (R3), and overall about 66.7%. Then, the conveyance efficiency in the areas (R1, R2 and R3) is lower than the efficiency given by FAO, which is 80%. Accordingly, it is considered that the conveyance efficiency could be improved to 80% in the target area by rehabilitating the facilities to secure the predetermined water level.

Accordingly, the present overall irrigation efficiency (Ep) is determined as follows:

Calculated as: Ep = Ec x Ea = 40%, where
Conveyance efficiency Ec = 66.7% (as shown in the table above)
Field irrigation efficiency Ea = 60% (as shown in Table 4.36, for surface irrigation)

The irrigation efficiency of 40% from this calculation turned out to be lower than 60.5% of the overall irrigation efficiency (represented in the Feasibility report on Bahr Yusef Canal). Apart from the two factors in the above formula, it should be noted that 60.5% of the overall irrigation efficiency included the repetitive water use downstream. Based on 60.5% of the overall irrigation efficiency, with consideration of the decrease in the conveyance efficiency, such as 79% to 47%, the present overall efficiency would be projected as 50% (60.5% x 66.7%/80%, shown in Table 4.40).

In the same way, the irrigation efficiency for each rotation is estimated as below, based on 60.5% of overall irrigation efficiency, with consideration of the decline in conveyance efficiency due to the deterioration of canals.

Table 4.40 Results of the Current Irrigation Efficiency (Tunsa-Kella Canal)

Rotation	Conveyance efficiency (Ec)	Irrigation efficiency (Ep)
Rotation 1	75 %	56% (60.5% x 75%/80%)
Rotation 2	68 %	51% (60.5% x 68%/80%)
Rotation 3	55 %	41% (60.5% x 55%/80%)
Total Average	66.7 %	50% (60.5% x 66.7%/80%)

Hence, the present condition shows that more water should be supplied in the system to satisfy the water duty of the command area especially during Rotation 3 where the conveyance efficiency is very low. Due to this reduction in conveyance efficiency, the required discharge on the main canal during each rotation should be increased to compensate for the loss due to low efficiency, which is not practical.

This condition was confirmed during the field survey that most of the beneficiary farmers especially at the terminals of the canal, especially at the Baha and Dandeel canals, complained about the lack of water supplied through in the main canal.

4) Malfunction of Water Flow and Control Caused by Garbage and Other Facilities

Many canals of the Ibrahimia canal system pass through residential areas compared to the Bahr Yusef canal system. Therefore, challenges relating to the fact that the hydraulic performance of the canal has dropped were discussed; the challenges were probably due to garbage dumping and illegally built interpenetrating structures. For a section of the main canal, such as that along El Gendia, a closed-type conduit was set to prevent garbage dumping, however, access to the conduit had become difficult and removal of sediment accumulated due to gentle slopes from the closed canal became impossible. This condition induced an insufficient performance of the canal system, which is common in many parts of the canal.

Source; JICA Survey Team

Figure 4.45 Malfunction of Water Flow and Control Caused by a Building (Mosque)

(3) Kased Main Canal System

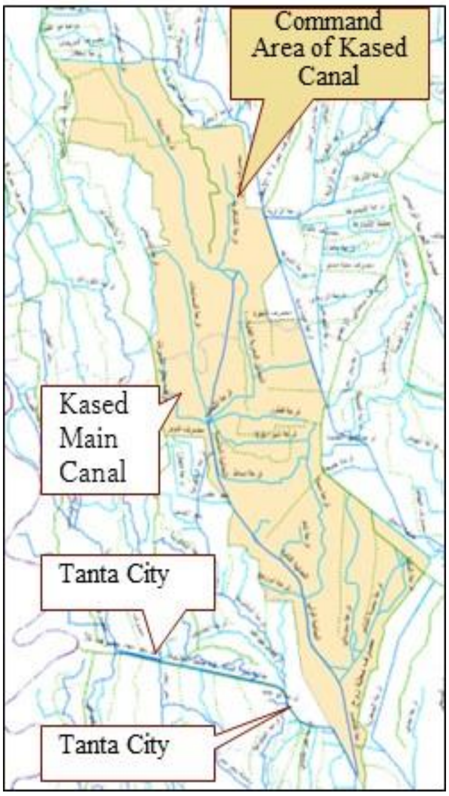
1) Main Canal System

The Kased Canal receives water from Tanta Navigation Canal fed by the Bahr Shebin, which takes water from the Rosetta branch of the Nile River. The Kased Canal takes water without a water regulating facility at the diversion of the Tanta Navigation Canal. The Kased Canal is about 42 km long and irrigates 67,000 feddan (28,000 ha). The shape of the canal is: the bottom width is 5 to 25 m, side slope is 3:2 (1:1 at downstream), water depth is 6 m. Its longitudinal slope varies from 1/10,000 to 1/20,000 reflecting the features of the flat terrain.

Table 4.41 General Specifications of Kased Canal

Section up to	Station (km)	Bed Width (m)	Side Slope	Canal Slope
Old Tanta Regulator	7.20	25.0	3:2~1:1	1/10,000
New Tanta Regulator	7.90	25.0	3:2~1:1	1/10,000
Mehala Menouf Regulator	17.45	25.0~18.0	1:1	1/10,000
Saad Regulator	30.20	15.0~12.0	1:1	1/6,700
End	41.70	10.0~5.0	1:1	1/6,700

Source: Prepared by JICA Survey Team from documents of MWRI



Source: JICA Survey Team

Figure 4.46 Location of Kased Main Canal

2) Main Canal, Branch Canal, and their Facilities

It is confirmed that the Kased Main Canal has four regulators (intermediate regulators), eighteen division facilities which are connected to primary branch canals, twenty-four bridges (except railway bridges), and six water treatment plants (except mobile type). In total, 24 branch canals are confirmed. Some of them are connected with the same division facilities (point).

Table 4.42 Lists of Structures on Kased Principal Canal

Zone No. *	Regulator	Canal Intakes / Feeders	Bridge	Total
1	2	8	10	20
2	1	5	8	14
3	1	11	6	18
Total	4	24	24	52

*Zone 1(Upper); From the entrance of Kased Dalil (0.0 km) to 13.5 km
Zone 2 (Middle); From 13.5 km to 27.0 km
Zone 3 (Lower); From 27.0 km to 41.73 km
Source: Compiled by JICA Survey Team from the Result of Inventory Survey of the Project

Four canals were selected as sample survey areas from all branch canals and the survey was conducted for grasping roughly the condition of irrigation facilities below branch canals. The summary of the branch canals targeted by the sample irrigation facilities survey is shown below.

Table 4.43 Summary of Facilities based on Sample Survey in Kased Canals (Primal Branch Canal)

No.	Main Canal Name	Station (km)	Length (km)	Command Area(feddan)	Number of Structures	
					Irrigation	Bridge
1	Shabshear	7.100	11.15	13,250	14	18
2	El Nashwo	17.600	4.16	1,900	2	5
3	Damat	25.700	11.40	4,650	11	14
4	El Samahat	29.950	15.10	9,500	2	19

Source: Compiled by JICA Survey Team from the Result of Sample Survey of the Project

Further, according to the interview made with Gharbia GD and the information from a JICA long-term expert, there is a plan for building new regulators about 2.5 km downstream from the branch point in the Tanta navigation canal, which aims to stabilize the water intake into the Kased canal.

The water intake into the Kased canal is done by adjusting the water level of the intermediate regulator about 10 km downstream from the branch point along the Tanta navigation canal. However, an unpredicted effect (bank-slope corruption of drainage canals caused by leaking water into the Tara drainage canal parallel to the Tanta navigation canal) has occurred accompanying the increase of the water level due to damming in the Tanta navigation canal. It was allegedly discussed that a sufficient water level for the Kased canal had not been secured, and it probably made the situation worse.

According to the survey by the Hydraulics Research Institute of NWRC (2008) that performed a comparative study about the challenge, it concluded (i) that construction of a new regulator is not appropriate, (ii) but the revetment of the Tanta navigation canal is a better plan for mitigating the backwater-effect by the existing regulator about 10 km downstream from the branch point. Based on the proposed construction location of the new regulator, which is outside the target area (outside Kased canal), the Survey does not plan any new construction of regulators.

3) Deterioration of Regulators in Principal Canals

The intermediate regulators are installed in the Kased canal as the main structures for dividing water. These facilities are shown in Table 4.44.

Table 4.44 List of Main Regulators in Kased Canal

Name of Facilities	Location (Km) (in Kased Canal)	Dimension	Condition
Tanta Old Regulator	7.200	4 Gate B=3m	No particular challenge. Partial repair (minor) is required.
Tanta new Regulator	7.900	4 Gate B=3m	No challenge.
Mehala Menouf Regulator	19.450	3 Radial gate	Not in operation (always open). Full repair is requested.
Saad Regulator	30.200	4 Gate B=2m	No challenge.

Source: Compiled by JICA Survey Team from the Result of Inventory Survey of the Project

The challenges facing the Mehala Menou regulator are confirmed as described below according to the interview with Gharbia GD and the information from a JICA long-term expert. The gate-hoisting machine is completely broken due to deterioration, the gate is not functioning and it always remains open. When closing the gate is required, a machine such as a crane is used. Its concrete body has also deteriorated, so Gharbia GD has requested full-scale repair because of this condition.

4) Deformation of Cross-section of Canals Passing through the Urban Area

The challenge facing the cross-section of canals passing through the urban area was confirmed based on the interview with Gharbia GD and the information from a JICA long-term expert.

Both banks of the section 4 km upstream of the Kased canal are bordered by paved roads. The road shoulders gradually protrude into the canal and the cross-section of the canal narrows. On top of this, in the section after about 3 km, the insufficient nature of the cross-section is severe. Therefore, Gharbia GD has expressed its willingness to preserve the cross-section of the canals by modifying the canal slope from an unlined soil surface to a vertical wall.

5) Water Quality

The water quality is maintained relatively well because the Kased canal has a separation system of irrigation from drainage. However, the report on technical cooperation for development planning, namely, "The project for drainage water quality control for irrigation in middle Nile Delta", pointed out that tackling "the challenges because of the constrains on the water supply" in the Kased canal is a common challenge in the Nile Delta region, in addition to the increase in demand for clean drinking water corresponding to population growth. In short, solving the water-quality challenge is one of the targets in summer when demand is rising.

6) Malfunction of Water Flow and Control Caused by Garbage and Other facilities

The population density of Gharbia where the Kased canal is located is high, and the canals pass through residential areas. A large amount of garbage has been dumped and accumulated around structures in canals that are close to residential areas, and has obstructed O&M of irrigation facilities. Further, the inflow of sewage and domestic wastewater from dwellings along the canals are also observed. These are typical and serious challenges facing water quality control in the Delta region

Accumulated garbage in upstream of Mehala Menouf Regulator

Saad regulator and the circumstances of garbage in the upstream

Source: JICA Survey Team

Figure 4.47 Accumulated Garbage in Upstream of Regulators

7) Functional Deterioration in Malfunction of Water Control Facilities

The sample irrigation facilities survey and the interview of GD revealed the following challenges facing branch canals of the Kased Main Canal system.

- In the Shabsher branch canal diverted from the right bank side upstream of the Tanta intermediate regulator, a section is located stretching about 1.5 km in between a railway on the right bank and a highway on the left bank. There is a collapsing canal slope caused by the heavy vehicle-load on both banks. GD is requesting repair of the concrete canal (box culvert) since the depth of the canal needs to be 4 m and the current slope is dangerously steep.

- The survey confirms that many of the water-intake gates along Kased canal are inoperable or malfunctioning. The gate (2.5 m in width) of the Omurabab intake (at 14.5 km) and Baharbon intake (2.0 m in width and located at 19.7km) are severely deteriorated and inoperable. Further, the gate of the Naga canal intake divided from the Damat branch canal is missing (Figure 4.48).

- In all branch canals, it is observed that the deformation of the canal cross-section is due to frequent dredging work to remove aquatic plants and garbage. Improvement is necessary in terms of facilities' O&M (Figure 4.49).

Source: JICA Survey Team

Figure 4.48 Naga Canal Intake of Damat Branch Canal (Gate Breakage)

Source: JICA Survey Team

Figure 4.49 Overgrowth of Aquatic Plants in Shasheer Branch Canal

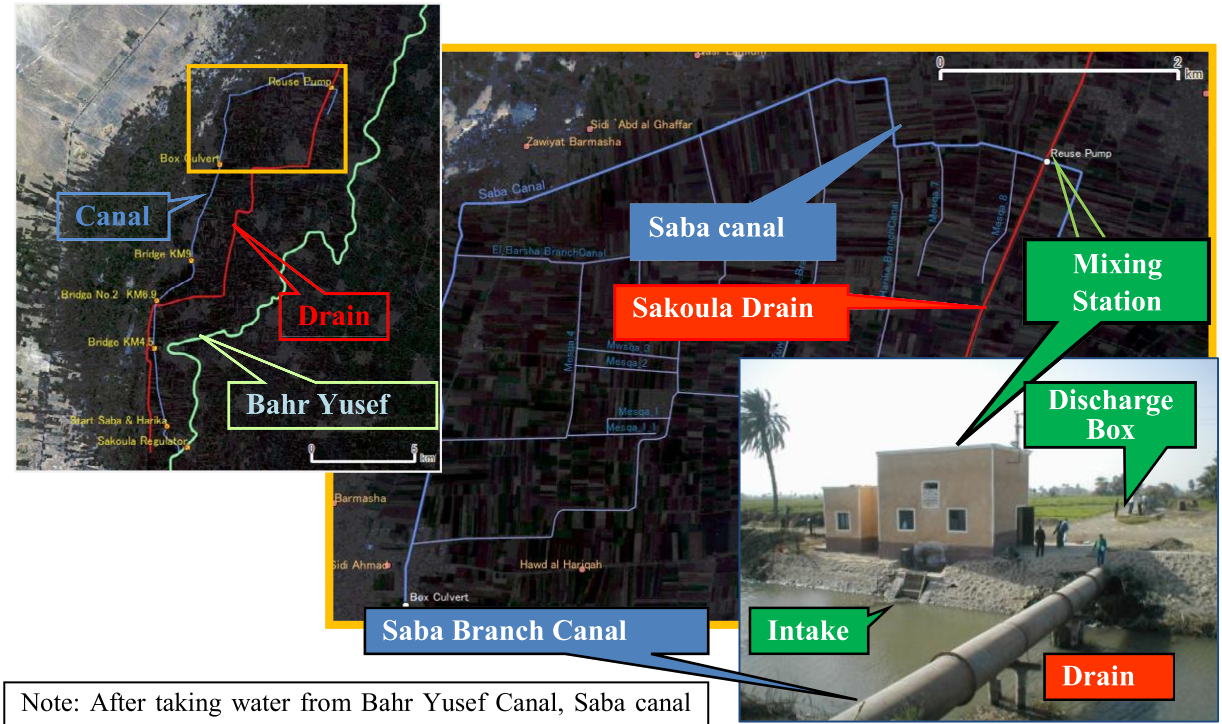
(4) Current Conditions of Facility of Reuse Pump Stations

The presence of reuse pump stations for the use of wastewater that aim at expanding water resources is a remarkable feature of irrigation systems in Egypt. This section describes the condition of water-reuse-pump stations, which are components common to all the aforementioned canal systems.

1) Overview of Drainage Reuse

According to Law No. 12 / 1984: "Irrigation and Drainage" and Law 48/1982: "Protection of Nile from Pollution", reuse of drainage water is defined as the active reuse of water (including mixing water) coming from drainage after irrigation, and it is clearly specified in NWRP. Drainage reuse is a means to increase the amount of available water resources, and plays a role by utilizing a "reuse pump station" to improve the norm of water distribution in the irrigation system.

An example of the station in the Survey area in Upper Egypt is shown in Figure 4.50.



Note: After taking water from Bahr Yusef Canal, Saba canal can deliver water downstream. So the Saba canal furnishes a mixing station located at it tail end, where Sakoula drain crosses under Saba canal. The station supplies water both upstream direction of Saba canal and to branch canals downstream of Saba canal.
Source: A base image is produced from ESA remote sensing data (2016).

Figure 4.50 Example of Mixing Station

The Egyptian irrigation system conducts water distribution to districts by allocating various facilities in order to improve the utilization efficiency of limited water resources (more effective use). The water-reuse pump station is also a type of facility that has several roles in the irrigation canal system. While other methods are mainly facilitated as "sharing-water" among sub-regions, drainage reuse is characterized by the use of drainage water in irrigation water as "using-water-again", to increase the supply volume of water.

Planning for the installation of the water-reuse-pump station is based on drainage and pumping water as well as irrigation water. Regarding the activities within MWRI, responsible actors, that is EPADP, Mechanical, and Electrical Department (MED), cooperate to carry out the plan.

At the Bahr Yusef Canal that functions as the principal canal of the irrigation system, there is a water-reuse pump station (MED management) that introduces water from the drainage system at the upstream of the Mazora Regulator (so-called mechanism where water reuse is repeated widely). The Ibrahimia Principal Canal also has the same water-reuse pump stations (IS management) but at smaller volumes than the Bahr Yusef Canal. In order to compensate for water shortages in the sub-regions, water-reuse pump stations are installed mainly in the branch canal to reuse water that relies on drains from surrounding areas.

The water-reuse pump stations managed by MED are operated moderately and challenges have not been specified. Regarding the water-reuse pump stations managed by IS (MWRI calls them intermediate mixing station); the installation status is shown in Table 4.45, which was prepared based on the reports from each irrigation directorate in the Survey areas in Upper Egypt. Each reuse-pump station was installed at a different period and conditions according to the situations in the field. In other words, some currently function without any challenges but others do not. At some pump stations, the main components such as pump units are damaged or deteriorated, and the equipment is degraded or malfunctioning. Water-reuse pump stations are not installed in the Kased district, which is the target survey district in the Nile Delta region.

Table 4.45 Status of Water Reuse Pump Stations Already Installed

Name of Irrigation Directorate	No. of Installments	Place of Installment			Installed Pump Stations		Remarks
		Ibrahimia Principal Canal	Mainly Branch Canals		No. of Pumps	Volume (m^3/s)	
			Middle	Terminal			
East Minya	5 (2) *1	0	4 (1)	1 (1)	1 (1)	1.0 & (0.1)	*1 ( ) are number of mobile units
West Minya	2	0	1	1	1	1.0 & 0.5	
Beni Suef	23	3	12	8	2~6	0.25~1.0	
Faiyum	43	—	—	—	2~4	0.15~0.35	Type unknown (not targeted)

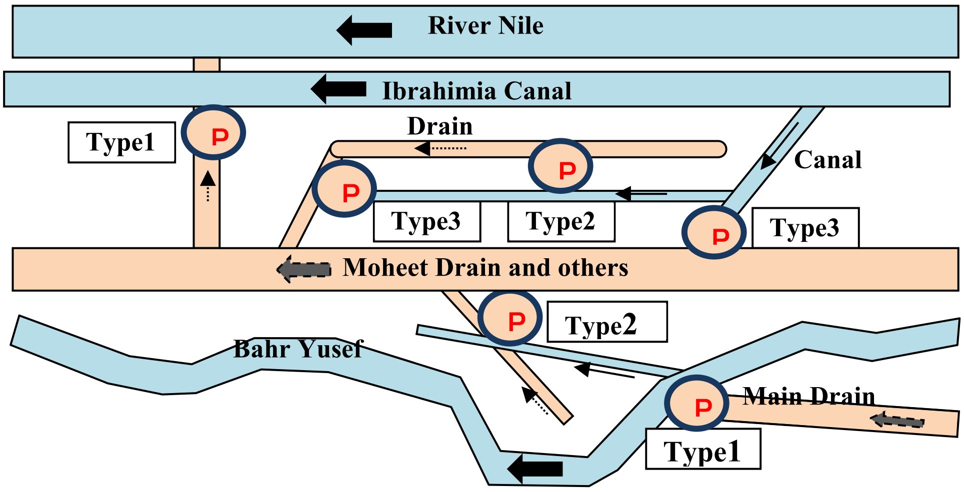
Note 1: Mobile units (diesel units) of West Minya are proposed to be introduced tentatively.
Note 2: Pump stations in Faiyum is excluded from the field survey, respecting the will of MWRI that states no challenges exist.
Source: JICA Survey Team

2) General Condition

The pump stations for water reuse, which have the task of increasing the quantity of irrigation water, are facilities of the hard component that constitutes part of the irrigation system. The facilities are installed in locations which are near to the drainage and irrigation canals. Water-reuse conditions are diverse due to the location of discharging points.

Table 4.46 Characteristics of Current Water Reuse

	Type 1	Type 2	Type 3
Target canal (injected location)	Principal canal (crossing main drainage canal)	Branch or intermediate main canal	End of branch canal etc.
Distribute (object) area from pouring point	Unspecified area(Wide and ·repetition)	Mainly downstream area Possible to the upstream area	The upstream direction of the downstream area
The general condition of irrigation	Flow in large quantity	Flow down	Not reaching
The general condition of introduction	Additional mixing of drainage	Mitigation of insufficient irrigation water (Mixing irrigation and drainage water)	Almost total quantity flow backward
Typical current condition	Mixing quantity is limited	The complement of area water distributing(The condition is individual diverse)	
Main limiting factor	The flow rate of the drainage canal	The flow rate of the drainage canal, water quality, and canal capacity	
Department in charge	MED(Large scale) IS(Small-scale)	Mainly IS(Small-scale)	



Source: JICA Survey Team

Figure 4.51 Type of the Pump Stations for Water Reuse Depending on Location

This Survey is carried out as an on-site survey for existing pump stations requested by IS and includes the above Type 1, Type 2, and Type 3.

Table 4.47 Existing Pump Station for Water Reuse (Upper Egypt)

GD	No	Station Name	ID	Pump Unit		
				No.	Discharge (m^3/s)	
					per Unit	Total
East Minya	1	El Ashmonin	Mallawy	1	1	1
	2	Karf El Mandawer	Maghagha	1	1	1
	3	West Aba	Maghagha	1	1	1
	4	Shams Eldin	Maghagha	1	0.1	0.1
	5	El Seka El Zraeias Mesqa	Maghagha	1	0.1	0.1
West Minya	6	Saba	Idwa	1	0.5	0.5
	7	El deer and Menbal	West Samalut	1	1	1
Beni Suef	8	El Hagary	East Beni Suef	4	0.25	1.0
	9	Barout	East Beni Suef	4	0.25	1.0
	10	El Sherif	Beba	4	0.25	1.0
	11	Abo Shahba	Beba	4	0.25	1.0
	12	El Shamashergy	Somosta	4	0.25	1.0
	13	Qoftan	Somosta	6	0.25	1.5
	14	Saharfet (Siphon) Mazoura	Somosta	5	0.5	2.5
	15	Telt	Somosta	3	0.5	1.5
	16	Absog	El_Fashn	4	0.25	1.0
	17	Kashesha	El_Wosta	5	1.0	5.0
	18	Qomn El Arous	El_Wosta	4	0.5	2
	19	El Mansour	El_Wosta	4	0.5	2
	20	El Diabia	El_Wosta	2	0.7	1.4
	21	Dalas	Nasser	3	0.5	1.5
	22	Baha	West Beni Suef	3	0.7	2.1
	23	Qella	West Beni Suef	5	0.5	2.5
	24	Ali Hafiz	Nasser	3	0.5	1.5
	25	El Walda	East Beni Suef	5	1	5
	26	El Sharhana	Beba	4	1	4
	27	Dandiel	West Beni Suef	2	0.5	1
	28	Anfast	El_Wosta	2	0.5	1
	29	El Mansur El Gded (New Mansur)	Nasser	3	0.25	0.75
	30	Fazara	Beba	1+1	1 & 0.25	1.25

Source: Compiled by JICA Survey Team from the article provided by MWRI.

In addition, new pump stations have been requested for new water-reuse in sub-regions. The new pump stations have been planned as a means to increase the quantity of irrigation water when a rural office confirms insufficient irrigation water. East Minya GD suggested installation of five new pump stations including replacement of two mobile pumps. West Minya GD suggested installation of three new pump stations. East and West Minya GD adopt a configuration in which three pumps (capacity: 0.5 m^3/s) per site (assuming one is for shift operation). In addition, Beni Suef GD suggested installation of six new pump stations that have four pumps (capacity: 0.5 m^3/s and including a reserve pump). In the Kased area (treated as a sub-region) located in Nile Delta, there is no existing pump station, but in order to mitigate insufficient irrigation water for the entire area, they have been suggested installation of four new pump stations that inject water to the branch canal. There are 31 water reuse pump stations in Kafr El-Sheikh located in downstream of Kased Canal[21], therefore, Gharbia Irrigation Directorate, which is in charge of this area, has experience in planning and installing pump stations. In addition, one of these pump stations also includes challenges unique to the Nile Delta, such as requiring the establishment of a treatment facility due to low drainage quality.

Since these pump stations constitute a part of the facility of the hard component, which plays various roles within the canal in the irrigation system, in this Survey, that is treated as a small-scale facility incidental to the canal as a regulating facility.

The water quality is an important point to consider in drainage reuse. Gharbia GD, which is in charge of mixing stations for water reuse in Kahr El Sheikh Province of the Nile Delta region, operates a mixing station by setting a mixing ratio for water-reuse based on periodical checks (twice a year) of the water quality in drains. On the other hand, the GDs in charge of water reuse in the Upper Egypt region do not undertake data collection so much. They only receive reports prepared by the Ministry of Health. According to the information of Beni Suef GD, it is reported that there has been no challenge so far by planning at the water mixing ratio of “drain: irrigation = 1:3” for mixing stations for water reuse. However, in the pump stations located in the end of the branch canal in the Saba canal, farmers use water from drainage directly because irrigation water does not reach the end of the canal. In this case, it seems necessary to check the water-quality of reused drainage water.

3) Plan Making

Since drainage-reuse is installed to mitigate insufficient irrigation water in a sub-region, it is necessary to synchronize the operation hours of the pump station with the rotation of regional water distribution. In Upper Egypt, the operation time of a pump station that injects water into a branch canal is planned and operated 120 days a year and 8 hours a day as standard. On the other hand, in the Survey, it is confirmed that operation time is extended by requests of water users.

The purpose of the reuse pump station (Type 2 or Type 3) is to mitigate the limit of water distribution and insufficient water supply in a sub-region. However, the operation of a pump station is not carried out as planned because priority is given to the examination of the amount of water that can be pumped at a point where drainage can be injected into the irrigation canal. Although such a situation may occur because of its nature which is premised on the fact that the drainage canal and the irrigation canal are close to each other, it is not a plan from the viewpoint of further improving the efficiency of use of the water in the sub-region. In the water-reuse plan, it is necessary to set the capacity and scale of the pump as an optimal facility in the irrigation system with consideration of the limit of the canal scale (flow capacity) that distributes irrigation water to a sub-region and as an impediment in irrigation water distribution (water management situation that cannot realize planned water delivery/distribution).

4) Degradation of Functions

Various conditions exist depending on (i) the situation of the site, and (ii) the installation time at the reuse-pump station (Type 2 and Type 3). Some pump stations do not have any function-related

[21] Project for Drainage Water Quality Control for Irrigation in Middle Delta、JICA、March 2016

challenges at present. However, others have the challenge of breakdown/damage, degradation of equipment, and degradation of function. In the field survey, it was found that the layout, such as the height of the floor of the pumping station, was a problem (for example, the Barout pump station is out of operation due to an inundated pump). Moreover, it also confirms the case that efficiency is unnecessarily reduced during operation due to the conduit's hydraulic loss by unnecessary long pipes. Especially, it is also pointed out that machinery engineers include some electric motors and they do not comply with safety standards.

These interferences in the function of the facility are creating a vicious cycle that decreases the function of the water-reuse pump station, because of longtime operation of entire pump stations and lengthening operation time caused by compensating for broken pump stations. Incidentally, reuse-pump stations (Type 1) are treated as important facilities for irrigation sectors and kept in relatively good condition through O&M.

In addition, the idea of unified design, etc., is not applied to all pump stations. Hence, challenges are different for each pump station. It is a problem that implementation of countermeasures to these are not systematically designed for decreasing the frequency of challenges currently occurring. This challenge is caused because there is not a clearly constructed mechanism that eliminates obstacles from the pumping operation to decrease the cost and time of maintenance

Among them, the suction of dust during pumping operation is a common challenge to existing pump stations in the survey area of Upper Egypt. Since many of the pump stations for water-reuse do not have any suction sumps and their suction pipes are connected to drainage canals directly, the dust intrudes into the pump and causes serious damage to the pump and malfunctions to the stop valve. Because of this, it is reported that monthly maintenance is required for suction pipes. In short, insufficient countermeasures to dust, garbage or foreign matter are a factor behind degradation of the function of the pump station.

4.2.3 Meska Level

(1) Overview of Meska

A meska is the tertiary canal at the terminal of a canal irrigation system, which commands irrigation fields at around 100 to 200 feddan in general.

A meska is categorized as private irrigation canals, or out of the category of public irrigation canals under the jurisdiction of the government. Its ownership and management responsibility belongs to water users (farmers). Deformation of a cross-section of meska is recognized as a negative phenomenon through the model areas survey. A meska has many lateral irrigation canals called marwas (small, farm-level irrigation canals) supplying irrigation water to each piece of cultivated land. Since the elevation of canal beds of meska is generally below the cultivated land, small water pumps are installed at the diverging point to a marwa in many cases.

1) Policy of Meska Improvement by MWRI

Meska has several improvement needs in its structural and functional performances. Until now, there are some meskas that have been improved by the self-efforts of the relevant farmers, and through subsidies by agricultural cooperatives, etc. However, improving meskas at the farmers' own expense could lead to unfavorable changes in the technical viewpoints of hydraulics and water management, because the convenience and interests of particular persons are apt to be contrary to the technical viewpoints and publicness. MWRI intends to improve meskas to be fully consistent with water distribution and management for a whole canal irrigation system because meskas plays an important role in water delivery and water use even though they are owned by private sectors of farmers.

As meska improvement could realize effective use of water relatively easier, MWRI is active in accelerating meska improvement under its control and instruction. In addition, MWRI urges the establishment of meska-level WUAs as well as branch-canal-level BCWUAs in order to enhance farmers' participation as rational water management. Though WUAs are to be established by the efforts and initiatives of relevant farmers, WUAs are not easily established and maintained as workable unless MWRI offers direct approaches and support. Currently, IIS of MWRI has prepared a meska improvement scheme under which both challenges of meska improvement and establishment of WUA could be dealt with simultaneously.

In this scheme, MWRI supports surveys, planning, design, constructional supervision, etc., for meska improvement. The Law No. 12 1984 designates the payment of all the construction costs by beneficiary farmers as a cost-recovery scheme. After completion, farmers must pay back the loan without interest in 20 years after a 1-year grace period. IIS calculates the cost per unit area, while the Survey Authority confirms the land title, and the Ministry of Finance collects the cost from the landowner as land tax[22.] The same financial flow is applied to the projects of the World Bank.

The Planning Sector of MWRI carried out a feasibility study (F/S) on meska improvement in Faiyum in order to advance meska improvement according to the MWRI's meska improvement scheme. The F/S targeted Faiyum because of the advantages in the geographical condition as canal water can flow by gravity in the entire area, and it can make improvement work of meska easier.

2) Effect of Meska Improvement

Concerning the benefits of meska improvement, there are many reports in the projects in which meska improvements were realized in several ways. For instance, IIP reported the benefits of meska improvement under their project[23].

a) The conveyance efficiency in the branch canal and meska has improved from 70% to 98%,

b) Reduction of irrigation time up to 50 to 60%,

c) Equity of water allocation was achieved between the head and tail of meska,

d) The improvement of the meska has reduced its facility occupancy and has produced about 2% of the command areas and made them available for new cultivation,

e) It increased crop yield ranges from 5% to 30% by improving water availability,

f) Cost of one irrigation application has decreased by 51% for winter crops and 57% for summer crops on average, and

g) Tail-end water users have been freed from the problem of pathogens and snail hosts.

(2) Survey in Model Area

From the results of the survey conducted in the Aros Abo Seer area of Faiyum (beneficiary area of approximately 13,500 feddan, 58 meskas) as a model area, the current situation and challenges for meska are summarized as follows:

- Because most of a meska is not lined, weeds grow around meska and slope surfaces, and leakage from holes created by rodents cause loss of the water flow rate, one of the causes of the shortage of necessary water.
- Roads constructed along meska were destroyed by the traffic, and soil and sand intruded into the canal hindering the water flow in meska.
- Like other main and branch canals, most of the current meskas present a deformed (wide section) cross-

[22] Issues of Cost Recovery for Irrigation and Drainage in Egypt, Koji KITAMURA (JICA Expert), Journal of the Japanese Society of Irrigation, Drainage and Rural Engineering, December 2000
[23] M.N. Allan et al, "Participatory Irrigation Water Management in Egypt: Review and Analysis", CIHEAM, 2004

section due to deterioration.

- Garbage and crop residues collect in meska, shrinking the cross-section of canals, hindering the supply of water to downstream farmers.
- Cleaning work in meska, such as weeding, is done by farmers who use the meska, so the burden on farmers is growing. In addition, there is the problem of the floating down of garbage and crop residues from upstream induced by the upstream farmer (farmers), and it becomes a problem that the downstream farmer (farmers) cannot solve alone.

According to the hearing survey, a problem was reported that water did not reach the end in 15 meskas out of 31 in the Abo Seer canal. It is observed since water barely reaches the end, the water level is low and the suction head of the pump is insufficient, so the required water quantity cannot be obtained. Furthermore, as another problem, the number of days when water reaches the end is also decreasing.

Source: JICA Survey Team

Figure 4.52 Situation of Meska in Faiyum

In short, meska, the terminal canal managed by farmers, has challenges, such as deformation due to deterioration of cross-sections, accumulation of aquatic plants, stagnation of garbage, accumulation of soil and sand, and decrease in water-supply efficiency, as well as the main and branch canal. There are also reports that the water loss at meska level reaches 30%, so suppression of loss is very important.

Moreover, there is a limit to what can be tackled for betterment of meska's O&M at an individual farmer level.

4.2.4 Current Situation and Challenge of O&M

O&M of irrigation facilities is implemented in between principal and branch canals by MWRI, and downstream in meska by WUA, and between marwa and fields by farmers. The current situation and challenges facing irrigation facilities are summarized below.

(1) O&M by MWRI

1) Current Situation

O&M of irrigation facilities by MWRI is under the jurisdiction of the General Directorate for Irrigation (GD), Inspectorate, and Irrigation District (ID). As for maintenance work of the irrigation facilities, under the framework called "the maintenance budget", constant removal of weeds and garbage in the canal, daily dredging of the canal, maintenance of the facility and minor repair work are carried out. On the other hand, under the framework called "the project budget", rehabilitation and updating of existing facilities and new

Source: JICA Survey Team

Figure 4.53 Dredging of Principal Canal

construction of irrigation facilities, pump stations, bank protection, etc., are carried out. The former budget is dominant in terms of monetary value.

As for the flow of O&M work, (i) firstly ID selects facilities in the area that need maintenance, (ii) the management project is planned, (iii) it is submitted to the GD and (iv) the GD compiles and send the plan to the central department and planning sector. Then, the project is carried out according to the approved budget plan. Regarding the implementation method, the construction related to irrigation structures, such as intake work, regulators, etc., is carried out directly by the Directorate for Preventive Maintenance of MWRI under a decision by the GD. However, for a facility larger than the main canal, the subcontractor does it because it is difficult to implement using maintenance facilities owned by the government. On the other hand, the cross-section of the principal canal and O&M of the irrigation facility on the principal canal are outsourced to a subcontractor under GD's supervision. Either way, the supervision of work and inspection after maintenance are carried out by each responsible agency, even with a limited number of staff. The method and contents of the implementation are shown in the following table.

Table 4.48 Method and Contents of Implementation of O&M for Irrigation Facility under IS (2014-2016)

Target	Responsible Body	Method and Contents of Implementation
Principal Canal	GD	Work by sub-contractor ◆ Dredging: once in several years ◆ Cleaning and weeding on the canal: every 4 months
Irrigation Facility on Principal Canal	Ditto	Work by sub-contractor ◆ Rehabilitation of intake
Main and Branch Canal	Responsible Inspectorate or ID	Work by sub-contractor or General Directorate for maintenance directly ◆ Cleaning and weeding on the canal: no less than three times per year
Irrigation Facility on Main & Branch Principal	Ditto	Work by sub-contractor or General Directorate for maintenance directly ◆ Rehabilitation of intake ◆ Rehabilitation of regulator

Source: Prepared by JICA Survey Team based on hearing survey

2) Challenge of O&M

i) Shortage of O&M Expenses

The shortage of O&M expenses is a big challenge. Table 4.49 shows the plan for the annual maintenance cost of four GDs in the survey area.

Table 4.49 Plan for Annual Maintenance Cost in Target Area (Fiscal Year 2016)

GD	Responsible area (ha)	Maintenance Cost (EGP)	Cost per ha (EGP/ha)
East Minya	136,831	27,693,039	202
West Minya	113,104	4,950,366	34
Beni Suef	142,199	6,012,735	46
Faiyum	154,019	8,736,273	51

Source: Prepared by JICA Survey Team based on hearing survey

As shown in Table 4.49, in Fiscal Year 2016, each GD mainly works on cleaning canals, removing weeds, repairing embankments and so on. In East Minya, because it included improvements of irrigation structures like pump stations, rehabilitation expenses, etc., it is expensive compared with others.

As a trend in the target area, the annual maintenance cost is from 30 to 50 EGP/ha (from 1.7 to 2.7 US$/ha) unless there are special projects. Regarding the O&M cost, it is said that the O&M cost of developing countries was from 30 to 50 US$/ha according to FAO[24]. The O&M cost in Egypt seems to not be enough even considering the lower level of construction of the facility and the national circumstances.

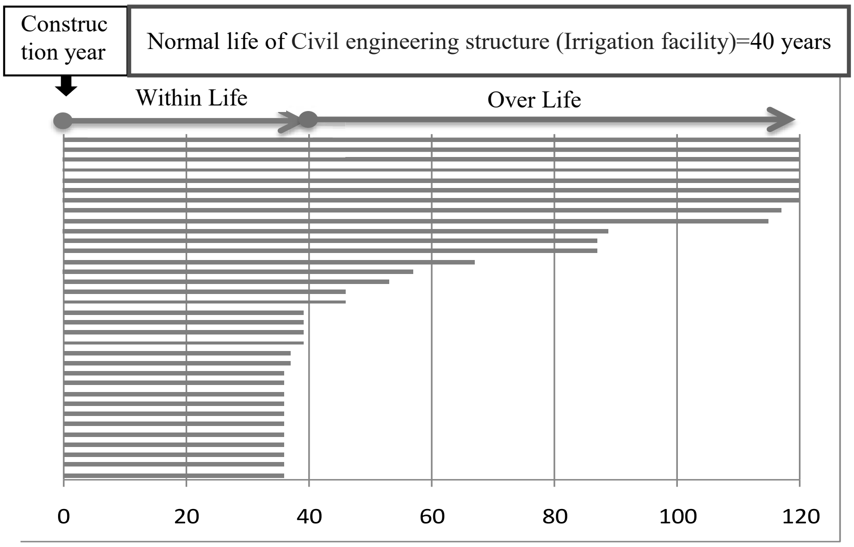
Under the severe restrictions on maintenance budgets, many facilities need to be improved because their eligible lifetime has finished. Prioritization of target facilities for improvement was done based on the experience of engineers concerned. It is needed to carry out the work systematically based on the deterioration amount of the facilities.

On the other hand, organizing information about irrigation facilities is insufficient. In fact, the current form of the facilities list varies according to every GD; it is not arranged for sharing and does not include positional information, nor the state of facilities. In addition, GD is not consolidated to grasp important information in an organized manner, and efficient correspondence is not made.

ii) Necessity of Facility Deterioration

As described above in irrigation systems, the degradation of facility functions is remarkable. In Tunsa-Kella, appropriate water management is not implemented, because of the insufficient intake gates and regulators in the area that have holes or are unmovable. Additionally, the main part of the facility has gradually deteriorated.

The figure on the right is the arrangement data of the construction year of facilities based on this survey-collected data. In the case of the life of facilities being set for 40 years, half of the facilities have passed 40 years[25] and some of them have passed 100 years. A large number of irrigation facilities continue to be used exceeding their useful life, but O&M rehabilitation projects have not kept up.



Source: JICA Survey Team

Figure 4.54 Elapsed Years after Construction of Small-scale Structures

Degradation by deterioration of facilities is an urgent challenge, and it needs planned countermeasures for both the medium and long-term.

(2) Current Situation and Challenges Facing O&M by WUA

As mentioned in Chapter 2, WUAs were established with the assistance of MWRI in areas where meska improvement projects were conducted; however, the establishment rate nationwide is estimated at about 5%. Although the general activities of WUA are prescribed, the participation of WUA for maintenance work is not so low as the establishment rate, and, under the support of ID, various activities are implemented depending on the proficiency of WUA. For example, a WUA is convening general assembly meetings before the initial cropping season and collects 50 EGP/feddan of annual fees from

[24] Realizing the value of irrigation system maintenance, IPTRID Issues Paper, 1999
[25] Referred from "Total Lifetime of Economic Efficiency by Land Improvement District (Taisei Publishing)"

the members for employment of a pump operator and repair costs. In addition, this association holds a meeting to discuss the planting schedule among members at the same time. These members bring the necessary fuel for pump operation by themselves. Another WUA collects 300 EGP/feddan of annual fees from the members for a reserve fund such as repair costs and employment of a pump operator with a security guard. On the other hand, from the results of the model area survey, the rotation rule of “one hour per one feddan per one week” in a meska of Faiyum is not really respected and the maintenance work of the meska, traditionally supposed to be done by farmers, is not carried out enough. The Survey results also confirmed that there is an inflow of soil to meskas due to the erosion of embankments and not enough maintenance on water wheels to convey irrigation water is carried out.

As for BCWUAs as well as WUAs, participation in maintenance work is not high enough but it is also affected by an undeveloped legal system. Although the general activities of BCWUA are also prescribed, under the support of ID, various activities are implemented. Some BCWUAs that are given special assistance by MWRI and donors undertake petitions to MWRI, canal dredging by collecting money from members and trash pickup activities as O&M. Moreover, members of a BCWUA contribute funds, purchase cleaning vehicles, collect 2 EGPs per month from each family, and conduct garbage collection. Similar activities were also implemented and have continued at the target BCWUA of SWMT; however, this situation is very limited, and the foundation for conducting O&M activities by BCWUAs is still in the process of development.

4.3 Current Water Management Situation

Water management raises the challenge of a soft component such as water distribution in the operation of the facility in addition to the challenge of a hard component such as the physical deterioration of the irrigation facility function. This section describes the status and current challenges of a systematic regime and components of water management and operation of supply and distribution of irrigation water. Since water management requires the appropriate supply of irrigation water over every part of the irrigation scheme that is managed by different institutional organizations, it describes the current status and challenge facing each canal level, respectively, from the principal canal to meskas, which are the terminal irrigation canal level.

4.3.1 General Overview of Water Management[26]

MWRI manages the principal canals and another parts of canal systems from intakes on the Nile River until meska intakes at the terminal facility, while WUA mainly manages areas after the meska in the canal network that constitutes the irrigation system in Egypt. Furthermore, there is also a movement to promote WMT in line with the policies of the Egyptian government, where roles in water management of branch canals distributing water to meskas are planned to be transferred to BCWUA.

The irrigation system in Egypt has a long history of operation and it is operationally managed through controlling the downstream water level by regulators and water management based on operational experience. The water management, such as recording of water levels, is carried out at the major facilities of each canal under the responsibility of MWRI. The water management mainly comprises reporting the water-level information, as well as the operation of the facilities, and is mostly done with the information communicated by telephone.

Apart from the above, a telemetry system to conduct a wide range of water-level observations in main canal network systems has been installed at intakes along the Ibrahimia Principal Canal and the Bahr Yusef Principal Canal, and major main canals such as the Serry main canal.

In this context, the plan of the construction project of the new Dirout Group of Regulators implemented with Japanese cooperation, as described in Chapter 3 of this report, proposes the installation of water management facilities. In the plan, the central management office will accumulate and process the

[26] This part was prepared summarizing the information with reference to the Final Report, the Preparatory Survey for the Rehabilitation and Improvement of Dirout Group of Regulators, JICA, 2010, etc.

information on water levels and other information at weirs and intakes on the principal canals to improve water management in fair and reliable directions. According to this plan, it is expected to implement the countermeasures of the hard component of water management at the regional level through the project.

On the other hand, water management is supported in many of the cooperation projects mainly at a terminal level to establish and enhance the capacity of WUAs and BCWUAs. The majority of this cooperation type is formed in a set of hard and soft components, namely meska improvement and capacity development. In such situation, BCWUAs and WUAs still remain at low establishment rates, so that performance is less under the national target.

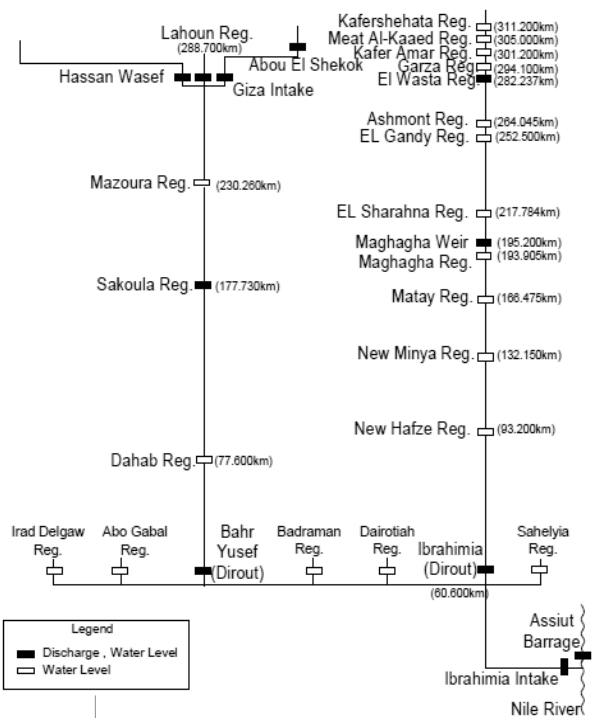
4.3.2 Systematic Regime of Water Management

(1) Water Management Regime in MWRI

MWRI conducts water management in the areas that respective offices divide into their responsible districts in the irrigation canal system composed of the principal canals to the branch canals and to meskas.

1) Water Management at Regional Level

CD of Water Distribution under IS in MWRI unequivocally manages water at intakes from the Nile River to major facilities of the principal canal level in the irrigation system, and supervises both the Upper and Lower Egypt divisions, which manage respective regions based on their territorial responsibilities. CD of Water Distribution directly implements water management of significant facilities like the Dirout Group of Regulators. GDs are responsible for water management of other major facilities along the principal canals and actually practice water management in their respective responsible areas, including arrangement on the Governorates border.



Source: JICA, 2010 Source: Final Report, the Preparatory Survey for the Rehabilitation and Improvement of Dirout Group of Regulators, JICA, 2010

Figure 4.55 Observation Points of Water Level etc.

Figure 4.55 shows about 30 sites treated in the construction project for the new Dirout Group of Regulators, in which the water levels and other information are observed in the Ibrahimia Principal Canal and Bahr Yusef Principal Canal. The regulators and intakes of the main canals along the principal canals manage water based on the water level downstream. Conversion tables from water levels to discharges are prepared for their management and are updated once a year.

The construction project for the new Dirout Group of Regulators is primarily going to construct a new Dirout Group of Regulators, and it also plans to install water management systems at eight regulators (all regulators of the Bahr Yusef principal canal and regulators for the functioning of the Ibrahimia canal upstream of the Wasta regulator) and at intakes of the major main canals. The project intends to improve the current practices in water management based on the existing facility operation on site. It will improve a method for monitoring and the transmission/processing of data and information and constructs a system where data and information are integrally treated. It mentions that the system may enable fair water management in distribution at restricted upper limits, and efficient response of water diversion in shortened water conveyance times, through simultaneous control and inspection of the water with the improved system in which several facilities can operate. In addition, it expects to reduce occurrences in communication failure and misconducted operations regarding information in current practices.

2) Water Management in Sub-region

GDs of MWRI are in charge of water management of the canal systems within the sub-regions where MWRI basically implements water management with an indicator of the water level according to experience-based interventions. IDs under the direction of the GDs actually implement daily work such as daily gate operation. Operators of gates and other work on site, called Bahari, are assigned to facility operations of their designated irrigation areas, and several laborers are mobilized in the case of large gates.

The information on water levels of major facilities is transferred to CD of Water Distribution through the Upper and Lower Egypt divisions, after passing GDs that receive the reports from the operators. The directions such as facility operations are transmitted in reverse order. The report and directions are done by phone. The operation to adjust water levels is ordinarily conducted at the facilities twice a day.

The sub-region is mostly an area composed of canal systems branched from the principal canals, and administered by several GDs and many of the IDs (25 IDs in the Bahr Yusef Principal Canal and 20 IDs in Ibrahimia Principal Canal as shown in Table 4.50).

Table 4.50 Jurisdiction Office of Bahr Yusef and Ibrahimia

Bahr Yusef Principal Canal

Governarate	GD	Regional Office	ID
Minya	East Minya	South	East Dirout
			Dermawas
			Mallawy
	West Minya	West Bahr Yusef	Monshat El Dahab
			East Kamadir
			East Terfa
			Edwa
		West Samalout	West Kamadir
			West Terfa
			Sakoula
Beni Suef	Beni Suef	South	Fashen
			Somsta
		North	West Beni Suef
			Ahnasia
			Nasr
			El Wasta
Faiyum	Faiyum	East Faiyum	Faiyum
			Silaa
			Tamaya
			Senoures
			Absh way
		West Faiyum	Esta
			El Gah
			Qota
			El Nazla

Ibrahimia Principal Canal

Governarate	GD	Regional Office	ID
Minya	East Minya	South	East Dirout
			Dermawas
			Mallawy
			East Abu kurras
		North	East Samalout
			Matay
			Beni Maza
			East Maghagha
	West Minya	East Bahr Yusef	West Abu Kurka
			West Minya
			West Samalout
			West Maghagha
Beni Suef	Beni Suef	South	Fashen
			Somsta
			Beba
			East Beni Suef
		North	West Beni Suef
			Ahnasia
			Nasr
			El Wasta

Source: JICA Survey Team

There are several main canals flowing through several IDs with large command areas, such as the Serry main canal and Tunsa main canal. In such case, they are managed based on water levels at the boundaries of IDs that are recognized between IDs in the same canal system of the sub-region.

While part of water management at the regional level covers the major intakes of the sub-regions, water management at the sub-region level targets other facilities for which the amounts and levels of water are dependent on the water from the intakes of the heads of canals.

The construction of water management systems at the regional level by the new Dirout Group of Regulators are for construction project plans to realize quantitative efficiency improvement in water management. However, the same practices are continuing in water management at the sub-regional level. This means no workable conditions have been realized in operations in the overall irrigation system. The water management at sub-regional level has not yet collaborated with the water management system constructed by the project.

Since the communication method at sub-region level is similar to that at the regional level, the same challenges appear with the water management at the sub-regional level. Risks, typically the failure of information transmission by telephone, are pointed out in reporting and directing the operations in water management at the sub-regional level. MWRI’s system has the same problem roots in water management at the sub-regional level as at the regional level.

Furthermore, it may be said that water level settings that repeatedly appear every year are managed in the same manner. In order to enhance flexible operations for increasing more water use efficiency, there will be an insufficient regime for distributing water throughout the sub-regions through management reflecting the status recognized in the irrigated areas.

(2) Water Management Regime of BCWUA/WUA

In water use in irrigation canal systems, cooperation and collaborative work among farmers are indispensable, as the farmers share canals to receive their water. In Egypt, there is a mechanism where farmers use irrigation water as group members from the same meskas while participating in facility maintenance. In line with such mechanism, a pump station was constructed with farmers’ funding to improve their meska; such was a case found in the model area of the Survey. Cooperation by foreign countries introduces the movement of strengthening water management at the meska level and promoting MIT for BCWUA chiefly in the Nile delta region. WUAs and BCWUAs are formed for different roles and features corresponding to the canal levels, respectively, at meskas and branch canals.

Past cooperation by foreign countries focuses on both establishment and strengthening of BCWUA/WUA and meska improvement. The cooperation is mostly that which relates to BCWUA establishment through capacity reinforcement of MWRI. As stated in Chapter 3, it is reported that most BCWUAs insufficiently perform after establishment. On the other side, the effectiveness of the cooperation is urged when the actual work of BCWUA and WUA are simultaneously activated together with meska improvement of the target areas.

Through these experiences, MWRI’s activities are strengthening BCWUA/WUA mobilization in their terminal water management. For example, in Faiyum governorate, meska improvement projects are implemented solely after the conditions of WUA establishment are satisfied. In another field survey of Beni Suef, arrangements regarding more efficient water use are exposed to changes of rules in water distribution after meska improvement.

1) WUA

WUA is a legislative body and is responsible for management of facilities and water at the meska level. Regarding water management, some donors’ evaluation reports mention successful cases in which the outcomes show that some WUAs have achieved a certain level of equitable water distribution through past supported projects. Although such cooperation has been carried out, the outcomes have not spread as expected in the projects. Further, the organized rate of WUA among water user groups in Egypt is estimated to be several percent of its target. From the facts above, the establishment of WUA stays at an unfavorable level.

WUA's expected roles are to coordinate water distribution among water users and to present in the planning, implementation and O&M for rotational scheduling in water use of meska areas through negotiations with water users before cropping starts. In particular, for water distribution among the water users, WUA's role also appears in intervening to solve problems about unequal water distribution and water conflict among water users.

2) BCWUA

BCWUA takes its position as the acceptor of WMT promoted in the government policy, and coordinates with MWRI to work in terminal areas after branch canals in the irrigation system. The BCWUA's activities relating to water management are mainly planning, implementation, and management, specifically monitoring, negotiations and hazard removal, and as a mediator of conflicts on water issues under branch canals where rotational scheduling is practiced in water use among meskas groups.

The cooperation by foreign countries' supporting BCWUA is mainly concerned with the prevalence and establishment of organizations as mentioned in the previous chapter. After the establishment of BCWUA, capacity and transfer water management have gradually enhanced. According to the roadmap created by SWMT, BCWUAs have roughly divided into the stage before establishment and the stage after establishment. SWMT plans to improve the establishment rate, which was about 40% in 2015, to 69% in 2025. However, it aims to make a functioning organization, and apart from the formation, it is necessary to promote the participation of members and capacity building in the future.

Under such circumstances, MWRI also has a movement to restructure BCWUA. However, the arrangements (mainly by CDIAS and GDIAS) are not in progress as proposed by SWMT, which sets conditions for activity development for strengthening functions through an increase in training staff.

4.3.3 Operation of Water Management

(1) Implementation of Water Distribution

Cooperation between water delivery (supply side) and water distribution (user side) is the basis of water management. MWRI and farmers' groups (users) are respectively in charge of the supply and usage of irrigation water. Description of the supply and usage (demand) sides of irrigation water will appear as below:

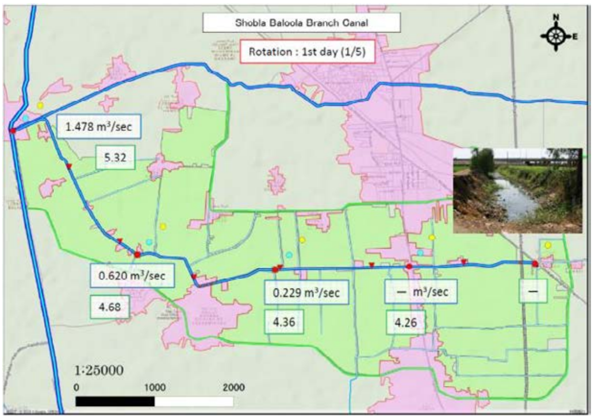
Based on the sizes of crop planning areas of governorates indicated by MALR, MWRI decides a water distribution plan based on standardized unit-water-use patterns (3 categories) with crop water requirements across the country and the areas proportional to sizes of the governorates. MWRI has traditionally provided irrigation water according to the amount in distribution planned in a rotational manner in most areas because of the restricted amount of water resources in the country. Water is commonly supplied 5 days on and 10 days off in the Upper Egypt area, and 5 days on and 5 days off in the delta area. In Faiyum, where irrigation water in a gravity system can flow naturally into Lake Qarun 45 m below sea level, continuous irrigation appears up to the meska level. For this reason, the water becomes unused after entering Lake Qarun in the water management of this Survey.

Under such situations, there will be cases where water users make requests regarding water distribution on a temporary basis. If both sides verify the requests, MWRI will change the irrigation schedules to supply irrigation areas. In most areas, these actions effect water distribution in other areas. They may doubt some transparent and impartial rules that decide the water distribution schedule. Such behavior may lead MWRI and representatives of water-users groups to believe that they can develop less cooperation at the sub-regional level. In addition, functional deterioration of irrigation facilities causes an unstable in water level and unreliable performance of water supply/distribution creates obstacles to implement planned water distribution.

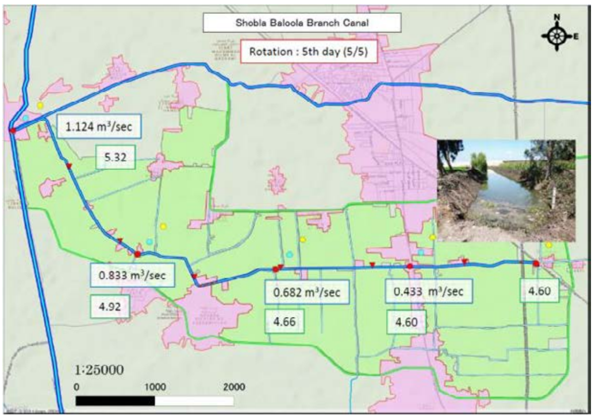
MWRI restricts cultivated areas of rice and sugar cane that are high water-consumption crops since the 1980s after cropping was liberalized. However, farmers who are willing to turn to profitable crops do not comply with this in many cases. This becomes a disturbance factor in the planned water supply. Information from the ID reports control difficulty in rice cultivation outside the restricted area of the Kased canal system.

Meanwhile, water users implement water management of terminal facilities of and after meska and practice irrigation according to their demands within the amount of supplied water. On the demand side, it is common among meskas in rotational water uses that water taking starts at the same time when water arrives in the areas of their branch canals. During the term that many pumps are working, the water level of a branch canal is lowered, but it rises at night when smaller numbers of pumps take water. This means that delays are common at the meskas located in the downstream part of branch canals in taking water during the scheduled time. Therefore, the number of days that water can be taken becomes smaller for the downstream area than the upstream area. Regarding taking water, the upstream area has an advantage, and the downstream area suffers from various issues that usually appear as water shortages.

Figure 4.56 presents the situation that shows water use in the Shobla Baloola branch canal before implementing distribution of water management by SWMT. After water does not flow downstream due to the water being excessively taken in upstream areas in the first day of irrigation implementation (left figure), all the areas distribute water on the last day where scheduled water is permitted (fifth day, right figure).



The first day



The last day

Source: JICA Technical Cooperation Project; SWMT Presentation of Project Report, 2015.3

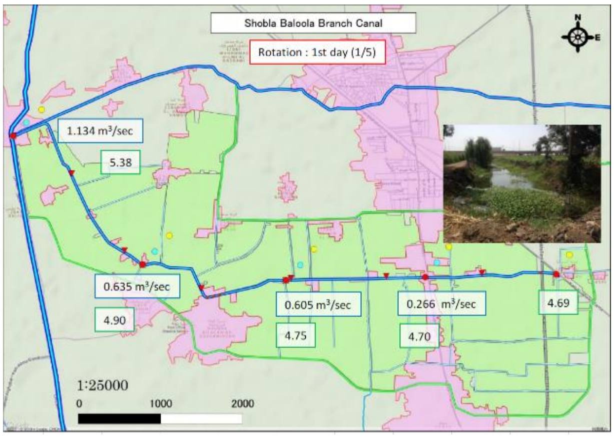
Figure 4.56 Situation of Water Distribution in Shobla Baloola Branch Canals (before Improvement)

It is also reported that the direct water intake from the branch canals by engine pumps are observed in an upstream portion of branch canals. Finally, SWMT creates an understanding of the amount of water supply and the water requirements in possible cropping where these situations have improved, and the water use in up and downstream in this area is presently equalized as shown in the figure in the left.

Basically, irrigation water should be channeled from branch canals to marwas and fileds through meskas. On the contrary, taking water from the upper levels of canals by pumping is prohibited. However, such activities are also observed in the Upper Egypt region.

Moreover, in Faiyum where continuous irrigation is going on, irrigation water is taken from the existing irrigation system without permission. The water is used on the land developed in the desert area around the existing arable land. Faiyum GD estimates that 50 thousand feddan (21 thousand ha) in East

Faiyum and 40 thousand feddan (17 thousand ha) in West Faiyum are irrigated without permission. In spite of the fact that paddy cultivation is completely prohibited in Faiyum, MWRI also says that there are actually some paddy fields that account for about 10% of the cultivated area.



Source: JICA Technical Cooperation Project; SWMT Water Management Manual

Figure 4.57 Situation of Water Distribution in Shobla Baloola Branch Canals (after Improvement)

(2) Operation of Water Management by Supply Side

MWRI, which manages water on the supply side of irrigation water, is expected to improve the water-use efficiency under the restrictions on the water supply volume.

In order to cope with this, a certain limitation is considered to apply to a simple plan of taking an ordinary approach based on the accumulation of the irrigation requirements of crops. A practical operation will make it possible to work to ease the conditions of gaps between supply and demand, with a plan taking water uses and distribution into consideration under the understanding of the existing irrigation systems. Currently, the plan has established water distribution under certain rules, but it is insufficiently functioning in water management, where changes are inserted in the planned schedules based on respective requests individually made by some water users.

MWRI has insufficiently enhanced utilization of the information accumulated to lead to improved operations that realize water use efficiency. Monitoring does not contribute to the process of forming supply plans that need inputs of the accumulated data and information. A mechanism has not yet been structured to have functional water-supply plans that enhance water use efficiency under flexible water management.

Especially at the sub-regional level, there are no plans to control water distribution in each area commanded by the respective canals in the irrigation system through grasping the water distribution for all the areas. In this situation, it is said that water-level management is conducted based on the previous experiences that repeatedly appear in a yearly cycle. It is pointed out in inflexible water management where an insufficient response to water demand easily becomes one of the factors that causes a water shortage in the terminal area of the irrigation system. In the sub-region of the Tunsa area, one of the sample survey areas, a plan stipulates that water be distributed in rotational scheduling in canals branching from the Tunsa-Kella main canal. However, the practice does not correspond to the plan, and there have been serious water shortages in the area (especially at the end portion of the canal). A reason for breaching rotational water use is combined with the hard component factor, such as impossible water diversion at the intake points caused by functional incompetence in the facilities. In spite of possible water shortages in the overall system, water is distributed more in the upstream areas, but less in the downstream area, thus enhancing unequal allocation within the system. (Details are described in 4.2.2(2)3)) Such a situation forms a vicious cycle preventing adequate water management and normally functioning irrigation, and reveals an unfair water distribution system.

In situations where the water distribution on the supply side is practiced under less flexible operations, water management has room for improvement in the water supply through water use reflecting the demands as much as possible in the plans. In the area of the Tunsa-Kella irrigation system, the situation is continuing where no water reaches the terminal portion of the system for scheduled irrigation. As no measures seem to have been taken during the Survey, the situation continues in the area.

(3) Operation of Water Management by Demand Side

WUA is expected to take responsibility to provide and practice the rules for equitable water utilization among the group users who receive water from the same meskas. However, WUA has not sufficiently taken up this role.

Most of WUAs are weak in achieving equitable water distribution among water users of the meskas where insufficient functionality derives from issues with the hard component. The sample survey has a report stating that for 20 days water does not reach the end portion of the meska of the Tunsa area in the Tunsa - Kella irrigation system. In addition, in the Aros Abo Seer canal located in the sub-region of Faiyum, there is a case where a pump station has been constructed and operated with WUA members' own funds in order to secure a water supply.

It is reported that many BCWUAs have not yet initiated the associations' activities. Accordingly, BCWUAs' participation remains in stagnant, which is against expectations. Except for a few cases where BCWUAs lead in the distribution of their water management policies after the cooperation projects, BCWUAs are not generally acting as leaders in water management at the terminal level.

The Terfa area, where water is pumped on a newly developed site in the western part of the system, suffers severely from water shortages at the terminal portions of the branch canals. Further, farmers destroy the concrete lining of the canal bottom and make pools to enable suction by water lifting devices in order to secure the water (as in Figure 4.58). To take water directly from the main or branch canals is illegal. Such acts were observed everywhere by the Survey team within the Survey area. Such occurrences can be said to be cases where the BCWUA/WUA functions insufficiently regarding water management.

Source: JICA Survey Team

Figure 4.58 Destroyed Concrete Lining Bottom Plate of Canal

MWRI has a mechanism to establish WUAs with supporting organizational activities when introducing meska improvement projects. MWRI set another mechanism to arrange recovery of the construction project costs in order to ease the budgetary burden on the government. Meanwhile, as stated in the status of the MWRI organizational structure, collaboration has not yet been enhanced in role-sharing between MWRI and BCWUA. MWRI's support of BUWUA is not in progress, as stated in the SWMT guide.

4.4 Summary of Challenges in Target Area

The status and challenges facing irrigation facilities and water management at the principal canal or regional level and at the sub-regional level are summarized below.

Table 4.51 Challenges of Facilities (Challenges of Hard Components)

Contents	Situation	Challenge
Bahr Yusef Principal Canal	◆ In the Bahr Yusef principal canal, the cross-section has become irregular, and concerns of overflow are reported due to the insufficient height of banks at the time when large flows especially peak irrigation periods occur.	Insufficient cross-section for conveyance
	◆ In the critical curve part of the Bahr Yusef principal canal, the scouring of the side bank occurs and it influences the stability of the bank, which is a concern.	Insufficient protection of canal bank
	◆ The existence of the meandering area affects the water level or the water surface to deteriorate the water supply function	Deterioration of conveyance function at critical curve

Contents	Situation	Challenge
Ibrahimia Principal Canal	◆ In a part of the Ibrahimia Principal Canal (crossing Minya City), the existing structures hinder dredging of the canal because of the existence of too many pillars. This situation increases sedimentation and surface erosion.	Insufficient protection of canal bank
	◆ The existence of the old Hafez regulator in the Ibrahimia Principal Canal is causing a large loss in water flow.	Disturbing point of water flow
Below main canal and branch canal (sub-region)	◆ Breakdown of intake facilities and regulators mainly due to long-term service and operational insufficiency interferes with the implementation of rotation plans and reduces water use efficiency. ◆ In the wastewater recycling plant, insufficient planning and functional deterioration become direct factors that cannot solve the water shortage. The lack of suction pool during operation is also a major factor of the breakdown of the pump unit. ◆ Canals become shallow and side surfaces are in a widened state due to scouring and sedimentation by water flow and over-excavation during maintenance and management work. It hinders the design flow of water in the canal. Besides, coupled with an inefficient water supply, it is an obstacle to ensuring proper water division among the branch canals. ◆ Meska has the remarkable challenge of canal deformation and it becomes a factor that increases canal loss and inconvenience of water use at the end of the canal (requiring time to raise the water level, etc.). ◆ Water flow inhibited due to illegal buildings. ◆ Illegally dumped garbage by residents has caused water flow inhibition and deterioration of facility functions.	Insufficient function of main and branch canal Insufficient function of meska
Facility Maintenance	◆ The deterioration of facility function and safety of facility structures has appeared as challenges in most parts of canal systems due to deterioration caused by long-term service. In addition, the system for appropriate maintenance and management is not sufficient. ◆ Planned maintenance and management has not been undertaken to minimize the impact of degradation of facility functions and conditions such as deterioration of facilities and difficulty in operation are getting worse (specifically, the absence of a facility management plan).	Insufficient system for sustainable maintenance Insufficient plan for sustainable maintenance

Table 4.52 Challenges of Water Management (Challenges of Soft Components)

Content	Current status	Challenge
◆ Water management	◆ Fair water distribution is not always enhanced by the demand side below meska. ◆ Activities are vulnerable to fair water distribution among users. ◆ The operation is inflexible in water distribution, as management of water levels is mostly based on practices based on previous experiences. ◆ Risks appear in the current method of telephone communication in the failure of data and information transmission (such as water level, flow rate). ◆ Institutional regime works insufficiently to improve water management towards more efficient use corresponding to the situations. ◆ There are frequent cases that BCWUA and WUA established through MWRI capacity created in the projects stay inactive.	Water conveyance and delivery are insufficiently practiced to improve water use efficiency.

	◆ Hazards appear in planned water distributions in farmers' attitudes where they do not comply with restriction of planting areas after liberalization in cropping. ◆ The weak process to reflect monitoring information (measured at certain facilities) in operation and planning to decide water distribution.	
	◆ Transparency and equity are not clearly incorporated in scheduling of water distribution. ◆ Due to the locational advantage of upstream priority in water taking, downstream has less access to the water during irrigation. ◆ In areas where water hardly reaches, water is taken at the upper level of canals by engine pumps that are legislatively prohibited.	

As summarized in the table above, the functions have not been fully realized due to the insufficient cross-sections and protection of canal surfaces at the level of the principal canal responsible for water supply to all the districts. At the level of main, branch and terminal canals responsible for water distribution to beneficiary districts as well, the functions of facilities are hindered due to the degradation of water control, the functional deterioration of cross-sections, deterioration of the water supply function due to garbage accumulation and illegal structures. Insufficient maintenance and management of irrigation facilities, due to insufficient systems and plans, are also one of the factors that can increase the deterioration of a facility's functions.

On the other hand, operation and management of water causes water shortages due to failure to follow rotational use of irrigation water, illegal water extraction and increased water extraction upstream that has an advantageous position, and other acts causing water shortages at the terminal areas of the irrigation system. Under the limitations in the supply water volume, unfair water distribution creates water shortages especially in the terminal areas in the irrigated regions.

Chapter 5 Challenges and Countermeasures and Roadmap for Comprehensive Irrigation Water Management

In the following chapters, i.e., Chapter 5 and onwards, countermeasures are considered based on the results of Chapter 4 and consequently, the midterm program and short-term measures are proposed. In Chapter 5, the concept of Comprehensive Irrigation Water Management (CIWM) is derived from challenges and the Roadmap for CIWM, a midterm program, is proposed based on the concept. In Chapter 6, the Improvement Program is elaborated upon as a short-term measure in the Roadmap and consequently, concrete measures are examined. In Chapter 7, all such measures are established in the Japanese cooperation schemes and a loan project and technical cooperation are proposed.

In the present chapter, causes of the challenges highlighted in the previous chapter are analyzed. The previous chapter summarized the outcomes of the field survey of the Survey Areas. Based on such analysis, the concept of CIWM is introduced as a concept of achieving function recovery of the whole irrigation system at all canal levels from the principal to the terminal, considering both hard and soft components. Afterward, countermeasures to address the causes of each challenge and their expansion are studied and organized. Finally, a roadmap for CIWM realization in the survey areas is formulated and the effect of the roadmap is examined.

5.1 Analysis of Causes of Challenges

As mentioned in Chapter 4, challenges with the irrigation system facilities related to hard components were identified as insufficient functioning of the principal canal, which plays the role of the aorta for the water supply system in the whole area. This includes insufficient functioning of the main, branch and terminal canals in the sub-regions where the water is distributed to the command area. Related to the soft component, it became evident that compared to the size of the irrigation system, maintenance for sustainable functioning of the irrigation facilities was not enough. On the other hand, regarding the water management of the soft components, the operation of water management is insufficient since the system for operation of water distribution is vulnerable and rules for water distribution are not always respected. The causes of these challenges found in the field survey have complex relationships and it is necessary to understand them in order to implement appropriate countermeasures to deal with the challenges. Therefore, the analysis of challenges will be discussed in this section.

In terms of irrigation facilities, cause analysis is conducted at each canal level that has different characteristics within the irrigation system. However, maintenance of facilities affects the entire irrigation system, and therefore the causes will be analyzed together. Likewise, cause analysis on operation of water management will be analyzed at an integrated level since it also affects the whole irrigation system.

5.1.1 Causes of Insufficient Functioning of Irrigation Facility

(1) Insufficient Conveyance Functioning of Principal Canals

Challenges arising in the water conveyance function of the principal canals occur due to the existence of bottlenecks. The causes that interfere with the functions of the principal canals are as follows:

Table 5.1 Causes in Decreased Water Conveyance Function of Principal Canals

Challenge	Cause
◆ Insufficient cross-section for conveyance	1. Insufficient height of canal bank 2. Higher canal bed than the plan 3. Accumulation of sediment
◆ Insufficient protection of canal bank	1. Erosion at outer side of canal curve 2. Deformation of canal's cross-section
◆ Insufficient hydraulic performance	1. Existence of flow obstacles
◆ Deterioration of conveyance function at critical curve	1. Unstable flow at critical curve

(2) Insufficient Conveyance Function at Sub-Region Level

The causes and challenges in the sub-region canal systems, which are composed of main and branch canals, and meska as terminal facilities, are shown in the table below.

Table 5.2 Causes of Insufficient Water Delivery and Conveyance Functions at Canal Systems in Sub-Regions

Challenge	Cause
◆ Insufficient function of main and branch canals	1. Deterioration of facility function 2. Deterioration of conveyance function due to deterioration of canal's cross-section 3. Insufficient cross-section for conveyance 4. Illegal dumping of garbage
◆ Insufficient function of terminal level	1. Deterioration of conveyance function due to deterioration of canal's cross-section 2. Illegal dumping of garbage

(3) Insufficient Maintenance of Irrigation Facilities

The system for maintenance of facilities that help minimize the influence on deterioration of its functioning is not enough. Factors that cause them are as follows:

Table 5.3 Causes of Insufficient Maintenance

Challenge	Cause
◆ Insufficient facility maintenance	1. Insufficient maintenance system of MWRI 2. Sustainable maintenance plan is not working efficiently enough. 3. Insufficient maintenance system of BCWUA/WUA 4. Insufficient collaboration between MWRI and BCWUA/WUA concerning maintenance

5.1.2 Factors of Insufficient Water Management

For enhancing rotational schedules planned for appropriate water distribution, both adequate water management and properly functioning facilities are required. Water management operations can achieve, desirably and adequately, water distribution with normally functioning facilities. Insufficient water distribution and failure to follow planned schedules in rotational water use noticeably results in water shortages in the terminal areas of irrigation canal systems. Therefore, a water shortage depends on both factors, namely an insufficient systematic regime in operation for water management, and insufficient rules for the operations. The challenges summarized from the viewpoints of both factors are as follows:

Table 5.4 Factors of Insufficient Water Management

Challenge	Cause
Insufficient water distribution	Mainly insufficient systematic regime
	1. MWRI system in operation to respond to information is not working rapidly enough 2. Insufficient supporting regime by MWRI on enhancing cooperation with water users 3. Weak performance of BCWUA/WUA
	Mainly weak respect of rules in facility operation
	1. Insufficient mechanism in water distribution considering possible flexibility to respond to water demands 2. Insufficient planning capacity of MWRI for elastic water management 3. Low performance of BCWUA/WUA in water distribution 4. Insufficient activities support for BCWUA/WUA by MWRI 5. Insufficient collaboration between MWRI and BCWUA/WUA

5.1.3 Summary of Cause Analysis

For the challenges identified in the field survey, a cause analysis has been done from the aspect of the functionality of facilities and operation. In terms of facilities, it was clarified that the functions of facilities were inadequate in the entire irrigation system and appropriate operations for water distribution were not consistently done. The goal of efficient use and delivery of irrigation water to the command area of the irrigation system is achieved only by addressing both issues. Although the terminal level has more challenges due to the influence and confluence of various challenges, the application of proper facility functions and system operation leads to sufficient water delivery at the terminal level. The challenges and causes discussed were organized in the diagram below, focusing on the central challenge, i.e.: “adequate amount of water is not distributed to the terminal level”. Each challenge is classified in terms of hard and soft components. Although the challenge of facility maintenance is considered as the hard component, the diagram shows that to succeed it needs to be addressed from the soft component’s viewpoint to improve an insufficient system and planning. Moreover, the challenges of facilities appear at the canal level, so comprehensive countermeasures throughout the entire system would enable the improvement of existing challenges throughout the whole irrigation system from upstream to the terminal.

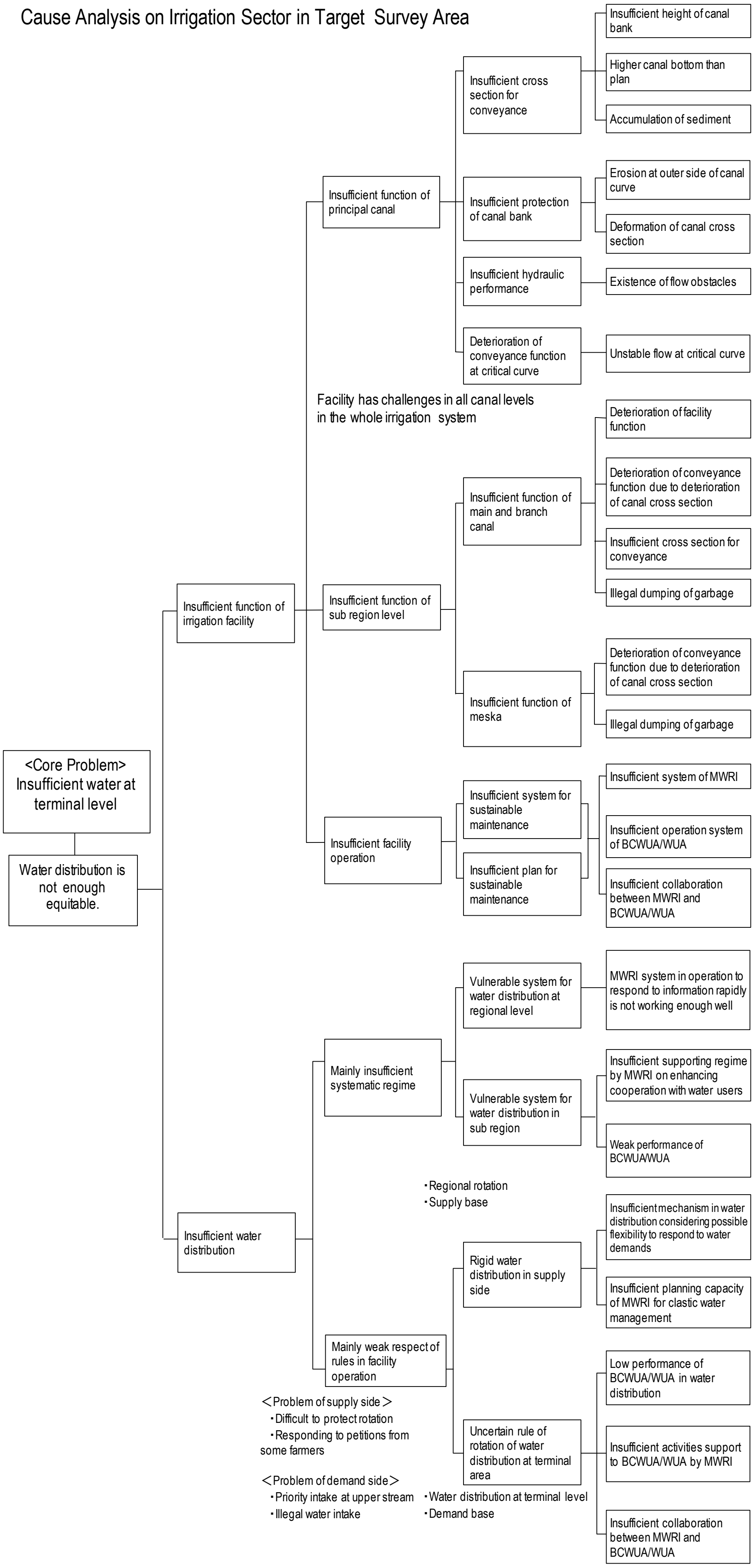


Figure 5.1 Diagram of Cause Analysis on Irrigation Sector in Target Area

5.2 Proposal for Comprehensive Irrigation Water Management

As described above, the irrigation system in the survey target area has various challenges, and as a result, it creates a situation where there is "Insufficient water at terminal level", which is considered as the central challenge. This is derived from "insufficient water distribution", which is caused by the fact that malfunctioning of irrigation facilities exists as the hard component, and insufficient management of water distribution is categorized as the soft component. By solving both issues, equitable water distribution can contribute, and a water supply delivering the required amount of water to the terminal can be realized. On the hard component, solving the challenges at each level from the principal canal to the terminal level can realize a sufficient water supply delivered to the terminal, and the maintenance and management to ensure the sustainability of the facility should be ensured. In addition, on the soft component, by improving rules and systems for realizing equitable water distribution, water distribution becomes equitable due to controlled water flow upstream and in respect of planned rotation. Also, on the soft component, it is confirmed that water distribution becomes inequitable due to uncontrolled water flow upstream and disturbance of planned rotations.

In other words, in order to improve water shortages at the terminal, which is the central challenge, it is necessary to solve the challenges of both hard and soft components, and realize equitable water distribution. The approach to cope with them will be referred to as CIWM and will be introduced as Japan's cooperation concept (Figure 5.2).

In CIWM, the hard component of the irrigation system from the principal canal to the terminal canal is regarded as a series of delivery/distribution water systems, and the countermeasures related to the tasks in this system are implemented in a complex manner. In addition, in terms of soft components, countermeasures are implemented along the hard components in order to improve challenges related to irrigation water management and facility maintenance, and to efficiently distribute water throughout the whole irrigation system.

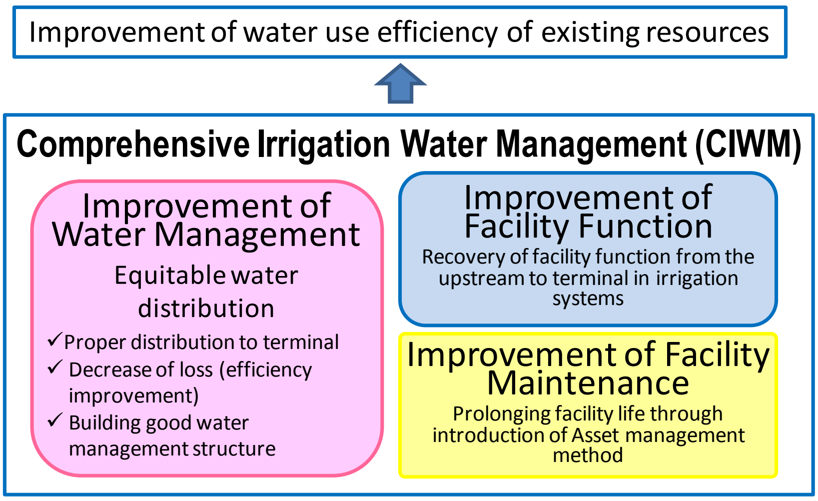


Figure 5.2 Image of CIWM

As countermeasures of the hard components for irrigation systems in the target areas, it is necessary to activate the functions of a series of irrigation facilities from the principal to the terminal level like meska, in order to facilitate planned water distribution under limited water resources conditions. The soft components are also required in water management and facility maintenance aspects, as well as facility improvement. Under these circumstances, countermeasures from the hard and soft aspects should be implemented at various canal levels, so that the final outcomes of projects will be enforced and conditions of the benefitting areas will be improved. Therefore, measures according to the canal levels and functions should be taken in the hard components and the water management related to the water distribution and facility O&M should be taken in the soft components in order to enforce the effects of the hard components, so the effects of improvement will be extended throughout the whole sub-regions. While countermeasures for the challenges are studied in the following parts, the concept of CIWM should be considered.

This concept has become a means of realizing the "efficient use of water resources" in the irrigation sector in integrated water management, which is the main pillar of secondary and tertiary NWRP. It also accords to Japan's support for the irrigation sector and it coincides with the water resource policy of Egypt.

5.3 Countermeasures against Challenges

In this section, based on the concept of the CIWM mentioned above, countermeasures for the challenges mentioned in the previous section are explained. Countermeasures for the hard components are considered at each canal level and given for each challenge. While the cause analysis for meska (the terminal level) and the primary/main canal were explained together considering their common challenges, each level of the canal should be addressed with different countermeasures and therefore proposed separately. Regarding facility maintenance, the challenges are evident in the hard component, but categorized as a soft component because its countermeasure belongs to the soft component. Since water management and maintenance affects the entire irrigation system, the countermeasures for the soft components are presented for all levels of the canals.

5.3.1 Countermeasures of Hard Components

(1) Countermeasures for Principal Canal

A summary of countermeasures against each challenge is given in Table 5.5.

Table 5.5 Summary of Countermeasures against Causes Affecting Principal Canal

Challenge	Cause	Countermeasure
◆ Insufficient cross-section for conveyance	◆ Insufficient height of canal bank ◆ Higher canal bed than the planned one ◆ Accumulation of sediment	◆ The embankments will be raised to secure cross-section of Bahr Yusef Canal. ◆ The higher parts of the canal bottom than the plan will be excavated and lowered to the planned level in Bahr Yusef Canal. ◆ Siltation will be removed by periodical dredging in Bahr Yusef and Ibrahimia Canal.
◆ Insufficient protection of canal bank	◆ Erosion at outer side of canal curve ◆ Deformation of canal's cross-section	◆ Canal banks of the outer side of curves of Bahr Yusef Canal will be protected. ◆ Canal banks of the collapsed stretch of Ibrahimia Canal will be reshaped and dredged.
◆ Insufficient hydraulic performance	◆ Existence of obstacles	◆ Obstacles for water flow will be removed in Ibrahimia Canal.
◆ Deterioration of conveyance function at critical curves	◆ Unstable flow at critical curve	◆ The shortcut will be made for curves causing turbulent flow. (However, the feasibility is considered in Chapter 6)

(2) Countermeasures for Main and Branch Canal

A summary of countermeasures against each challenge of main and branch canals at the sub-region level is given in Table 5.6.

Table 5.6 Summary of Countermeasures against Causes Affecting Main and Branch Canal

Challenge	Cause	Countermeasure
◆ Insufficient function of main and branch canal	◆ Deterioration of facility-function	◆ Small irrigation facilities will be rehabilitated/replaced to secure their functions for water distribution. ◆ The mixing pump stations are included in the small facilities. Since the installation of the stations will contribute to the improvement of water use, appropriate plans should be made in the improvement plans of sub-regions. The improvement plan should include new stations and rehabilitation of existing stations.
	◆ Deterioration of conveyance function due to deterioration of canal	◆ Canal improvement like canal lining will be made to decrease loss during the water use and to prevent deterioration of the earth canal's cross-section.

Challenge	Cause	Countermeasure
	cross-section	◆ The cross-section of canals will be recovered to secure the distribution level of water for appropriate water delivery.
	◆ Insufficient cross-section for conveyance	◆ Enough cross-section will be secured by removing illegal structures and earth fill.
	◆ Illegal dumping of garbage	◆ Garbage will be trapped and collected by nets, which will be removed during the maintenance work. ◆ Water users will remove garbage by the equipment granted by MWRI. ◆ Awareness campaigns not to throw garbage will be conducted. ◆ Box culverts or canal coverage effective for garbage prevention will be applied in the populated areas as a necessary countermeasure for the deterioration of facility functions.

(3) Countermeasures for Terminal Facility

A summary of countermeasures against each challenge of the terminal facility is shown in Table 5.7.

Table 5.7 Summary of Countermeasures against each Cause Affecting Terminal Facility

Challenge	Cause	Countermeasure
◆ Insufficient function of terminal canal	◆ Deterioration of conveyance function due to deterioration of canal's cross-section	◆ In order to prevent deterioration of meskas' cross-section and to keep water-conveyance function in order, widened cross-sections will be reshaped and concrete or pipe lining provided, which will help reduce delivery-time to each field (saving irrigation time).
	◆ Illegal dumping of garbage	◆ Garbage will be trapped and collected by nets, which will be removed during the maintenance work. ◆ Water users will remove garbage by the equipment granted by MWRI. ◆ Awareness campaigns not to throw garbage will be conducted.
	◆ Low irrigation efficiency at farm levels	◆ MWRI is concerned with irrigation efficiency at the field level, and thus requests for the introduction of modern irrigation. Countermeasures are the introduction of modern irrigation techniques like sprinkler, drip, and center pivot, etc., so that the irrigation efficiency at the field level will be improved. (However, the feasibility is considered in Chapter 6)

5.3.2 Countermeasures of Soft Components

Countermeasures of soft components shall be implemented in collaboration with that of the hard components. To ensure outcomes of functional recovery and rehabilitation of facilities of the irrigation system, the two countermeasures are considered in the soft components: namely the facility management to ensure the sustainable facility functions, and the water management to secure efficient water conveyance and delivery.

(1) Water Management

The factors behind insufficient water management are derived from the insufficient systematic regime in water management operation, and the insufficient rules of the operations. The following table (Table 5.8) summarizes the countermeasures for the challenges.

Table 5.8 Summary of Countermeasures against Water Management Challenges

Challenge	Factor	Countermeasure
Water distribution management is not equitable enough.	Insufficient systematic regime	
	◆ MWRI system in operation to respond to information rapidly is not working efficiently enough	◆ The integrated water management system introduced by the Project for Construction of the New Dirout Group of Regulators will improve the regional water management in the area commanded by the Dirout group of regulators. The water management facilities will be also installed at major

Challenge	Factor	Countermeasure
		points of main canals in the sub-regions. Through the constructed system (hard component), water management (soft component) including the methodology of their use will be established. ◆ Water distribution condition will be monitored and will be responded to in facility operation to distribute water. In addition, planning and implementation will be improved in water management practices. For these, regimes will be constructed.
	◆ Insufficient support regime by MWRI on enhancing cooperation with water users ◆ Weak performance of BCWUA/WUA	◆ Capacity building of MWRI and Water Users Organizations (WUOs) will be carried out for rational water management. MWRI should implement the equitable water supply plan considering water demand in a sub-region and WUOs should implement the rotation plan in water use. A system to realize those issues will be established. ◆ A framework where MWRI and WUOs play each role in a collaborative manner in a sub-region is formed.
	Mainly weak respect of rules in facility operation	
	◆ Insufficient mechanism in water distribution considering flexibility to respond to water demands ◆ Insufficient planning capacity of MWRI for elastic water management	◆ It is not possible to supply water fulfilling the demand due to the huge scale of irrigation systems and limitation of water resources. However, water distribution considering water users' preference of cropping should be practiced. Accordingly, the planning system considering water demand at the sub-region level will be established in MWRI.
	◆ Low performance of BCWUA/WUA in water distribution ◆ Insufficient support to BCWUA/WUA by MWRI ◆ Insufficient collaboration between MWRI and BCWUA/WUA	◆ Training for BCWUA/WUA such as water management of branch canals will be undertaken. ◆ MWRI's capacity to support BCWUA/WUA will be strengthened through training. ◆ Shared roles and collaboration to make sure the responsibility between MWRI and WUOs will be confirmed and strengthened through activities.

(2) Facility Maintenance

It was seen that insufficient facility maintenance is caused by lack of a proper functioning system and planning for sustainable maintenance. The two challenges have common causes: insufficient maintenance system in MWRI and BCWUA/WUA and weak collaboration between the two actors. The following table summarizes the countermeasures for those causes.

Table 5.9 Summary of Countermeasures against Causes Affecting Facility Maintenance

Challenge	Cause	Countermeasure
◆ Insufficient facility maintenance	◆ Insufficient maintenance system of MWRI ◆ Sustainable maintenance and operation plan is not working efficiently enough ◆ Insufficient maintenance system of BCWUA/WUA ◆ Lack of effective collaboration in maintenance between MWRI and BCWUA/ WUA	◆ The asset-management approach will be introduced for the facility survey, diagnosis and database setup to decrease the influence of the facility's deterioration and lowered safety. ◆ The technical capacity to practice the planned facility maintenance will be obtained through application of the asset-management approach. ◆ MWRI's capacity building as well as facilitation of WUOs participation in the terminal water management will be enhanced.

5.3.3 Summary of Countermeasures

Countermeasures are considered to alleviate or resolve the causes of the challenges. Where the challenges have several causes, it may be effective to address them with multiple countermeasures.

On the other hand, countermeasures for causes are better be established on a one-to-one basis whenever possible to ease the selection of an effective solution.

From this perspective, countermeasures for each cause are organized in the following diagram. As mentioned above in the section of cause analysis, these countermeasures may be necessary to be combined or carried out in conjunction with others measures, to bring synergistic effects.

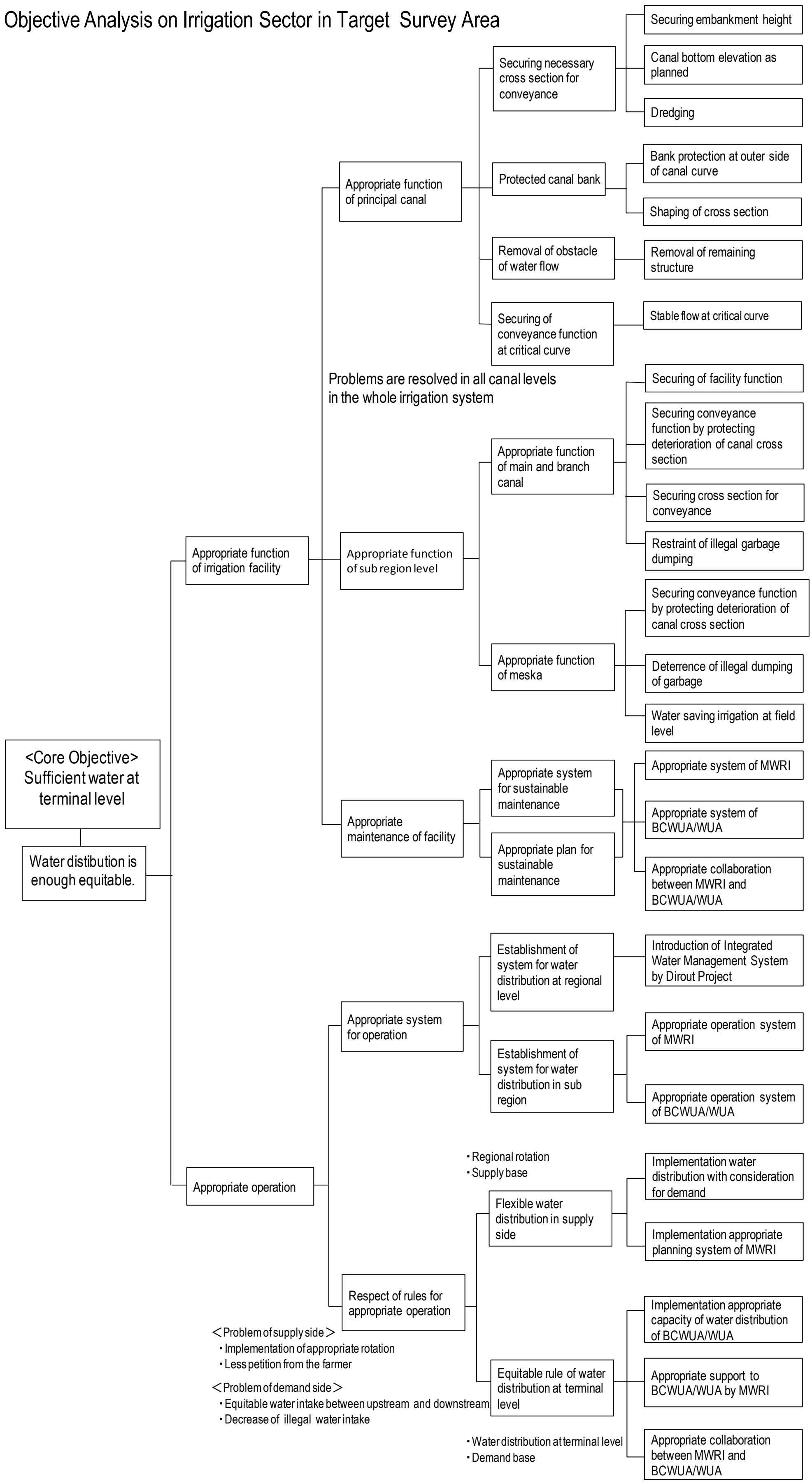


Figure 5.3 Countermeasures for Challenge

5.4 Development of Countermeasures

5.4.1 Countermeasures for Hard Components

(1) Basic Concept

Primarily, since principal canals are upstream facilities that play the role of the main source to supply irrigation water to sub-regions, it is very important to maintain the canal function to ensure the smooth flow of water. Therefore, it is necessary to place priority on eliminating bottlenecked sections that retard water flow and to clear any obstacles that hinder the supply of enough irrigation water to each sub-region.

Secondly, countermeasures shall be implemented in sub-regions, where irrigation waters are taken directly from the principal canal. This shall solve the challenges on each structure such as intakes, regulators, pumping facilities and water-reuse facilities, together with the main canals, branch canals, and meskas. As a result of this multiple intervention, it becomes possible to realize the situation in which irrigation water is conveyed and distributed up to the end of the sub-region.

(2) Framework of Countermeasures

Based on these considerations, countermeasures for the hard components shall be implemented through the following frameworks. However, based on budgetary limitations and other factors, implementation work as countermeasures at target points is selected with consideration such as urgency, impact and so on.

(a) The conveyance function of principal canals on Ibrahimia and Bahr Yusef should be secured for supplying water to sub-regions through the implementation of remedial work as a countermeasure to solve a bottlenecked section affecting the hydraulic performance of the canal. In this case, the remedial work will be selected considering budget limitations and urgency. The countermeasures corresponding to this framework are securing canal embankments, setting the designed canal bed evaluation, dredging of sediment, bank protection at canal curves, removal of old structures and stable flow at critical curves.

(b) Countermeasures for main/branch canals and meska will be implemented as a unit of sub-regions including small-scale structures related to these canals. All sub-regions are divided into 3 groups and all of the countermeasures for canals and related small structures are assumed to be completed within about 20 years (from 6 to 8 years of project duration for each group). "Securing the facility function" is a definite countermeasure that pertains to these frameworks. However, considering the urgency of each countermeasure, "securing conveyance function" by protecting a deteriorated canal's cross-section, securing a cross-section for conveyance and restraint of illegal garbage dumping would be limitedly included in terms of target construction and area.

(c) As for meska, it is difficult to start implementation without the consent of beneficiaries for construction and setting up of rules for water use. Therefore, implementation will be started from the formation of WUAs that agree with the given conditions. Hence, at the beginning, priority areas are set for meska improvement in areas where WUA is formed and the users are ready and agree to the set of conditions, and are afterwards expanded to other areas. Meska within the whole survey area shall be improved based on the experience of implementation within priority areas and expanded successively. The countermeasures that relate to these frameworks would be "Securing conveyance function by protecting deterioration of canal cross-sections" and "Restraint of illegal garbage dumping" at meska level and these countermeasures are considered necessary.

(d) Re-use pump stations, which increase limited water resources, are rehabilitated based on the capacity of existing facilities with necessary improvement for smooth operation. New pump stations shall also be planned for solving water deficiency within branch canals. However, in case a more efficient plan for a reuse pump station is suggested, a plan of the facilities at a sub-region shall be formulated taking into consideration the change of capacity of existing pumping facilities. In addition, the use of groundwater shall be considered as a countermeasure for water deficiency within sub-regions in the future. The countermeasure that relates to these frameworks would be "Securing of facility function" at main/branch canal levels and this countermeasure is considered necessary.

(3) Development of Countermeasures of Facility Improvement

Improvement of the hard components will be developed based on the framework mentioned above and aims at improvement of deterioration of the functioning of facilities (partially, improvement of the functioning) for realization of continuous operation. The process of the improvement of facilities is depicted in the following figure reflecting the levels of canals due to the difference of countermeasures.

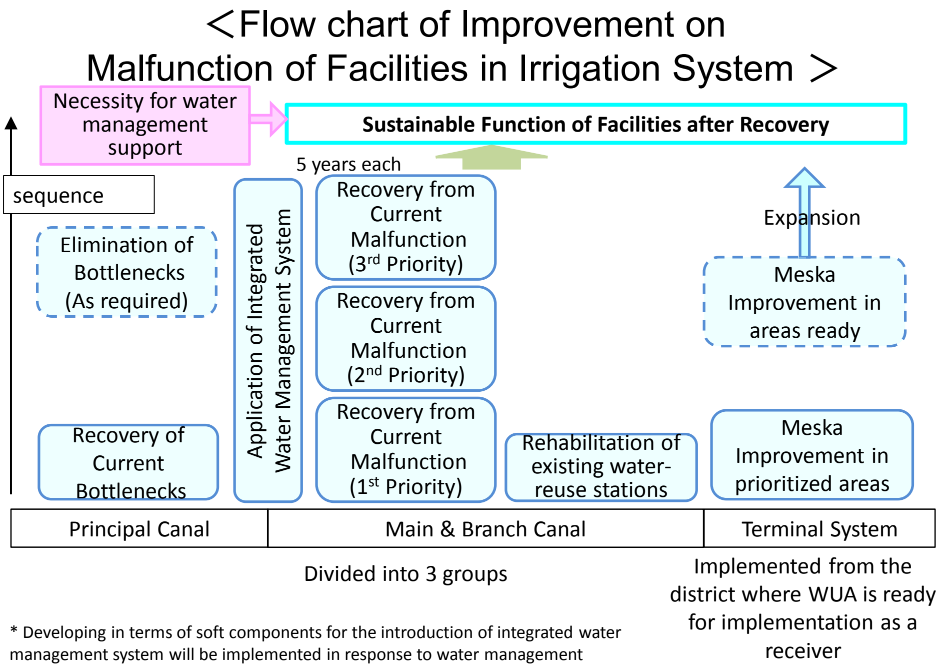


Figure 5.4 Development of Countermeasures of Facility Improvement

At the level of the principal canals, partial bottlenecks will be removed within about 3 years after starting the project and the function will be recovered ("Recovery of current bottleneck") and the future bottlenecks caused by natural conditions, etc., will also be removed when it is necessary ("Elimination of bottleneck"). At the level of the main/branch canals, sub-regions are divided into 3 groups according to the priority and rehabilitated accordingly ("Recovery from current malfunction (1st to 3rd priority)", about 5 years each) and the rehabilitation of the mixing pump stations are expected from the viewpoint of water resources improvement. At the terminal level, the meskas which farmers have ready and want rehabilitated will be improved ("meska improvement in prioritized areas", 5 to 7 years), and targets will be extended in the future ("meska improvement in areas readied"). The improvement of facility function will be targeted by these undertakings in the middle and long term, while "Necessity for water management support" in the upper part shows that water management is required for a sustainable facility function.

Four projects located at the lowest point in the figure are necessary as model creations of a facility's function improvement, and are urgent in the near future. So Japanese support is expected. Future undertakings should be afterward implemented by MWRI, while meska improvement by other donors is also expected.

Countermeasures against factors within the Survey are shown above. Especially, main/branch canals are pivotal points for water conveyance and distribution of the irrigation system, so improvement of facilities is implemented mainly as a core activity. Priority is set for project implementation and highly prioritized sub-regions become the target of implementation according to stages. Urgent work for principal canals is implemented beforehand.

Facilities after improvement have to be operated properly to show they are fully functioning, and then, water management of the soft component activities are expected to be carried out as soon as possible after completion of improvement of facilities. Therefore, the basic parts of the rotational plan shall be confirmed at the planning stage and rotational irrigation is practiced as soon as possible after implementation of facility improvement. Especially, as for meska improvement, it is very important that the work is carried out in parallel with water management for higher efficiency, because the rotation planning should be considered as an appropriate water use reflecting water demand.

For maintenance of facility functions after the recovery of all functions of facilities, it is necessary to complete the establishment of the structure and framework for carrying out periodical checkups (grasp the condition of facilities, diagnosis, etc.) corresponding to implementation of facility improvement at each canal level. The reason was because it is an effective measure to minimize deterioration of the function of facilities considering the budget situation and operation and maintenance system.

These necessary soft component techniques of asset management shall be transferred to MWRI. It is most effective to carry out this technical support in steps with a series of improvements of the canal for recovery of facility functions after understanding the necessary basic techniques at the preparation stage.

5.4.2 Countermeasures of Soft Components

The countermeasures of the soft components are composed of the water management and the facility management, and are introduced together with the countermeasures stated in the previous section. The water management will establish techniques and mechanisms that enable functional regimes to construct and continue defining operation and operation rules of the facilities. The facility management will construct desirable regimes that ease the influences derived from the functional deterioration of the facilities in employing asset management approaches. Development of their respective countermeasures is as follows:

(1) Development of Countermeasures for Water Management

The countermeasures need to show a method that contributes to solving the challenges or problematic phenomena identified with water management in Egypt. In this regard, a book[27] of 'Irrigated Agriculture in Egypt' presents the findings on challenges and countermeasures of water-use and water-management chiefly in the Nile delta region, as well as the development of irrigated agriculture in Egypt. Based on the findings, lecture material[28] is prepared for MWRI staff who have joined the JICA program that will work to find solutions to the challenges with irrigation water management in Egypt. In selected slides of the material, the outline of the countermeasures of Egyptian water management will appear as follows:

[27]Dr. Masayoshi Satoh, Dr. Samir Aboulroos Co-editing、Springer Publisher, 20172

[28]Material prepared for JICA program by Dr. Masayoshi Sato of Professor Emeritus of Tukuba University, Irrigated Agriculture in Japan and Egypt – Efficient and Sustainable management of Irrigation Projects, October 2017

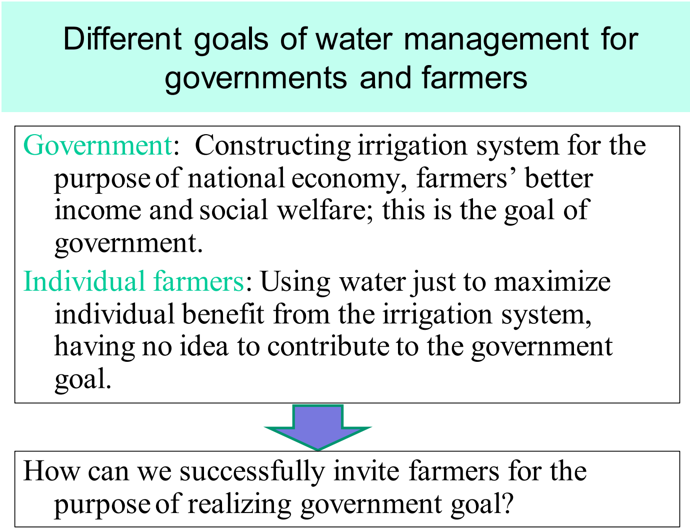


Figure 5.5 Difference in Goal of Water Management between Supplier and Water Users

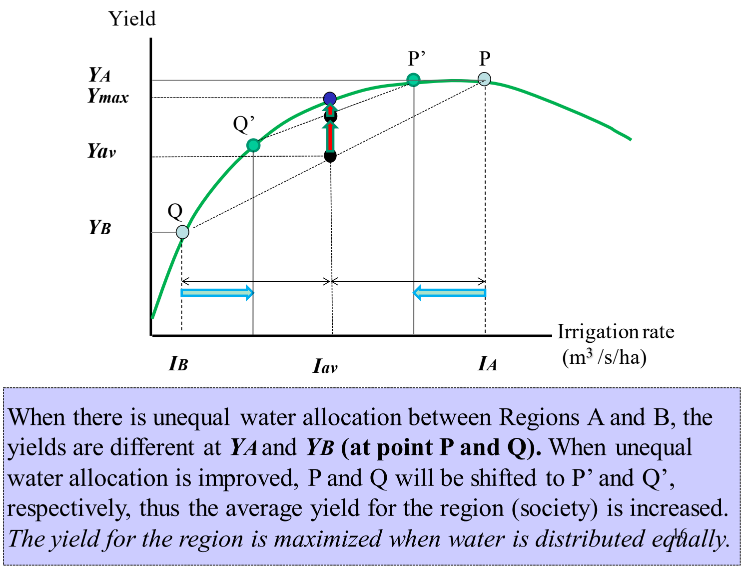


Figure 5.6 Image of Water Distribution to Maximize Crop production in Irrigated Area

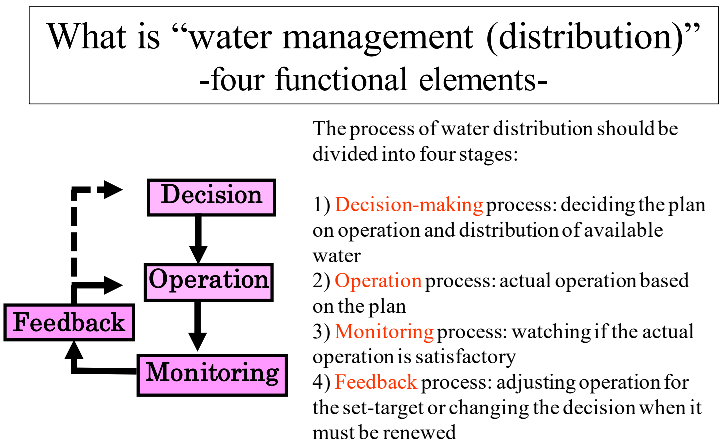


Figure 5.7 Relation Among Three Components of Irrigation Management

Discussions are held on water management in Egypt focusing on similarities and differences between Japan and Egypt on the subject of management of irrigation fields. Firstly, it stipulates the different goals between MWRI and farmers' groups (water users) on irrigation management. While MWRI is a water supplier, the farmers' groups are water users on the demand side. The farmers aim at maximizing their own benefits, while MWRI envisages maximization of effectiveness throughout the entire irrigation areas through its water management (Figure 5.7). This situation means MWRI and the farmers practice water management respectively in their different criteria, and that both cannot develop their collaboration without adequate coordination. It is pointed out, while trying to achieve the national irrigation policy, there is weak collaboration between both sides because they are without rules and with their implementing regime on water management after IMT.

The slide on the left (Figure 5.8) urges that a basic target for a national policy on water management is set on the management of water distribution that maximizes efficiency of irrigation water use through equitable water sharing among the irrigated areas in the same irrigation canal systems. However, it raises the point that the government cannot proceed with its national policy without coordination where farmers can accept a system organized by the government. It is required that the farmers should concur with the actions in line with the national policy.

Furthermore, the slide for Figure 5.8 explains a condition that leads the activities required to maintain desirable and sustainable functions of irrigation facilities (Good Maintenance), and institutional arrangements together with human resources and the financial

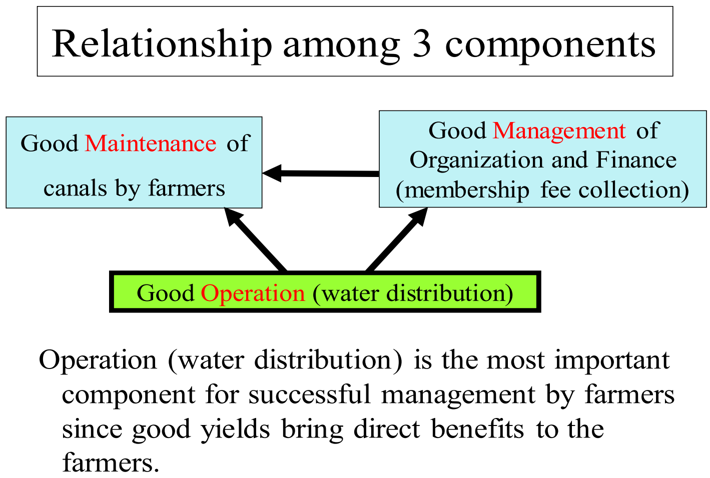


Figure 5.8 Flow of Efficiency Increase in Irrigation Water Supply

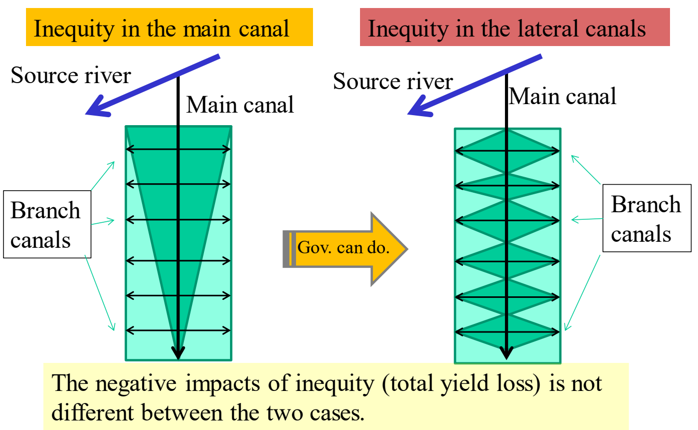


Figure 5.9 Situation after Water Distribution Change at Upper Level of Canal

background for its preparation (Good Management of Institution). To secure good management in both activities, the slide gives a prerequisite condition for Good Water Distribution.

Based on the introduction above, the concept of 'Water Distribution', composed of four functional elements, is presented. It explains that the four functional elements are more important aspects to construct a practical water distribution system than to nominate caretakers who simply appear during operation. The reason is given as follows: 'The operation of facilities' inevitably accompanies its targets and purposes (This does not matter if they are vague or not.), so that someone or some process decides the operation. Personnel concerned in water distribution observe/inspect the performance of 'the operation' and state of water distribution through 'the operation', and then evaluate the results, e.g., 'Insufficient operation', 'unsatisfactory situations in the result' based on the performance. Based on the evaluation, personnel systematically or responsively process and digest data/information to reflect actions in the corrective operation. Sometimes the performance is unsatisfactory after the operation is correctly practiced based on the established decision. In such case, the target itself frequently needs to be modified. This feedback does not always remain in the stage of operation, but sometimes comes to the decision stage.

The above (Figure 5.8) introduces a general explanation for water distribution. However, information sharing is an important mechanism to enhance a more efficient irrigation water supply. The material emphasizes that information sharing is required to understand the situation by respective stakeholders in irrigation management.

The slide of Figure 5.9 shows that when the government practices water distribution properly at the main canal level, the inequitable situation will remain at the lower level (lateral canal level in the figure).

Especially in Egypt where water distribution is practiced in a rotational arrangement at the upper locations in the canal systems, unfavorable conditions in crop production are likely to continue under unequal water distribution as indicated in Figure 5.7. The whole irrigation system remains in inequitable conditions where unequal water distribution continues within lateral canals and terminal facilities such as meskas, even though water delivery improved at intakes of the lateral canals managed by MWRI.

The material points out that unequal water distribution appears at any of the canal levels when equitable water distribution is not enough within the groups composed of the same canal level. This results in insufficient water delivery in terminal areas of the irrigation system, or creates challenges that affect water distribution in rotational scheduling.

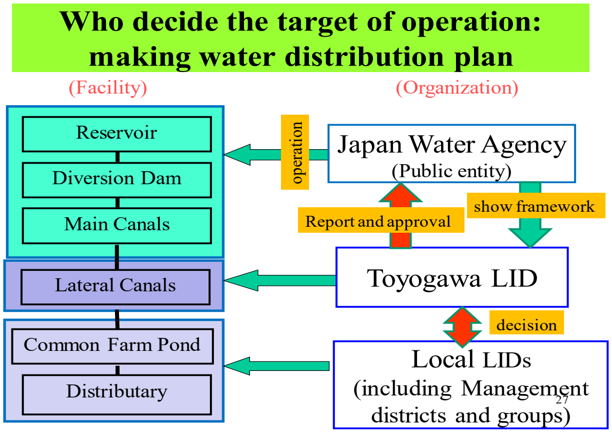


Figure 5.10 Water Management Structure of Toyogawa Irrigation Project

The material introduces the example of the Toyogawa irrigation project in Japan to explain water management where a supplier cannot meet water demand requested by the water users. Managing bodies are composed of the supplier up to the main canals, Land Improvement District (LID, association of water users groups) after lateral canals, and individual water users' groups in terminal facilities in the irrigation system. The bodies and their responsibilities concerned in water management are shown in Figure 5.10.

In this case, the irrigation district formed by the farmers takes actual responsibility to determine water distribution targets in its process, while in official management of irrigation systems, it still remains as the supplier (JWA: Japan Water Agency) that is a public authority and maintains a neutral position in system management. The supplier conducts water delivery and operation of the facilities up to the lateral canals, but not all water management operations are practiced. This is a practical case to realize the effectiveness of the concept of four elementary factors in water management as shown in Figure 5.8.

In Egypt, respective bodies take certain roles: namely, MWRI is the supplier, BCWUA is the irrigation district, and WUA is the water users group. The example introduces a successful case in water management establishment in a planned manner in that a limited amount of water resources is allocated in consideration of water users' intentions and under agreements between the supplier and the water users. Figure 5.11 shows the water shortage situation at the beginning stage where the water supply is arranged on a request basis. Figure 5.12 displays improved water distribution after comprehensive understanding by the water users who recognize the available amount of water for distribution through participation in planning and operations. This contributes to smooth water distribution, as well as decreases the frequency of water shortages.

Experience of failure in water distribution

- The water distribution system of Toyogawa failed during the early operation stage of the project. It was based on the request from the farmers. The application from farmers was to be 3 days before the delivery.
- Under this condition, the request was too big that the irrigation efficiency was so low and the system frequently met water shortages.
- New constriction of regulating reservoirs inside the benefitted area, installation of facilities that stop water supply when a farm pond is full, were effective to control the loss of water.
- The water request system was also changed to the fixed water delivery table system, in which the monitoring is used to adjust water delivery.

Figure 5.11 Problems in Water Distribution of Toyogawa Irrigation Project (Before)

Summary of the water management in the Toyogawa project

- Responsibility for different levels of canal system is clearly demarcated into 3 levels of organizations.
- Decision for the water distribution is practically decided by farmers even for the main canal. (JWA doesn't *manage* all about the main canal.)
- The operation is not done by the farmers, the concerned party on using water.
- Farmers are sensitive to whether planned amount of water is delivered or not and the amount satisfies the actual water demand.
- In case of water shortage, they adjust water distribution inside each local LID area.
- Water saving case at the project level, the delegates from every sector as well as from JWA will discuss and decide how to behave. JWA mainly behaves to provide information and technical advice.

Figure 5.12 Improvements in Water Distribution of Toyogawa Irrigation Project (After)

Accordingly, the countermeasures are developments of systematic regimes of MWRI and water users' groups, and establishment of rules and compliance in water management in the Study area, which concurs principally with the idea of the material.

1) Establishment of System

For the countermeasures to establish the appropriate water management systems, there are two systems for regional water management at the principal canal level and local water management at the sub-region level. At the level of the principal canal, the integrated water management system is being planned as a part of the new Dirout Group of Regulators Construction Project. The system, including the telemetering stations used for information collection on management and its usages, is the countermeasure for the regional level.

On the other hand, for water management related to conveying and distributing water through the main canal to terminal facilities in the sub-region, a framework of activities on the soft component is formulated to supply irrigation water to a benefitting area through rotational irrigation based on necessary information for supplying water from the principal canal to the whole benefitting area. At the facilities targeted within the main/branch canals, caretakers of MWRI are stationed to carry out measurement, operation, and reports. The countermeasures will be organized so that the functions are strengthened and systems are formulated to transmit the necessary information (reporting and recording of the water level each day, etc.) for irrigation water management throughout the sub-region. While facilities are operated with the current procedures, such as opening and closing of gates, switching on and off pumps, etc., they are regulated based on this information. Therefore, the countermeasures, which include telemetry systems linking the system of the principal canal level, are implemented for major facilities for rehabilitation of the sub-regions.

Beneficiary groups (WUA and BCWUA) shall participate in water management to distribute water at branch canals and meskas level and shall report (for information sharing) their activities to MWRI. It will become one of the countermeasures in constructing a system for water management. Within this process, it is very important to properly convey the water from one group to another. Therefore, mechanisms on coordination and co-working among MWRI, BCWUAs, and WUAs should be incorporated. Improvements through these activities require capacity building in water management both of MWRI and BCWUA/WUA. They also form the countermeasures.

2) Compliance with Rules

Since the irrigated area is huge and the limitation of water resources is severe, MWRI should supply irrigation water in a supply-oriented way at the regional level. Since the water distribution plan likely depends on past records, it is not very flexible in its ability to reflect demands in the current practice. On the other hand, farmers as water users are apt to take water according to their needs and this activity links to disrupting rotational water use. The countermeasures to enhance efficient use and equitable water distribution require the following: setting of a supply quantity based on cropping and farming in the area, introduction of a water management system through discharge measurement for improving water distribution, control water supply considering information from WUAs on the demand side and periodical meetings to coordinate better water distribution.

At the terminal level under traditional meskas, as farmland is generally situated at a higher elevation than irrigation canals, farmers have to lift water at least once. In such a case where water is used in a demand-oriented way, the upstream farmers have the advantage of being able to extract water to their area. Then the downstream farmers have limited time and quantity regarding water use. It is also observed that some farmers take water not from the designated level of canal systems but from the upper level. Regarding these operational challenges, it is required to create appropriate rules for water distribution in the area, enhance the capacity of BCWUA/WUA for its practical use, enhance the capacity of MWRI to support BCWUA/WUA and promote collaboration between the two organizational bodies.

3) Proposed Framework Water Management at Sub-region Level

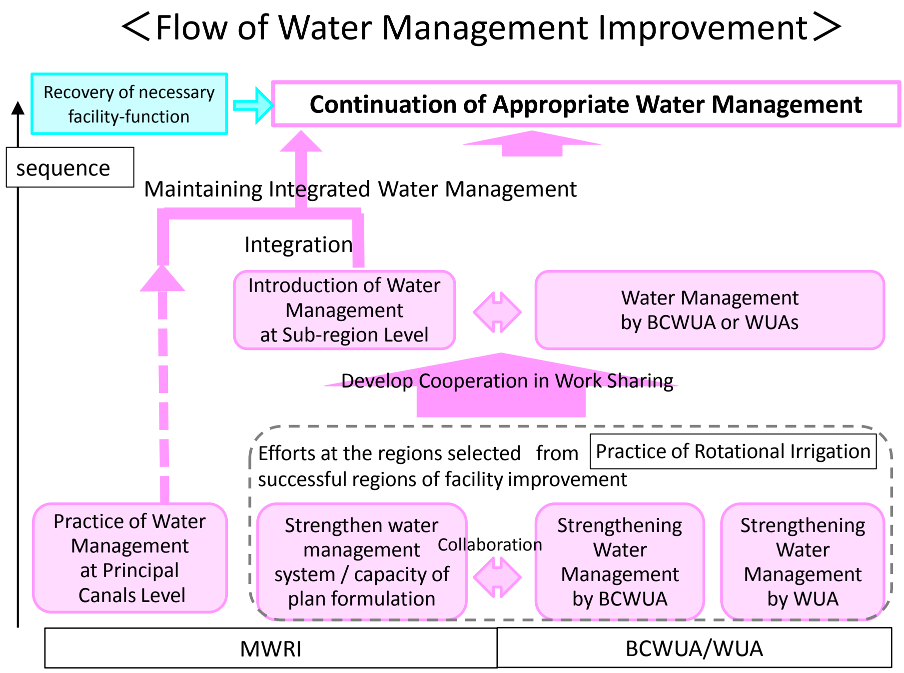
The establishment and compliance of the systematic regime and rules is a mechanism for implementing equitable distribution of water management, which is embodied by sharing information and practicing water management on the premise of trust between MWRI and BCWUA. Such a water distribution plan needs to be created, so that both MWRI and BCWUA can agree. MWRI will formulate the plan based on information on water supply, while BCWUA, which is responsible for water distribution within its respective concerned area, collects and provides (reports) information on which the expected amount of water distribution can be presented. Based on the rules in accordance with this plan, organizations concerned in the water management work according to their respective shared roles, and thereby equitable water distribution can be achieved within the sub-regions. In this case, it is desirable that MWRI should be a guide to realize expected developments, so that the efficiency of water use is maximized within the sub-regions according to the national policy of irrigation development in the country.

In order that BCWUA functions as a collaborating body with MWRI and as a representative of WUAs, the mechanism requires organizing and coordinating WUAs' demands on water distribution. In addition, the mechanism needs to reflect the principle of water distribution presented by MWRI in actual operation. This mechanism also includes negotiations if necessary for this water management. The mechanism should be supported by MWRI, which will introduce BCWUA as an institutional body for water management. In the mechanism, BCWUA is expected to report on the results of operations such as adjustment of water distribution, satisfactory level of water supply, and so on. MWRI creates the mechanism to inform BCWUA of the plans for its branch canals based on the actual status of water distribution in the sub-region level.

In addition, it is desirable that a mechanism of the facility management should be dealt with in the same manner in order to make both of the mechanisms work well. From the viewpoint of decreasing the maintenance burden of the branch canals connected to meskas, it is also an effective means for MWRI to manage the challenges occurring in the irrigation facilities in cooperation with BCWUA.

Rotational water use under planning conditions needs improved facilities to be effective. Then, water management should be considered, as its design at the implementation stage of a facility will enable the full recovery of functionality. On the other hand, practical activities will become possible corresponding to facility rehabilitation. Then, improved water management can be practiced in line with the progress of facility rehabilitation.

These improvements in water management will be initially introduced at model sites in a pilot area at each level of main/branch canals and at the meska level in order to establish a system and mechanism. Then, the system and mechanism will be able to extend to all sub-regions. (This timing will possibly concur with that for hard components that are going to be implemented.) In addition, the water management system both at the principal canal and at the sub-region level (main/branch canal and meska) shall be integrated at the proper stage to construct an overall water management system under the Dirout Group of Regulators. This process is shown in Figure 5.13 below.



Source: JICA Survey Team

Figure 5.13 Development of Countermeasures of Improved Water Management

At the principal canal level for regional water management, the countermeasure is the integrated water management system in the New Dirout Group of Regulators Construction Project (yen loan project) ("Practice of water management at principal canal level": including equipment instalment as seen on the left side in the figure above). At the sub-region level, water management will be conducted in model sites of a pilot area (in the broken line) selected from the sub-regions for facility rehabilitation to achieve local water management. Based on the actual status, the rules and responsibilities for water management among stakeholders should be identified beforehand, and then the system and planning of water management of MWRI will be improved ("Strengthen water management system/capacity of plan formulation"). The roles of BCWUA and WUA will be clarified and will function in practical activities towards realizing proper water distribution ("Strengthening water management by BCWUA" and "Strengthening water management by WUA"). Undertakings in the model sites of the pilot area will be extended to other parts of the sub-regions ("Introduction of water management at sub-region level" and "Water management by BCWUA or WUAs") through practice of their roles and responsibilities ("Develop cooperation in work sharing"). Water management of the sub-region level will be merged with water management of the principal canal level to complete the water management from upstream to the terminal of the irrigation system. The improvement of water management will be targeted by these undertakings in the middle and long term, while "Recovery of necessary facility functions" in the upper part of the figure shows the recovery of facility functions is also required for improved water management. It is noted that the water management system of "Introduction of water management at sub-region level" will be started at major facilities during rehabilitation work in the sub-regions.

(2) Development of Facility Maintenance Countermeasures (Asset Management Approach)

According to the present conditions, O&M of facilities for irrigation systems seems to be carried out and does not cause any fatal damage to conveyance and supply of water from the viewpoints of safety measures and deterioration of the facility function through long-term use. It is considered that improvement of these conditions could be very difficult in case the budget for O&M is not secured in the future.

So, it is very important to maintain the recovered functions of facilities through a series of improvements for long-term operation of the irrigation system, and to introduce techniques and structures to maintain such a condition is an effective countermeasure. It is important to establish structures of MWRI and WUOs, and the linkage between them to cope with such establishment. The extended countermeasures focus on the introduction of the asset management approach to sustain the facility function and appropriate water management. (Asset management is a method that collects information on the functions and safety of facilities, diagnoses, etc., while the facility maintains a certain level of soundness. It is a method intended to increase the lifetime of facilities by implementing the necessary countermeasures.) As for asset management, focus is placed on surveys of facilities and diagnosis, which are necessary to implement O&M of facilities systematically, and practical techniques required for MWRI are established and transferred, then afterward, the framework is introduced to prepare an O&M plan for facilities within model areas applying this technique. At this stage, the practices for maintenance activities (mainly, daily checks and light O&M work) by BCWUAs for branch canals and WUAs for meskas are enhanced.

Instead of the present list of facilities, an O&M plan for facilities shall be prepared by IDs, and at the same time, a framework is formulated to minimize deterioration of the function of facilities through systematic O&M of facilities after recording O&M activities, and the functional conditions of each facility within the sub-region are put together.

O&M at the principal canal level has different aspects, because the facility is large and complicated, so a detailed survey is necessary. However, O&M of the principal canal shall be conducted by adding investigation methods, diagnostic methods and by creating a facility management plan. From the above, the flowchart of countermeasures for facility maintenance covering the whole irrigation system led by MWRI is shown in the figure below.

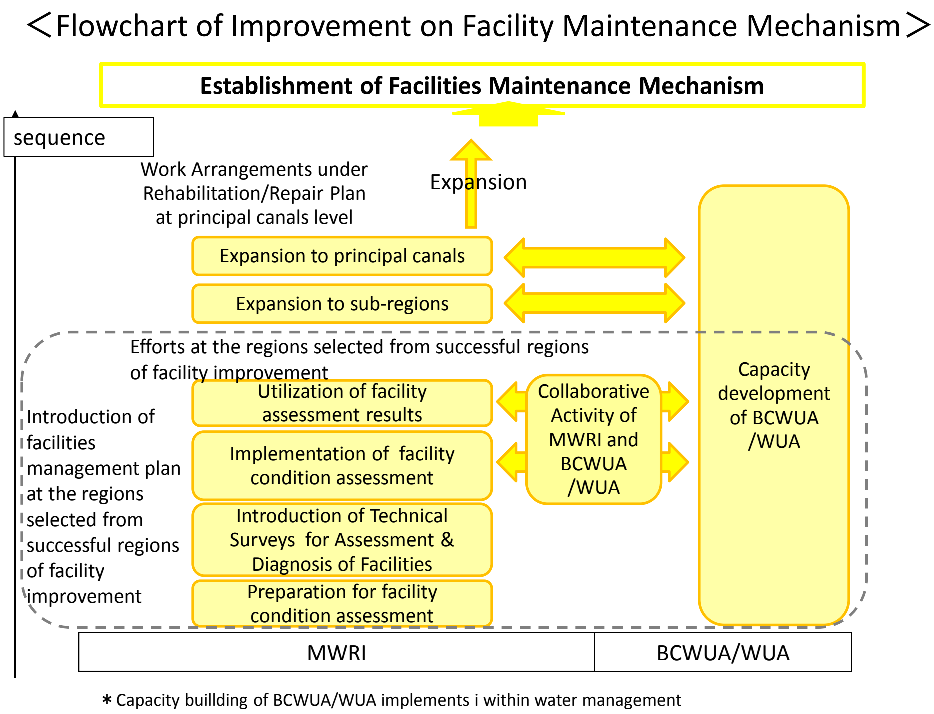


Figure 5.14 Development of Countermeasures on Facility Maintenance as Asset Management Approach

A step-wise introduction would be realistic, while MWRI is not familiar with asset management. Preparations such as data sheet formulation, formation of an information collection methodology, etc., are needed at first to grasp facility conditions in pilot sites ("Preparation for facility condition assessment"). Subsequently, as shown in the figure above, "Introduction of technical surveys for assessment and diagnosis of facilities" is conducted to formulate a method to grasp facility conditions and "Implementation of facility condition assessment" is carried out to collect information of real facility conditions. Based on those, ways to utilize the results and to lead to the formulation of a facility maintenance plan are considered ("Utilization of facility assessment results"). On the other hand, the capacity development of WUOs should be continued from institutional aspects (Capacity building of BCWUA/WUA) and it is important to facilitate cooperation between MWRI and WUOs (Collaborative Activity of MWRI and BCWUA/WUA). Those activities are conducted at pilot sites first, and they are expected to extend to other sub-regions and the principal canal level, so the mechanism for facility maintenance will be established in the end.

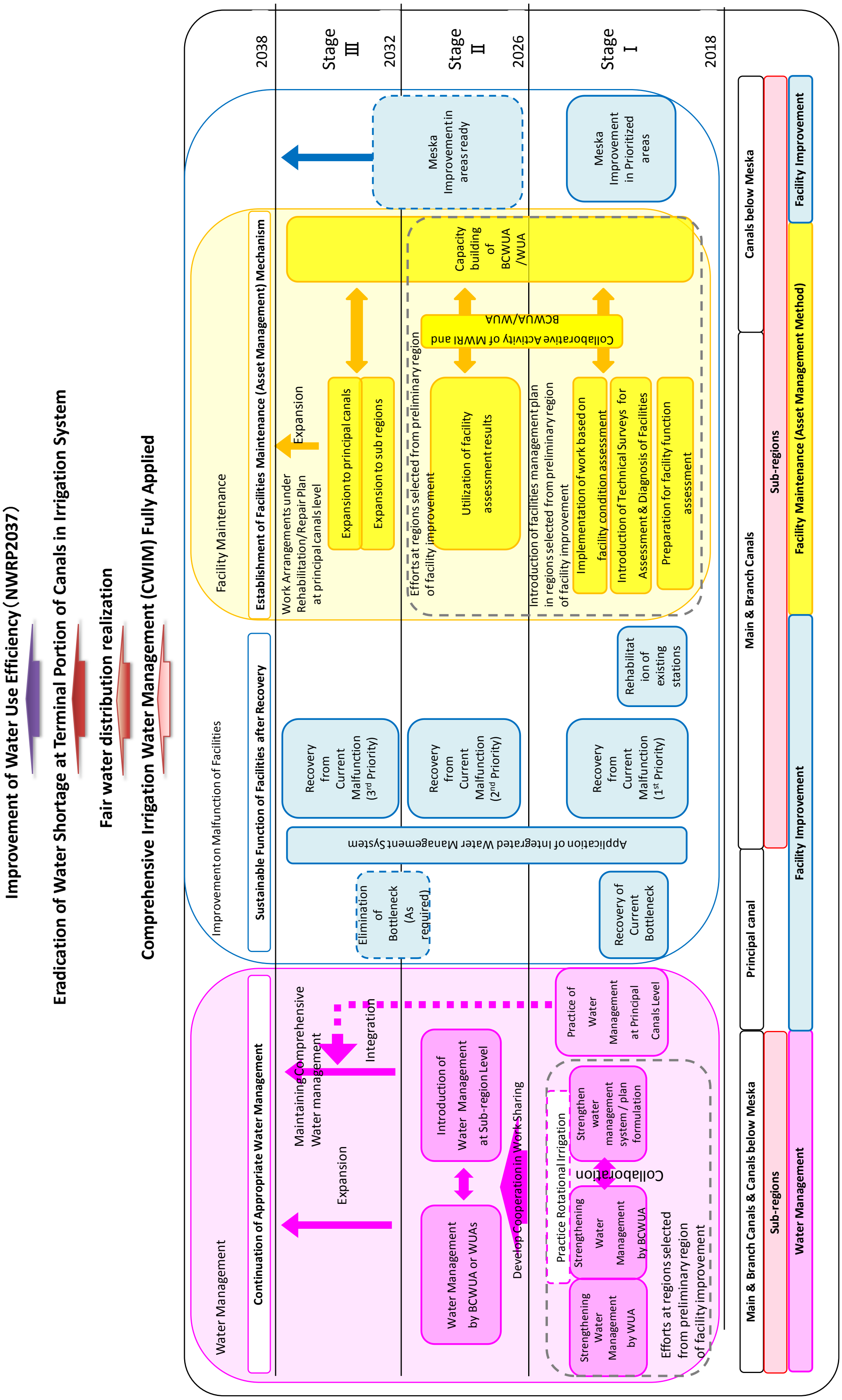
Having experienced asset management of irrigation infrastructures, Japan has an advantage through its technical knowledge for capacity building for MWRI to be undertaken first, so support from Japan is also expected from the viewpoint of CIWM. The basic technologies and systems will be extended by MWRI afterward.

5.5 Proposal of Roadmap to Achieve CIWM

Based on countermeasures as mentioned above, a cooperation program is proposed in order to improve the irrigation efficiency in irrigation sectors in the target survey area. The irrigation system in Egypt is huge and there are restrictions on use of limited water resources. In order to carry out continuous O&M of the irrigation facility in consideration of such a situation, it is necessary to ensure water management for planned irrigation rotation and to manage functional deterioration precisely by grasping the condition of the facility.

In the rehabilitation of facilities in the hard components, it is reasonable to make groupings of the sub-regions and carry out planned countermeasures by implementing the improvement of the facilities. In the soft components, asset management, which supports the maintenance of hard components, and water management of delivery and conveyance are a target cooperation. The cooperation program sets the target period of 20 years as the same as the end of the next NWRP2037, and takes into consideration the sequence of each countermeasure such as the hard and soft components shown in this chapter.

Based on the above concept of CIWM, the image of the cooperation program is shown in the following figure. The image relates to support recovery or improvement of the function of the whole irrigation system in the Survey area. Facility improvement is shown in blue, while improvement of water management is shown in red and facility maintenance is shown in yellow, respectively. In addition, the image indicates the improvement level by setting the stages, stage I for the most recent 8 years, stage II for 6 years after stage I, and stage III for the following 6 years.



Source: JICA Survey Team

Figure 5.15 Roadmap for CIWM

5.6 Effect of Roadmap for Applied CIWM

As explained in the previous chapter, in order to achieve equitable water allocation under the present constrained water resources, it is necessary to eradicate the bottleneck of related irrigation facilities from the principal canal up to the terminal level. (As a hard component). It also needs to apply comprehensive implementation of planned and efficient water management using sound and functional irrigation facilities (operation of soft components). The specific effect created by introducing CIWM in the target area is evaluated from the viewpoint of "efficient use of water resources" as the most important point.

The effect of CIWM will be analyzed first on the target model area (Tunsa-Kella sub-region), which will be extended to the entire target area. The explanation is presented as follows. As explained in Chapter 4, 4.2.2, in this Survey, the irrigation efficiency in a sub-region is estimated, because the improvement of water use efficiency and projects to achieve it are considered for each sub-region. The irrigation efficiency is calculated by <used water amount / supplied water amount> in a certain area. Since the unused water and seepage are regarded as losses, the irrigation efficiency in a sub-region is relatively small. Considering the water balance in a broad area, such losses are reused downstream and the available water amount increases, so the irrigation efficiency also rises. Water saving by the irrigation system was calculated as the difference between the amount of current demand and water demand after intervention, that is, reduction of water demand by the plan, in this report.

5.6.1 Effect of CIWM on the Model Area (Tunsa-Kella Sub-region)

(1) Estimated Irrigation Efficiency of the Tunsa-Kella Sub-region

As described in Chapter 4, section 4.2.2 above, the water flow through the existing canal systems with existing conditions for three-rotation irrigation was determined. Generally, the present condition of the Tunsa-Kella irrigation system is characterized as having malfunctioning irrigation facilities and deformed canal cross-sections. The effect of this condition has resulted in a decrease in the discharge to each branch canal and loss of available water into the drain before being used. Under this condition, a hydraulic analysis was implemented to determine the present efficiency of the irrigation system as follows:

The result of the analysis is shown in Figure A of Annex 6 and the present conveyance efficiency for each rotation is shown below.

Table 5.10 Conveyance Efficiency of Tunsa-Kella at Present Condition

Major Canal System	Rotation		
	R1	R2	R3
Average eff. per each Rotation	75%	68%	55%
Conveyance efficiency (Ec)	66.7%		

Source: JICA Survey Team, calculated by obtained information from MWRI

Compared to the original conveyance efficiency of the system, the present conveyance efficiency has been reduced as low as 55% during Rotation 3. From this conveyance efficiency, the overall irrigation efficiency of the system at the present status is calculated as 50%. This irrigation efficiency is expected to improve with the implementation of the proposed intervention as explained below.

(2) Proposed Plan of Intervention in Tunsa-Kella Sub-region

In order to improve existing canal systems for guaranteed water delivery from the most upstream part (intake) to the terminal and appropriate diversion to branch canals in sub-regions, reasonable facility improvement plans as countermeasures are studied. The validity of the measures is evaluated for the following improvement levels from the aspect of the improvement of irrigation efficiency.

- Plan 1 (minimum intervention): Rehabilitation of irrigation facilities (intake, regulator, mixing pump station, etc.) in sub-regions without lining of canals.

- Plan 2: Plan 1 plus shaping and lining of a main canal.

- Plan 3: Plan 2 plus shaping and lining of branch canals.

Implementation of such a hard component for facility improvement also requires a soft component like the proper operation of a water management system for appropriate water distribution (constant irrigation rotation).

1) Plan 1: Minimum Intervention

i) Facility Rehabilitation (Hard Components)

This report proposes the countermeasures responding to the minimum intervention and aiming at (i) to recover the existing system to its original state and (ii) to secure the water to be conveyed and fairly distributed from the main canal to the terminal canal system covering a large irrigated area in a sub-region. This countermeasures are the rehabilitations of the existing irrigation facilities.

The minimum intervention represents the condition (a) where the irrigation system realizes equitable and well-planned distribution of the available water delivered from the main canal to branch canals up to the terminal level and (b) where proper irrigation-rotation is implemented with the water level raised by regulators in a main canal and operation of intake gates. However, the degree of deterioration of a canal's cross-sections raises an issue about the lack of irrigation efficiency, which may prevent the required amount of distributed water from reaching the terminal level.

The summary of the major rehabilitation work on irrigation facilities of the Tunsa-Kella sub-region proposed as minimum interventions are presented below. The target facilities are the regulators and intake systems at the main canal as well as the drainage reuse facilities at the branch canals.

Table 5.11 Summary of Major Rehabilitation Work on Plan 1 (Tunsa-Kella Sub-region)

Canal	Station	Facility	Content of intervention	Remark
Main Canal	2+760	Kela Regulator	Rehabilitation & replacement of the regulator	Double gate (3 m width each)
Main Canal	2+760	North Amar Gate	Replacement & rehabilitation of gate	2.8 m wide
Main Canal	2+760	South Amar Gate	Replacement & rehabilitation of gate	Double gate (2 m wide each)
Main Canal	5+600	Towa Regulator	Replacement & rehabilitation of gate	Double gate (3 m wide each)
Main Canal	5+600	Towa Intake gate	Installation of new sluice gate	The new type of gate installed by IIP project is not functioning well
Main Canal	14+410	Kella reuse pump	Rehabilitation of the pump house, replacement of pump, installation of suction pool	5 units of old pump with no suction pool
Main Canal	18+100	Baha Intake + Regulator	Replacement of Gate	3 m wide old facility
Main canal	19+600	Dandell intake + Regulator	Replacement of Gate	2 m wide Regulator and 3 m wide intake
North Amar canal	4+210	Barout Reuse Pump	Installation of New pump house	Totally broken 4units of old and malfunctioned pump house
North Amar	7+000	El Hagery	Rehabilitation and replacement of	Old pump

Canal	Station	Facility	Content of intervention	Remark
Canal		Reuse Pump	pump	
Baha Canal	15+900	Baha reuse Pump	Rehabilitation and replacement of pump	3 units of old pump
Dandeel Canal	21+000	Dandeel reuse pump	Provision of suction pool	2 units of newly installed pump
Abshena canal	23+000	Abshena reuse pump	Construction of new pump house	1 unit of old pump (no pump house)

Source: JICA Survey Team

In addition, all other intake gates installed at each branch canal of the irrigation system shall be rehabilitated (see Figure 5.15).

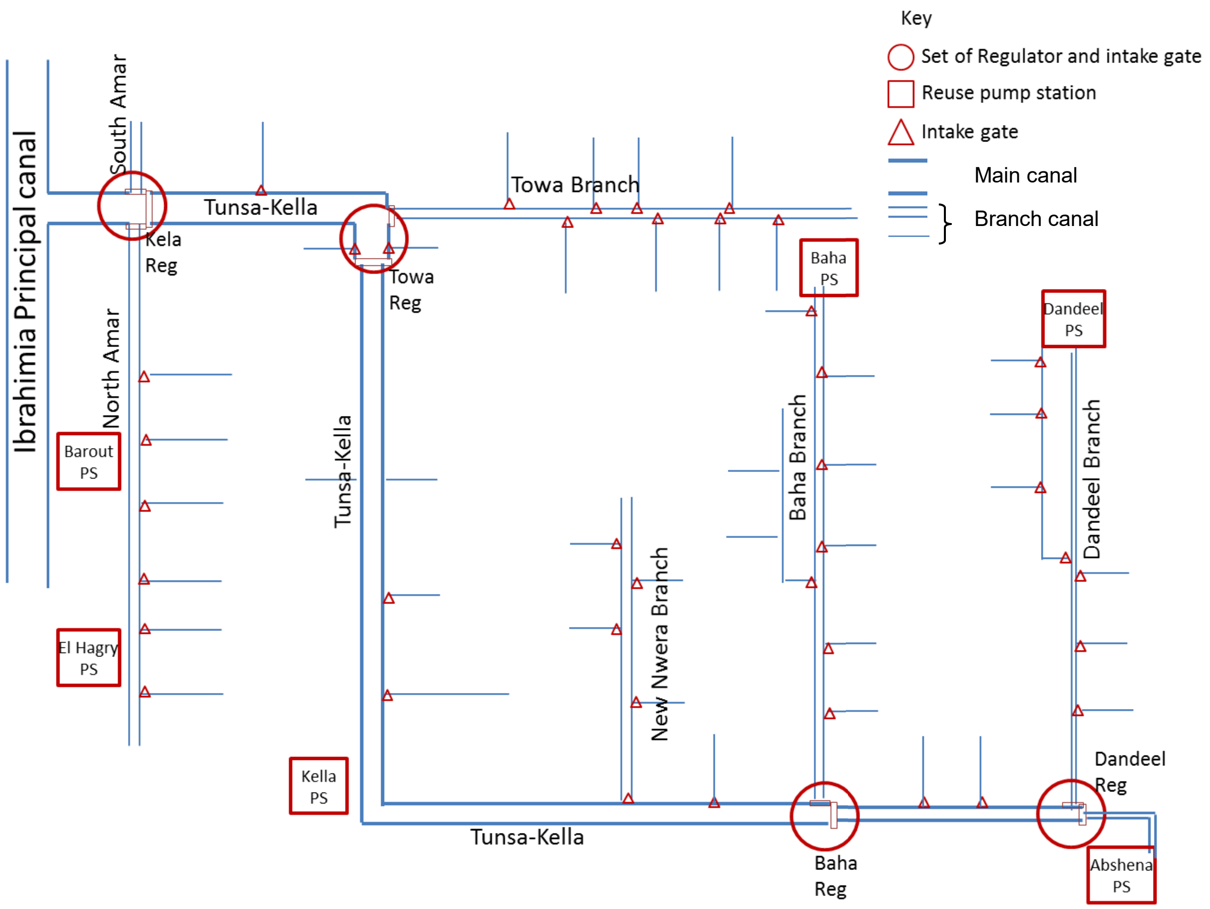


Figure 5.16 Sketch Showing the Minimum Intervention on Tunsa-Kella Sub-region

The figure above shows the simple sketch of the layout of irrigation systems and the location of irrigation facilities proposed for rehabilitation as a minimum intervention. Through rehabilitation of these water facilities set out at major points between the main canal and each branch canal, the functions of the large distribution system of the Tunsa-Kella sub-region (about 10,400 ha) should be improved to some extent.

ii) Water Management (Soft Component)

On the other hand, besides the rehabilitation of the irrigation facilities of the system (hard components) a properly operating water management system, as a soft component, shall be set for the system to function effectively and efficiently. The water management shall be designed in consideration of the existing irrigation rotation being applied in the sub-region.

2) Plan 2: Plan 1 Plus Main Canal Lining

The deformation of the existing canal system is believed to be one of the causes of poor distribution efficiency of the irrigation system. As part of achieving fair and equitable distribution of the available water resources, the reshaping of the distribution system (main canal), in addition to the minimum intervention proposed above, is confirmed as a necessary intervention. Through this intervention, the designed water level in the main canal can be attained and the design discharge to each branch canal will be secured. This will lead to highly efficient distribution throughout the entire target area.

The lining of branch canals alone without lining of the main canal is not reasonable because the irrigation efficiency is low due to the difficulty of securing the necessary water level at branch intakes, the time-lag to raise the water level and the necessity to supply more than the design discharge.

Under the present conditions, the reshaping of the canal is possible through lining of the canal (concrete or masonry lining) because reshaping of the earth canal is insufficient. The lining shall be prioritized to be undertaken on the part of the main canal where the expected effect is large. Hence, the canal between the Kella Regulator and Dandeel Regulator is considered as the important portion of the canal lining. The remaining part of the main canal is either already lined (the first 2.76 km of the canal) or also serves as part of the branch canal (Abeshena canal). With the lining of the main canal, the following additional benefits are expected:

- Seepage loss is avoided and evaporation loss is reduced [the conveyance efficiency after the lining would be improved to about 95%. Refer to Table 4.37 (Irrigation Efficiencies).]
- The area used by the canal shall be reduced and shall be used for other purposes. (However, the area cannot be significantly scaled down, and thus it would be limited to be used for canal-maintenance or other purposes.)
- The irrigation system attains a fast response to rotation of water delivery (better water management) due to the relatively high velocity of water flow in lined canals.
- Ease the cleaning and maintenance work of the canal.

The figure below depicts the extent of the intervention on the main canal as Plan 2 in addition to the minimum intervention mentioned above.

The lined main canal would channel water to all the branch canals in the sub-regions. Therefore, further improvements in distribution efficiency would be possible in the target area from the most upstream level to the terminal level (to the meska entrance).

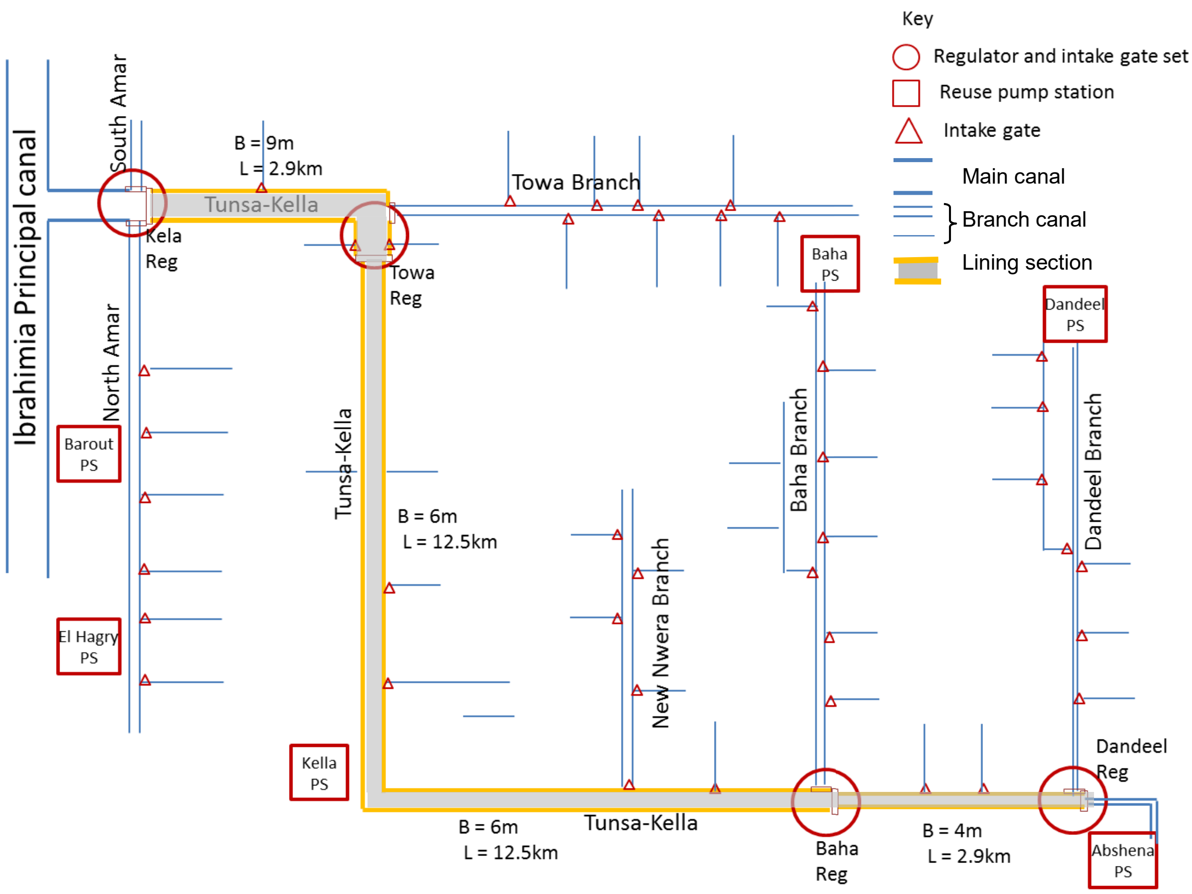


Figure 5.17 Sketch Showing the Plan 2 Intervention on Tunsa-Kella Sub-region

3) Plan 3: Plan 2 Plus Branch Canal Lining

In addition to the above two interventions (Plan 1 and Plan 2), to further improve the irrigation efficiency of the system and to implement stable water management of the sub-regions, the reshaping of the deformed canal system up to the entire branch canal system of the sub-regions is considered as Plan 3 of the intervention. Lining of branch canals as well as the main canal would enable the reshaping of the canal's cross-section, and thus it shall improve the distribution function throughout the canal system to the terminal level of meska and enable further advancement of irrigation efficiency. However, the expected project-cost for this intervention is high. Therefore, the degree of deterioration of the branch canals should be analysed in detail in order to make a thorough consideration of the expected improvements of the distribution functions and efficiency and the balance between the investment costs. For this reason, instead of conducting lining of branch canals equally, it should be prioritized to those at low cost and projected to have a high impact.

(3)Validation of Effect of the Proposed Intervention on Tunsa-Kella Sub-region

As discussed above, in order to evaluate the effects of CIWM intervention in the system, the irrigation efficiencies were estimated. The results and calculations are as follows:

Table 5.12 The Summary of Efficiency after the Intervention

Rotation	No intervention	Plan 1	Plan 2	Plan 3
Irrigation Eff (Ep)	50%	60.5%	66%	72%

Source: JICA Survey Team

Regarding the table above,

- Plan 1: By ensuring the water intake level, the irrigation efficiency shall be improved to 60.5%, which is based on the figure shown in the feasibility study report of the Bahr Yusef Canal in 1992 when the deteriorations of the facilities were milder than the present conditions.

- Plan 2: Improve the conveyance efficiency by main canal lining (from 80% at earth canals to 90% at lining canals). The ratio of effectiveness of the main canal lining is considered as "main canal/ (main canal + branch canal)". The length, width and area of the main canal and branch canal is determined as follows:

  Main canal: Length (L)=23 km, Width (w)=1 m~9 m, Area (A_1)=132 thousand m^2

  Branch canal: Length (L)=140 km, Width (w)=1 m~4 m, Area (A_2)=101 thousand m^2

  According to the proportion of areas of the main canal to that of the branch canal, A_1: A_2=57:43, the improvement ratio of conveyance efficiency by main canal rehabilitation would be estimated as 8.55% (15% x 57/100), which leads to 67% for irrigation efficiency.

  < 60.5% x (80%+8.55%) / 80% = 67% >

- Plan 3: The conveyance efficiency shall be improved by branch canal lining (from 80% to 95%).

  < 60.5% x 95%/80% = 72% >

In order to evaluate the effectiveness by the intervention of CIWM, the water requirements for these three plans were calculated. Monthly irrigation requirements for the Tunsa-Kella sub-region were calculated by using the estimated overall irrigation efficiencies with CROPWAT 8.0 (See Annex 5 for detailed calculation results).

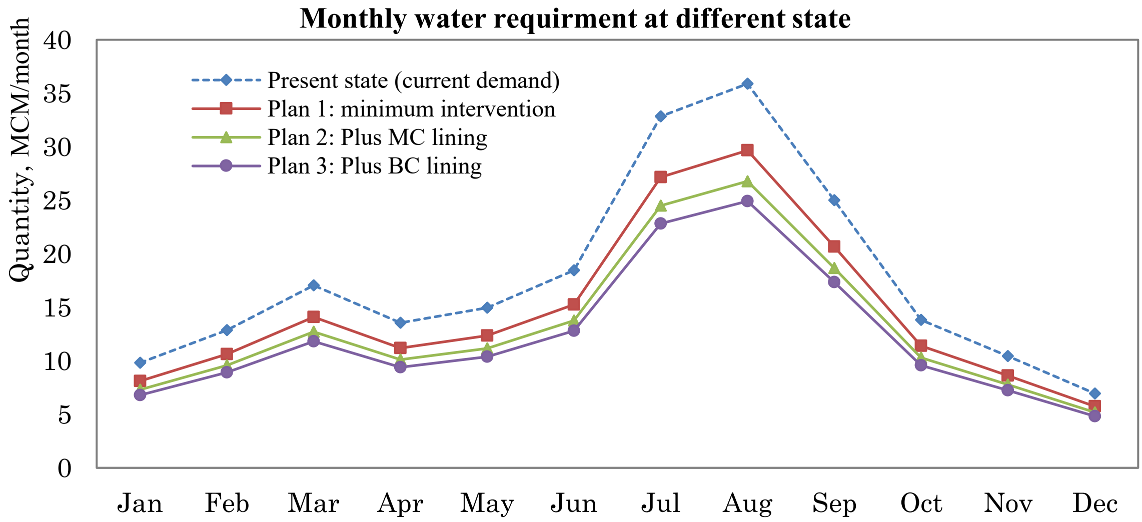


Figure 5.18 Comparison of Irrigated Water Requirement with Improved Plan

The relationship between saved water amount through the improvement of the irrigation efficiency and the necessary cost for improvement work is considered. Table 5.13 and Figure 5.19 summarize the results of calculations for the cost of improvement work of each improvement level, the required water amounts, the possible saved amounts and the irrigation efficiencies during each case.

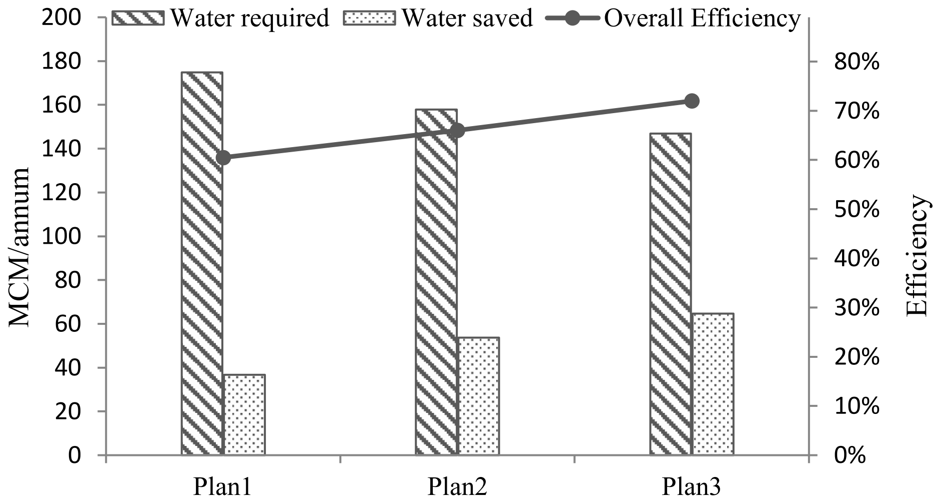
Table 5.13 Irrigation Efficiency and Cost of Improvement Works (Tunsa-Kella Area)

Item	No intervention	Plan 1 (minimum intervention)	Plan 2 (plus main canal reshaping)	Plan 3 (plus branch canal reshaping)
Cost (in Million US$)	0.0	15.6	22.2	31.3
Water Required (MCM/year)	211.6	174.9	157.9	146.9
Water Saved (MCM/year)	0.0	36.7	53.7	64.7
Cost per m^3	0.0	0.43	0.41	0.48
% water saved	0.0%	17%	25%	31%
Irrigation Eff. (Ep)	50%	60.5%	67%	72%

Source: JICA Survey Team

According to the calculated results above, compared with the current water required, about 37 MCM of water can be saved annually by Plan 1. The possible water saving will increase to 54 MCM by Plan 2. It is estimated that 65 MCM of water can be saved per year by Plan 3.

In addition, the necessary water demand for each plan, the possible saved amounts and the irrigation efficiencies according to improvement levels are shown in the figure below. These results show that about 17% of water can be saved through minimum intervention (Plan 1), 25% of water can be saved by Plan 2, and 31% of water can be saved by Plan 3.



Source: JICA Survey Team

Figure 5.19 Relationship between Possible Saved Amount and Irrigation Efficiency (Tunsa-Kella Area)

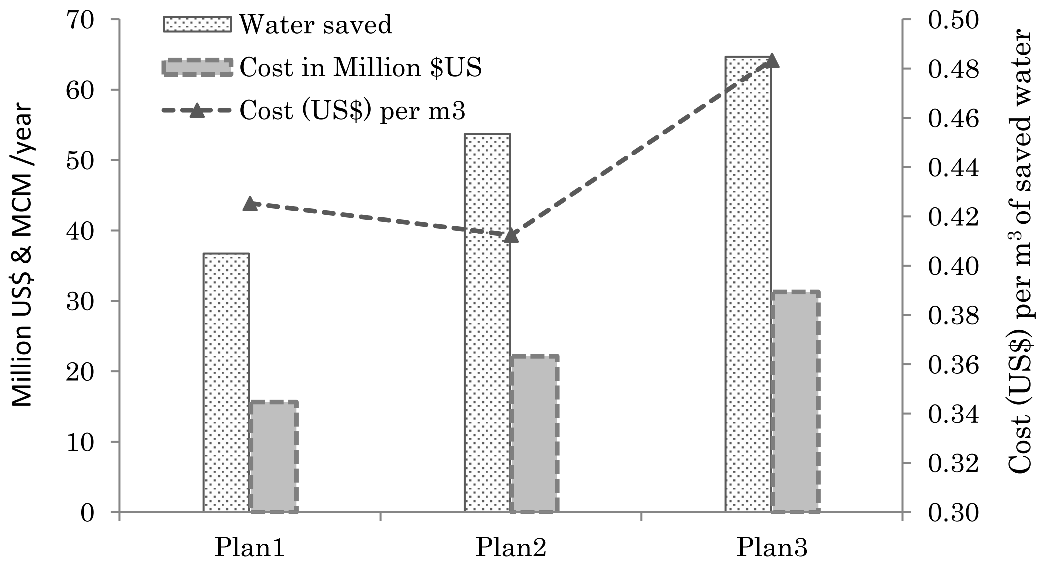
Table 5.14 Details of Cost of Improvement Works (Tunsa-Kella Area)

(Unit: 1,000 US$)

Item	Plan 1	Plan 2	Plan 3
Small-scale water facilities	11,572	11,572	11,572
Main canal lining	0	4,832	4,832
Branch canal lining	0	0	6,750
Total direct cost	11,572	16,404	23,154
Other expense (35%)	4,050	5,741	8,104
Total construction cost	15,622	22,145	31,258

Source: JICA Survey Team

The figure below shows the relationship between the possible saved amount of water and the total cost of improvement work. It can be seen from the figure that Plan 2 requires the lowest cost at US$0.41 per m^3 of saved water. In contrast, a slightly higher cost is needed for Plan 1 than Plan 2 (US$0.43 per m^3 of saved water). The cost would be the highest for Plan 3 (US$0.48 per m^3 of saved water). These results show that Plan 1 and Plan 2 more or less outweigh Plan 3. However, this does not mean that Plan 3 is unnecessary. In fact, if the deterioration of the canal cross-section is severe at the branch level, this could greatly affect the distribution from the perspective of the CIWM, the branch canal linings also need to be prioritized as well as the main canal. These possibilities would be determined through detailed research.



Source: JICA Survey Team

Figure 5.20 Relationship between Possible Saved Amount and Improvement Cost (Tunsa-Kella Area)

According to the results above, it is expected that the improvement of irrigation facilities and the main canal lining have a significant effect on the irrigation facility improvement from the viewpoint of CIWM. The plan for lining of branch canals (Plan 3) should be studied not only for further improvement of irrigation efficiency, but also for more efficient and equitable water distribution in the future.

5.6.2 Effect of Principal Canal

The principal canal located in the upstream part of the irrigation system is responsible for ensuring water supply to the main and branch canals. Therefore, it is easy to presume that the water supply function is maintained by eliminating the current bottlenecks (securing efficient hydraulic performance of the canal), and functional recovery corresponding to the role is realized.

5.6.3 Effect of Main/Branch Canal

This effect is evaluated through the effect of interventions on the irrigation efficiency of the system. The implementation of the proposed CIWM is expected to improve the conveyance efficiency and eventually the irrigation efficiency of the system, which in turn improves the overall efficiency of the irrigation system.

As discussed above, through hydraulic analysis, the present overall irrigation efficiency of the Tunsa-Kella sub-region is determined. Using these distribution efficiencies, the overall irrigation efficiencies for each plan are determined as 50% (no implementation; present condition), 60.5% (Plan 1; implementation of minimum intervention), and 67% (Plan 2; Plan 1 and reshaping of the main canal and canal lining), 72% (Plan 3; Plan 2 and reshaping of branch canals and canal lining), respectively. By applying the same overall irrigation efficiency on all the sub-regions, the total volume of the water annually saved is estimated. In the calculation, differences between the current water requirement and the water required after interventions of the plans define the saved amounts of water of the respective plans. The summary of the cases responding to the plans are shown in the table below.

Table 5.15 Situation and Assumed Conditions

Situation	Assumed Conditions
Present condition (Before intervention)	It corresponds to the current situation where irrigation facilities are malfunctioning, canal-shapes' deformed, and poor irrigation-water management induced by malfunctioning irrigation facilities. Under this situation, the overall irrigation efficiency of the system is determined as 0.50.
Plan 1: minimum intervention; Improvement of distribution efficiency though rehabilitation of malfunctioning irrigation facilities	The state after implementation of the project corresponds to the elimination of bottlenecks on the main canals, renovation and improvement of small-scale structures, implementation of irrigation-rotation within the sub-regions, and operation of them as planned. Under this situation, the overall irrigation efficiency of the system is determined to increase to 0.605. <u>About a 10% increase on overall efficiency is expected compared to the present situation</u>
Plan 2: Plan 1 plus main canal lining	In addition to Case 2, reshaping of the main canal that improves the distribution efficiency by lining the canal and establishment of maintenance management system to properly operate and manage it. Under this situation, the overall irrigation efficiency of the system is determined to increase to 0.67. <u>About a 17% improvement can be expected compared to the present situation.</u>
Plan 3: Plan 2 plus branch canal lining	In addition to Case 3, reshaping and lining of branch canals and establishment and an appropriate maintenance management system are projected. Under this situation, the overall irrigation efficiency of the system is determined to increase to 0.72. <u>About a 22% improvement can be expected compared to the present situation</u>.

Source: JICA Survey Team

Based on the results above, the relationship between the actual amount of irrigation water and the planned amount of water required for each case is determined. Henceforth, these values are compared with the actual amount of available water in the system. The actual amount of available water is determined from the monthly average discharge recorded for the target area (excluding Giza) between 2006 and 2017. The irrigation requirement for each case is determined from the crop water requirements of the area calculated using CROPWAT 8.0. See Annex 5 for detailed calculation results.

Compared to the available monthly discharge in the system in the target area, the required amount of water in the current situation is extremely high and the water supply is confirmed to be insufficient especially during the peak season from July to August (see table and figure below). Referring to Table 5.16 below, it is supposed that an additional 355 MCM of water is needed annually to satisfy needs at the present condition, since the annual current demand is 8,407 MCM and annual available water is 8,052 MCM. This situation can only be improved through increasing the overall efficiency of the system. With the intervention of Plan 1, the overall efficiency is increased by about 10% and the gap between the monthly available water and the peak required amount (Table 5.16, July and August) is narrowed by 17% (from 1,369 MCM to 1,131 MCM in the table below). Although water amounting to 1,459 MCM (17.3% of the current volume) is annually saved through the implementation of Plan 1, there may be water shortages during the peak season in July and August.

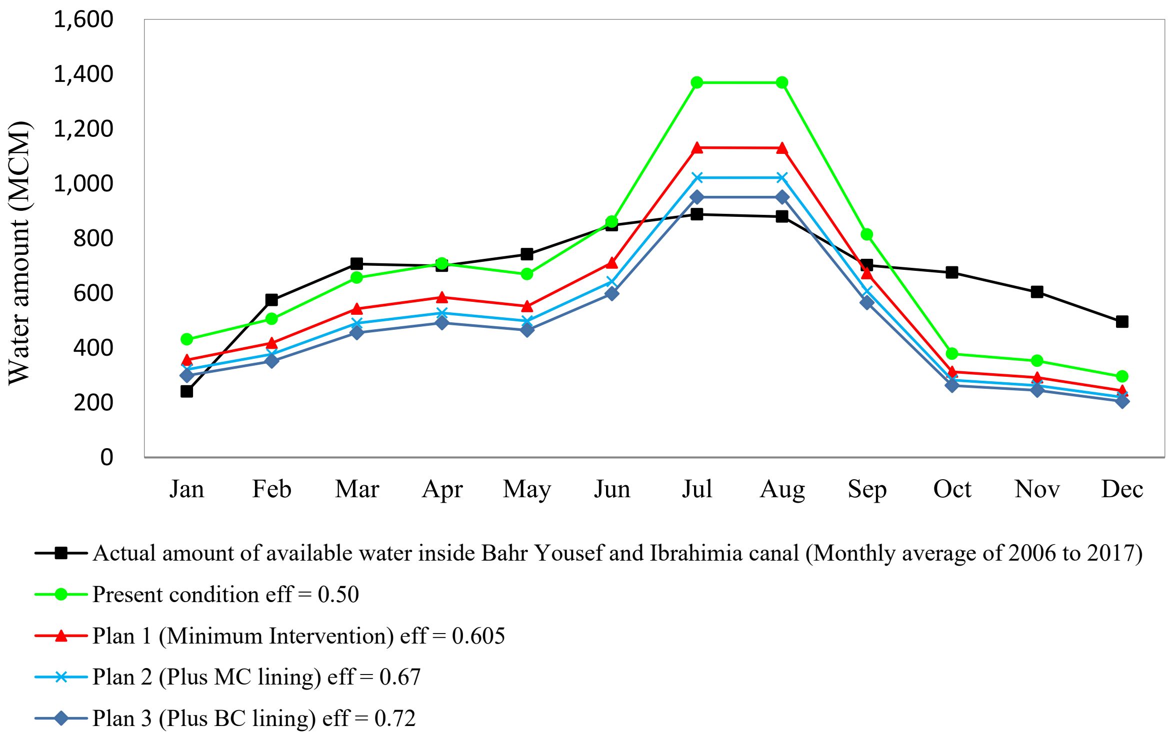
Similarly, with the implementation of Plan 2, (main canal reshaping (lining) on all sub-regions), it is estimated that the overall irrigation efficiency will increase by 17% compared to the current condition and a total of 2,133 MCM of water (about 25.4% of the available water) will be saved annually. Moreover, Plan 3 (branch canal lining in addition to Plan 2) is expected to increase the overall irrigation efficiency by 22% compared to the current condition and annually save 2,569 MCM (about 30.6% of the available water) against the current water demand. It is also projected that water shortages would be unlikely to occur during the peak month.

According to the estimated results, it is considered that through the implementation of CIWM, which combines improvements of functions of irrigation facilities from upstream to downstream in the sub-regions and appropriate distribution management, the irrigation efficiency will be enhanced and sufficient savings of water resources would be possible.

Table 5.16 Comparison of Monthly Available Water, Demand at Present and after Improvement (in MCM)

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Available water	240	575	707	700	741	847	888	879	702	675	603	495	8,052
Current Demand :(Eff. = 50%)	431	506	657	708	669	861	1,369	1,369	814	378	353	295	8,407
Plan 1 (Minimum Intervention)	356	418	543	585	553	711	1,131	1,131	672	313	291	244	6,948
Plan 2 (Plus MC lining)	321	378	490	528	499	642	1,022	1,021	606	282	263	220	6,274
Plan 3 (Plus BC lining)	299	351	456	491	464	598	951	950	565	263	245	205	5,838

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.21 Comparison of Actual Amount of Irrigated Water and Improved Plan

Table 5.17 Annual Water Demand and Saved Water after Intervention (MCM)

Condition	Current demand	Required water	Difference	Percent saved
Plan 1 (Minimum Intervention)	8,407	6,948	1,459	17.3%
Plan 2 (Plus MC lining)	8,407	6,274	2,133	25.4%
Plan 3 (Plus BC lining)	8,407	5,838	2,569	30.6%

Source: JICA Survey Team

5.6.4 Effect of Roadmap for Applied CIWM on Agricultural Aspect

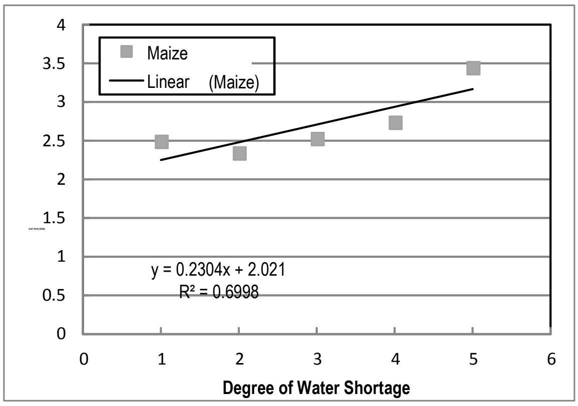
Improvement of the unit yield is expected owing to the improvement of water shortages as an effect of the roadmap on the agricultural aspect. A similar study[29] was carried out in the area where farmers are suffering from water shortages, and in the study, the farmers were asked about the degree of water shortages (Table 5.18). The proposed incremental yield ratio by improving water distribution was examined based on the analysis of the correlation between the level of unit yield and the degree of water shortages (Figure 5.22 and Figure 5.23).

Table 5.18 Water Shortage Degree and Unit Yield

Degree of Water Shortage	Ave. Yield(t/fed)		No. of Valid Sample	
	Maize	Wheat	Maize	Wheat
1	2.495	2.191	37	49
2	2.345	2.501	19	25
3	2.531	2.511	27	23
4	2.741	2.483	21	36
5	3.449	2.685	5	11
Statistics	3.33	2.800		

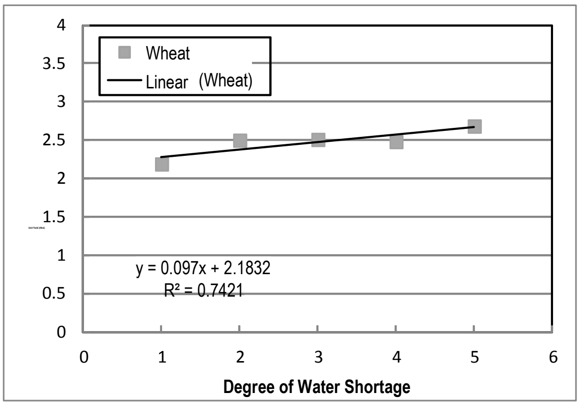
Note) Degree;
1 Water shortage frequently occurs and gives considerable damage to crops.
2 Water shortage frequently occurs and gives little damage to crops.
3 Water shortage often occurs but does not after crop growth.
4 Water shortage occurs only on a few occasions.
5 Water shortage does not occur at all.

Source: Final Report, the Preparatory Survey for the Rehabilitation and Improvement of Dirout Group of Regulators, JICA, Oct. 2010



Source: Final Report, the Preparatory Survey for the Rehabilitation and Improvement of Dirout Group of Regulators, JICA, Oct. 2010

Figure 5.22 Yield and Degree of Water Shortage (Maize)



Source: Final Report, the Preparatory Survey for the Rehabilitation and Improvement of Dirout Group of Regulators, JICA, Oct. 2010

Figure 5.23 Yield and Degree of Water Shortage (Wheat)

[29] The incremental ratio of the unit yield proposed was set with reference to "Preparatory Survey for the Rehabilitation and Improvement of the Dirout Group of Regulators, The Arab Republic of Egypt, Final Report, JICA 2010"

Table 5.19 Proposed Incremental Ratio with Project

Maize (to represent Summer/Nile crop)					Wheat (Winter/ Perenial crop)			
Degree	Yield	Increment			Degree	Yield	Increment	
	(t/fed)	per rank	cumlative.			(t/fed)	per rank	cumlative.
1	2.25				1	2.28		
2	2.48	10.2%	10.2%		2	2.38	4.4%	4.4%
3	2.71	9.3%	20.4%		3	2.24	3.8%	8.3%
4	2.94	8.5%	30.7%		4	2.57	4.0%	12.7%
5	3.14	7.8%	40.9%		5	2.67	3.9%	17.1%
	Ave.	9.0%				Ave.	4.0%	
Y= 0.2304X + 2.021					Y= 0.097X + 2.1832			

Source: Final Report, the Preparatory Survey for the Rehabilitation and Improvement of Dirout Group of Regulators, JICA, Oct. 2010

Based on this analysis, the incremental ratio of the unit yield by improving water distribution to one degree in five ranks is proposed at 9% for maize (summer crop) and 4% for wheat (winter crop). Therefore, this survey also estimates the same rate for the unit yield increase through improvement of water shortages at one degree.

Chapter 6 Improvement Program

In the previous chapter, after deriving the concept of CIWM, which is support through factor analysis on the challenges facing irrigation systems, countermeasures against the challenges were addressed and organized as a roadmap for applied CIWM. Among them, in terms of both hard and soft components, the pillar of CIWM is the requirement to improve the facilities throughout the irrigation system from principal to terminal canals. In this chapter, the draft of improvement program proposals for applying CIWM is presented. Each effort that constitutes the improvement program is examined more concretely and its contents are presented. Sub-regions are prioritized and the overall budget size of facility improvement projects in all sub-regions is estimated.

6.1 Improvement Program

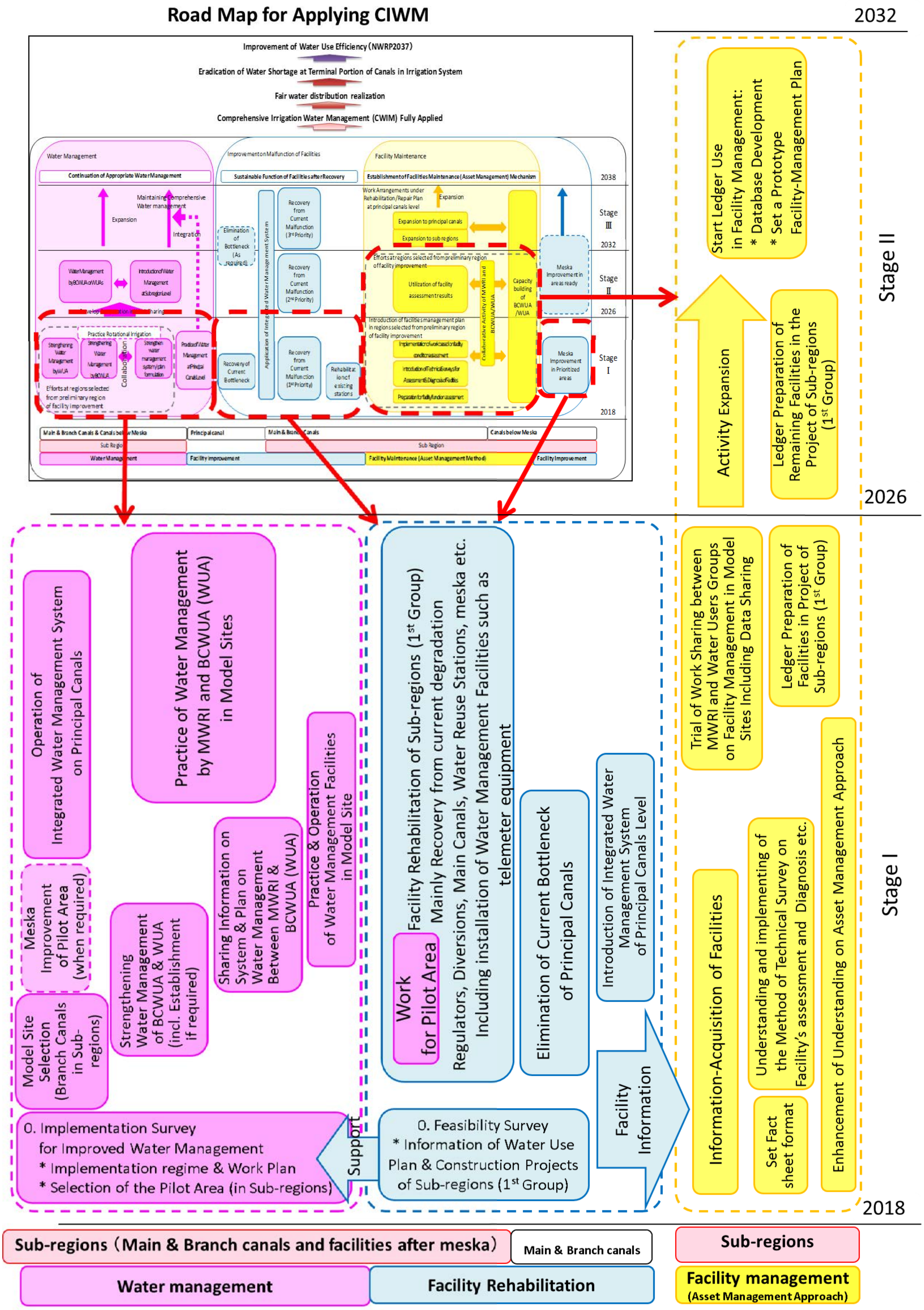
The roadmap for applied CIWM shows the long-term direction for CIWM process that appears in the cause analysis and the countermeasures. It does not explain the precise timing or detailed contents of CIWM. This chapter proposes the Improvement Program that clarifies the activities to be undertaken in the respective countermeasures with their timing in order to exhibit a series of rehabilitation work on irrigation system from the principal canals to the meskas, in collaboration between construction work (hard components) and water management practices (soft components), as well as to introduce facility management (an asset-management approach).

Hence, in the three areas of facility rehabilitation, such as water management, facility management and the Improvement Program, specific measures are employed as countermeasures in the roadmap for a fundamental stage when construction of the CIWM is implemented. In this case, it is necessary to carry out water management and facility rehabilitation correspondingly, in order to restore the functions of overall irrigation systems from the principal canal to the terminal (to secure water distribution to the terminal). Water management might be fully implemented after completion of facility rehabilitation. Since it is necessary to sustain the functions of the facilities, facility management will be started at the time when the facilities are constructed. With regard to facility management, its introduction may be set within a relatively long span, as it may be a new concept for stakeholders in this area to apply an asset management approach that enables it to retain the functions of hard components. The span should be enough to confirm the outcomes that enable further development in sub-regions for facility management. Details are explained in Section 6.2 and later, but here the Program is looked at as follows:

Regarding facility rehabilitation, firstly, a feasibility study is conducted to formulate a project plan and introduce the executive work of the countermeasures. Later on, multiple activities will be implemented simultaneously. As indicated in the figure below, water management systems will be constructed respectively at the principal canals and at the sub-regional level. In addition, functional improvements of the principal canals will be focused on by the removal of their bottlenecks. At the sub-region level, the first priority group, such as rehabilitating irrigation facilities (intakes and distribution structures), refurbishing the existing reuse pump stations, and improving meskas in the selected priority areas will be implemented. In order to accept better support from the facility management related to facility rehabilitation, careful activities are required such as a ledger preparation to refer to information on facilities rehabilitated in the projects.

Concerning water management, initially, a detailed planning survey is arranged for establishing a plan based on assessment for improvement of water management, and then specific activities are prepared, such as an implementation system, rules on water management, and other requirements for a pilot region, which will be selected among the first priority sub-regions. After that, the prepared activities will be carried out based on the plan. The main proposed activities will be conducted in the branch canals of the model sites considered as the target areas. The activities shall be carried out as capacity development for MWRI's on water management. It will (i) strengthen the management capacity of MWRI in formulating practical plans, and (ii) enhance organizational activities on water management of BCWUA/WUA. In addition to the sub-regions and at the principal canal level, the water management components will be focused on as a proper operation system going to be installed by the project for the construction of the new Dirout Group of Regulators.

Regarding facility maintenance (an asset management method) at the beginning, activities to grasp the facility's situation such as formatting inventories, etc., are undertaken, through which counterpart officers can learn techniques on how to tackle the issues through gradual understanding of asset management. Through the facility survey to accumulate information and utilize its results in the future, the counterpart officers are expected to formulate maintenance plans for wider areas, and they can promote efficient facility maintenance. In parallel, MWRI and BCWUA/WUA will attempt to improve information and systems, and therefore, various problems can be solved accordingly.



Source: JICA Survey Team

Figure 6.1 Draft Cooperation Program

6.2 Contents of Facility Improvement

6.2.1 Tasks in Facility Improvement

Specific efforts for facility improvement indicated by the improvement program are shown in Table 6.1. Each of the countermeasures will be described in detail in the following sections.

Table 6.1 Facility Improvement Efforts

No.	Efforts	No.	Contents	Target areas
0	Feasibility Study	0-1	Field survey：Extract constrains of water management, Survey water balance, List up countermeasures, Organize facility ledger (draft) for the rehabilitation target, Prioritize the target sub-regions	Principal Canals, Sub-regions (1st Priority)
		0-2	Select target for priority work	
		0-3	Surveying, Geological surveying	
		0-4	Basic design：Prepare standard construction design, Construction plan, Outline quantitative calculation, Estimate construction cost	
		0-5	Formulate a work plan (Social and environmental consideration, economic evaluation, financial evaluation, procurement plan)	
1	Practice Integrated Water Management System at Principal Canal Level	1-1	Procurement equipment for Integrated Water Management System's operation	Target of construction work of New Dirout Group of Regulators
2	Practice Integrated Water Management System at Sub-region Level	2-1	Procurement equipment for Integrated Water Management System operation	Sub-regions (1st Priority)
3	Elimination of Current Bottlenecks	3-1	Secure Cross-sectional areas of flow：Form the section	Principal Canals
		3-2	Protect canal slope of Principal canal ：Retaining wall work, Implant work, Revetment work	Ditto
		3-3	Remove discharging inhabitation part：Remove Old Hafez Regulators	Ditto
		3-4	Securing conveyance function at critical curve: Short-cut	Ditto
4	Recovery from Current Malfunction（1st group）	4-1	Rehabilitate intake work and regulators	Sub-regions (1st Priority)
		4-2	Main canal lining	Ditto
5	Rehabilitation of Existing Reuse Pump Stations	5-1	Rehabilitate water reuse stations in branch canals (new construction of suction sumps, improve pump/machinery equipment, renovate pump stations), lining of branch canal where pump station is located	Ditto
6	Meska Improvement in Prioritized Area	6-1	Meska improvement (areas to be ready)	Ditto

6.2.2 Feasibility Study

The current situation through various investigations on the principal canal and priority of sub-regions (1st Priority) is studied and the project plan is formulated by performing a basic design.

6.2.3 Integrated Water Management System

The Integrated Water Management System is divided into principal canal-level management and sub-regional-level management, and the former system will be introduced in the New Dirout Group of Regulators Construction Project at the principal canal level. To deal with the sub-regional level, an observation system that can interlock with the above system will be introduced. The details will be decided according to the progress of the New Dirout Group of Regulators Construction Project.

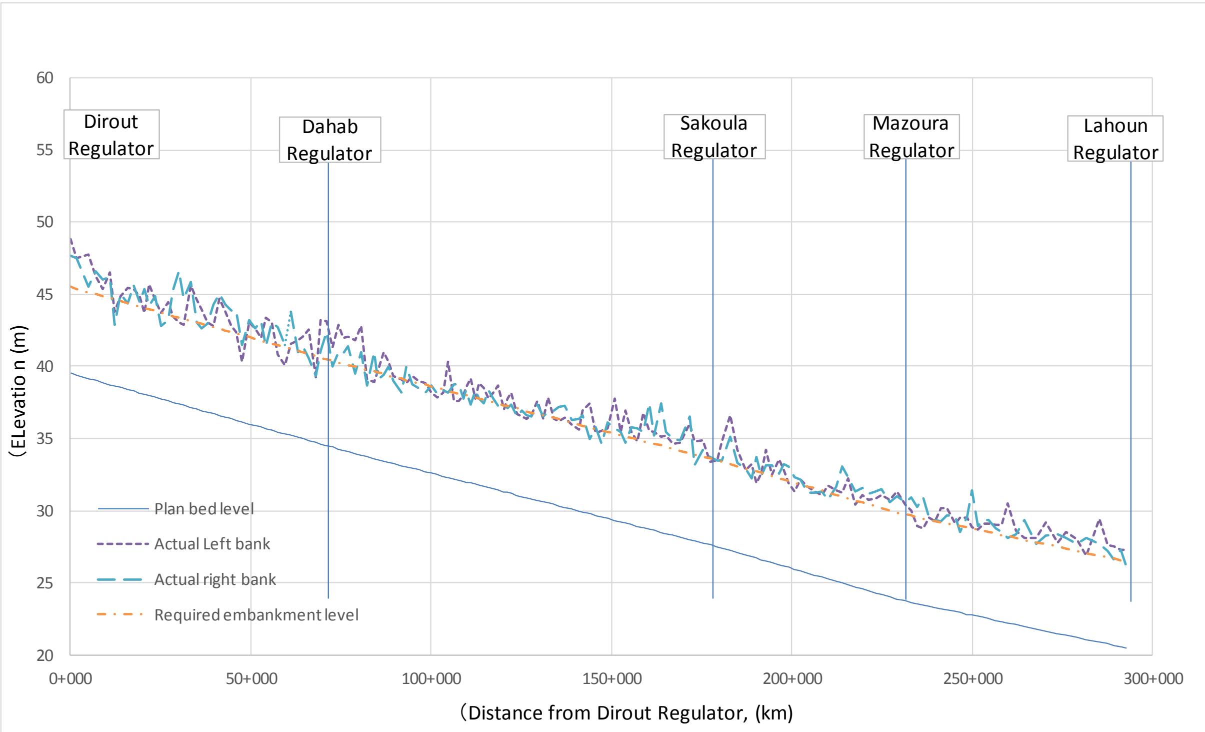
6.2.4 Principal Canal

Major countermeasures are: 1) Securing a canal's water flow capacity, 2) Canal slope protection, 3) Removal of blocking structures, and 4) Preservation of conveyance function at critical curves. These are measures to partially eliminate the bottlenecks. Since it is located in the most upstream part of the irrigation system, it is regarded as an important maintenance item for realizing CIWM including the downstream area (each sub-region). The details of each of them will be described in detail below.

(1) Securing Canal Flow Capacity

Compared to common irrigation canals, which generally are artificial canals, the Bahr Yusef Canal meanders like a natural waterway. This greatly affects changing the water flow status and results in unstable water flow. Although MWRI has carried out some maintenance work such as dredging and slope protection, the Survey Team confirms that the present cross-sections in some portions of the canals are insufficient to allow the design discharge to flow and becomes an obstacle to convey and distribute the allocated design water to the command area.

As explained in Chapter 4, the Bahr Yusef Principal Canal lacks the capacity to convey the planned water flow through the current cross-section. Figure 6.2 presents the result of hydraulic flow calculation using canal parameters (bottom level and width, suggested in the Bahr Yusef rehabilitation plan (1992)) to evaluate the water flow capacity. The planned water level includes the freeboard (maximum 0.6m) added to the calculated level.



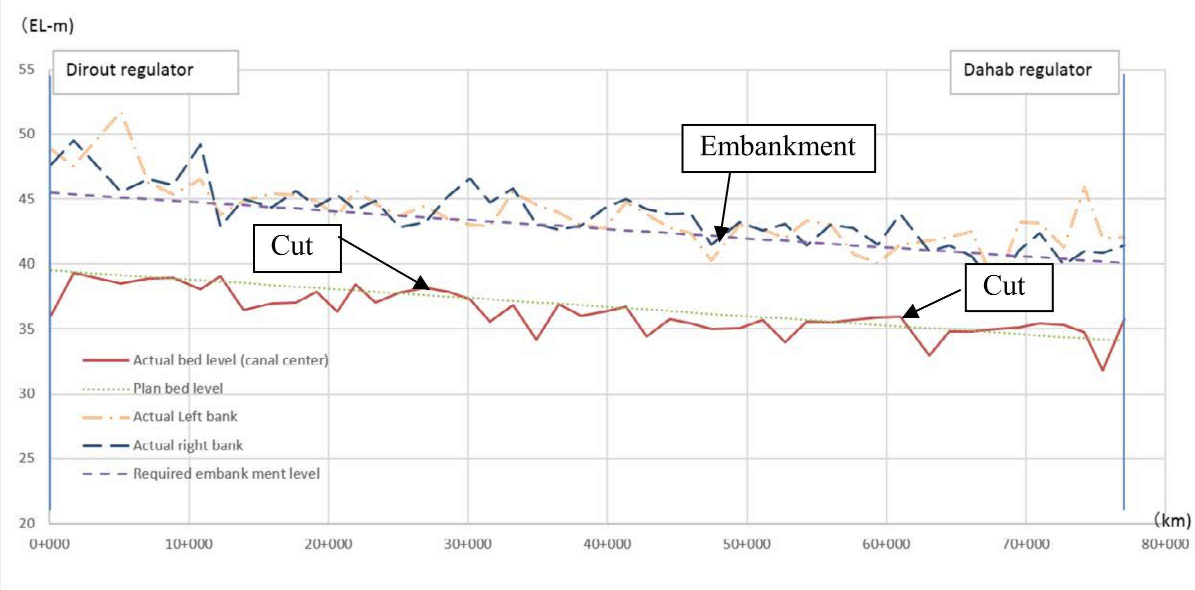
Source: JICA Survey Team

Figure 6.2 Result of Water Flow Capacity of Bahr Yusef Principal Canal after Reshape of Canal Bottom (Hydraulic Profile)

As is clear from the result above, the planned water level surpasses the top of the bank level of the canal in many sections. It indicates that the capacity of the canal is not sufficient to convey the required water through the canal.

Hence, this condition necessitates securing the required cross-section with respect to the designed water flow and to implement rehabilitation work to eliminate hydraulic bottlenecks.

From the results of the cross-section survey, a sample longitudinal profile for the upstream section of the Bahr Yusef Principal Canal (from the Dirout Group of Regulators to Dahab Regulator) is presented in Figure 6.3. The figure also shows the planned canal's bottom level and planned water level (including freeboard).



Source: JICA Survey Team

Figure 6.3 Longitudinal Profile and Improvement Plan between Dirout Group of Regulators and Dahab Regulator

As shown in the figure above, the section where the current level of the embankment is below the planned water level requires raising the canal bank's height. In addition, there are sections where the bottom level is higher than the planned canal's bed level. Securing the cross-section by excavation is necessary for these sections.

Table 6.2 shows the approximate volume of work and cost that are assumed as countermeasures (bed excavation and embankment fill) for the entire Bahr Yusef Principal Canal (from the Dirout Group of Regulators to Lahoun regulator).

Table 6.2 Approximate Construction Costs of Reshaping of Bahr Yusef Canal Cross Section for Securing Hydraulic Function

Location		Excavation (m^3)	Embankment・Fill (m^3)		Direct Construction Cost	
From	To	Canal bed	Left Bank	Right Bank	(in, 000 EGP)	(in, 000 US$)
Dirout	El Dahab	577,000	235,000	140,000	131,273	7,408
El Dahab	Sakoula	2,100,000	35,000	30,000	195,253	11,019
Sakoula	Mazoura	190,000	97,000	105,000	60,292	3,403
Mazoura	Lahoon	530,000	20,000	40,000	58,754	3,315
					Total	25,146

Source: JICA Survey Team

On the other hand, unavoidable sedimentation that progressively occurs is treated periodically as part of facility maintenance, and is expected to be dredged by MWRI.

(2) Canal Side Protection

The proposed protection of the bank of the canals is treated separately for the Bahr Yusef Principal Canal and Ibrahimia Principal Canal, as the specific approaches needed are different between the two canals. The approaches are described as below.

1) Bahr Yusef Canal

Scouring of the canal occurs on the outer side of the curve while sedimentation usually occurs on the inner side. Since scouring at the convex parts of the canal was confirmed, bank protection at these parts is needed as a countermeasure.

Countermeasures for this issue shall be a method to secure the bank slope's stability against water flow. The prevention method shall include many methods: the provision of gabion mattresses, ripraps, groins, retaining walls (pile-vent type), bottom vents and implant structures, which is the latest method for environmentally friendly pile construction.

At the time of actual construction, a method, which is reflected by the individual field status, should be selected. In this survey, two methods, namely implant (for a densely populated residential area with many restrictions) and retaining walls (for general area where usual construction is possible), are proposed as countermeasures. The implant method (sheet piling) can minimize the working space required for construction, while the retaining-wall method is the one commonly implemented by MWRI.

Reference: [Implant method]

Implant method is a sheet pile work with low noise and low vibration. The machine drives the steel sheet piles and press-in piles by hydraulic pressure with the casted sheet pile acting as a reaction force. A Japanese construction company developed the method of remote operation and penetration with Silent Piler, harmless pile jacking machine. The method can be applied in many parts of the country where retaining walls are required to protect resident and other structures.

Source: https://www.giken.com/ja/

Figure 6.4 Implant Method

The estimated volume and costs of the work as countermeasures are shown in Table 6.3.

Table 6.3 Approximate Construction Costs of Slope Protection and Upgrading of Hydraulic Function

Structure	Target	Work	No.	Estimated Unit Cost (US$)	Direct Construction Cost (US$)	Remarks
Retaining wall	Critical Curves	Piles + Retaining walls	35	429,543	15,034,000	The estimation will be modified based on the result of feasibility survey.
Implant	Sites difficult to construct a retaining wall by an ordinary method, within the critical curves, e.g. Restriction of workspace	Sheet piles by Implant Method	10	2,635,800*	26,358,000	
				Sub Total	41,392,000	

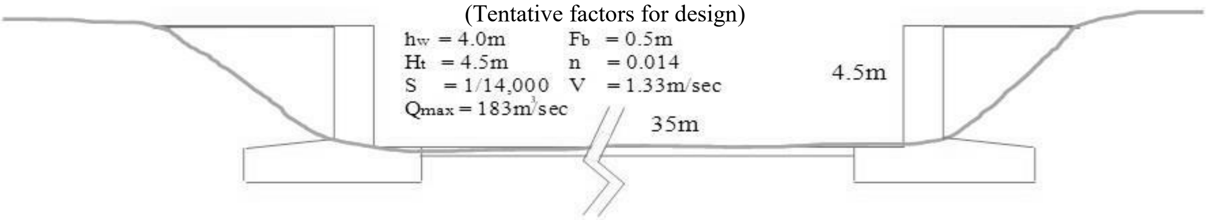
*The cost of the implant method is provided by Japanese Construction Company.
Source: JICA Survey Team

Since the erosion of the critical curved part of the Bahr Yusef Principal Canal continues year by year, it is extremely important to periodically maintain critical curves that are not included in the project implementation in order to maintain the water flow function of the canal and structural safety aspects. For this reason, it is desirable to establish an O&M system in GD related with MWRI, since maintenance can be implemented in a plan. As for maintenance improvement, the introduction of asset management as support work for soft components is proposed (see 6.4).

2) Ibrahimia Principal Canal

The countermeasures for the Ibrahimia Principal Canal shall be implemented in the section where operation and maintenance work related to dredging is difficult. The countermeasure is adopted for the section passing through several kilometers of the urban area of Minya where sediment accumulation is severe and dredging work becomes difficult. The proposed intervention is a reconstruction of the canal structure, which can reduce the maintenance, and management work needed. In particular, canal lining with reduced canal width is implemented, and it enables the increase of the flow velocity in this section. In addition, slope protection in this section will result in the reduction of O&M work.

Regarding the design of this canal, the canal shape with slopes and the water level, which do not cause problems upstream and downstream of the site, the construction materials (bricks and concrete) and the influence of existing structures such as piers should be taken into consideration. The preliminary proposed canal section (with the side retaining wall type) is presented in Figure 6.5 below.



Source: JICA Survey Team

Figure 6.5 Draft Reconstruction Plan of Cross Section of Ibrahimia Principal Canal

The volume and cost of the work for countermeasures are estimated as shown below.

Table 6.4 Construction Cost for Slope Protection of Ibrahimia Principal Canal

Structure	Status	Proposed Intervention	Direct Construction Cost (US$)
Ibrahimia Principal Canal	• According to the study made by Institute of Hydraulics on this reach, the canal can convey only 64% of design discharge. • Constructions invaded into the river make it difficult to maintain.	Bank protection by the concrete of 3 km canal reach that crosses Minya city	16,994,000

Source: JICA Survey Team

The design including the specifications (structure, the shape of the cross-section and installed elevation, and the construction plan including temporary work such as diversions) should be determined after a detailed investigation at the time of the detailed design.

Moreover, almost all of the Ibrahimia Main Canal flows parallel with the railway line, and thus safety work is needed to secure some sections when maintenance work is undertaken. In comparison to Minya City, it is assumed that normal maintenance work is possible in these sections. It is important to implement stable maintenance work with well-prepared plans in order to maintain the safety of the functions and structure of the canals.

(3) Removal of Obstacles Blocking Water Flow

This countermeasure focuses on the removal of the structure that hinders the free flow of water through Ibrahimia Principal Canal, and retaining functions that currently remain. The structure is the Old Hafez Regulator, used to control the water flow to upstream intakes. However, at present, it raises the water level unnecessarily and, accordingly, causes water losses. Hence, a direct countermeasure is the removal work of the Old Hafez Regulator. The cost estimation of this intervention is summarized in the table below.

Table 6.5 Construction Cost for Removal of Obstacle and Construction of New Bridge

Structure	Status	Proposed Intervention	Direct Construction Cost (US$)
Old Hafez regulator	The regulator is creating a considerable big head-loss on Ibrahimia Principal Canal.	Removal of regulator and construction of substitute bridge for trafic	182,000

Source: JICA Survey Team

However, the removal of this regulator necessitates the provision of a new access bridge. Since the old regulator was serving as an access bridge a substitute crossing facility should be installed. As a result, it is necessary to confirm the influence on the intakes of East and West Hafez canals located upstream close to the old regulator. Moreover, the East Hafez Canal crosses a railroad that is parallel to the Ibrahimia Principal Canal. Therefore, countermeasures should be detailed more precisely during the feasibility study.

(4) Preservation of Conveyance Function at Critical Curves

Short cut (cut-off canal) is an alternative countermeasure for shortening the canal length and avoiding the critical curves of the Bahr Yusef Canal. It also helps reduce the flooding damage to residential areas. An example of the proposed site for a cut-off canal is located around Nazlet Ramadan Village. Implementation of this cut-off canal at this particular point could reduce the canal length over 4 km and avoid about five canal curves, of which two are critical. The cut-off canal may affect around 30 feddan of existing farmland, whereas over 70 feddan of farmland can be secured from flooding by reclaiming the old canal course.

In this survey, some of the most critical shortcut points were selected and discussions were undertaken with general directors and undersecretaries of Minya and Beni Suef. The conclusion of the discussions is that land acquisition will especially be very difficult to solve, thus the method is not feasible. For this reason, the shortcut is not considered in the Survey.

On the other hand, although no great improvement in the flow status of the Bahr Yusef Canal by slope protection is expected, it enables the securing of the stability of scouring points in the critical curves. Slope protection can be a more effective countermeasure by combining it with the countermeasures for insufficient cross-sections.

6.2.5 Countermeasure in Main and Branch Canals in Sub-regions

Major countermeasures against main and branch canals are: 1) Secured facility function of key irrigation structures, 2) Recovery and upgrading water delivery and distribution function of canals and 3) Reduction of illegal garbage dumping. Details are described as follows:

(1) Securing Facility-Function of Small-scale Water Facilities

In order to distribute the necessary amount of water from the main canal to each branch canal in the sub-regions, an adequate water level at the main canal (the distribution level to channel the necessary water to branch canals) needs to be assured. The required water level of the main canal is controlled and maintained by the regulators, and the water volume that flows to the branch canal is controlled at the intake gate by the intake system. The weir and intake gate for distribution control are particularly crucial facilities to deliver CIWM in the sub-regions.

Small-scale facilities in the sub-regions are composed of a combination of intake structures, regulators, conduits (especially for countermeasures against garbage) and irrigation pumping stations including reuse pumps. The water distribution functions of these facilities are interrelated. Planned water distribution will be implemented through the execution of the improvement of these facilities.

In this section, the countermeasure for each facility such as (a) settled civil engineering facilities (including a structure with gates) and (b) mechanical equipment (pumps) or electric motors at pump stations that must be moved for operation are separate and are described as follows.

In preparing the actual plan for these facilities, it is essential to conduct a detailed field survey to confirm the detail situation of each facility, improve the accuracy of detailed design and produce a facility plan for project formulation.

Even the small-scale facilities of category (a) attached to the canals, the contents of implementing countermeasures should be separately considered as the materials they are made from, namely concrete and iron parts and as equipment such as gates. For the former part, concrete or iron, the implementing countermeasure corresponds to the level of deterioration, such as whether they need full replacements because their functionality is completely lost, such as breakage of structural parts, or they need partial repair because of functional decline such as water leakage. For the operational equipment, the parts that obstruct the water distribution function are replaced.

Concerning small-scale facilities that are classified as (b) a mechanical facility, the operation status varies from station to station, such as one which has no problems at present, but which is not operational. For mechanical facilities, as their functional deterioration may progress during operation and directly results in the decline of the performance of facilities, elimination of obstacles and improvement of facilities should basically be carried out at the time of repair and replacement.

In the field survey of reuse pump stations, common problems were confirmed as deterioration of electrical equipment such as motors as well as damage to major apparatus parts (especially valves) due to the presence of garbage caused by suction. Narrow building spaces and improper pipe layouts were also observed. As a countermeasure for them, repair and replacement of major parts of pumping facilities, renewal of the building and installation of cranes should be carried out. The installation of suction pools (and screens when required) will also be considered. Especially, a pumping station whose function was lost due to submergence will be reconstructed by raising the basement level.

The arrangement of the equipment such as pumps and motors should be determined according to the field status. A schematic image of the layout of a pump station is described in Annex 11.

In addition, regarding the construction of new reuse pump stations, an effective plan should be incorporated into the project formulation for sub-regions, based on the confirmation of the water shortage in sub-regions and available reuse water (in quantity and quality). In the plan, several pump units including a spare unit will be installed. In consideration of the compatibility of parts renewal, pumping stations should be equipped with pump units of the same capacity as much as possible (the existing station mostly consists of centrifugal pumps with a horizontal shaft of about 3 to 5 units with a capacity of 0.5 m^3/s or 0.25 m^3/s that are operated by electric motors).

Furthermore, as for the lifting pump stations, which are installed at diversion points along the Bahr Yusef canal to compensate for the lowering of the water level, it is vital to consider refurbishment corresponding to functional deterioration and equipment security during the project implementation plan after checking water requirements and canal capacity (however, they are out of the scope of this survey).

(2) Recovery and Upgrading Water Delivery and Distribution Function of Canals

The water delivery system of the canals is not properly functioning so cannot deliver sufficient water to the terminal of the canal system. This is because the canal's cross-section is deformed due to continuous sedimentation and excessive excavation of the canal's side slopes, which leads to widening of the canal. Specifically, it takes time to raise the water level from the initial state (poor recovery speed of water level), which is slower than water delivery downstream of the canal since the amount of water allowed to enter downstream of the canal system is limited, depending upon the water amount that intake facilities convey. In addition, if there is water loss or water intake in the upper stream of the canals, the influence of the decrease in the water flow rate to the downstream part becomes large leading to insufficient water for irrigation (less water downstream).

As a countermeasure, in addition to rehabilitation and updating of small irrigation facilities as mentioned before, it is essential to restore the function of the water supply/distribution system in the main/branch canals to ensure the water supply up to the end of the canal and implement planned irrigation rotation properly throughout the whole canal system. In this proposal, improvement of the water supply/distribution function is selectively added as a countermeasure according to the degree of improvement in water use of the sub-regions. Each countermeasure is discussed as follows:

1) Securing Free Flow of Water in the Canal (Countermeasure for Obstacles in Canal)

Due to illegal construction of facilities in the canals, some of the main and branch canals suffer from narrow cross-sections. This has resulted in the blockage of water flow (poor hydraulic performance of the canal). Regarding these issues, MWRI currently promotes the removal of these illegal structures blocking the water flow. Therefore, it is not accounted for as a construction cost.

2) Functional Upgrading of Canal

The countermeasures for the functional upgrading of the canals are related to preservation and restoration of a canal's cross-section. Preventing the decline of the water level of the canals and maintaining the necessary distribution amount for each branch canal would help restore the function of the conveyance system. In addition to the restoration of the canal's cross-section, canal lining can reduce the burden of maintenance work and contribute to preventing excessive excavation of side slopes. Hence, lining is an effective countermeasure to maintain and stabilize the canal structure in a situation where it is difficult to implement countermeasures for maintenance due to the lack of budget or manpower.

Lining is also expected to improve the coefficient of roughness, to reduce the water loss caused by seepage from earth canals, and to improve the efficiency of water distribution. Especially, it is an effective measure for a project to improve the distribution efficiency of main and branch canals.

In addition, when lining the branch canal, the canal's occupying land can be smaller than the soil canal, thereby increasing the available land for other usages. However, the increment is relatively small, and its use is limited as a management road, etc. Therefore, it cannot be calculated as an effect of economic activity even by considering these areas as a benefit.

Moreover, canal covering (culvert or covering by concrete) in an urban area will be considered as a countermeasure to avoid the garbage issue in conjunction with canal maintenance work in the sub-regions after confirming the status of garbage disposal. When planning culvert work of a canal, it is important to investigate securing enough cross-section to undertake maintenance activities inside (sediment discharge) or considering a hydraulic countermeasure (traction) so that it can cope with the accumulated inflow sediment.

As a construction method of canal lining, several measures could be considered as the material, economic lifetime and cost for each measure is different. In the Survey, there are three measures: i) masonry (common construction material in Egypt), ii) concrete lining and iii) concrete flume, which are compared and examined. Hence, the type of construction would be determined to formulate the project as an additional countermeasure for functional recovery described above. Since irrigation should be continued during the canal lining work, implementation on one side of the canal in certain construction spans by enclosing them with sheet piles is expected.

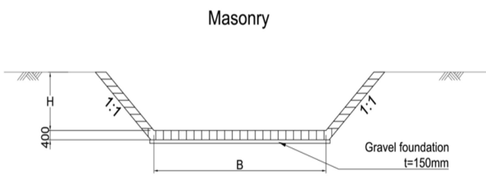
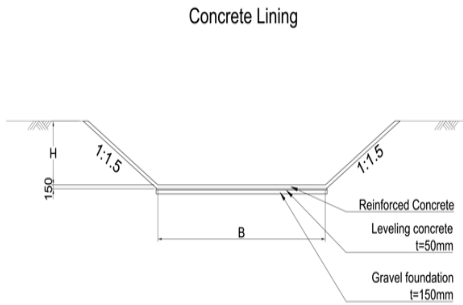
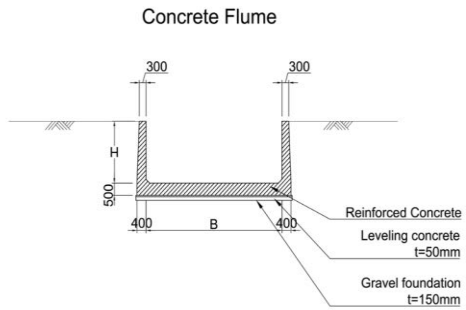
The service period of irrigation systems is predicted to be 100 years and the economic efficiency of the facilities is compared. The result is summarized in the following table. The Survey selected masonry lining as the most economically efficient countermeasure for canal lining.

Implementation of lining for all existing canals could be difficult due to time requirements and a huge budget. Consequently, lining of main canals can be planned as one of the countermeasures if it could create a greater impact when construction is undertaken.

In the planning of canal lining for each sub-region, the site condition should be carefully considered and the appropriate lining work for each sub-region should be chosen during a feasibility survey.

The following table shows the construction cost per hectare by each construction method for countermeasures for rehabilitating canals.

Table 6.6 Comparison and Examination of Construction Method of Lining

Case	Case 1	Case 2	Case 3
Method	Masonry	Concrete Lining	Concrete Flume
Features	Lining with wet masonry based on the shaping of the existing cross-section. The canal's cross-section is the same as the initial cross-section, and the gradient of the slope is about 1:1. The service period is shorter than that of concrete structures. The construction cost is small. Since the canal bottom consists of bricks, it is advantageous for implementation with other portion's simultaneous water-conveyance compared to cases 2 and 3.	Concrete lining based on the shaping of the existing cross-section. The canal's cross-section is the same as the initial cross-section, and the gradient of the slope is about 1:1.5. The service period is longer than that of masonry, but the construction cost is higher than that of masonry.	Canal construction with concrete flume. The service period is longer than that of masonry, and the hydraulic performance is also better, but the construction cost is the highest among all methods. The canal's land-occupancy can be the smallest, and thus the required area for construction work is the smallest.
Standard Cross Section			
Service Period (years)	30	50	50
Number of Construction (times/100 years)	3.33	2	2
Construction Cost (US$/ha)	477	937	1、521
Total Construction Cost (US$/ha)	1,590	1,874	3,042
Ratio of Annual Cost for O&M (%)	1.0	0.3	0.1
Annual Cost for O&M (US$/ha)	4.77	2.81	1.52
Total Cost for O&M (US$/ha)	477	281	152
Overall Cost (US$/ha)	2,067	2,155	3,194
Assessment	1 (Lowest cost)	2	3

Note: Construction cost of each type uses an average of construction unit cost in the sample area. Working life until reconstruction uses 30 years for masonry, 50 years for concrete. Ratio of annual O&M cost uses 1.0% for masonry, 0.3% for concrete lining and 0.1% for concrete flumes.
In case of rehabilitation of soil canal without lining, it embanks inside the canal and shapes the cross-section, but since it is easy to scour by running water, the canal bank will collapse and rehabilitation will be required frequently. For this reason, the repair plan with no lining canal was excluded from the comparison.
Source: JICA Survey Team

Regarding the estimation of project costs for sub-regions, the unit construction cost per hectare has been calculated using the result of average construction costs by sample survey areas, which was based on the respective construction costs for the target facilities, such as main and branch canals, small-scale structures and reuse pump stations. For this estimation, the lining of the main and branch canals can be expected to have a large effect on water-use efficiency, but its construction is costly. Hence, the construction cost was calculated for both cases with and without lining. Furthermore, the reuse pump stations largely affect the cost estimation, so calculation was respectively done for two cases, namely, the existence of pump stations within the sub-regions or the non-existence of pump stations within the region.

The repair work cost and construction cost for each sample area were categorized into maintenance levels and organized as follows:

- Plan 1: Improvement of small irrigation facilities (intakes, regulators and reuse-pump stations) in main and branch canals
- Plan 2: In addition to Plan 1, reshaping cross-section and lining of main canals
- Plan 3: In addition to Plan 2, reshaping cross-section and lining of branch canals

The summary of construction cost for the target sample sub-regions is presented below. Regardless of the lining of the main and branch canals, when rehabilitation of a pump station is implemented (with a reuse pump station), the lining of a branch canal where the pump station is situated is also considered immediately after the pump station's rehabilitation (set with the cost of a reuse pump). For additional lining of the main and branch canals, 70% of the cost was estimated for each canal extension, based on the results of the Survey in the Tunsa-Kella sub-region. (From the study on the main canal, it was determined that the existing lined section including covered canals accounted for 30% of the whole canal extension.)

The unit construction cost per hectare of each sample irrigation facility survey area is shown in Annex 10.

Table 6.7 Rehabilitation Cost of Each Sample Area (Direct Construction Cost) (1,000 US$/ha)

Contents	El Gandia	West Hafez	West Hafez	Saba	Koftan	Abo Shousha
① Small scale facility	347	616	983	587	339	163
② Reuse pump station	2,503	-	10,589	2,326	572	4,022
③ Lining cost of main canal	3,221	4,826	4,832	5,429	6,791	4,804
④ Lining cost of branch canal	3,369	13,199	6,750	4,487	5,267	4,107
Plan 1 (①+②)	2,850	616	11,572	2,913	1,195	4,185
Plan 2 (①+②+③)	6,071	5,442	16,404	8,342	7,986	8,989
Plan 3 (①+②+③+④)	9,440	18,641	23,154	12,829	13,253	13,096

For the rehabilitation and construction at the main/branch canal in the sub-regions, it is assumed that the work for small-scale water facilities and canal linings can be implemented without special construction methods, and all the work can be undertaken by existing methods in Egypt. Moreover, pump equipment and other materials would be available to procure in Egypt (including imported products) because the facilities are small-scale.

(3) Reduction of Illegal Garbage Dumping

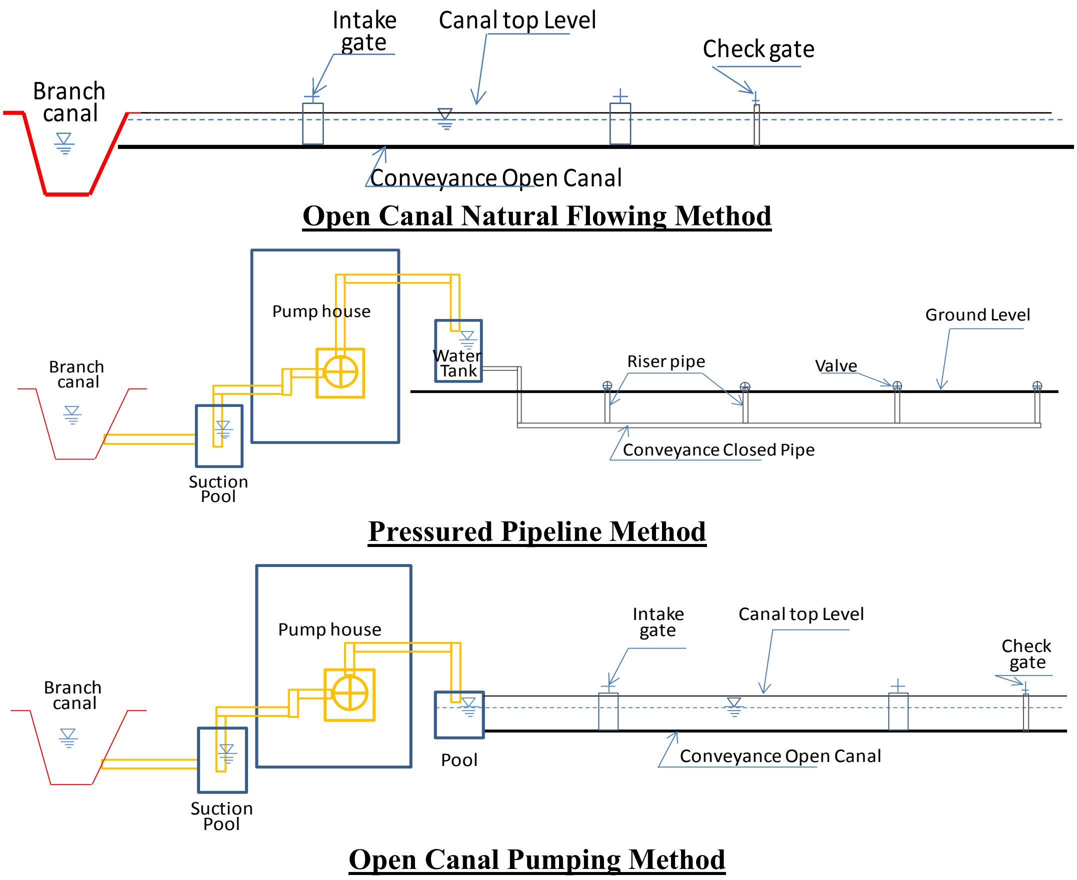
Illegal dumping of garbage by residents floats or is conveyed by the flow of water and accumulates in front of water-controlling structures such as regulators, intakes, etc. This situation has affected the performance of canals and facilities. As a countermeasure, the SWMT project promotes WMT for BCWUA through training such as garbage-reduction education, campaign of countermeasures against garbage dumping and provision of garbage-collection equipment. With this background, the Survey tackles the garbage issues as countermeasure activities against deterioration of the canal system and lists it as facility management issues in project formulation of hard and soft components. However, as mentioned above, when dealing with a conduit in canal improvement work in an urban area, several countermeasures are taken into consideration according to the situation of garbage dumping.

6.2.6 Terminal Level

The countermeasures against issues at the terminal level of irrigation canal systems are two: 1. Secure water conveyance function, 2. Introduction of modern irrigation at a farming plot level. Each detailed countermeasure is explained below. Though the reduction of illegal garbage dumping is an important countermeasure at terminal canals, the content is omitted due to the similarity to the main and branch canals.

(1) Secured Water Conveyance Function

MWRI recognizes that there is more water loss at the meska level due to insufficient irrigation facilities. Thus, MWRI considers meska improvement as an effective countermeasure to improve the situation. In addition, since meska is the terminal facility in irrigation systems, water users can understand the importance of water management through their involvements in O&M at meskas. Reflecting these situations, many supporting projects by donors have been implemented since the 1990s in Egypt. Generally, there are three methods of meska improvements implemented so far, these are open canal natural flowing method, pressured pipeline method and open canal pumping method. Meska distributes water from branch canals to meskas by gravity and meskas are open canals with lining. By the pressured pipeline method, meska pumps up water from branch canals to a water tank and the meskas are made of pipelines. Meskas of a pressurized open canal pumping method are also observed in some parts of the target area.



Source: JICA Survey Team

Figure 6.6 Method of Meska Improvement

The choice among these methods solely depends on the preference of the farmers (WUA). According to the previous interview, some farmers preferred to see the water flow in the meska canal, and the others wanted to use the additional land that was previously used by meska as farming fields when they chose the buried pipeline method.

In the beginning, the open canal meska improvement system was predominant in Minya and Faiyum governorates. Gravity flow needs a terrain gradient, which is appropriate to divert the water from branch canals to meska. For this reason, the open canal method was adopted mainly in Faiyum due to the applicable gradient and the continuous irrigation to the meska level. In addition, Faiyum needs better water management than the other area, because it faces serious water shortages in the peak period.

On the other hand, the use of water lifting devices in the meska improvement eases the restriction of terrain requirements, and it shows specific features enabling the elimination of the need for pumping after meska. Recently, the adoption of the pressurized pipeline method for meska improvement is increasing. At present, about 70% of meska improvement is conducted by a closed pressurized method especially in Minya and Beni Suef. The reasons for this trend might be an increase in the water-use efficiency that is derived from the fact that there is no evaporation from the water surface and water leakage decreases. Moreover, it is expected that the waiting time for irrigation water to reach the terminal is greatly shortened. This can decrease the water management loss, and make it easy for the operation to distribute the water.

With regard to water use at the terminal level, improved efficiency can be achieved through proper water management by the users of the rehabilitated facilities. This kind of improvement has been implemented by the previous supporting projects. Both the countermeasures of meska improvement of hard components and water management by WUA (BCWUA) as the users of the soft components are simultaneously introduced to solve the lack of water at the terminal of the irrigation system. Therefore, regarding the maintenance of facilities from the viewpoint of hard components, the pressured pipeline method is superior to others. That is, the success of the water management of the soft components mostly depends on the intention of the users who manage and operate the terminal facilities.

Considering the situation above and the adaptability of meska improvement at individual sites, these methods can be applied through countermeasure selection, respecting the intentions of WUA (or BCWUA) as water users.

Since the meska improvement will be implemented in specific sub-regions at first, the cost is estimated based on the information obtained at the area. As the result, it is calculated at 15,000 EGP (US$846)/feddan, equivalent to US$2,015/ha. The breakdown is shown in Table 6.8.

Table 6.8 Cost Breakdown of Meska Improvement Project

Item	Cost (EGP/feddan)
Meska body	10,000
Pumphouse	1,500
Pump and control panel	2,000
Temporary and indirect cost	1,500
Total cost	15,000

Source: JICA Survey Team based on date from MWRI

Table 6.9 Tentative Cost of Meska Improvement Project

No.	Sub-region	Targeted Meska	Beneficiary Area(ha)	Unit Cost (US$/ha)	Amount (US$)
1	22. Aros Abo seer	➢ Meska of Abo seer canal ➢ Meska of Arose canal	6,006	2,000	12,012,000
2	19. El Gharka	➢ Meskas of Tatoum, ➢ Gergeba and ➢ Bushunt Branch canal	8,610	2,000	1,722,000
3	21. Bahr Wahby	➢ Meskas of Wahbi, ➢ El Roubyat and	4,746	2,000	9,492,000

No.	Sub-region	Targeted Meska	Beneficiary Area(ha)	Unit Cost (US$/ha)	Amount (US$)
		➢ Bahr El Mahgara canal			
4	27. Sanhour	➢ Meskas of west El-Robee, East el Robee, El Robee El Kebeer, El Robee El Sagher, ➢ El Robee El Waty branch canal	6,930	2,000	13,860,000
5	29. Desia, 31. El Gharbia	➢ Meskas of Main Motawel ➢ Tabohar, Gardo ➢ El Koom ➢ El Awsay ➢ Abo Esha	5,250	2,000	10,500,000
6	28. Senrew	Meskas of Ganabyet El Seka El Hadeed	710	2,000	1,420,000
7	30. Bahr Talat	Meskas of Anz and Ganabyet Anz	588	2,000	1,176,000
		Direct Temporary		15%	9,852,000
		Total Price	32,840		75,532.000

Source: JICA Survey Team

This unit cost is used for the estimation of the projects cost as shown in Table 6.9. The sub-regions subject to meska improvement in the cooperation program are shown in Table 6.9, positive attitudes and approval of the farmer groups are essential. Hence, the proposed meska improvement project targets the region where beneficiaries take the initiative with positive attitudes and MWRI starts preparation for project implementation. This targeted area is considered an appropriate area and is located in Faiyum, which is the terminal level of the Bahr Yusef Principal Canal.

(2) Consideration of Irrigation Improvement on Farm Level

In Egypt, although new reclamation of farmland in the desert area has been undertaken, the introduction of modern irrigation systems in the area, based on water saving technologies, such as sprinkler irrigation, drip irrigation, etc., is required from the viewpoint of efficient water use at the field level. The main target in the Survey is existing farmland called "old cultivated land" in which small farmers operate self-sufficient agriculture. Although these existing farmlands are different from the new settlement places, which is premised on commercial development, MWRI is also interested in introducing modern irrigation systems to the existing farmlands in order to further improve the efficiency of water use. The issue of a field-level irrigation system is examined preliminarily. In the actual introduction, it is necessary to overcome the issues, such as the economic, technical and institutional aspects as described below. Then, it required processes such as appropriate investigation and testing. In this context, the modern irrigation system is not accounted for as construction costs.

Table 6.10 Each Type of Irrigation Efficiency

Type	Irrigation Efficiency (%)
Surface Irrigation	60
Sprinkler Irrigation	75
Drip Irrigation	90

Source: Irrigation Water Management: Irrigation Scheduling Annex I, FAO, 1989

1) Irrigation Efficiency

Each type of irrigation efficiency of surface irrigation, sprinkler irrigation and drip irrigation is shown in Table 6.10. The efficiency of water conservation is expected to be 15% by sprinkler irrigation and 30% by drip irrigation compared with surface irrigation, which is implemented in existing farmland in Egypt. Therefore, it is suggested that the efficiency of water conservation is significant when modern irrigation systems are installed.

Table 6.11 Initial Investment Amount of Modern Irrigation

Items	Sprinkler irrigation (Pump)	Drip Irrigation (Pump)
Ownership cost	760	1,270
Maintenance and inspection expenses	80	100
Labor costs	150	40
Electric bill	80	120
Total amount	1,070	1,530

Source: JICA Survey Team

2) Issues

In a case where the introduction of the modern irrigation systems to existing irrigated farmland is examined in the target area, the following issues can be considered.

i) Consideration of the Economic Efficiency

The initial investment amount (refer to the Table 6.11) for introducing modern irrigation systems and the subsequent O&M costs are not small. This is because a modern irrigation system requires (a) pumps and pipelines to deliver the pressed water to terminal level and (b) a variety of equipment such as flow meters and pressure gauges, etc., to achieve adequate water management in the farm level. Consequently, in general, the modern irrigation system is applied to commercial crops such as vegetables, fruit trees, etc., rather than cereals produced self-sufficiently. Therefore, it is necessary to properly estimate the investment cost and profit and to forecast the income and expenditure when the modern irrigation system is introduced.

In addition, the small-scale farmers in the existing farmland cannot afford to pay the high initial investment and the introduction of the irrigation system by their own funds would be hard unless some incentives drive them with financial and practical supports.

However, it is not easy to make a profit in this situation where the advances in terms of scale merit cannot be expected even if high-value-added crops are produced. This is because the average cultivated land area of farmers is as small as one hectare or less. Therefore, careful consideration subsequent to development is required through a model case, which is introduced and formed as a pilot project.

ii) O&M of Modern Irrigation System

The modern irrigation system is rather complicated compared to the surface irrigation system, because it required various pieces of equipment, and technical skills and knowledge. In the situation where there is no experience of farmers who introduced a modern irrigation system in the area, it is controversial whether appropriate O&M can be implemented in this situation. In particular, the source of the irrigation water in the target area is surface water containing silt and minute pieces of garbage from the Nile River. In order to introduce a modern irrigation system in this area, filters to remove the silt and garbage are essential and appropriate O&M of the system is a prerequisite.

iii) Collaboration among Ministries and Agencies

Field irrigation is under the jurisdiction of MALR and the introduction of a modern irrigation system is the same. Therefore, it is not realistic for only MWRI to proceed with its introduction, so it is expected to proceed jointly with MALR. Meanwhile, cooperation and collaboration between the two ministries are indispensable; however, the cooperative system between the two ministries is not currently very active. Thus, it is necessary to establish a better cooperative framework.

6.2.7 Summary of Countermeasures in Facility Maintenance

As mentioned above, various countermeasures are required as facilities maintenance, and these contents are diverse. The following explains the countermeasures for each canal level. Then, the impact of project implementation is validated at each maintenance level.

(1) Countermeasures for Each Canal Level

Countermeasures for the hard components are described in 5.3.1, and the countermeasures assumed for principal, main, branch and terminal canal levels are as shown in the table below. Basically, all countermeasures are effective for realizing CIWM.

Table 6.12 Countermeasures for Each Canal Level

Canal	Purpose	Countermeasure
Principal canal	1. Securing necessary cross-section for conveyance	＜Bahr Yusef Principal Canal＞ ・Banking of canal bank that height is insufficient. ・Excavation at the high bottom of the canal
	2. Protecting canal bank	＜Bahr Yusef Principal Canal＞ ・Bank protection works at critical curves (Retaining wall and implant Method) ＜Ibrahimia Principal Canal＞ ・Bank protection works at the urban area (Retaining wall)
	3. Removal of obstacles for water flow	＜Ibrahimia Principal Canal＞ ・Removing an old regulator and construction of a new bridge
Main and branch canal	1. Preserving function of small-scale structures	Rehabilitation of Irrigation facilities such as intake, regulator, weir, conduit, water-reuse station, and pump station: Essential
	2. Rehabilitation and Improvement of water-distribution function of the canals	・Lining of main canals (wet masonry) ・Lining of branch canals that need to be improved (wet masonry)
	3. Securing necessary cross-section for conveyance	Removing illegal building by MWRI
	4. Deterrence of illegal garbage dumping	・Enlightenment activities etc. ・Including box culvert and lidding that are effective for dust prevention in countermeasures against function-retention of small-scale irrigation facilities
Terminal canal	1. Improvement of water-distribution function	Meska improvement in Faiyum etc. (Lining and Pipeline)
	2. Improvement of irrigation at field level	Sprinkler and drip irrigation might be introduced. However, institutional aspects and validity should be verified through testing from the viewpoint of economic efficiency.

In terms of the rehabilitation works of the hard component, MWRI requests meska improvement, construction and refurbishment of pump stations, the introduction of modern irrigation facilities and utilization of land.

As for the use of the land to become available, a plan to utilize it for the maintenance road and/or other purposes is considered in the following steps. Meanwhile, the meska improvement, and the construction and refurbishment of pump stations are factors contributing to CIWM realization. The meska improvement has great relevance to WMT, which plans the terminal facilities in which water user groups are actively expected to participate. Since this participation is one of the indispensable factors for the terminal facilities of the canal systems, the meska improvement is an essential part of CIWM. In addition, the construction and refurbishment of pump stations have a major role to play in increasing water volume in the sub-regions where water is expected to be supplied as much as possible to meet irrigation requirements. From this point of view, the construction and refurbishment of pump stations contribute to furnishing conditions for dealing with equitable water distribution in the canal systems. Accordingly, its significance in CIWM is obvious. In terms of the introduction of modern irrigation facilities, which is mainly an activity at field level, insufficient conditions are currently prevailing among farmers who have not yet acquired new irrigation skills. CIWM might not demonstrate its practical outcomes in such conditions. Therefore, the facility development is not realistic for current CIWM. However, it is an important issue from the aspect of improvement of efficiency of irrigation water use in the end. Thus, it is worth considering for the modern irrigation systems to include in the scope of the technical cooperation of water management as explained in the following section.

(2) Impact of Each Rehabilitation Level

Regarding the facility maintenance plan (rehabilitation of principal canals and plans 1, 2 and 3 that are maintained within sub-regions) at each rehabilitation level shown above, the impact of implementing these facility rehabilitation projects for achieving project goals will be arranged in Table 6.13. If these countermeasures are not taken, the facility function will decline as a negative impact. Then, the water management work will be hard to carry out, and appropriate water distribution will be difficult. Therefore, early implementation of these countermeasures is required.

The Goal of Project Implementation: Applying CIWM (recovery of facility's function in a wide area)

- Principal canal: Applying for distribution of the required water to each sub-region
- Main and branch canal: Enabling the water to reaching the end of the canals at each sub-region. Equitable water distribution and improvement of irrigation efficiency (saving water).
- Terminal canal: Improvement of water distribution at meskas

Rehabilitation Standard:

- Plan 1: Improvement of small irrigation facilities in main and branch canals (basic countermeasures)
- Plan 2: In addition to Plan 1, lining and reshaping cross-section of main canals
- Plan 3: In addition to Plan 2, lining and reshaping cross-section of branch canals

Table 6.13 The Impact of Implementing Facilities Rehabilitation Projects each Rehabilitation Level

Canal level	Rehabilitation level	Impact
Principal	Improvement of bottleneck	• The planned amount of water is delivered safely and securely by rehabilitation of insufficient water-flow and insufficient canal banks, and removing of obstacles from the canal. • Implementation of canal-bank protection work facilitates rehabilitation of the section and reduces labor and cost. • Erosion is prevented, and the land related to local residents (farmland, residential land, road, railroad etc.) is secured by implementing protective work in a dangerous place (critical curve, urban section, etc.)
Main and branch canal	Plan 1	• Planned rotation of irrigation is possible by rehabilitation of small-scale structures such as regulators and intakes (However, it is a prerequisite to accompany improvement in water management technology on the soft component). • Effective use (water saving) is possible by rehabilitation of reuse-pump stations. • Rehabilitation of culverts in urban areas, etc., can reduce dumping of garbage in canals. • It is possible to improve the water-distribution function to each branch canal by rehabilitation of irrigation facilities. However, under the widening/deformation of the cross-section, it is insufficient in terms of "secure" arrival of water to the terminal of the canal and realization of equitable water-distribution to each branch canal. • Formalization of deformed canal's cross-section is difficult in soil canals (even if it can be shaped temporarily, it will deform with the passage of time and cannot maintain its durability).
	Plan 2	• Planned rotation of irrigation is possible by rehabilitation of small-scale structures. • Effective use (water saving) is possible by rehabilitation of reuse-pump stations • Rehabilitation of culverts in urban areas, etc., can reduce dumping of garbage in canals. The lining of main canals will reduce rehabilitation and management work (removal of soil and sand, water grass, etc.). • Reshaping the canal's cross-section is possible by lining the main canal. Then, the water division and the water discharge will be easy to secure. • However, if the cross-section's deformation of the branch canal is serious, even if the water level and the water discharge can be secured at the entrance to the branch canal, the water supply function cannot be sufficiently fulfilled, and it is impossible to guarantee reliable delivery to the terminal canal. • Since canal cross-section width can be narrowed by lining the main canal, effective utilization of areas (management passage etc.) is possible.

Canal level	Rehabilitation level	Impact
	Plan 3	• Planned rotation of irrigation is possible by rehabilitation of small-scale structures. • Effective use (water saving) is possible by rehabilitation of reuse-pump stations • Rehabilitation of culverts in urban areas, etc. can reduce dumping of garbage to canals. The lining of main and branch canals will reduce rehabilitation and management work (removal of earth and sand, water grass, etc.). • Reshaping canal's cross-section is possible by lining the main canal, and water elevation and water discharge will be easy to secure. • Whole water-distribution function to meska is sufficiently improved by implementing lining of branch canals. • In addition, appropriate and equitable water distribution to the terminal becomes possible. • Canal's cross-section width can be narrowed by lining main and branch canals, effective utilization of area (management passage, etc.) is possible.
Terminal canal	Meska improvement	• By meska improvement, the water-arrival time to the end becomes shorter, the water-management loss is reduced and water distribution becomes easy. This is particularly noticeable in the pipeline system. • Water evaporation, leakage, transpiration from undesirable aquatic plants, etc., are reduced. Thus, water-use efficiency is improved. This is particularly noticeable in the pipeline system. • The occupied land width is reduced (effective utilization of saved land), and land-border problem is alleviated. • Irrigation time and labor, and rehabilitation efforts of meska will be reduced. • Pipelining reduces garbage-dumping problems.

6.3 Contents of Water Management Improvement

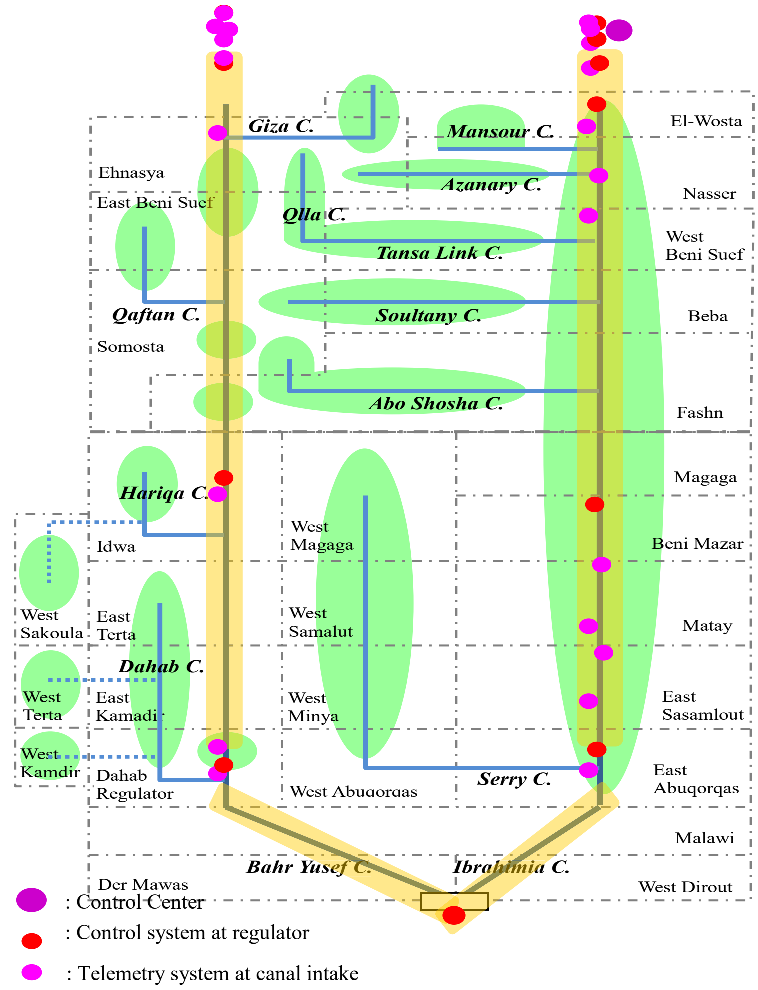
6.3.1 Concept of Water Management Improvement

Concerning water management, its countermeasures are primarily different between the principal canal level covering a broader region and the sub-region level composed of a canal system under the main canal. The details are described respectively as below. Regarding water management within the sub-regions, the management entity differs from each canal system. Hence, practiced roles expected of each organization should be discussed: namely MWRI is as a supplier of water and BCWUA and WUA are as users of terminal facilities.

(1) Concept of Water Management Improvement at Principal Canal Level

The Integrated Water Management System is going to be introduced in the new Dirout Group of Regulators Construction Project. A central water management center is planned to be set up in Beni Suef, and it will supervise each of the offices in charge of water management. The Integrated Water Management System covers 13 main regulators in the principal canals and 41 intakes at the major main canals along the principal canals. Its responsibility is comprehensively managing and monitoring water-use in the area under the Dirout Group of Regulators. Its layout appears in Figure 6.7, and the area in orange in the figure schematically shows the target management area under the Integrated Water Management System.

By establishment and operational practice of the Integrated Water Management System, the status of water management will become visible, and possible to be recognized as rational, unitary, and proper. Then, information sharing will accelerate and promote better collaboration among stakeholders. Accordingly, the new Dirout Group of Regulators Construction Project is a prerequisite for the implementation of the project on soft components, or water management, to be undertaken in the Survey area.



Source: JICA Survey Team

Figure 6.7 Plan of Integrated Water Management System

Meanwhile, in the new Dirout Group of Regulators Construction Project, the soft components of water management are not included. Then, technical capacity development for MWRI, which is directly related to water management at the principal canals, is outside of the project. As for supporting the hard components installed in the new Dirout Group of Regulators Construction Project, a project for the soft components concerning water management at the principal canals is required. In addition, since stations are also located at intake points of the main canals, it is reasonable that ID staff and IS staff who participate in water management at the main canals are also targets of the water management strengthening. Understanding by CIWM is also a significant prerequisite in order for it to mutually combine with the projects on soft components for water management between sub-regions and principal canals.

(2) Concept of Improvement in Water Management of Sub-regions

In a system including a series of canal levels in the sub-regions, flexible and consistent water distribution/management needs to be introduced for a further increase of water use efficiency. Based on the circumstances that various staff are in charge of water management at respective parts of the canal system, MWRI should develop and implement a supply-oriented water-distribution plan with flexible operation, and BCWUA/WUAs should respond to the practice of equitable water distribution within their management areas. Moreover, it is essential that MWRI and BCWUA/WUAs should collaborate in the establishment of sustainable and equitable water management systems.

The vast irrigation system has been continuously functioning over a considerable period. This aging system largely depends on MWRI's capacity for irrigation system operation to fully utilize water resources with water management. MWRI's management know-how for water distribution is based on (1) the precise implementation of conveyance and delivery of irrigation water derived from years of experience, (2) the operation of irrigation facilities for water distribution, the accumulated experience to grasp the situation, and (3) the ability to respond in an emergency, etc. While fully using this know-how, MWRI is required to implement a plan for water distribution (supply) that responds as much as possible to changeable water demand in order to further improve water-use efficiency to tackle the constraint of limited water resources. The water management would be responsible for the supply side of the irrigation system.

Meanwhile, BCWUA/WUAs need to undertake their roles for putting in practice the planned water use of branch canals or meska-level areas in cooperation with MWRI's water distribution. This involves establishing and strengthening the organization of BCWUA. However, at this moment, it is not in progress as planned by IDs who promote this direction at the field level. For this reason, it is important to strengthen the capacity to contribute to both MWRI's policy on the technical side and BCWUA/ WUAs' concern regarding water management. It is an essential requirement to enhance functions corresponding to the responsibilities of water management among the organizations in a series of irrigation systems.

Especially, cooperation among MWRI offices is crucial to promote rational water distribution by the supply side in the system. In addition, in order to practice equitable water distribution under a planned rotation rule in the irrigation system of sub-regions, which recover their functions by implementing the hard component projects, it is necessary to clarify the roles on water allocation and cooperation on water management between MWRI and WUAs. Establishing a participation mechanism is also required with MWRI and BCWUA/WUAs for collaboration.

6.3.2 Tasks in Water Management Improvement

Detailed activities of water management improvement are described in the improvement program in Table 6.14.

Table 6.14 Tasks in Water Management Improvement

No.	Subject	No.	Contents	Target Group	Target Area
0	Detailed Planning Survey for Formulation of Water Management Improvement Plan	0-1	Grasp Current Status & Plan of Water Management of F/S Area		Sub region (1st Priority)
		0-2	Selection of Pilot Region (Sub region targeted with Technical Cooperation)		
		0-3	Confirmation of Regime in Pilot Region		Pilot Region
		0-4	Showing a Development Plan of Water Management on Pilot Region and its Implementation Plan		Pilot Region
		0-5	Proposal of Approach in Water Management (Implementation & Method)		
1	Strengthening Regime & Planning Water Management & Its Practice	1-1	Confirmation of Facility Rehabilitation Project in Pilot Region		Pilot Region
		1-2	Formulation of Regime & Implementation of Water Management based on CIWM	Mainly MWRI	Pilot Region
		1-3	Setting of MWRI's Detailed Water Management Plan for Pilot Region	Mainly MWRI	Pilot Region
		1-4	Selection of Model Site (Branch Canals in Subregion for Cooperation)		Pilot Region
		1-5	Agreement & Sharing of Detailed Water Management Plan	MWRI and BCWUA&WUA	Model Site
		1-6	Practice based on Detailed Water Management Plan	MWRI and BCWUA&WUA	Model Site
		1-7	Operation by Detailed Water Management Plan	MWRI and BCWUA&WUA	Agreed Branch Canal Area in Pilot Region
2	Strengthening Water Managemer of BCWUA and WUA	2-1	Reconnaissance Survey of BCWUA & WUA	BCWUA&WUA and MWRI	Pilot Region
		2-2	BCWUA & WUA Establishment (if required)	Mainly MWRI	Model Site
		2-3	Training on Capacity Development for Water Management	BCWUA&WUA	Pilot Region including Model Site
		2-4	Agreement & Sharing of Detailed Water Management Plan	BCWUA&WUA and MWRI	Model Site
		2-5	Practice based on Detailed Water Management Plan	BCWUA&WUA and MWRI	Model Site
3	Operation of Water Management System	3-1	Practice of O&M for Integrated Water Management System	MWRI	Stations Constructed in the new Dirout group of regulators construction project etc.
		3-2	Training for O&M for Water Management System of Pilot Region	MWRI	Pilot Region
		3-3	Practice of O&M for Water Management System of Pilot Region	MWRI	Pilot Region

Note: The pilot region is a sub-region subject to technical cooperation. In the improvement program, it is a region that rehabilitation facilities for loans that allow for the start of cooperation on the soft components.
In addition, the model site is a site covered by technical cooperation in the pilot region. Since it is targeted at WUA/BCWUA, it is assumed that implementation is carried out within the range of branch canal level. For details, see 7.3.1 (3).
Source: JICA Survey Team

6.4 Activity of Improvement in Facility Maintenance

6.4.1 Concept of Improvement of Facility Maintenance

Similar to water management, it is important to note that the roles and organizations of MWRI and irrigation associations are different among management entities. As mentioned in the previous chapter, basic countermeasures are the introduction of the asset management method.

Since MWRI is the primary operator of the irrigation system as a whole and has the role to be responsible for the continuous use of the system, it is necessary to lead the maintenance activities of irrigation facilities. For this reason, while having limited input in the budget, etc., it is needed (1) to promote maintenance by minimizing the deterioration of the structure/function of individual irrigation facilities in the system, (2) to oversee the entire irrigation system, such as whole principal canals, the regulators on the canal, etc., and (3) to maintain canals and small-scale structures within the sub-region after the intakes.

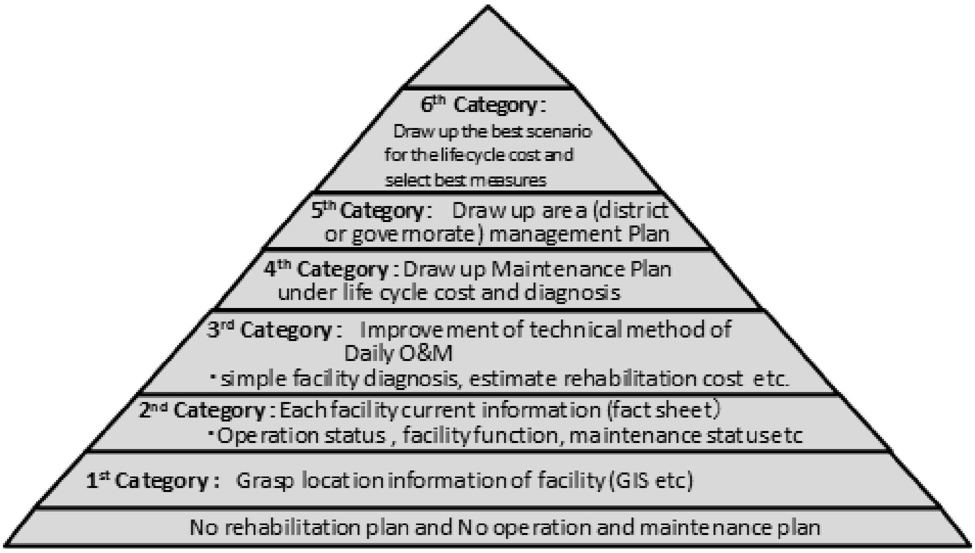
Meanwhile, BCWUA/WUA are expected to participate in the maintenance of terminal facilities as well as water management under the guidance of MWRI, and it can play a role in maintaining and controlling the terminal irrigation facilities.

Therefore, although it is necessary to expect BCWUA/WUA to play the maintenance role at the terminal, it is assumed that the maintenance of the irrigation system as a whole is performed by MWRI at the initial stage. Therefore, it is important that MWRI periodically confirms the state of irrigation facility's function deterioration, the safety of facility structures, etc., at a series of canal levels, and acquire maintenance-related technology/a mechanism to reduce the negative influence on those irrigation facilities. Then, a part of the asset management method is introduced.

As for the asset management mechanism, while the facility maintains a certain level of health, it aims (a) to lengthen the lifetime of the facility by taking necessary measures and (b) to reduce the life-cycle cost. In practice, it is necessary (i) to accurately grasp and organize the basic information of the facility, (ii) update the information through routine and periodic inspections, functional diagnostic surveys, etc., and (iii) take appropriate countermeasures. In the case of Egypt, which is aiming to newly introduce asset management, MWRI is expected to construct a mechanism to implement maintenance of planned facilities through a field survey to grasp the facility state by the asset management method, mainly visual examination of the function diagnosis, and making the facility management ledger (function, position, year of construction, repair history, etc.). In addition, through the creation of the facility maintenance plan with the assistance of the asset management method, it is also necessary to help facility management personnel understand the technologies and methods, which are necessary for smooth maintenance work.

Figure 6.8 shows the triangle categorization of asset management. From the bottom, 1st Category: Grasp locational information of facilities, 2nd Category: Maintenance of the facility ledger, 3rd Category: Improvement of technical method of daily O&M, 4th Category: Draw up maintenance plan, 5th Category: Draw up maintenance plan of regional facilities, and 6th Category: Selection of the countermeasure considering life-cycle cost. As for the improvement program, it is required to build a structure to implement more reasonable facility maintenance. Therefore, the realization of 4th Category in the pilot region is assumed.

In addition, as with water management, it is necessary to divide and coordinate the roles of maintenance of each irrigation facility controlled by MWRI and BCWUA/WUA in order to carry out maintenance on irrigation systems that have recovered their function by improving hard components. Then, it is vital to create a mechanism for MWRI officials and BCWUA/WUA.



Source: JICA expert at MWRI

Figure 6.8 Leveling of Asset Management

6.4.2 Efforts to Be Made for Improvement of Facility Maintenance

Specific efforts to improve facility maintenance indicated in the improvement program can be arranged as shown in Table 6.15.

Table 6.15 Efforts in Improvement of Facility Maintenance

No.	Efforts	No.	Contents	Target	Target Area
1	Prepare to grasp facility condition	1-1	Acquire facility information (location, condition, etc)	ID (IS、IIS、RGBS)	Sub-regions (1st Priority)
		1-2	Prepare a fact-sheet format and acquire technique of facility survey method	ID (IS、IIS、RGBS)	Ditto
2	Introduce technical survey on facility condition and diagnose	2-1	Foster understanding of Asset management method	MWRI	-
		2-2	Acquire survey techniques (theory)	MWRI	-
3	Conduct works recommended by facility condition survey and diagnose (establish method)	3-1	Conduct facility survey	ID (IS、IIS、RGBS)	Pilot regions in sub-regions (1st Priority)
		3-2	Organize accumulated facility survey (data)	ID (IS、IIS、RGBS)	Ditto
		3-3	Establish database by the results of facility survey	-	Ditto
4	Utilize facility-survey's results	4-1	Utilize database	-	Ditto
		4-2	Prepare manuals	-	Ditto
		4-3	Discuss/propose budget and structure	-	Ditto
5	Cooperative activities between MWRI and WUA	5-1	Collect data of BCWUA/WUAs	BCWUA、WUA	Ditto
		5-2	Collect data of BCWUA/WUAs	BCWUA、WUA	All areas other than the pilot region within the Survey's target area

Source: JICA Survey Team

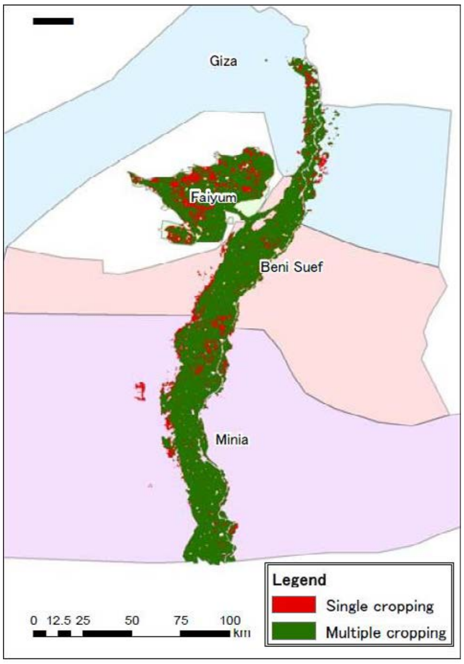
6.5 Prioritization of Sub-regions

In the Survey’s target area, there are 80 sub-regions and the total area covers about 550,000 ha. Considering temporal and budgetary constraints, it is not realistic to undertake all the maintenance work of the irrigation systems of the hard component at the same time. For this reason, it is planned that functions are improved in all areas in 20 years, which is the duration of the roadmap, by setting criteria or prioritizing. They are divided into three groups. The procedures and results of prioritization will be described as below.

6.5.1 Procedure of Prioritization

Regarding 80 sub-regions in total that are set up in the Bahr Yusef, Ibrahimia and Kased areas, sub-regions are prioritized based on available information through the Survey.

Five policy priorities (urgency, necessity, gravity of impact, effectiveness, and sustainability) are set to prioritize the sub-regions based on Egypt's policy priorities. In addition, improvement items in the soft and hard components emphasized by MWRI corresponding with each policy priority are discussed and finalized together with MRWI. Based on those results, each sub-region is provided scores based on the data collected in the Survey. For scoring, 1 to 3 points were allocated depending on the degree of influence including 0 points (no relation). Policy priority and improvement items in the soft and hard components emphasized by MWRI are as follows:



Source: JICA Survey Team

Figure 6.9 Map of Times of Cropping (2009)

(1) Urgency

The urgency for intervention is evaluated from the extent of water shortages in the target area and it is judged that a higher percentage of the single cropped area means higher water scarcity. Judged from the satellite image analysis (2009) (as discussed before, and see Figure 6.9) in which the degree of drought is high, the ratio of single cropping area to arable land for each area was calculated (See Table 6.16 below).

Table 6.16 Extent of Water Shortage of Each Governorate (Unit: ha)

Governorate	Total Cultivated Area	Single Cropped Area	% of Single Cropped Area
Faiyum	206,966	45,263	21.9%
Beni Suef	186,356	16,556	8.9%
Minya	319,619	35,438	11.1%

Source: JICA Survey Team

In the whole area where the water shortage situation is analyzed, it was 14% in the year when the single production area is large, and 8% in years when the single production area is smaller (See Chapter 2). Therefore, these values are set as thresholds and points were allocated.

In the surveyed area in Upper Egypt, the percentage is shown in Table 6.16, and it is judged that Faiyum governorate has an area where water shortages occur frequently. In addition, it is judged that Gharbia governorate, which is out of satellite image analysis and is located downstream of Faiyum governorate, indicates a similar tendency. Hence, Gharbia governorate is segmented as an area where water shortages occur frequently.

(2) Necessity

Accordingly, the intervention priority proposed by MWRI (reuse pumps and meska improvement) is considered as one of the criteria used for prioritization. The existence of reuse pumps and the proposed meska improvement per each sub-region is evaluated as an indicator for prioritization with 3 points.

(3) Gravity of Impact

It is believed that the larger scale of the irrigation system per sub-region positively affects the impact of project implementation. Therefore, the command area per sub-region is divided into three levels and is scored out of 3 points. More than 10,000 ha scored 3 points and those less than 5,000 ha scored 1 point, while the remaining scored 2 points.

(4) Effectiveness

Two indexes of canal density and structure distribution are used in the evaluation of the effectiveness of the project. The investigation on the project area indicates that the major problem of the system is lack of proper functioning of the conveyance and distribution system. The conveyance and distribution system in any irrigation system can be determined from canal density and structure distribution of the system, respectively.

The project implementation in an area where more canal density or more structure distribution is observed has more effect on the area where less canal density and less structure distribution is observed.

(5) Sustainability

Farmers' participation can be one of the indicators of the sustainability of a project. The existence of BCWUA is used as an indicator of farmers' participation. According to the data collected from the MWRI, the North Nile Valley (where Faiyum is located) has the largest participation of farmers and more than 49% of farmers have formed BCWUAs. The percentage of the establishment of BCWUAs per each region is used to give a score for the target governorate as shown in Table 6.17.

Table 6.17 Percentage of the Establishment of BCWUA (Toward the Target)

Region	Establishment of BCWUA	Point	Remark
North Nile Valley	49.2%	3	Faiyum is located
Beni Suef	11.5%	1	Beni Suef
Middle Nile Valley	37.9%	2	Minya is located
Middle Delta	43.9%	3	Gharbia is located

Source: MWRI

(6) Summary of the Prioritization

Improvement items emphasized by MWRI, criteria, scoring points, etc., are shown in Table 6.18.

Table 6.18 Improvement Items as Hard and Soft Components Emphasized by MWRI and the Points

Political Priority	Improvement items emphasized by MWRI	Decision criteria	Points	Description of the "Improvement items emphasized by MWRI"
Urgency	Frequency of water scarcity	≧ 14%	3	From satellite-image analysis, it was judged that the urgency of project implementation is high in the single cropping areas, evaluated by the state of water scarcity based on the cropping rate of the drought years.
		< 14%	2	
		< 8%	1	
Necessity	Prioritized MWRI policy	Pump	3	Improvement of water-use efficiency by recycling drain water and meska improvement (Faiyum) are
		Meska	3	

Political Priority	Improvement items emphasized by MWRI	Decision criteria	Points	Description of the "Improvement items emphasized by MWRI"
		Nile	0	the priority of MWRI. Points are given to these target areas.
Gravity of impact	Size of command area	≧ 10,000ha	3	Regions with large irrigated areas have a higher positive impact on project implementation, so the evaluation points in sub-regions with large irrigated areas were set higher.
		＜ 10,000ha	2	
		＜ 5,000ha	1	
Effectiveness	Canal density	≧ 10m/ha	3	Conveyance density indicates the total length of canal per unit area. Sub-region with high density can be judged as areas where there are many problems related to the conveyance of water, and there is much room for improvement. For this reason, the evaluation points of sub-regions with high canal density were set higher.
		＜ 10m/ha	2	
		＜ 5m/ha	1	
	Structure Distribution	< 200ha	3	Similar to the canal density, the amount of infrastructure per unit area indicates the extent of the problem related to irrigation water distribution within the irrigation system. It can be judged that the more infrastructure in the irrigation unit, the more problems in the water distribution system to be tackled.
		＜ 400ha	2	
		> 400ha	1	
Sustainability	The ratio of the existence of BCWUAs	Faiyum & Gharbia	3	The rate of establishment of BCWUAs is the higher criteria because a BCWUA is responsible for water management of a part of an irrigation system. Moreover, its establishment is a precondition of sustainability.
		Minya	2	
		Beni Suef	1	

Source: JICA Survey Team

6.5.2 Result of Prioritization of Sub-regions and Division of Prioritized Regions toward Project Formulation

Priority classification for sub-regions is applied, and 80 regions are scored and set in the ranking. Based on the prioritization, 80 sub-regions are divided into three groups, because 200,000 ha out of 550,000 ha is appropriate to technically formulate the project plan. Each group has a similar area in total. The prioritization result is listed in Table 6.19 and shown in Figure 6.10.

Table 6.19 Result of Prioritization of the Sub-region

Sub Region	GD	ID	Water Scarcity	Size (Area)	Canal Intensity	Structure Distribution	MWRI Priority	Water Users formation	Score	Priority	Area (ha)	Source of Water
Bahr Wahby	Faiyum	Sayla, Tamya	3	3	3	3	3	3	18	1	16,462	Bahr Yusef
Bahr Talat	Faiyum	Ebshawy	3	1	3	3	3	3	16	1	3,875	Bahr Yusef
El Ghark	Faiyum	Atsa, El Ghark	3	3	2	1	3	3	15	1	20,174	Bahr Yusef
Aros & Abo Seer	Faiyum	Atsa	3	2	1	3	3	3	15	1	5,680	Bahr Yusef
Sanhor	Faiyum	Senories	3	2	2	2	3	3	15	1	6,892	Bahr Yusef
Sery	West Minya	West Abu Kurkas, West Minia, West Samalout, West Maghaga	2	3	3	2	3	2	15	1	50,511	Ibrahimia
Tansa-Kella	Beni Suef	East Beni Suef, Ahnasia, West Beni Suef	2	3	3	3	3	1	15	1	10,424	Ibrahimia
Kased	Gharbia	Tanta, Kotor	3	3	2	1	3	3	15	1	21,531	Kased
El Gharbia	Faiyum	Ebshawy	2	3	2	1	3	3	14	1	10,902	Bahr Yusef
Senrw	Faiyum	Ebshawy	3	2	1	2	3	3	14	1	7,964	Bahr Yusef
Desia	Faiyum	Ebshawy	3	2	2	1	3	3	14	1	8,847	Bahr Yusef
Dahrout and other	East Minya	Beni Mazar, East Maghagha	2	2	3	2	3	2	14	1	7,350	Ibrahimia
Abo Shosha	Beni Suef	El Fashen, Samosta	2	2	3	3	3	1	14	1	6,266	Ibrahimia
El Soultani	Beni Suef	Samosta, Beba, Ahnasia	2	3	3	2	3	1	14	1	20,115	Ibrahimia
Bosh and other	Beni Suef	Naser	2	2	3	3	3	1	14	1	5,572	Ibrahimia
Senours	Faiyum	Senories	3	3	2	2	0	3	13	2	13,237	Bahr Yusef
El Zawia	Faiyum	Senories	3	2	2	3	0	3	13	2	6,520	Bahr Yusef
Saba	West Minya	Edwa	2	2	2	2	3	2	13	2	6,846	Bahr Yusef
El Gandia	East Minya	East Maghagha	2	2	2	2	3	2	13	2	5,141	Ibrahimia
El Mansour Eyosra	Beni Suef	Naser	2	1	3	3	3	1	13	2	2,335	Ibrahimia
Qashisha and otherr	Beni Suef	El Wasta	2	1	3	3	3	1	13	2	1,294	Ibrahimia
Ibrahimya and other	Beni Suef	El Wasta	2	1	3	3	3	1	13	2	1,890	Ibrahimia
Kom El Zohir and other	East Minya	East Abu Kurkas, East Samalout	2	2	2	2	3	2	13	2	7,752	Ibrahimia
Koftan	Beni Suef	Somusta	2	2	2	2	3	1	12	2	8,036	Bahr Yusef
El Nazie	Faiyum	Atsa, Yousif El Seddik, El Ghark, El Nazla	3	3	2	1	0	3	12	2	39,315	Bahr Yusef
El Elam & Dar Ramada	Faiyum	El Faiyum	2	2	2	3	0	3	12	2	7,977	Bahr Yusef
El Dahab	West Minya	Monshat El Dahab; West Kamadir, East Terfa	2	3	3	2	0	2	12	2	28,363	Bahr Yusef
Absouge and other	Beni Suef	El Fashen	2	2	2	2	3	1	12	2	9,596	Ibrahimia
Tanhala	Faiyum	El Faiyum, Tamya	2	2	2	2	0	3	11	2	9,260	Bahr Yusef
Kamadir	West Minya	West Kamadir	2	2	3	2	0	2	11	2	5,040	Bahr Yusef
East Hafez	East Minya	East Abu Kurkas	2	1	3	3	0	2	11	2	2,738	Ibrahimia
Bani Khalid & Other	East Minya	Der Mewas, Melwy, Monshat El Dahab	2	2	2	2	0	2	10	3	5,573	Bahr Yusef
Harika	West Minya	Edwa	2	2	2	2	0	2	10	3	6,468	Bahr Yusef
Sakola PS	West Minya	Sakoula	2	2	2	2	0	2	10	3	5,040	Bahr Yusef
Ahanasya-Beni Haroun	Beni Suef	East Beni Suef	2	2	1	1	3	1	10	3	7,791	Ibrahimia
South Ashmant Canal	Beni Suef	Naser	2	1	3	3	0	1	10	3	1,940	Ibrahimia
El Zawya and other	Beni Suef	El Wasta	2	1	3	3	0	1	10	3	1,065	Ibrahimia
Atwab-El houma	Beni Suef	El Wasta	2	1	3	3	0	1	10	3	1,770	Ibrahimia
Medoum	Beni Suef	El Wasta	2	1	3	3	0	1	10	3	2,276	Ibrahimia
El mansaur	Beni Suef	El Wasta	2	1	3	3	0	1	10	3	1,961	Ibrahimia
Damaris and other	East Minya	East Samalout	2	2	2	2	0	2	10	3	5,901	Ibrahimia
Mazora PS	Beni Suef	Somusta	2	3	2	1	0	1	9	3	10,710	Bahr Yusef
Raaheel	West Minya	Monshat El Dahab	2	1	2	2	0	2	9	3	2,780	Bahr Yusef
Terfa	West Minya	West Terfa	2	2	2	1	0	2	9	3	8,211	Bahr Yusef
Shoieb Darwishl	East Minya	Mataya	2	1	2	2	0	2	9	3	2,992	Ibrahimia
Mataua and other	East Minya	Mataya, Beni Mazar	2	2	2	1	0	2	9	3	5,756	Ibrahimia
Maghagha El Fashina	East Minya	East Maghagha	2	2	2	1	0	2	9	3	5,198	Ibrahimia
Saedyhat El Feshna	Beni Suef	El Fashen	2	1	3	2	0	1	9	3	2,428	Ibrahimia
North Sharahna	Beni Suef	Beba	2	1	3	2	0	1	9	3	1,840	Ibrahimia
El Azhay	Beni Suef	West Beni Suef	2	1	3	2	0	1	9	3	4,835	Ibrahimia
El Saayda	Beni Suef	West Beni Suef	2	1	2	3	0	1	9	3	1,361	Ibrahimia
South Qashisha	Beni Suef	Naser	2	1	3	2	0	1	9	3	3,053	Ibrahimia
West Hafez	East Minya	East Abu Kurkas	2	2	2	1	0	2	9	3	9,763	Ibrahimia
El Disout	East Minya	East Samalout	2	1	2	2	0	2	9	3	2,566	Ibrahimia
El Safsaf	East Minya	East Samalout, Mataya	2	1	1	3	0	2	9	3	2,163	Ibrahimia
Samalout	East Minya	East Samalout	2	1	2	2	0	2	9	3	2,184	Ibrahimia
Harika Delhans	Beni Suef	El Fashen	2	3	1	1	0	1	8	3	11,634	Bahr Yusef
Bahnasa & other	West Minya	West Terfa, Edwa	2	1	2	1	0	2	8	3	2,451	Bahr Yusef
Adkak	East Minya	Mataya	2	1	1	2	0	2	8	3	2,310	Ibrahimia
Beni Mazar and other	East Minya	Beni Mazar	2	1	1	2	0	2	8	3	3,121	Ibrahimia
El Fant	Beni Suef	El Fashen	2	1	2	2	0	1	8	3	2,940	Ibrahimia
El Fashnya and other	Beni Suef	El Fashen	2	1	2	2	0	1	8	3	4,515	Ibrahimia
South Ahmed Pasha	Beni Suef	Beba	2	1	3	1	0	1	8	3	2,908	Ibrahimia
Sheikh Haroun	Beni Suef	East Beni Suef	2	1	1	3	0	1	8	3	1,218	Ibrahimia
El Shahra	Beni Suef	East Beni Suef	2	1	1	3	0	1	8	3	2,600	Ibrahimia
North Ashmant	Beni Suef	El Wasta	2	1	2	2	0	1	8	3	3,557	Ibrahimia
Atwab	Beni Suef	El Wasta	2	2	1	2	0	1	8	3	6,421	Ibrahimia
Haram medoum and other	Beni Suef	El Wasta	2	1	2	2	0	1	8	3	4,390	Ibrahimia
Belhansa	Beni Suef	West Maghaga, El Fashen	2	1	2	1	0	1	7	3	4,761	Bahr Yusef
Wady El Ryan & other	Beni Suef	Ahnasia	2	1	2	1	0	1	7	3	4,619	Bahr Yusef
Waslat Bahabshin & other	Beni Suef	Ahnasia	2	1	2	1	0	1	7	3	2,369	Bahr Yusef
El Soultany-2	Beni Suef	Ahnasia	2	2	1	1	0	1	7	3	9,277	Bahr Yusef
Right Giza	Beni Suef	West Beni Seuf	2	1	2	1	0	1	7	3	1,428	Bahr Yusef
Abo Essa	East Minya	Mataya	2	1	1	1	0	2	7	3	3,608	Ibrahimia
Abo Hasiba	East Minya	Mataya, Beni Mazar	2	1	1	1	0	2	7	3	3,885	Ibrahimia
El Sahlyah	East Minya	East Abu Kurkas	2	1	1	1	0	2	7	3	2,940	Ibrahimia
North Amhmed Pasha	Beni Suef	Beba	2	1	1	2	0	1	7	3	2,100	Ibrahimia
West Magroufa and other	Beni Suef	East Beni Suef	2	1	1	2	0	1	7	3	1,528	Ibrahimia
Right Tansa-Tezment	Beni Suef	East Beni Suef	2	1	1	2	0	1	7	3	2,646	Ibrahimia
Monshaat El Hag	Beni Suef	Ahnasia	2	1	2	1	0	1	7	3	4,956	Bahr Yusef
								Total			555,711	

Source: JICA Survey Team

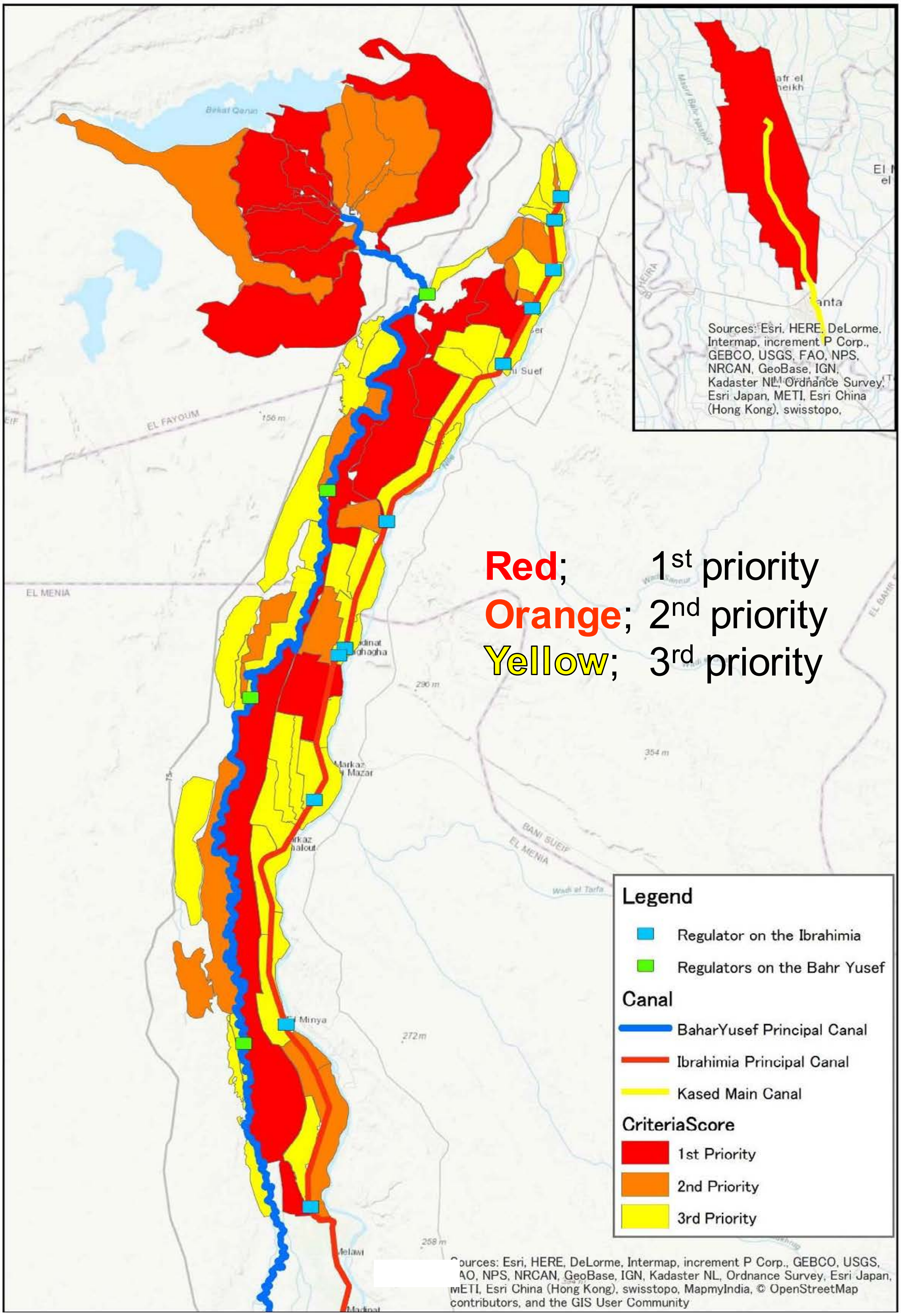


Figure 6.10 Result of Prioritization of Sub-regions

The number of prioritized sub-regions per each governorate in the target area of the Survey is shown in Table 6.20.

Table 6.20 Prioritized Sub-regions (GD) per Each Governorate

Governorate	GD	1st Priority	2nd Priority	3rd Priority	Total	
					No. of Sub-regions	Area (ha)
Faiyum	Faiyum	8	5	0	13	157,105
Beni Suef	Beni Suef	4	5	30	39	180,425
Minya	West Minya	1	3	5	9	115,710
	East Minya	1	3	14	18	80,941
Gharbia	Gharbia	1	0	0	1	21,531
Total	No. of Sub-regions	15	16	49	80	
	Area (ha)	202,565	155,340	197,806		555,711

Source: JICA Survey Team

A total of 15 sub-regions are categorized as first priority for intervention, in which many sub-regions are selected mainly from Faiyum. The third priority has the largest number of sub-regions, but their area is almost the same as the first priority. Table 6.21 shows prioritized sub-regions per each target basin.

Table 6.21 Prioritized Sub-regions per Each Canal System

Canal System		1st Priority	2nd Priority	3rd Priority	Total	
					No. of Sub-regions	Area (ha)
Bahr Yusef		8	9	14	31	285,666
Ibrahimia		6	7	35	48	248,514
Kased		1	0	0	1	21,531
Total	No. of Sub-regions	15	16	49	80	
	Area (ha)	202,565	155,340	197,806		555,711

Source: JICA Survey Team

The first priority contains sub-regions from all the three canal systems. The first and second priorities are inclusive of the Bahr Yusef canal system the most, and the third priority contains sub-regions from the Ibrahimia canal system the most.

In the construction contents shown in Table 6.22, it is assumed that almost all construction work may be done by conventional construction methods in Egypt, except for some critical curves in the Bahr Yusef Principal Canal. There is some construction work for the Bahr Yusef Principal Canal that is judged difficult to adopt conventional construction methods for due to the sites' condition. It is proposed to instead introduce a special construction method (Implant Construction Method: Japanese technology) for this construction work. In addition, pump instruments and gates of water reuse stations are procurable in Egypt since they are small in scale.

6.5.3 Scale of the Overall Project and Projects of each Priority Area

The standard cost breakdown is applied to all projects for the principal canals of Ibrahimia and Bahr Yusef and those in the three priority sub-regions. Individual project costs were calculated based on the direction of cooperation of facility maintenance. The breakdown for each maintenance plan of construction costs included in the overall project cost is shown in Table 6.23.

Table 6.22 Construction Breakdown included in the Project of each Maintenance Plan

Maintenance Plans	Construction Contents
Plan 1 (Rehabilitation of irrigation facility, without a lining of main and branch canals)	● Rehabilitation of Principal Canal (Eliminating Bottlenecks) ・Raising of canal banks whose height are insufficient in Bahr Yusef Canal, excavation at high bottom areas of the canals, bank protection work at critical curves ・Bank protection work of Ibrahimia Canal at Minya city, removing an old regulator and construction of a new bridge ● Rehabilitation of small-scale facilities of main and branch canals (intakes, regulators, weirs, conduits, water-reuse stations, and pump station) ● Meska improvement (in Faiyum)
Plan 2 (Plan 1 + lining of main canals)	● Rehabilitation of Principal Canal (Eliminating Bottlenecks) ● Rehabilitation of small-scale facilities of main and branch canals (intakes, regulators, weirs, conduits, water-reuse stations, and pump stations) ● Meska improvement (in Faiyum) ● Reshaping cross-sections of main canals by lining
Plan 3 (Plan 2 + lining of branch canals)	● Rehabilitation of Principal Canal (Eliminating Bottlenecks) ● Rehabilitation of small-scale facilities of main and branch canals (intakes, regulators, weirs, conduits, water-reuse stations, and pump stations) ● Meska improvement (Faiyum) ● Reshaping cross-sections of main canals by lining ● Reshaping cross-sections of branch canals by lining

Source: JICA Survey Team

Table 6.23 Total Project Cost in the Whole Target Regions by the Survey

(Unit: US$)

Item		Construction Cost		
Principal Canal Direct Construction Cost (including cost of temporary works)				
	Bahr Yusef	66,538,000		
	Ibrahimia	17,176,000		
	Sub total	83,714,000		
Sub Region Direct Construction Cost (including cost of temporary works)		Plan	Plan 2	Plan 3
	1st Priority	115,938,000	254,779,000	491,330,000
	2nd Priority	58,259,000	164,875,000	298,185,000
	3rd Priority	48,488,000	182,496,000	37,871,000
	Sub total	222,685,000	602,150,000	1,107,386,000
Intermediate total		306,399,000	685,864,000	1,191,100,000
Indirect Cost (35%)		107,240,000	240,052,000	416,885,000
Total Project Cost		413,639,000	925,916,000	1,607,985,000

Source: JICA Survey Team
Note: Total Project Construction does not include consulting service expenses, labor cost, taxes, contingencies and inflation rate nor reserve expenses.

The total project cost of each facility maintenance plan (plans 1, 2, and 3) and the project cost of each priority area are shown in Table 6.23. They were calculated by adding 35% of the indirect costs. Table 6.23 shows compositions of the project costs for each construction breakdown corresponding to the facility rehabilitation level described in the roadmap for CIWM realization.

In CIWM, the principal canals (Bahr Yusef and Ibrahimia Principal Canal) are responsible for water supply to all the sub-regions, and work on them is preferentially implemented by all plans for facility maintenance of the sub-regions. Accordingly, the construction work of the principal canals will be carried out in all plans concerning the sub-regions. Facility rehabilitation work of the sub-regions will be implemented as described in Plan 1, Plan 2, and Plan 3 which are based on the coverage determined to correspond with the rehabilitation level that affects the efficiency of water utilization. The total project cost corresponding to each rehabilitation level was calculated by adding indirect costs (35% of the total construction costs of each case) in the table. Regarding the sub-regions, the breakdown of each priority area appeared in the CIWM roadmap, namely the respective project costs of the first, second, and third priority groups, and is shown separately in the table.

Chapter 7 Recommendation on Japan's Cooperation

In the previous chapters, the roadmap was drawn to show the process of CIWM and the contents under the roadmap were set with their chronological sequence. Consequently, the improvement program elaborated on the contents compiled to conduct CIWM.

In this chapter, a draft of Japan's cooperation program is prepared based on the improvement program and will invoke a package of projects composed of hard and soft components. JICA Survey Team proposed the projects formulated to fit JICA schemes, which are able to be implemented on a request basis. For the projects on the hard component, the outline was described as the Japanese cooperation schemes, and the financial feasibility was examined employing cost and benefit estimations, preliminarily using financial assessments. The JICA Survey Team proposes implementation of a feasibility study for hard components to conduct detailed work and basic design work based on the results of the Survey. For the projects on the soft components, several types of technical cooperation schemes are nominated for water management and facility management stipulated in the improvement program.

7.1 Draft Japan's Cooperation Program

The formations of facility rehabilitation, water management and facility management (as an asset management approach) are displayed corresponding to possible forms of Japan's cooperation as shown in Table 7.1.

Table 7.1 Cooperation in Subject of the Improvement Program

	Activities	Proposal of Japan's Cooperation
Facility Improvement	Feasibility Study	F/S
	Procurement of equipments for Integrated Water Management System's operation	Construction Project of New Dirout Group of Regulators
	Procurement of equipments for Integrated Water Management System's operation	Facility Improvement Project
	Securing cross-section of water flow : Reshaping canals	
	Protection of canal slope of Principal canal : Retaining wall works, Implant works, Revetment works	
	Removal of discharging inhabitation part : Remove Old Hafez Regulators	
	Rehabilitation of Intake works, regulators	
	Improvement of water-distribution function	
	Main canal lining	
	Rehabilitation of water-reuse stations in branch canals (new construction of suction sumps, improvement of pumps/machinery equipments, renovating pump stations)	
	Meska Improvement (Areas be ready)	
Water Management	Grasping and surveying of reality of water management	Planning of Water Management Improvement
	Selecting technical items	
	Selecting pilot areas	
	Acquiring consensus with MWRI about management policy/system of water management(draft) toward the realization of CIWM	
	Discussing management policy/system of water management (draft) toward the realization of CIWM	Development a Equitable Water Management System
	Proposal/sharing of management policy/system	
	Practicing training on equipment operations and integrated water management system's operation	
	Sharing management policy/system with BCWUA	
	Practicing CIWM	
	Updating/revising management policy/system of water management toward the realization of CIWM	
	Grasping current status of BCWUA	
	Selecting model site	
	Practicing capacity-strengthening training for BCWUA (Utilize training materials of SWMT)	
	Grasping current situation/making a list of informal/formal WUA in the target area	
	Conducting capacity-strengthening training to WUA (Utilize training materials of SWMT)	
	Instructing water-management practices at the field	
	Updating/revising training materials based on the practices	
Facility Maintenance (Asset Management Approach)	Acquiring facility information (location, condition, etc.)	Partial Management of Ledger
	Preparing fact-sheet format and acquiring technique of facility survey methods	
	Fostering understanding of asset management approach	Core Human-Resources Development
	Acquiring survey techniques (theory)	
	Conducting facility survey	Policy Advisor of Facility Management
	Organizing accumulated facility survey (data)	
	Producing database by facility survey	
	Collecting data of BCWUA/WUA	
	Utilizing database	Trial of Asset Management Approach
	Preparing manuals	
	Discussing/proposing budget and structure	

Japan's cooperation program is drafted according to the schemes in chronological order as shown in Figure 7.1.

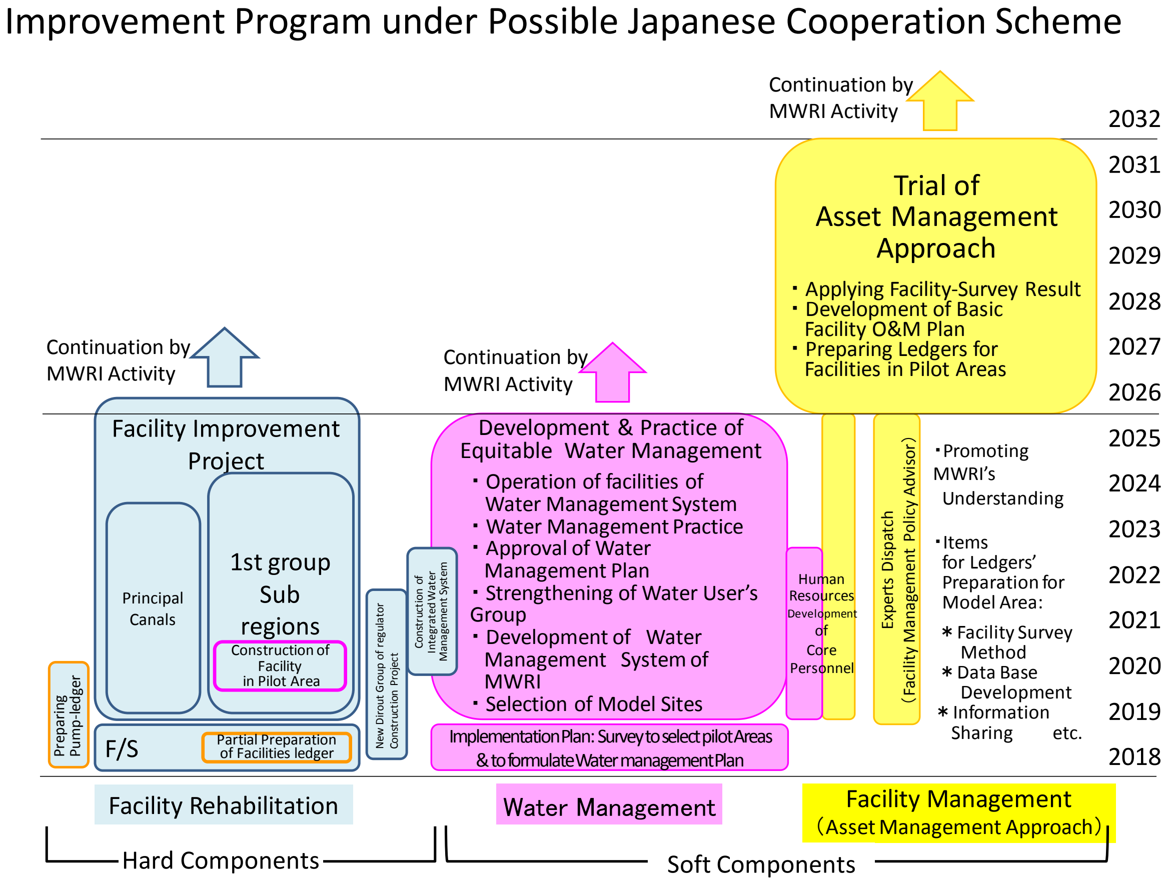


Figure 7.1 Japan's Cooperation Program (Draft)

As cooperation activities on hard components, a facility-rehabilitation project is proposed. Targets are improvement of bottlenecks of principal canals and the recovery of facility functions in the selected sub-regions among the first priority sub-regions. The feasibility study (F/S) is conducted before the construction project to plan the components of the project.

As cooperation activities on soft components, improvement of water management and facility management are proposed. A technical cooperation project is proposed for water management to realize equitable water distribution. The project targets the sub-regions where the facility improvement is completed. However, beforehand, a pre-phase survey to formulate an implementation plan is conducted to select pilot areas, to analyze water balance in the areas and to study the water-management mechanism covering from upstream, which MWRI-manages, to canal ends, which farmers manage. Developing core staff is also proposed.

As for facility management, the introduction of the asset management approach is proposed, but MWRI is not accustomed to it, so the formulation of a facility ledger with the support of Japanese experts and the capacity development of core staff are proposed as initial activities during a project framework. The full-scale technical cooperation project for asset management is proposed after the facility improvement and the technical cooperation for water management.

Japan's possible cooperation for hard and soft components is detailed as follows:

7.2 Project Proposal for Hard Components

In Chapter 6, the project cost for construction of the whole target area of the Survey is shown. Among the overall projects that are nominated in the improvement program, Japan can possibly support some cooperation projects implemented in the two principal canals, namely Bahr Yusef and Ibrahimia Principal Canal, and in some of the sub-regions, which are a major priority for rehabilitation, namely being one or a few of the first priority group areas. Specifically, these cooperation projects taking part in the facility rehabilitation are composed of items such as bottleneck eliminations in the two principal canals and the functional restoration of the facilities and canals within the sub-regions continuing to the principal canals. Through these cooperation projects, irrigation systems can convey and deliver water to secure their benefits up to the terminal portion. In the sub-regions of the second and third priority groups where projects are going to be implemented as a response afterward, it is expected that the Egyptian government will implement functional recovery of the facility by utilizing the results of the project and their experiences acquired through Japan's cooperation.

7.2.1 Outline of the Project Proposal for Hard Components

In order to effectively support project implementation for the hard component (facility rehabilitation) included in cooperative projects by Japan, it is appropriate to employ schemes of yen loan projects. Outlines of the facility rehabilitation project and F/S for project preparation under a yen loan scheme are described below.

(1) Target Area

(a) The portions of the Bahr Yusef Principal Canal from the Dirout Group of Regulators to the Lahoun Regulator, and the Ibrahimia Principal Canal from the Dirout Group of Regulators to the El Wasta Regulator in the upper Egypt region

(b) Fifteen sub-regions of the first priority group, or a few sub-regions among the first priority group that is composed of some areas of the Bahr Yusef Principal Canal and the Ibrahimia Principal Canal of Minya, Beni Suef and Faiyum GD in Upper Egypt, as well as of the sub-region of the Kased Canal under the control of Gharbia GD.

(2) Feasibility Study (Preparing Cooperation Survey)

A feasibility study will be conducted on the cooperation project proposed in the Survey. The study will identify project components of the hard component, implementation plan, and project planning for the construction work including funding. The study will also examine the relevance of the yen loan project in detail. For a project plan and a facility design, it is required to follow CIWM sufficiently. The feasibility study differs depending on the sub-regions to be targeted for the construction work. For this reason, two types of approaches to the main study items and the scheduling are respectively shown below.

1) Main Study Items

i) Portion of Principal Canal

To design specific countermeasures for the principal canals, field surveys will be conducted on detailed construction work concerning bottlenecks. Especially, to determine levels to raise the heights of the embankments and to avoid negative influences in upstream sections, the flow condition in the principal canals are investigated. The dimensions and work volumes will be determined in confirming the required heights of the embankments.

The geographical survey, such as longitudinal and cross-sectional surveys, and the geological survey will be respectively conducted at the sites of bottleneck eliminations of Bahr Yusef and Ibrahimia Principal Canal. In the geological survey, representative locations are selected for the boring surveys. Standard penetration tests and horizontal load tests using a borehole, and indoor soil tests are conducted.

Socioeconomic factors are considered through examination of impacts on socioeconomic influences, such as the magnitude of large-scale influence on third parties, prevailing large-scale malfunctions of the facilities that have certain types and scales that affect the irrigation systems, as well as possible risks to the residential area and major facilities at the principal canal level.

ii) Sub-regions

To identify the facilities to be rehabilitated within the sub-regions, a detailed field survey will be conducted. Specifically, the survey reveals the portions that induce hazardous obstacles in water management from the intakes to the terminal facilities of the irrigation systems in the sub-regions. The survey also examines functional degradation and safety reliability of the facilities. Based on these identifications and examinations, the study will summarize the situations on the soft and hard components in water conveyance and delivery of the irrigation canal systems. During the survey, ledgers of the facilities that shall be rehabilitated in the projects, will be prepared, and the facility status, such as basic specifications and the current conditions of the facilities (e.g., canals and small-scale structures) will be recorded.

Considering that all the irrigation systems are part of CIWM, the meska improvements will constitute one of the project components. The meskas to be improved in the sub-regions of the project areas will be selected from the districts where BCWUAs and WUAs have been established, or are going to be organized.

In particular, the study should cover the subjects related to irrigation planning, such as the current available volumes of irrigation water, capacities of the facilities, beneficial areas in the projects, and farming conditions in cultivating activities, and it should accumulate its outcomes individually to create project planning for each sub-region. In this case, water reuse shall be incorporated in the planning as much as possible to be a means of supplying additional water to the project areas that are facing water shortages.

2) Study Procedure

F/S for yen loan project implementation basically formulates project planning which is composed of sub-plans such as farming and land use plans, water use plans, water resource plans, and facility plans on beneficiary areas under a project. The sub-plans are interrelated with each other to form the project planning. When preparing the yen loan project, F/S procedures are different between project loan and sector loan types.

In the case of a project loan type, F/S formulates project planning by applying an ordinary process for project preparation on some sub-regions selected from the first priority group. Its procedure starts with investigating farming, agricultural management, land use, water use and water resources, and facility conditions in detail for each targeted sub-regions, where irrigation water is distributed. Based on the investigation results, F/S reveals the current situations of the subjected items (Diagnosis of facility-function is especially important in the Survey.) and the plans which are about to be realized in the project implementation, and then conducts project planning including benefits realized by the project's execution. Since these items are related to each other, the F/S employs project planning in a feedback process where the sub-plans can be modified. Because the planning of the project loan type works on detailed investigation such as surveys that cover a wide range or large numbers of samples, it takes time to prepare individual project planning. However, it provides enough details on designs of facilities to be constructed when a project is being implemented. Accordingly, the detailed design can stay at a supplemental level during project implementation.

Meanwhile, an F/S procedure for a sector loan type is similar to the project loan type. However, F/S prepares project planning of each sub-region based on the standardized designing of structures in order to create a project package mainly for setting the total project cost in a project formulation. For this reason, the construction work of respective facilities will be conducted with a detailed design after inaugurating project implementation. However, from the viewpoint of grasping distinctive conditions of the sub-regions of the project area, the sizes of the surveys for preparing the project planning of each sub-region can take smaller scales in the sector loan type than in the project loan type.

The Survey proposes alternatives for sub-region selection as a target of support; namely a case of covering 15 sub-regions in the first priority group (assuming a sector loan-type yen loan) and a case of selecting a few sub-regions among the first priority group (assuming a project loan-type yen loan). The F/S takes different procedures in the respective types. Based on this difference, the procedures are described in three parts: namely i) the part where items do not differ in the procedures (common), ii) the part of a case where the study covers all the first priority sub-regions, and iii) the part of a case where the study covers several sub-regions among the first priority group. They are respectively shown below:

i) Common Part (Items in the procedures are common between both sector loan and loan in project type)

a) Nature, Farming, Social and Other Basic Conditions Survey

(Part of a case of all the first priority sub-regions: work item [3] and Part of a case of a few sub-regions: work item [5])

The surveys collect basic information to grasp general conditions of project areas for planning. Specifically, the geographical, geological and other surveys are conducted to design facilities of the major structures and other structures in the sub-regions. For farming, socioeconomic surveys are also carried out to recognize the current situations to form irrigation projects, e.g., stipulating irrigation planning where water requirements are determined for sub-regions.

b) Site Survey for Planning

(Part of a case of all the first priority sub-regions: work item [5] and Part of a case of a few sub-regions: work item [6])

The on-site survey, in particular, the facility condition survey, is conducted to identify the facilities and coverage in their rehabilitation work. The survey will prepare ledgers that contain the information collected on the facilities targeted in the projects.

c) Flow Analysis of Principal Canals (Work Item [4])

In this analysis, the water levels of the planned cross-sections (after project implementation) will be confirmed. Based on these water levels, the heights of the embankment are determined to be implemented in the projects.

d) Procurement Circumstances Survey (Work Item [12])

This survey collects various information on project cost estimations, and consultant and contractor procurement for the project formulations.

e) Social and Environmental Concern Survey and Evaluation (Work Item [13])

This survey evaluates environmental impacts responding to facility plans in the project planning. This survey shall be conducted as necessary for confirmation of environmental assessments.

f) Project Cost Estimation

(Part of a case of all the first priority sub-regions: work item [14] and Part of a case of a few sub-regions: work item [15])

In this work, the project costs are estimated with the information on construction costs accumulated during the procurement circumstances survey and the basic design of facilities.

g) Project Evaluation and Cost and Benefit Analysis

(Part of a case of all the first priority sub-regions: work item [16] and Part of a case of a few sub-regions: work item [17])

To affirm financial verification on formulated projects, project evaluation will be carried out. Simultaneously, cost and benefit are analyzed on the projects.

In this case, it should be noted that equitable water management is a prerequisite for enhancing project effectiveness.

ii) Part of a Case of All the First Priority Sub-regions (Assuming Sector Loan)

a) Irrigation Planning Determination (Work Item [7])

This plan forms irrigation water distribution in an equitable manner incorporating water requirements in planning that are prepared mostly in the current water supplies.

b) Preparation of Overall Project Plan (Work Item [8]) and Plans except for Irrigation Plan (Work Item [9])

Taking the water supplies in the irrigation sub-plans and the standardized structures in a facility's sub-plans into account, project planning will be formulated with other sub-plans[30]. Together with the sub-plans, the surveys on farming and socioeconomic situations support the determination of beneficiary area, development of farming sub-plans, calculation costs, and benefits of projects of the project planning.

c) Basic Design and Construction Work Plan of Facilities (Work Item [10])

The facility's sub-plans are formulated with facilities basic designs based on the various surveys to input for project formulations. The facilities basic design prepares drawings of typical structures that are standards in the sub-regions. Based on the design, work plans on construction will be stipulated, and a bill of quantity and construction cost will be calculated.

iii) Part of a Case of a Few Sub-regions (Assuming Project-Type Loan)

a) Sub-region Selection (Work Item [3])

A few sub-regions are selected among the first priority group in order to determine the project areas F/S targets, which is the model CIWM wishes to realize. For example, the F/S selects three sub-regions representing respective regions in the Survey. This selection shall be done in consultation with MWRI.

In this case, so that the sub-regions are selected from the viewpoint of facility rehabilitation under CIWM effectiveness, it is essential to select the sub-regions that possibly have the smallest gaps between supply and demand of irrigation water. In order to realize CIWM effectiveness, these gaps shall be confirmed in brief investigations into the supply and demand. In this context, irrigation planning will consider the reduction of the gaps and increase in water volume to be supplied by water reuse.

[30] Other sub-plans are farming and land use plans, water resources plans, and other components of project planning.

b) Determination of Irrigation Planning of Targeted Sub-regions (Work Item [8])

After satisfying the items on irrigation conditions required in the project areas and that are fulfilled in the sub-plans that appeared in c) below, the work is based on possible water volumes planned in the projects and determines water distribution plans to realize equitable conveyance and delivery of irrigation water.

c) Project Planning Preparation except for Irrigation Plan (Work Item [9])

In this work, sub-plans prepare components of the project planning, such as determination of beneficiary areas, development of farming sub-plans, facility sub-plans and calculation of costs and benefits. The components are mostly determined based on data and information of geographical surveys, farming, financial and social surveys, current facility surveys, and other surveys to form the project planning. During these sub-plan formulations, it should be noted that this process is strongly interrelated with irrigation planning which needs a water balance to realize the project requirements.

d) Determination of Project Planning (outline) of Targeting Sub-regions (Work Item [10])

Only project planning outlines are drafted for the sub-regions at this time since the detailed facility sub-plans have not been prepared yet. In this work, the project costs, benefits, and other subjects will be defined from the materials already obtained.

e) Basic Design and Construction Work Plan of Facilities (Work Item [14])

For the facilities targeted for construction work in the facility's sub-plans, the facility's basic designing will be done based on data and information derived from the geographical and geological surveys. The facility's basic designing creates design drawings for each target facility. Based on the designing, work plans on construction will be stipulated, and a bill of quantity and construction cost will be calculated.

3) Draft Schedule

Regarding procedures of F/S, respective implementation schedules of each case are shown in Table 7.2 (case of sector loan type) and Table 7.3 (case of a project-type loan).

Table 7.2 Draft Feasibility Study Schedule (Case of All 1st Priority Sub-regions (Assuming Sector Loan))

Work		Month											
Nos.	Item	1	2	3	4	5	6	7	8	9	10	11	12
【1】	Inception Report preparation & consultation (including reconfirmation)												
【2】	Basic information renewal & review on development plans in irrigation sector												
【3】	Geographcal & geological suevey, & Basic data collection: e. g. water quality												
	Farming, social & environmental surveys												
【4】	Non-uniform flow analysis												
【5】	Site survey for planning (Principal canals, Beni Suef & Minya GDs)												
	Site survey for planning (Faiyum GD)												
	Site survey for planning (Kased canal subregion)												
【6】	Ledger format preparation & formate												
【7】	Irrigation planning (incl. water balance of the areas) of target subregions												
【8】	Development of sub-plans of parts in project planning, such as farming & landuse and water resources plans: Project planning												
【9】	Outline of project planning (include facility planning)												
【10】	Bacic design & construction work plan of facilities												
【11】	Interim Report preparation, explanation & consultation												
【12】	Procurement circumstances survey												
【13】	Social & environmental concerning surveys and evaluation												
【14】	project cost estimation												
【15】	Local components (including funding) confirmation												
【16】	Project evaluation & cost and benefit analysis												
【17】	Draft final Report preparation, explanation & consultation												
【18】	Final report preparation & submission												

Source: Created by JICA Survey Team

Table 7.3 Draft Feasibility Study Schedule (Case of A Few Sub-regions (Assuming Loan in Project Type))

Work		Month											
Nos.	Item	1	2	3	4	5	6	7	8	9	10	11	12
【1】	Inception Report preparation & consultation (including reconfirmation)												
【2】	Basic information renewal & review on development plans in irrigation sector												
【3】	Subregion selection on F/S implementation												
【4】	Non-uniform flow analysis in the principal canals												
【5】	Geographcal & geological suevey, & Basic data collection: e. g. water quality												
	Farming, social & environmental surveys												
【6】	Site survey for planning in target sub-regions (Principal canals)												
	Site survey for planning in target sub-regions of a few areas												
【7】	Ledger format preparation & formate												
【8】	Irrigation planning (incl. water balance of the areas) of target sub-regions												
【9】	Development of sub-plans of parts in project planning, such as farming & land use, water resources and facility plans: Project planning												
【10】	Outline of project planning (include facility planning outline)												
【11】	Interim Report preparation, explanation & consultation												
【12】	Procurement circumstances survey												
【13】	Social & environmental concerning surveys and evaluation												
【14】	Bacic design & construction work plan of facilities												
【15】	Project-cost estimation												
【16】	Local components (including funding) confirmation												
【17】	Project evaluation & cost and benefit analysis												
【18】	Draft final Report preparation, explanation & consultation												
【19】	Final report preparation & submission												

Source: Created by JICA Survey Team

(3) Coverage of Japanese Yen Loan

1) Rehabilitation of Principal Canal

a) Ibrahimia canal system: Removal of Old Hafez Regulator, construction of new bridge, rehabilitation of side slope along the principal canal that passes Minya city

b) Bahr Yusef canal system: Increasing the capacity of the principal canal, protection work of critical curves

2) Rehabilitation of Irrigation Facilities in Sub-region

a) Rehabilitation of small structures along the main and branch canals

b) Improvement of water distribution function

c) Lining of the main canal (selection condition) and countermeasure against impediment factors

d) Rehabilitation of mixing pump stations

e) Meska improvement

3) Consulting Service

When an agreement is made for a Japanese yen loan as a financial source for this project, the project will be prepared efficiently and effectively as an ODA loan offering project, and hence a consultant will be hired for the implementation of the project. The consultant will conduct a topographic survey, detailed design, preparation of bidding documents, bid supervision, construction supervision, and strengthening the capacity of the implementing agency. Consulting services consist of the following items.

Table 7.4 Components of Consulting Service

No.	Items	Contents
1	Topographic and Geological Survey	Topographic survey (plane survey, longitudinal/cross-section surveys) and geological survey (core boring survey) will be carried out in candidate areas along the principal canals. At the same time, standard penetration test using a borehole, dynamic horizontal loading test, and a soil test will be conducted.
2	Detailed Design	Detailed design will be carried out for rehabilitation work of the principal canals, main and branch canals, small-scale structures, and pump stations in the prioritized sub-regions. Construction drawings will be prepared for construction work. Before drawings, detailed structural analysis will be done for the structures. Furthermore, the construction plan will be prepared and the construction cost will be estimated.
3	Preparation of Bidding Documents	Necessary bidding documents will be prepared for International Competitive Bidding.
4	Bid Supervision	Preparation of necessary documents and execution of necessary activities for all stages including preliminary examination, bidding, and bid evaluation will be done to support the implementing agency. Contract signing between the implementing agency and the contractor is also supported.
5	Supervision of Construction Work	As a representative of the Egyptian implementing agency, the consultant will undertake all activities related to the construction work (design change, specification change, change of construction quantity, supervision of material procurement, supervision of construction, etc.) during the construction period.
6	Implementation of Soft Components	The soft components are expected to conduct activities such as organizing documents that support the main project. To be more precise, the activities include the establishment of a format for a facility ledger concerning the targeted facilities for rehabilitation, which is conducted in line with the cooperation program, and the implementation of seminars and workshops to explain them.

Source: JICA Survey Team

7.2.2 Implementation Structure

(1) Borrower

The Government of Egypt

(2) Implementing Agency

1) Ministry

Ministry of Water Resource and Irrigation (MWRI)

2) Main Implementing Organization

Irrigation Department (ID), in charge of implementation, O&M of the irrigation system

Since this project is related to the rehabilitation of irrigation facilities in order to secure the distribution function of irrigation water, it is implemented as a project under the responsibility of the Irrigation Department in MWRI.

3) Construction and Operation/Maintenance and Management of Integrated Water Management System

RGBS, IS, IIS and local offices

4) Implementation, Operation, and Management of Rehabilitation Work of Irrigation System

Irrigation Sector (IS) and GDs under IS

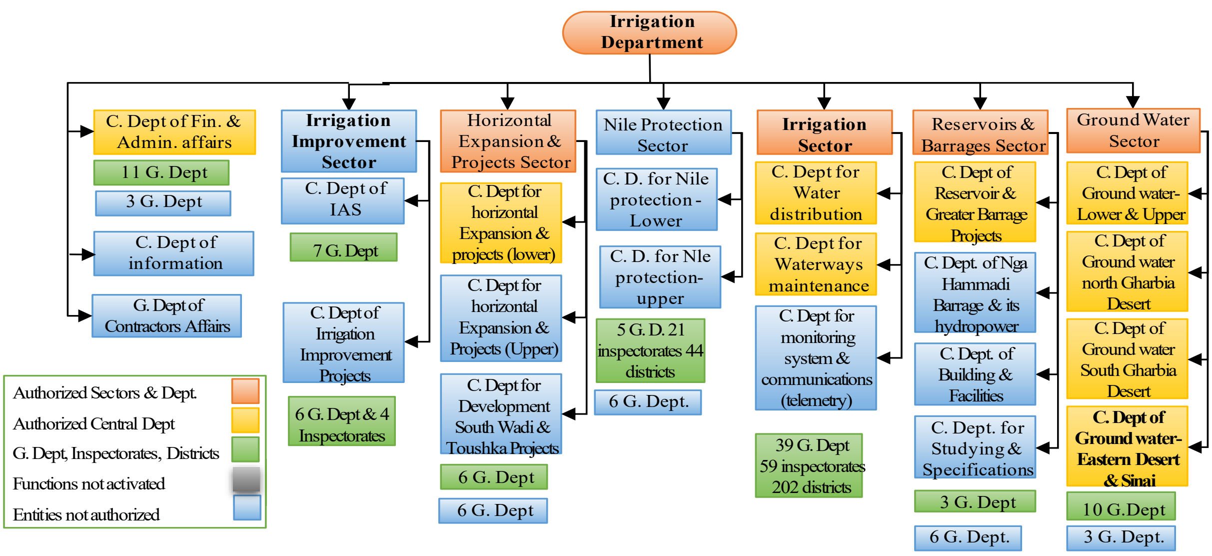
5) Implementation, Operation, and Management of Meska Improvement

Irrigation Improvement Sector (IIS) and GDs under IIS

(3) Operation Structure and Capacity

While MWRI has implemented projects to rehabilitate the barrages along the Nile River with loans from foreign donors, it also recently started "Rehabilitation Project of Dirout Group of Regulators" by an ODA loan from Japan. MWRI has experience with large-scale irrigation projects with loans in the past. Thus, there is no concern about its technical, organizational and management capacity.

The Irrigation Department as the main implementing organization is the main organization in MWRI and has the largest number of local offices. The organization chart of the Irrigation Department is as follows:



Source: Information from JICA expert

Figure 7.2 Organization Chart of Irrigation Department

Since irrigation facilities such as canals and small structures are managed by the Irrigation Sector (IS) and its local offices, the rehabilitation of those facilities is managed by IS. On the other hand, although meskas are managed by farmers, the Irrigation Improvement Sector (IIS) and its local offices are responsible for meska improvement.

Each department is independent in terms of budget, procurement, and its approval process. While IIS has been in charge of the rehabilitation project of four regulators on the Bahr Yusef canal system implemented by a Japanese grant, it has also implemented meska improvement by loan projects such as IIP and IIIMP from the World Bank. Hence, IIS has extensive experience as the implementing body. IS has undertaken rehabilitation of irrigation facilities with its own budget and it also implemented rehabilitation and new construction of regulators, renewal of bridges and canal reshaping in a loan project of IIIMP.

7.2.3 Financing Plan

The project will obtain a loan as "Sector Loan Funds" from the government of Japan. The costs not covered by the loan will be shouldered by the budget from MWRI.

7.2.4 Contents of Project Cost

The project cost includes the direct construction cost, cost of temporary work, indirect construction cost, engineering service fees, and physical and price contingencies. The cost estimation was made using the exchange rate of JICA in December 2017.

(a) Foreign currency: JPY/US$ US$1 = 111.291 JPY
(b) Local currency: JPY/EGP EGP1= 6.280720 JPY (EGP: Egypt pond)

(1) Direct Construction Cost

The basic unit costs for labor, materials and mechanical equipment are estimated from the quotations collected during this Survey. Other special materials such as sheet piles were estimated from similar examples in Egypt such as the cost estimation of the Dirout Group of Regulators.

Estimation of the costs of rehabilitation of principal canals and irrigation facilities in sub-regions is summarized in section 7.2.5 below. Other fees related to the total project cost is determined as discussed below.

(2) Cost of Temporary Work

This project is for canal rehabilitation, and during the construction, watering by sheet-pile cofferdam, etc., is normally a prerequisite. Although the cost of the temporary work of the New Dirout Group of Regulators that are being constructed in a limited area is 10% of the direct construction cost, the cost of temporary work of the proposed project is estimated at 15% of the direct construction cost, because this construction has the possibility that various limitations occur due to the long canal length. However, this is the current numerical value, and the appropriate expenses are decided in the course of further examinations.

(3) Indirect Cost

It is defined as 35% of the direct construction cost based on the information of the Dirout Group of Regulators.

(4) Cost of Engineering Service (Consulting Service)

It is defined as 10% of the construction cost based on the information of the Dirout Group of Regulators.

(5) Administration Cost

It is defined as 5% of the direct construction cost.

(6) Taxes

It is defined as 10% of the local currency portion of the direct construction cost.

(7) Price Escalation

Based on the inflation rate from 2013 to 2017, the average annual escalation rates of the currencies were defined as follows. For the foreign currency, the value of the Dirout Group of Regulators was applied.

(a) Local currency: 12.0% (Average annual escalation rate)
(b) Foreign currency: 1.8% (Average annual escalation rate)

(8) Physical Contingency

Five percent is adopted based on the appraisal manual issued in September 2008 for the Dirout Group of Regulators.

7.2.5 Estimated Cost of Cooperation Project

According to the component for each construction cost and project cost, estimated in the previous chapter, which considered the direction of cooperation for the facility rehabilitation as a hard component, the total project for the draft cooperation program is summarized as shown in Table 7.5 below. The summary of the project costs for the sub-regions are prepared for three plans: without lining (Plan 1), with the lining of main canals only (Plan 2), and with the lining of both main and branch canals (Plan 3).

Table 7.5 Summary of Estimated Cost of Draft Cooperation Project

<table>
<tr><th>Plan</th><th>Proposed Intervention</th><th>Target area (fed)</th><th>Project cost (US$)</th></tr>
<tr><td rowspan="2">Plan 1</td><td>Improvement of two principal canals</td><td>601,110</td><td rowspan="2">343,264,000</td></tr>
<tr><td>Improvement of small-scale structures of the first priority area in the sub regions</td><td>(202,565)</td></tr>
<tr><td rowspan="2">Plan 2</td><td>Improvement of two principal canals</td><td>601,110</td><td rowspan="2">581,946,000</td></tr>
<tr><td>Improvement of small-scale structures of the first priority area in the sub regions including the lining of main canals</td><td>(202,565)</td></tr>
<tr><td rowspan="2">Plan 3</td><td>Improvement of two principal canals</td><td>601,110</td><td rowspan="2">885,519,000</td></tr>
<tr><td>Improvement of small-scale structures of the first priority area in the sub regions including the lining of main and branch canals</td><td>(202,565)</td></tr>
</table>

Note: The numbers in parentheses indicate the included number of target areas of the main canal.
Note: The project cost includes construction cost, O&M, consulting service and physical contingency.
Source: JICA Survey Team

7.2.6 Environmental Impact Assessment

(1) Alternative Analysis including Zero Option

Regarding the analysis of the alternative plan, since the project area has not been specified at present, the comparison was made by components of the project. Plan A assumes improvement of canals, and improvement and new construction of irrigation facilities for all canals from the principal canal to meska within the target sub-region, except for lining of the main canal. Plan B assumes improvement of canals, and improvement and new construction of irrigation facilities for all canals from the principal canal to meska within the target sub-region, including the lining of the main canal. Plan C is the Zero option plan. Results of the analysis are shown in the Table below.

Table 7.6 Alternative Analysis including Zero Option

	Plan A Excluding lining of the main and branch canals	Plan B Including lining of the main canals	Plan C Including lining of the main and branch canals	Plan D Zero option
Outline	・Principal canal – dredging, bank raising, protection dike ・Main and branch canal – an improvement of irrigation facilities, reuse-pumps and their stations ・Meska improvement	・Principal canal – dredging, bank raising, protection dike ・Main and branch canal – Lining of the main canals, improvement of irrigation facilities, reuse-pumps and their stations ・Meska improvement	・Principal canal – dredging, bank raising, protection dike ・Main and branch canal – Lining of the main and branch canals, improvement of irrigation facilities, reuse-pumps and their stations ・Meska improvement	・No action plan.
Comprehensive Irrigation Water Management (CIWM)	・CIWM can be rationalized with a series of irrigation systems from the principal canal to meskas within the target sub-region. ・Water distribution will be improved by facility rehabilitation and water management. ・Irrigation efficiency will be 15% higher than zero option, but lower than Plan B due to excluding main canal lining.	・CIWM can be rationalized with a series of irrigation systems from the principal canal to meskas within the target sub-region. ・Water distribution will be improved by facility rehabilitation and water management. ・Water conveyance loss will be decreased by main canal lining ・It will be easier to maintain water distribution function, division water elevation and division water discharge due to stable cross-section by main canal lining.	・CIWM can be rationalized with a series of irrigation systems from the principal canal to meskas within the target sub-region. ・Water distribution will be improved by facility rehabilitation and water management. ・Water conveyance loss will be decreased by main and branch canal lining. ・It will be easier to maintain water distribution function, division water elevation and division water discharge due to stable cross-section by main and branch canal lining.	・Comprehensive water management from the principal canal to meskas has not been achieved at present. ・Effective use of limited water resources will not be promoted. ・Water flow capacity will decline further.
Economic Impact	・Income increase for farmers is expected with the increasing yields by improving water flow capacity. ・Employment opportunities associated with construction work are expected. ・Since there will be places where irrigation water cannot be used during the construction period, yields will possibly be decreased.	・Almost the same as Plan A, but its extent is low.	・Almost the same as Plan A. However, since the construction scale is the largest, its extent is low.	・Stable irrigation water cannot be obtained at present, which is the obstacle to the development of the agricultural sector.
Social environment	・Resettlement or land acquisition is not assumed, but there is a possibility that land lease may be necessary for the temporary working yard for construction.	・Same as Plan A.	・Same as Plan A.	・Resettlement of land acquisition will not occur.

	Plan A Excluding lining of the main and branch canals	**Plan B Including lining of the main canals**	**Plan C Including lining of the main and branch canals**	**Plan D Zero option**
Natural environment	・ Since the project shall be an improvement of existing canals and facilities, and the construction scale is not large, impact on the natural environment is not assumed.	・ Same as Plan A.	・ Same as Plan A.	・ Same as the current situation.
Technical point of view	・ Currently, there are enormous parts that are aged or damaged in canal from the principal canal down to the meska as well as the irrigation facilities. ・ Based on these improvement work volume and difficulty level, it is important to select the area that can be an effective model to aim for integrated water management.	・ Same as Plan A.	・ Same as Plan A.	・ Inefficient water use and irrigation facility's malfunction will continue, or the places where functional deterioration will further increase.
Construction period	・ Shorter than Plan B.	・ It is determined by the amount of construction work, but the longest among the alternatives.	・ Although the construction volume is larger than Plan B, it is possible to achieve the same level of construction period by proper lot-division, etc.	・ No construction work (0 days).
Construction Cost	・ Since it will not carry out the main canal lining, the cost is the lowest.	・ Since it will carry out the main canal lining, the cost is about 1.7 times higher than Plan A	・ Since it will carry out the main canal lining, the cost is about 2.7 times higher than Plan A.	・ Nil.
Maintenance	・ Introducing the concept of Stock Management ・ Meska shall be managed by WUA.	・ Same as Plan A.	・ Same as Plan A.	・ Same as the current situation.
Evaluation	Recommended.	Most Recommended.	Recommended.	Not recommended...

Source: JICA Survey Team

(2) Environmental Impact Evaluation of Similar Projects

Categorization of environmental categories of similar past JICA projects and their reasons are shown in Table 7.7.

Table 7.7 Categorization of Environmental Categories of Past JICA Similar Projects

Project	**Environmental Category (Egyptian EIA Category)**	**Reason**
The rehabilitation and improvement of Dirout group of regulators in the Arab Republic of Egypt Duration : March 2015 – December 2022	Category C	Leaving the existing regulator group as a historic building and planned to construct a new regulator group downstream. In this case, it was regarded as a new project and categorized category C.

Project	Environmental Category (Egyptian EIA Category)	Reason
The Project for Rehabilitation and Improvement of Monshat El Dahab Regulator on Bahr Yusef Canal Completion：July 2010	Category B	Rehabilitation of existing Dahab regulator and its facilities. 1) Renewal of the existing Dahab Regulator 2) Renewal of the main gates 3) Rehabilitation of the regulator bridge 4) Rehabilitation /Renewal of the Control House Since these facilities are improved and built in the Bahr Yusef irrigation main canal where the existing Dahab regulator located and in the surrounding site, they will not bring about new environmental changes and will not adversely affect society.
The Project for Rehabilitation and Improvement of Sakoula Regulator on Bahr Yusef Canal Completion：June 2006	Category: unspecified （No EIA conducted）	Rehabilitation of existing Sakoula regulator and its facilities. 1) Renewal of the existing Sakoula regulator 2) renewal of the main gate to the motorized overflow type 3) Construction of the Control House 4) Renewal of the regulator bridge There were no EIA implementation examples on the improvement of irrigation facilities and the new establishment of medium- and small-scale irrigation facilities. Accordingly, this project was decided not to be carried out EIA.

(3) Screening

Although precise project target areas have not been decided at present, expected construction work as the hardware of the project are shown in Table 7.8 below. As described in Chapter 2, 2.5.2 (2) Categorization of Projects, according to the Egyptian EIA guidelines, the medium-scale irrigation and drainage project is categorized as category B and the large-scale irrigation and drainage project, dam and weir are categorized as category C where EIA is required. According to MWRI, the improvement of irrigation facilities such as aqueducts and weirs is category B, new irrigation facilities built on the Nile and main canals are classified as category C irrespective of the magnitude of the environmental impact[31]. From these descriptions and from examples of similar projects in above (2), it is assumed that this project will be categorized less than category B.

Table 7.8 Expected Construction Work

Category	Construction Work
Canal rehabilitation (principal, main, branch)	Lining (Masonry, concrete lining, concrete flume), bank raising, protection dike (critical curve), dredging
Rehabilitation or newly establishing of irrigation facilities	intakes, regulators, weirs, removing old weirs, reuse pumping stations, siphons, culverts, aqueducts and bridges
Rehabilitation of tail-end canals	Meska improvement (gravity open, pressured pipeline, pressured open canal)

As for the EIA procedure, categories A, B, and C have to follow the flow of the EIA procedure shown in Figure 2.14 in 2.5.2. A full-scale EIA report is required for Category C. On the other hand, categories A and B require to fill each form shown in the EIA guideline with simpler survey items than Category C. Further, Category C requires the holding of a public hearing, but it is not required for categories A and B.

(4) Scoping

Table 7.9 shows the scoping results of the preliminary evaluation items for environmental and social considerations for the construction shown in Table 7.8 in the above (3) scoping, which are considered to be important at present. For selecting evaluation items, environmental checklist No. 3 “Hydraulic power plant, Dam, and Reservoir” and No. 16 “Agriculture, Irrigation and Livestock” of the JICA

[31] JICA: The Preparatory Survey for the Rehabilitation and Improvement of Dirout Group of Regulators in the Arab Republic of Egypt, Oct. 2010

environment and social consideration guidelines were referred to.

Table 7.9 Scoping Result

	Item	Rating: Pre-/Const.	Rating: Operation	Description of Impact
Pollution				
1	Air	B-	D	[Construction phase] Temporary but the deterioration of air quality is assumed due to the operation of construction equipment and others. At present, the project site is not specified, but if there is a possibility that the residential area will be adjacent to the construction area, the negative impact is expected. [Operation phase] The power of the repairing pumping station and for the gate operation is assumed to be electricity and hence the activity that causes air pollution is not anticipated.
2	Water	B-	C	[Construction phase] There is a possibility of water pollution due to discharge water from construction sites, heavy machinery, vehicles, and construction camps. [Operation phase] Rehabilitation of existing irrigation facilities is mainly and hence the activity that causes water pollution is not anticipated. However, water quality may deteriorate unless thorough measures are taken to dispose of garbage into the canal.
3	Solid Waste	B-	D	[Construction phase] It is expected that solid waste, remaining construction soil, and waste materials will be generated as a result of removal or relocation of existing structures. [Operation phase] Solid waste which will cause the impact to around is not expected.
4	Soil Contamination	B-	D	[Construction phase] There is a possibility of soil contamination due to oil leakage from construction machinery. [Operation phase] Soil contamination which will cause the impact to surroundings is not expected.
5	Noise and Vibration	B-	D	[Construction phase] Noise and vibration caused by construction equipment and vehicle operation, pile construction work, canal excavation work, etc. are assumed. [Operation phase] Activities causing noises and vibrations are not assumed. Noise is reduced if the gate is improved to be operated by electric power.
6	Ground Subsidence	C	C	Will be confirmed after the project site is specified.
7	Offensive Odor	B-	C	[Pre-Construction phase] At the intake facility, there are bad smells due to garbage deposits and piled plants. [Construction phase] Construction work on the canal can generate a bad smell, which impairs the well-being of the residents of the neighborhood. [Operation phase] Unless thorough measures are taken to dispose of garbage in the canal, there is a bad smell from garbage accumulation near the gate.
Natural Environment				
8	Protection Area	D	D	[Pre-Construction phase] There is no protected area in the assumed target project area, but from Faiyum city center, Lake Qarun is located 25 km northwest and Wadi Rayan Lake is located 35 km west. [Construction phase] Activities which will cause an impact on both lakes are not expected. [Operation phase] Activities which will cause an impact on both lakes are not expected.
9	Ecosystem	D	D	Since this project is mainly the rehabilitation of existing facilities, it is hardly expected that there will be the impact on the ecosystem.
10	Hydrological Situation	C	C	[Construction phase] Changes in the groundwater table in the surrounding areas may occur due to the type of construction work, changes in the water currents on the bottom of the canal. [Operation phase] There is a possibility of change in groundwater table in the surrounding area.

Item		Rating		Description of Impact
		Pre-/Const.	Operation	
11	Topography and Geographical Features	D	D	Since the assumed construction work is the rehabilitation of the existing facility or new establishment of the facility on the existing canal, the works which greatly alter the topography or geology are not expected.
Social Environment				
12	Involuntary Resettlement/Land Acquisition	B-	D	[Construction phase] Since the project is the rehabilitation of the existing facility or new establishment of the facility on the existing canal, the work that needs involuntary resettlement or land acquisition is not expected. Although it is assumed that the land for temporary yards for construction-use is owned by MWRI, a temporal land-lease might occur. [Operation phase] In case a land is leased temporally, it will be returned after restored.
13	Living and Livelihood	B-	B+	[Construction phase] It is expected that inconvenient situation will occur in traffic around the construction area. [Operation phase] Irrigation water is supplied stably with the improvement of irrigation facilities. It is expected to have double cropping, increased yields, and stable production, hence positive impact to farmers and the local economy is expected.
14	Heritage	C	C	Will be confirmed after the project site is specified.
15	Landscape	B-	D	[Construction phase] The landscape is temporarily damaged by construction works. [Operation phase] Since the assumed construction works are the rehabilitation of the existing facility or new establishment of the facility on the existing canals, the impact on the landscape is not expected.
16	Ethnic Minorities and Indigenous Peoples	C	C	Although survey will be done after the project site is identified, issues of ethnic minorities and indigenous peoples are not assumed at present.
17	Working Conditions	C	D	[Construction phase] It is necessary to pay attention to the working conditions of construction workers.
Others				
18	Impacts during Construction (Accident)	B-	D	[Construction phase] Accidents during construction and traffic accidents due to the operation of construction vehicles and construction machinery are concerned.
19	Cross-border issue /climate change	D	C	The principal canals of the project take water from the Nile River, and the agricultural drainage water is finally returned to the Nile River. It is assumed that the influence of agricultural drainage water at the time of operation on water pollution of the Nile River is limited. In addition, the construction of large-scale dams or weir is not planned. It is assumed that realizing effective water use will reduce the amount of water-use, so big impact on water is not assumed even climate change may happen.

Rating:
A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is slight or unknown. (Further examination is needed, and the impact could be clarified as the study progresses) D: No impact is expected.

Source: JICA Survey Team

(5) TOR for EIA Study

In the above scoping, the contents and method of the survey assumed at present for items rated to have some negative influence or are unclear are summarized in the table below as TOR of the environmental social consideration survey.

Table 7.10 TOR for EIA Study

Evaluation Item	Survey Item	Survey Method
Pollution		
1.Air	(1) Regulations and/or act of ambient air quality (2) Impact during the construction	(1) Review of existing information/data (2) Confirmation of the contents of construction, construction method, term, construction scope and buildings that require special consideration, and hearings
2.Water	(1) Regulations or act on water quality/effluent water (2) Impact during the construction	(1) Review of existing information/data (2) Confirmation of the contents of construction, construction method, term, construction scope and buildings that require special consideration, water sampling, and hearings
3. Solid Waste	(1) Act or regulations about disposal management (2) Impact during the construction	(1) Review of existing information/data (2) Confirmation of the contents of construction, construction method, term, construction scope and buildings that require special consideration, and hearings
4.Soil Contamination	(1) Act or regulations about soil contamination (2) Impact during the construction	(1) Review of existing information/data (2) Confirmation of the contents of construction, construction method, term, construction scope and buildings that require special consideration, soil sampling, heavy metal content in soil, and hearings
5.Noise and Vibration	(1) Act or regulations of noise and vibrations (2) Impact during the construction	(1) Review of existing information/data (2) Confirmation of the contents of construction, construction method, term, construction scope and buildings that require special consideration, and hearings
6.Ground Subsidence	(1) Act or regulations about ground subsidence (2) Impact during the construction	(1) Review of existing information/data (2) Confirmation of the contents of construction, construction method, term, construction scope and buildings that require special consideration, and hearings
7.Offensive Odor	(1) Act or regulations about an offensive odor (2) Impact during the construction	(1) Review of existing information/data (2) Confirmation of the contents of construction, construction method, term, construction scope and buildings that require special consideration, and hearings
Natural Environment		
10. Hydrological Situation	(1) Impact during the construction (2) Impact during the operation phase	(1) Confirmation of the contents of construction, construction method, term, construction scope and buildings that require special consideration, groundwater table, and hearings (2) Confirmation of groundwater level, and hearings
Social Environment		
12.Involuntary Resettlement/Land Acquisition	(1) Regulations and acts regarding land acquisition and land lease (2) necessity and its scope of regarding land acquisition and land lease (3) Compensation method	(1) Review of existing information/data, and hearing (2) Confirmation of the contents of construction, term, construction scope and landowners (3) Confirmation of compensation cases in similar cases, and hearing
13.Living and Livelihood	(1) Impact during the construction (2) Impact during the operation phase	(1) Confirmation of the contents of construction, term, construction scope and traffic volume (2) Confirmation of the area of double cropping, cultivated land, planted crops and yield.
14.Heritage	(1) Regulations and acts regarding heritage (2) Impact during the construction	(1) Review of existing information/data (2) Confirmation of the contents of construction, construction method, term, construction scope and buildings that require special consideration, and hearings
15. Landscape	(1) Regulations and acts regarding landscape (2) Impact during the construction	(1) Review of existing information/data (2) Confirmation of the contents of construction, construction method, term, construction scope and buildings that require special consideration, and hearings

Evaluation Item	Survey Item	Survey Method
16.Ethnic Minorities and Indigenous Peoples	(1) Regulations and acts regarding ethnic minorities and indigenous peoples (2) Impact during the construction	(1) Review of existing information/data (2) Confirmation of the contents of construction, construction method, term, construction scope and buildings that require special consideration, and hearings
17. Working Conditions	(1) Regulations and acts regarding Industrial Safety and Health Law (2) Impact on workers under construction	(1) Review of existing information/data (2) Confirmation of the contents of construction, construction method, term, examples of countermeasures in similar projects
Others		
18. Impacts during Construction (Accident)	(1) Accidents occurred (2) Impact during the construction	(1) Hearings (2) Accident Prevention and cases of safety countermeasures in similar projects
19. Cross-border issue /climate change	(1) Confirmation of international and domestic law concerning the Nile River (2) The impact of climate change	(1) Review of existing information/data (2) Confirmation of the contents of construction, construction method, term, Water storage effect and flood control function of canals

Source: JICA Survey Team

(6) Results of the EIA Study including Prediction Results

The table below shows the results of the EIA study conducted based on the Scoping.

Table 7.11 Results of the EIA Study

Items	Results of the EIA Study
Pollution	
1. Air	During construction, flue gas from fuel combustion, exhaust gas (CO2, NOx), and dust caused by vehicles traffic and civil engineering work by construction machinery will be discharged to the atmosphere. Degradation of air quality can affect the health of local residents. Although the negative impact is expected, its impact is minimal since construction term is a short-term, and not a phenomenon in a wide range. At the operation phase, regarding repairing pump stations, exhaust gas emissions are reduced if the power of the pump is electric power.
2. Water	It may be affected by hydrocarbons derived from construction and accidental outflow of oils or other waste. In particular, the latter is important in activities before / during the construction period (site maintenance, waste management, equipment maintenance). In addition, at the time of operation, water quality may deteriorate unless thorough measures are taken to the disposal of garbage into the canal.
3. Solid Waste	Solid and liquid waste is generated from the initial stage of construction. Solid waste includes food, plastics, plants, etc. Liquid waste can be discharged water, waste oil, wastewater base camp.
4. Soil Contamination	Soil contamination can be caused by hydrocarbon runoff which may occur during an oil change and construction-equipment’s repair at the construction site, hazardous solid waste, random discharge of waste liquid, etc.
5. Noise and Vibration	Pre / during the construction period, the civil works (drilling, leveling, dredging), transportation and unloading of materials, and traffic of heavy machinery can generate noise and vibration. Such noise may have an effect on the hearing of construction workers and neighboring residents. At the time of operation, the risk of noise and vibration are small. Noise and vibration are reduced when the gate operation is powered by electricity.
6. Ground Subsidence	Although land subsidence caused by the project implementation is not assumed at the moment, it is confirmed after the project site is specified.
7. Offensive Odor	Improvement of the canals generates a bad smell which impairs the well-being of the residents of the neighborhood. Unless the measures to dispose of garbage dumped in the canal are thoroughly carried out, the malodor from dust accumulation near the gate cannot be improved.
Natural Environment	
9. Ecosystem	Since assumed project components are the rehabilitation of existing facilities, no impact is assumed.
10. Hydrological Situation	Changes in flow regime and groundwater table are assumed by drilling and shaping of canal bottom, raising banks, protecting banks, protecting the slope, dredging, etc.
Social Environment	
12. Involuntary Resettlement/Land Acquisition	Resettlement of residents is not assumed because the project is an improvement of existing facilities or establishment of facilities on existing canals. The temporary yard for construction assumes to use the land owned by MWRI, but if temporary land lease occurs, it will be restored and returned.

Items	Results of the EIA Study
13. Living and Livelihood	During construction, it may hinder the passage around the construction area and possibly inconvenience the residents' daily lives. Meanwhile, irrigation water is supplied stably due to the maintenance of the irrigation facilities, double cropping, increased yields and stable production are expected, and positive impacts on farmers and the local economy are expected.
14.Heritage	Heritage will be confirmed after the project site is specified. Mosques may be located inside the construction area, but it is assumed that these are generally built on land owned by MWRI. Resettlement will be avoided as much as possible. Even if it is inevitable, it shall be relocated to the neighboring site owned by neighbor MWRI.
15. Landscape	Despite changes in the landscape during the construction period, no significant impact on the landscape is assumed
16. Ethnic Minorities and Indigenous Peoples	It is confirmed after the project site is specified, but the existence of ethnic minorities and indigenous peoples who should consider the rights is not expected.
17. Working Conditions	Articles 208 and 211 of the Labor Law stipulate that employers need to take all necessary measures to protect workers from hazards, chemicals, machinery, infections, noise and noise pollution in the workplace. In addition, Article 212 and 214 of the Labor Law stipulate that employers are obliged to establish necessary emergency measures and fire indication measures in the workplace. These laws should be observed for securing the working environment of workers.
Others	
18. Impacts during Construction (Accident)	Measures to prevent accidents shall be taken at the construction site, but there is concern that the occurrence of traffic accidents caused by the operation of construction vehicles and construction machinery.
19. Cross-border issue /climate change	The impact of agricultural drainage water on the Nile water quality at the operation phase of the project is limited. It is assumed that realizing effective water use will reduce the impact on water available amount due to climate change.

Source: JICA Survey Team

(7) Result of EIA

Based on the results of the EIA Study, the impact on the environment and society is summarized in the table below.

Table 7.12 Result of EIA

Evaluation Items		Scoping results		Evaluation		Reason
		Pre-/Const	Operation	Pre-/Const	Operation	
Pollution						
1	Air	B-	D	B-	D	[Construction phase] Temporary but the deterioration of air quality is assumed due to the operation of construction equipment and others. At present, the project site is not specified, but if there is a possibility that the residential area will be adjacent to the construction area, the negative impact is expected. [Operation phase] The power of the repairing pumping station and for the gate operation is assumed to be electricity, hence the activity that causes air pollution is not anticipated.
2	Water	B-	C	B-	C	[Construction phase] There is a possibility of water pollution due to discharge water from construction sites, heavy machinery, vehicles and construction camps. [Operation phase] Rehabilitation of existing irrigation facilities is the main part, hence the activity that causes water pollution is not anticipated. However, water quality may deteriorate unless thorough measures are taken to dispose of garbage into the canal.
3	Solid Waste	B-	D	B-	D	[Construction phase] It is expected that solid waste, remaining construction soil and waste materials will be generated as a result of removal or relocation of existing structures. [Operation phase] Solid waste which will cause the impact to around is not expected.

Evaluation Items		Scoping results		Evaluation		Reason
		Pre-/Const	Operation	Pre-/Const	Operation	
4	Soil Contamination	B-	D	B-	D	[Construction phase] There is a possibility of soil contamination due to oil leakage from construction machinery. [Operation phase] Soil contamination which will cause the impact to surroundings is not expected.
5	Noise and Vibration	B-	D	B-	D	[Construction phase] Noise and vibration caused by construction equipment and vehicle operation, pile construction work, canal excavation work etc. are assumed. [Operation phase] Activities causing noises and vibrations are not assumed. Noise is reduced if the gate is improved to be operated by electric power.
6	Ground Subsidence	C	C	C	C	Ground subsidence will be confirmed after the project site is specified.
7	Offensive Odor	B-	C	B-	C	[Pre-Construction phase] At the intake facility, there are bad smells due to garbage deposits and piled plants. [Construction phase] Construction work on the canal can generate a bad smell which impairs the well-being of the residents of the neighborhood. [Operation phase] Unless thorough measures are taken to dispose of garbage in the canal, there is a bad smell from garbage accumulation near the gate.
Natural Environment						
10	Hydrological Situation	C	C	C	C	[Construction phase] Changes in the groundwater table in the surrounding areas may occur due to the type of construction work, changes in the water currents or the bottom of the canal. [Operation phase] There is a possibility of change in groundwater table in the surrounding area.
Social Environment						
12	Involuntary Resettlement/Land Acquisition	B-	D	B-	D	[Construction phase] Since the project is the rehabilitation of the existing facility or new establishment of the facility on the existing canal, the work that needs involuntary resettlement or land acquisition is not expected. Although it is assumed that land for temporary yards for construction-use is owned by MWRI, a temporal land-lease might occur. [Operation phase] In case a land is leased temporally, it will be returned after restored.
13	Living and Livelihood	B-	A+	B-	A+	[Construction phase] It is expected that inconvenient situation will occur in traffic around the construction area. [Operation phase] Irrigation water is supplied stably with the improvement of irrigation facilities. It is expected to have double cropping, increased yields, and stable production, hence positive impact to farmers and the local economy is expected.
14	Heritage	C	C	C	C	Heritage will be confirmed after the project site is specified.
15	Landscape	B-	D	B-	D	[Construction phase] The landscape is temporarily damaged by construction works. [Operation phase] Since the assumed construction works are the rehabilitation of the existing facility or new establishment of the facility on the existing canals, impact on the landscape is not expected.
16	Ethnic Minorities and Indigenous Peoples	C	C	C	C	Although survey will be done after the project site is identified, issues of ethnic minorities and indigenous peoples are not assumed at present.

Evaluation Items		Scoping results		Evaluation		Reason
		Pre-/Const	Operation	Pre-/Const	Operation	
17	Working Conditions	C	D	C	D	[Construction phase] It is necessary to pay attention to the working conditions of construction workers.
Others						
18	Impacts during Construction (Accident)	B-	D	B-	D	[Construction phase] Accidents during construction and traffic accidents due to the operation of construction vehicles and construction machinery are concerned.
19	Cross-border issue /climate change	D	C	D	C	The principal canals of the project take water from the Nile River, and the agricultural drainage water is finally returned to the Nile River. It is assumed that the influence of agricultural drainage water at the time of operation on water pollution of the Nile River is limited. In addition, the construction of large-scale dams or weir is not planned. It is assumed that realizing effective water use will reduce the amount of water-use, so big impact on water is not assumed even climate change may happen.

Rating:
A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is slight or unknown. (Further examination is needed, and the impact could be clarified as the study progresses) D: No impact is expected.

Source: JICA Survey Team

(8) Mitigation Measures and Costs

The mitigation measures and costs examined based on the above survey results are shown in the table below.

Table 7.13 Mitigation Measures and Budget

No.	Impact item	Mitigation Measures	Implementing Organization	Responsible Organization	Cost (US$)
[Pre construction / Construction phase]					
1	Air	• Sprinkle water on the road to prevent dust. • Educate construction work vehicle drivers and workers not to idle vehicles and equipment. • When transporting construction materials, install a scattering prevention cover.	Contractor	MWRI	Including in BoQ
2	Water	• For the discharge, water produced by the construction work set up a sand pond and drains the intermediate water to the downstream. • Alkaline drainage shall be drained gently so that it will not have a sharp impact on the downstream. • Cure the surface of the concrete lining sufficiently, dry it thoroughly, and then start water flow. • Thorough measures to deal with garbage dumped in the waterway should be taken.	Contractor	MWRI	Including in BoQ
3	Solid Waste	• Reuse or process dredged soil properly. • Waste generated when improving existing structures is temporarily stored in a safe place and discarded to the place designated by the administration.	Contractor	MWRI Local Govt.	Including in BoQ

No.	Impact item	Mitigation Measures	Implementing Organization	Responsible Organization	Cost (US$)
4	Soil Contamination	• Use a drip tray when doing work that may have an oil spill. • Periodically inspect and maintain heavy equipment and materials to prevent oil leakage.	Contractor	MWRI	Including in BoQ
5	Noise and Vibration	• Perform regular maintenance of equipment to prevent abnormal sounds and vibration. • Provide ear pads on others to workers who work near machinery producing operational noises.	Contractor	MWRI	Including in BoQ
6	Ground Subsidence	• If excavation work with pumping groundwater is undertaken, waterproofing countermeasures, etc. to reduce pumped water volume shall be implemented, and the scope of impact shall be minimized. • Excavation method, etc. shall not disturb the geological fragile part, etc.	Contractor	MWRI	Including in BoQ
7	Offensive Odor	• Accumulated garbage and aquatic weed are treated such as drainage and discarded to the place designated by the administration.	Contractor	MWRI	Including in BoQ
10	Hydrological Situation	• If excavation work with pumping groundwater is undertaken, waterproofing countermeasures etc. to reduce pumped water volume shall be implemented, and the scope of influence shall be minimized. • Excavation method etc. shall not disturb the geological fragile part, etc. • Observe the groundwater regularly. • Analyze groundwater table at design stage and judge countermeasures according to the results.	Contractor	MWRI	Including in BoQ
12	Involuntary Resettlement/Land Acquisition	• Resettlement or land acquisition is not planned, but temporary land lease contracts are assumed for a temporary construction yard. • Secure payment of lease fee.	Contractor	MWRI	Including in BoQ
13	Living and Livelihood	• Properly organize traffic around construction sites	Contractor	MWRI	Including in BoQ
14	Heritage	• Construction work shall omit the heritage area. • If relocation is inevitable, select and moves to relocation destination appropriately.	Contractor	MWRI	Including in BoQ
15	Landscape	• During construction, make efforts to improve the scenery as much as possible by construction landscape-conscious fences etc.	Contractor	MWRI	Including in BoQ
16	Ethnic Minorities and Indigenous Peoples	• Comply with the laws on the rights of ethnic minorities and indigenous peoples. • Consider reducing the impact on ethnic minorities, indigenous peoples' cultures, and lifestyles.	Contractor	MWRI Local Govt.	Including in BoQ
17	Working Conditions	• Provide appropriate occupational safety equipment (helmet, shoes, etc.) according to the contents of work. • Provide safety education for workers.	Contractor	MWRI	Including in BoQ

No.	Impact item	Mitigation Measures	Implementing Organization	Responsible Organization	Cost (US$)
18	Impacts during Construction (Accident)	• Implement regular maintenance of heavy machinery and equipment. • Install a sufficient number of the first-aid kit on site. • Prepare an accident emergency response manual including safety measures.	Contractor	MWRI	Including in BoQ
[Operation Phase]					
2 7 19	Water Offensive Odor Cross-border issue /climate change	• Thorough measures to deal with garbage dumped in the waterway should be taken.	Local Govt.	MWRI	Administrative budget
18	Accident	• Organize the occurrence record of accidents and take measures to prevent recurrence. • Check the status of the intrusion-and-fall-prevention fence installed on the irrigation facility regularly, and reinforce and repair if necessary.	Local Govt.	MWRI	Administrative budget

Source：JICA Survey Team

(9) Environmental Management and Monitoring Plan (EMMP)

The environmental management monitoring plan (EMMP) described in the table below shall be conducted on the implementation status of mitigation measures at the pre-construction and construction phases and operation phase. Depending on the monitoring items, the executing organizations are different, but the responsible organization is MWRI, which is the project implementing entity.

Table 7.14 Environmental Management and Monitoring Plan (EMMP)

Impact Item	Monitoring Item	Frequency	Indicator	Place	Implementer
[Pre construction / Construction phase]					
0. General	Complaints handling record	Weekly	The existence of the record	Project site	Contractor
	Maintenance and inspection record of equipment	Daily and Periodically	The existence of the record	Project site	Contractor
1. Air	Implementation status of water spray	Monthly	Whether water spraying was done	Project site	Contractor
	Conditions of occurrence of dust by visual observation	Monthly	The existence of the dust	Project site	Contractor
2. Water 7. Offensive Odor	pH, SS, COD, BOD, dumped garbage	Once before construction work, and Monthly	The existence of the record	A certain spot of the canal, and garbage accumulation spot in front of the gate	Contractor
3. Solid Waste	Recycling status of site-generated soil	Monthly	Whether reuse is implemented	Project site	Contractor
	Processing status of concrete debris, forms, waste oil, etc. at the designated disposal location	Monthly	Status of proper disposal	disposal location	Contractor
	Education related to garbage and waste disposal to workers	Monthly	Whether education is implemented	Project site	Contractor
4.Soil Contamination	Drip tray usage status	Monthly	The existence of the record	Project site	Contractor

Impact Item	Monitoring Item	Frequency	Indicator	Place	Implementer
5. Noise and Vibration 17. Working Conditions	Safety education implementation status	designated month	The existence of the record	Project site	Contractor
	Distribution status of helmets, protective goggles, ear pads, etc. to workers	Monthly	Whether distribution is done and the status of usage	Project site	Contractor
	Status of placement of first aid kits (FAK)	Monthly	Whether placement is done	Project site	Contractor
	Preparation of accidental-emergency response manual and announcement to workers	Monthly	Record of preparation manual and announcement	Project site	Contractor
6. Ground Subsidence	Monitoring of groundwater table and ground subsidence	Monthly	The existence of the record	Project site	Contractor
10. Hydrological Situation	Monitoring of groundwater table and ground subsidence	Monthly	The existence of the record	Project site	Contractor
12. Involuntary Resettlement/Land Acquisition	Resettlement and land acquisition are not assumed, but the temporary land lease is assumed due to the provisional yard for construction. Payment status of lease fee	Monthly	The existence of the record Proof of lease payment	Project site	Contractor
13. Living and Livelihood	Number of traffic accidents around the construction area	Monthly	The existence of the record	Project site neighboring area	Contractor
14. Heritage	Change by visual inspection	Monthly	The existence of the record	Project site	Contractor
15. Landscape	Scenery condition such as construction fences	Monthly	The existence of the record	Project site	Contractor
16. Ethnic Minorities and Indigenous Peoples	Complaints handling record	Weekly	The existence of the record	Project site	Contractor
18. Impacts during Construction (Accident)	Status of Advanced notification of construction section to surrounding area	Monthly	Whether notification is done	Project site	Contractor
	Installation status of signboards and introducers in areas around construction sites and sections with bad visibility	Monthly	Whether installation is done	Project site	Contractor
	Confirmation of the record describing the extent, number of times, cause, future measures, etc. of the accident that occurred	Monthly	The existence of the record	Project site	Contractor

Impact Item	Monitoring Item	Frequency	Indicator	Place	Implementer
[Operation Phase]					
2. Water 7. Offensive Odor 19 Cross-border issue /climate change	pH, SS, COD, BOD, dumped garbage	Monthly	The existence of the record	A certain spot of the canal, and garbage accumulation spot in front of the gate certain point downstream of the outlet of the main drainage canal that drains into the Nile River	MWRI
10. Hydrological Situation	Monitoring of groundwater table and ground subsidence	Monthly	The existence of the record	Project site	MWRI
13. Living and Livelihood	the ratio of double cropping rate income Rotational water supply	Semiannual	Comparison with pre-project baseline survey results	Beneficiary area	MWRI
18. Accident	Accident occurrence record including accident prevention measures in the future	Annually (Duration: two years)	The existence of the record	Interviews with traffic police on residents if necessary	Local administration
	The situation of the intrusion and fall prevention fence of the facility, and repair history when the repair was done	Annually (Duration: two years)	Whether the situation is good, whether there is repair	Intrusion and fall-prevention fence installation location	MWRI

Source：JICA Survey Team

7.2.7 Preliminary Examination of the Financial Feasibility of Proposed Yen Loan Projects

In the financial analysis of the yen loan projects proposed, the JICA Survey Team examines the expected effect with the implementation of components and compares the project-benefit converted to a monetary value with the project cost, and evaluates the financial efficiency of the project.

The effect of the yen loan project that can create more rationally management of irrigation water and reduce water shortages by the rehabilitation of the principal canals and irrigation facility in the priority sub-regions. As a result, an increase in agricultural productivity in the beneficiary area of the project will be expected. In addition, the effect of the yen loan project is calculated by grasping the improvement in the productivity of crops as equivalent to the increase of unit yield. (The JICA Survey Team calculates the increase converted to the monetary value of the project in agricultural production by improving agricultural productivity and analyzes the financial aspects of the project.)

The financial evaluation of the yen loan project is carried out by Economic Internal Rate of Return (EIRR), cost-benefit ratio (B/C) and Net Present Value (NPV), which are indicators using financial price.

(1) Basic Assumption

The following basic assumptions are adopted for the financial analysis.

(a) The financial project life is 30 years.

(b) All local prices such as good, services, and materials are expressed at the price level as of April 2017. However, the farm gate price of agricultural products in 2017 was predicted based on current market conditions and the liberalization of the exchange rate in November

2016 from the data of the cropping season of 2016.

(c) The exchange rate is US$ 1 = EGP 17.7194653=JPY 111.291 as of December 2017

(d) Transfer payments such as administration cost, taxes, duties, subsidies, and interest are excluded from the financial analysis.

(e) Conversion of market price to financial price is converted by applying Standard Conversion Factor (SCF) 0.93. The shadow wage rate for agriculture labor work is estimated at 0.63.

(2) Project Cost

The financial project cost consists of construction cost, O&M cost, consulting service cost and physical contingencies. The financisl project cost was converted from market project cost using SCF 0.93.

(3) Benefit of Planned Project

1) Yen Loan Project Benefit

The proposed projects will improve the principal canal of Bahr Yusef and Ibrahimia, and improve the main canals/branch canals by partially lining and renovating reuse pumps in the main canals/branch canals. It is expected that the improvement of water distribution will lead to an increase in agricultural productivity. The increase of productivity will be calculated by the increase of the unit yield of crops.

2) Estimation of Project Benefits

The yen loan project benefit is estimated from the increase of the unit yield of crops based on the incremental ratio of the unit yield proposed and the following points are considered to estimate the benefits.

a) In farming in the project command area, maize in the summer season and wheat/berseem in the winter occupy the greater part of the cultivated area. These crops are the major staple grains and fodder, and they will be cultivated to the same extent as present and are important crops in the future. There would also be a possibility of changing the cultivated area of vegetables due to the change of market environment, but the water requirements for vegetables are not much different from maize and wheat, and the project doesn't include development of farming practices. Therefore, the effects of the proposed Project in this Study are mainly considered from the increase of productivity with appropriate irrigation water distribution regardless of changing cropping patterns.

b) Since the present cropping intensity of beneficiary areas namely four governorates (Giza, Beni Suef, Faiyum, and Minya), is already as high as 182%, increase of cropping intensity is not considered in the future plan. The Project applies the cropping intensity based on the present cropping pattern and intensity values derived from the agriculture statistics.

Table 7.15 Percentage of Cultivation of Representative Crops in Beneficiary Governorate

Season	Crops	Giza		Beni Suef		Faiyum		Minya		Total	
		Area (fed)	Share (%)	Area (fed)	Share (%)	Area (fed)	Share (%)	Area (fed)	Share (%)	Area (fed)	Share (%)
Winter	Wheat	46,278	9.7%	143,990	25.4%	225,753	28.5%	262,943	29.9%	678,964	25.0%
	Berseem	40,615	8.5%	29,753	5.2%	86,372	10.9%	79,881	9.1%	236,621	8.7%
	Vegetables	105,084	22.0%	53,624	9.5%	25,028	3.2%	20,296	2.3%	204,032	7.5%
	Others (majoram)	17,203	3.6%	46,673	8.2%	70,653	8.9%	38,696	4.4%	173,225	6.4%
	Total	209,180	43.7%	274,040	48.3%	407,806	51.5%	401,816	45.6%	1,292,842	47.6%
Summer	Maize	41,589	8.7%	174,600	30.8%	114,153	14.4%	229,736	26.1%	560,078	20.6%
	Sorghum	1,778	0.4%	5,013	0.9%	117,650	14.9%	14,548	1.7%	138,989	5.1%
	Oil Crop (Peanuts)	6,719	1.4%	12,984	2.3%	6,009	0.8%	44,976	5.1%	70,688	2.6%
	Vegetables	88,092	18.4%	39,520	7.0%	56,887	7.2%	84,547	9.6%	269,046	9.9%
	Total	138,178	28.9%	232,117	40.9%	294,699	37.2%	373,807	42.5%	1,038,801	38.2%
Nile	Maize	19,577	4.1%	34,467	6.1%	36,219	4.6%	0	0.0%	90,263	3.3%
	Vegetables	38,307	8.0%	6,703	1.2%	21,309	2.7%	29,868	3.4%	96,187	3.5%
	Total	57,884	12.1%	41,170	7.3%	57,528	7.3%	29,868	3.4%	186,450	6.9%
Perennial	Sugar cane	1,623	0.3%	106	0.0%	464	0.1%	36,098	4.1%	38291	1.4%
	Fruit trees	45,408	9.5%	19,248	3.4%	29,993	3.8%	36,897	4.2%	131,546	4.8%
	Date	26,439	5.5%	341	0.1%	1,158	0.1%	1,786	0.2%	29,724	1.1%
	Total	73,470	15.3%	19,695	3.5%	31,615	4.0%	74,781	8.5%	199,561	7.3%
Total		478,712	100.0%	567,022	100.0%	791,648	100.0%	880,272	100.0%	2,717,654	100.0%
Winter vegetables		Tomato		Onion		Tomato		Tomato		Tomato	
Summer vegetables		Tomato		Tomato		Tomato		Tomato		Tomato	
Nile vegetables		Tomato		Tomato		Tomato		Potatoes		Tomato	
Fruit trees		Citrus		Citrus		Citrus		Grape		Citrus	
Cultivated Area (fed)		282,650		294,035		439,428		476,597		1,492,710	
Cropping Intensity (%)		169%		193%		180%		185%		182%	

Source: JICA Survey Team

c) The extent of the benefited area with the Project will also be taken into consideration for the degree of contribution to the irrigation system.

d) The incremental ratio of the unit yield proposed for improvement of the principal canal and improvement of small structures in the main canals/branch canals and improvement of the principal canal and main/branch canals and lining of main canals is used for the incremental ratio in a similar study[32].

e) Based on this analysis, the incremental ratio of unit yield by improving water distribution by one in five ranks is proposed at 9% for maize (summer crop) and 4% for wheat (winter crop). The degree of current water shortage in the target area is degree 2 when applied to Table 5.18. The incremental ratio of unit yield in Case 1 is expected to improve the water shortage from degree 2 to 3 in Table 5.19, and an increase of 9% in summer and 4% in winter are expected. In the case of implementing Case 2, improvement of water shortage from degree 2 to 4 is expected, so the incremental ratio is expected to be 18% in summer and 8% in winter. Moreover, even in the case of meska improvement, an increase in yield can be expected. Based on the data on MWRI, the incremental ratio is 24% in summer and 4% in winter. In this project, since the yield is expected to increase even in the other improvement, half of the MWRI's ratio should be applied for meska improvement.

f) Standard data for a crop budget by the Ministry of Agriculture and Land Reclamation at the governorate level is applied for estimating benefits. However, the statistical data are of the 2016 version, and interviews were conducted in order to consider the influence of agricultural material prices and farm gate prices of agricultural products after the liberalization of the exchange rate in November 2016. As a result, agricultural material prices rose by 50% and farm gate prices of agricultural products increased by 40%. Reflecting these effects in the crop balance of statistical data, the benefits shown in the table below were calculated based on the above-mentioned data for calculation of project benefits.

[32]The incremental ratio of the unit yield proposed was set with reference to "Preparatory Survey for the Rehabilitation and Improvement of the Dirout Group of Regulators, The Arab Republic of Egypt, Final Report, JICA 2010".

3) Financial Analysis of Planned Project

Financial analysis has been carried out based financial cost and benefit flows. The following indicators are to be applied.

a) Benefit-cost ratio (B/C ratio) is used to compare the benefit with cost, on a present value basis 12% discount rate.

b) Net production value (NPV) is used to convert the amount of incremental benefit into the present value using a 12% discount rate. The NPV figures indicate the project investment advantage.

c) EIRR is used to verify the financial feasibility of the project.

4) Facility Improvement and Extent of Benefited Area

The expected effect is an increase of crop production through the stabilization of water distribution by facility improvement. The extent of the benefited area with the Project in the case of improvement excluding the linings of the main canals will be 25% of the target area, out of the improvement of the main canals and the improvement of the irrigation facility in the priority sub-region. In the case of including the lining of the main canals, the benefited area is assumed to be 50% of the target area. Moreover, in the case of lining all canals including the branch canals, the benefited area is projected to be 60%. These figures are based on current assumptions and there is a possibility that they can be reexamined in the course of further examination.

In addition, the prospected benefited area through bottleneck rehabilitation of the principal canal is 20% of the irrigation area. Details of the facility improvement and the benefited area are shown in the table below.

Table 7.16 Facility Improvement and Extent of Benefited Area

Facility Improvement	Points to Improve	Expected Effect	Benefited Area*
Improvement of the principal canal	The increase of water flow in the canal	Significant elimination of water shortage for irrigation at the water peak time (July to August)	20% of the target area should benefit.
Improvement of small facilities	Improvement of water use efficiency in the target sub-regions	The increase of available water volume in the target sub-regions	25% of the target area should benefit.
Improvement of small facilities and the lining of main canals	Improvement of conveyance efficiency of main canals in the target sub-regions and improvement of water use efficiency of irrigation canals in the target sub-regions including securing of water level to branch canals	Stabilization of supply of water by improving conveyance efficiency in the target sub-regions and a decrease of water distribution loss at branch canals	50% of the target area should benefit.
Improvement of small facilities and the lining of the branch and main canals	Improvement of conveyance efficiency of main and branch canals in the target sub-regions and improvement of water use efficiency of irrigation canals in the target sub-regions including securing of water level to meskas	Stabilization of supply of water by improving conveyance efficiency in the target sub-regions and a decrease of water distribution loss at meska	60% of the target area should benefit.

*: Benefited area is referred by Preparatory Survey for the Rehabilitation and Improvement of Dirout Group of Regulators in the Arab Republic of Egypt, p. 7-4, Oct. 2010, JICA

7.2.8 The Results of Financial Analysis

The results of the financial evaluation of the cooperation project proposed are as shown in Table 7.17. Plan 1 is lower than Plan 2 in financial terms. The water should reach the end of the canals by implementing Plan 1, and although the amount of water would not sufficiently meet the demands, financial efficiency is expected to improve. Meanwhile, in Plan 2, the facility functions should be improved in addition to the intervention of Plan 1, thus the division water elevation and division water discharge to the branch canal are expected to be more secure. Due to its financial efficiency, Plan 2 is recommended as a cooperative project plan. Plan 3 enables the sufficient improvement of the whole distribution function to the meska level by including the lining of branch canals. Although Plan 3 has the highest prospective cost, it deserves consideration for a cooperative project plan.

Table 7.17 Economic Comparison of Each Plan

Plan	Proposed Intervention	Target Area (ha)	Effected Area (ha)	Project cost (Economic Price) (thousand US$)	EIRR (%)	B/C	NPV (thousand US$)
Plan 1	Improvement of two principal canals	601,110	120,222	127,790	14.4	1.16	31,435
	In the first priority sub regions; - improvement of small-scale structures	202,565	50,641	176,980			
	Sub Total	803,675	170,863	304,770			
Plan 2	Improvement of two principal canals	601,110	120,222	127,790	20.7	1.62	198,850
	In the first priority sub regions; - Plan 1 plus main canal lining	202,565	101,283	388,921			
	Sub Total	803,675	221505	516,711			
Plan 3	Improvement of two principal canals	601,110	120,222	127,790	14.2	1.15	74,594
	In the first priority sub regions; - Plan 2 plus branch canal lining	202,565	121,539	658,428			
	Sub Total	803,675	272,146	786,218			

Note 1) This project costs calculated from the economic prices that include construction costs, O&M, consulting services, and physical contingency. It is converted from the domestic market price by applying SCF 0.93.
2) Detailed design 2 years, construction period 5 years, yearly O&M cost is 1% of construction cost, consulting service cost is 10% of construction cost is adapted.
3) B /C is the ratio of the benefit and cost at the present value when discounted at 12% per year.
4) Project life set for 30 years
5) Administration cost, tax, subsidy, the interest of resettlement and price changes are not included in the economic price.
Source: JICA Survey Team

7.3 Possible Cooperation for Soft Components

Taking into account the improvement program on irrigation facility rehabilitation, the following projects are proposed as soft components: water management for equitable distribution in collaboration with the hard component project, and facility management for enhancing sustainable O&M of the rehabilitated irrigation systems. The project for water management will enhance capacity strengthening and workable mechanisms to increase water-use efficiency. The project for facility management will set approaches for the asset management concept towards continuingly functioning irrigation facilities.

7.3.1 Japanese Cooperation on Water Management Proposed in CIWM

(1) Formulation of Plan on Water Management Improvement

In order to implement water management that aims to enhance CIWM, a detailed planning survey will be conducted to formulate the project planning of water management in the target areas of the hard component project. The survey will preliminarily provide complete views of the areas before project implementation. Especially, the survey considers site selection for the water management project and will request an agreement with MWRI on a water management plan to identify a few sites (possibly two sites of branch canals) as the pilot area among the first group of sub-regions of the F/S. The soft component shall be implemented in the selected areas of the pilot area that are rehabilitated by the hard component project. Regarding the timing of the survey, it is desirable to formulate plans in water management at the same time as FS for applying effectively CIWM, to which hard and soft components are connected.

(2) Human Resources Development of Core Personnel

Human resource development schemes are introduced to MWRI staff who can continuously conduct technical training for those who are concerned with water management in the technical field. The schemes will provide an environment for understanding the theoretical and structural system of water management through participation in the academic arena and exchanging opinions with personnel in advanced technologies application areas. In such case, attention will be paid to providing know-how on asset management and facility management, since they may enhance efficiency and effectiveness of cooperation for the soft components. Moreover, it is noted to consider that the candidates may come from the current organizations concerning the water management field in order to increase the capacity of the current organizational bodies. Specifically, the cooperation is expected to be for the central staff of MWRI-related offices (ID, IS, IIS and RGBS) who are to be the possible counterparts to the Japanese side. The candidates may be identified and selected through discussions with the Egyptian counterpart organizations. The schemes are composed of the accepting trainees and overseas scholarship programs through possible Japanese cooperation. A tentative proposal is shown in Table 7.18 below.

Table 7.18 Tentative Proposal for Human Resources Development

Scheme	Acceptance of Trainees	Overseas Scholarship Program
Implementation period	4 years from 2019-2022	2 or 3 years in 4 years from 2019-2022
Acceptable location	Japan under invitation program, Japan & a third country for the training program	Japanese universities for Master or Doctor program
Target participation	The staff of central offices of MWRI (ID, IS, IIS and RGBS) or staff of regional offices who are eligible counterparts of Japanese cooperation	The staff of central offices of MWRI(ID, IS, IIS and RGBS) who are eligible counterparts of Japanese cooperation
Number of participants	Invitation program: 1 person per office, 4 central offices and 4 years: 16 persons in total The training program in Japan: 3 persons per office, 4 offices a and 4 years: 48 persons in total Third-country training program: 3 persons per office, 4 offices and 4 years; 48 persons in total	2 persons per office and 4 central offices: 8 persons in total

(3) Development of Equitable Water Management System for CIWM

A systematic regime and operation of water management at the sub-regional level will be modeled through the concept of CIWM. The systematic regime and appropriate operation for equitable water management covering from upstream to the terminal level of the system are developed. This was set as a core activity for MWRI's staff that needs an increase in water management capacity, and capacity strengthening of BCWUA and WUA will be implemented through MWRI's involvement. Since the hard component projects involving Japan's cooperation are presumed to be implemented by the yen loan project, the cooperation of water management for the soft components is supposed to be arranged as a technical cooperation project attached to yen loans. Accordingly, this technical cooperation project may be formulated together with cooperation for the operation of the Integrated Water Management System at the principal canal level. Technical cooperation will start with organizational strengthening of BCWUA and WUA in the model sites, which are selected from the areas receiving water from the branch canals in the pilot area, half a year prior to completion of the construction work on the pilot site (This construction work is estimated to take about two years.). This makes it possible to practice the technical cooperation project of water management where water in a series of irrigation canals should be physically manageable from upstream to the terminal facilities. Details of the project will be confirmed during the detail planning survey and determined in consultation with the Egyptian counterpart organization. A tentative framework of the project is described in Table 7.19.

Considering the previous technical cooperation projects that have prepared training materials and manuals for the same purposes of the capacity strengthening of BCWUA and WUA, the project formulating this time might adopt the training materials of the previous cooperation project.

Table 7.19 Tentative PDM for Technical Cooperation Project Attached to Yen Loan Project

Project Title: Project for Developing Base System for Equitable Water Management in Egypt
Implementing Period: 2019-2026 (7 years) Target area: Partial Areas of a Sub-region in First priority group
Target group: MWRI Officers, BCWUA and WUAs in the target area

Summary	Indicators	Means of Verifications	Important Assumptions
Overall goal To Contribute to a goal of NWRP, "Improvement of effective water use", integral irrigation-water management is practiced.	An indicator of "effective use of water resources", a NWRP's goal, is achieved by 20XX.	1. Appraisal report of NWRP 2. Ex-post evaluation after completion of the project	
Project purpose Systematic regime and mechanism for equitable and sustainable water management is established in the target area	1. Monitoring record of information on water management (items, frequency etc.) transferred to offices concerned 2. Comparison of a report on the beneficially water shortage in areas by principal canals 3. Changes of un-approved operations on irrigation facilities 4. Satisfactory ratio of water management and irrigation facility management for MWRI evaluated by WUAs 5. Participation ratio to the activities of WUA evaluated by MWRI, increased as XX% at the end of the project	1. Baseline survey at the beginning of the project 2. Related reports 3. Result of periodic monitoring and monitoring sheets	Egyptian political/economic situation are not in turmoil. Importance of a Goal of NWRP, "Improvement of effective water use" doesn't decrease.
Outputs 1. Water management considering tail-end users is operational. 2. Information transmission system of MWRI is improved. 3. The capacity of BCWUA and WUA on water management is strengthened.	1. Function of water management of MWRI is improved to facilitate implementing the plan. 2. Water management of targeted BCWUA is improved as XX% by MWRI's evaluation. 3. Water management of targeted WUA is improved as XX% by MWRI's evaluation.	1. Interviews as on the baseline survey and end-line survey in the project. 2. Progress reports in the project 3. Management record on the integrated water management system 4. Training results of MWRI staff 5. Training results of target WUAs 6. Training results of target BCWUA	Facility rehabilitation does not delay nor be changed. Integrated water management system is applied as planned.

Activities	Input		Important Assumptions
Project activities 1.1 Select model sites from a pilot area, and conduct reconnaissance survey to grasp the status of water management. 1.2 Formulate proper plan on water management based on the surveyed status. 1.3 Share information on water management plan with MWRI. 1.4 Share information on water management plan with MWRI and BCWUA/WUA. 1.5 Practice of water management plan by MWRI and BCWUA/WUA. 2.1 Develop an operational plan of Integrated Water Management System. 2.2 Operate Integrated Water Management System according to the plan. 3.1 Confirm (and formulate) water management plans in pilot area. 3.2 Conduct capacity assessment to MWRI staff. 3.3 Understanding formulating and operating irrigation plan by MWRI's staff concerned in water management. 3.4 Construct system of water management confirming roles of each organization towards WMT. 3.5 Grasp current activities of formal / informal WUAs in pilot area, and identify their required activities. 3.6 Set program of training based on reality of water management and activities of WUA, containing Training materials developed by SWMT. 3.7 Conduct training for WUA 3.8 Conduct training for BCWUA * Activities 1.4 and 1.5 will be done in collaboration with activity 3. Activity related to output 2 is implemented in activities 1 and 3.	Input Japanese side Long-term expert 1) Chief advisor/ Water management system: 7 years 2) Comprehensive water management / irrigation Planning : 7 years 3) Participatory water management/ Capacity strengthening of water users group: 5 years 4) Human resources development in irrigation (Analysis/ Training planning): 5 years 5) Project Coordinator/ Training: 7 years Short term expert 1) On-site water management practice: as per necessary 2) Irrigation facilities: as per necessary 3) Irrigation planning/ water scheduling: as per necessary 4) Equipment for water management system: as per necessary 5) Capacity assessment: as per necessary 6) Other experts: as per necessary Equipment 1) Vehicles 2) Equipment for water management 3) Equipment for training 4) Office equipment and supply 5) Others * Meska improvement will be introduced when necessary.	 Egyptian side Experts 1) C/Ps assigned to Japanese expert (for required numbers and periods) Equipment 1) Office spaces in the Central building and GD of site location 2) Others	 C/Ps and trained MWRI staff continues their current activities.
	Budget 1) Part of expenditure for project activities in Egypt 2) Cost of training in Japan for C/Ps 3) Cost of training in the third country (except Egypt and Japan)	Budget 1) The salaries for C/Ps of Egypt 2) Travel expense for Egyptian officers (included C/Ps) for project operation 3) Others	Pre-conditions MWRI's central and regional offices understand approaches of the project.

Source : JICA Survey Team

7.3.2 Japanese Cooperation for Facility Maintenance (Introducing Asset Management Method)

(1) Ledger Preparation for Some Facilities

A facility maintenance and management plan will be improved in employing the asset management approach conducted during F/S for the facilities targeted in the yen loan project. The activities are mostly composed of survey techniques and data processing and include the introduction of facility ledgers containing facility dimensions and features, records of facility rehabilitation and repair and so on. Seminars and workshops will be held to explain facility maintenance and ledger preparation.

(2) Human Resources Development of Core Personnel

Human resources development schemes are introduced for the MWRI staff concerned to encourage them to continue their careers in facility maintenance using the asset management method over the long term. In the same way as a water management scheme, this scheme will also provide the conditions for understanding the theoretical and structural system of asset management through participation in the academic arena and exchanging opinions with personnel in advanced technology application areas. Moreover, it is noteworthy to consider that the candidates may come from the current organization concerning the water management field to increase the capacity of the current organizational bodies. Specifically, the cooperation is expected to be for the central staff of MWRI-related offices (ID, IS, IIS and RGBS) who are eligible counterparts of the Japanese side. The candidates may be identified and selected through discussions with the Egyptian counterpart organizations. The schemes are composed of the accepting of trainees and overseas scholarship programs through possible Japanese cooperation. A tentative proposal is shown in Table 7.20 below.

Table 7.20 Tentative Proposal for Human Resources Development

Scheme	Acceptance of Trainees	Overseas Scholarship Program
Implementation period	8 years from 2019 to 2026 (	several years in 8 years from 2019-2026
Acceptable location	Japan under invitation program, Japan & third country for the training program	Japanese universities for Master or Doctor program
Target participants	The staff of central offices of MWRI(ID, IS, IIS and RGBS) or staff of regional offices who are eligible counterparts of Japanese cooperation	The staff of central offices of MWRI(ID, IS, IIS and RGBS) who are eligible counterparts of Japanese cooperation
Number of participants	Invitation program: 1 person per office, 4 central offices and 8 years: 32 persons in total The training program in Japan: 3 persons per office, 4 offices a and 8 years: 96 persons in total Third-country training program: 3 persons per office, 4 offices and 8 years; 96 persons in total	2 persons per office and 4 central offices: 8 persons in total

Source: JICA Survey Team

(3) Dissemination of Asset Management Approach

Taking into account the issues of facility deterioration caused by the aging irrigation system, urgent implementation of the countermeasures is required for proper facility management. On the other hand, as facility construction is implemented within a certain time-span in the sub-regions, it is expected to introduce a systematic regime and a mechanism for facility management corresponding to the progress of facility rehabilitation. Since the numbers of facilities targeted by the asset management approach are gradually increasing according to the progress of construction work, development of asset management is expected to apply step by step during the project's timespan as described in the last two chapters. In the situation above, dispatching an expert, as an advisor on facility management policy shall create a fundamental base to introduce and expand the asset management approach in the sub-regions where the facility's rehabilitation work is conducted. For this purpose, the following cooperation framework is tentatively framed (Table 7.21):

Table 7.21 Tentative Proposal for Expert Dispatch on Facility-management Policy

Item	Contents
Implementation period	2019-2026 (8 years)
Purpose	Asset management approach is established to introduce in the areas of facility rehabilitation projects, and the fundamental base is created for further development.
Outputs	1. MWRI's understanding of asset management is enhanced. 2. Ledger of facilities where projects are implemented is logically arranged. 3. A proposal for further development of asset management approach is proposed.

Source: JICA Survey Team

(4) Trial of Asset Management Approach

After implementation of construction work for facility rehabilitation by the Japanese yen loan project, schemes of a technical cooperation project or an expert dispatch are proposed to support effective use of the database established under CIWM. This cooperation mainly aims to promote the asset management approach and to expand its target facilities, and its framework is shown in Table 7.22.

Table 7.22 Tentative Proposal for the Trial of Asset Management Approach

Item	Contents
Cooperation name	Project for the Development of Asset Management Approach in Irrigation Field of Egypt
Implementation period	Some requested period of yeats in 11 years from 2027 to 2037
Purpose	To apply asset management approach in the facility management is applied
Outputs	1. A systematic regime and a mechanism are further developed for development of asset management approach. 2. A facility maintenance and management plan are developed to apply asset management approach.
Assigned field	Facility's maintenance and management plan, database development, survey techniques of facility diagnosis

Source: JICA Survey Team

7.4 Cooperation among Organizations in MWRI

The projects recommended under the possible Japanese cooperation schemes are an F/S project and a sector loan project as hard components, as well as a detailed survey on water management, a technical cooperation project, acceptance of trainees, an overseas scholarship program and the dispatch of experts as soft components. It should be noted that the most important issue is to realize CIWM through appropriate coordination of hard and soft components, and sustainable development of its effects to contribute to effective irrigation water use. In order to achieve these goals, it is necessary that MWRI accumulate knowledge and experience obtained through appropriate implementation of projects. It is also important to establish a better allocation of the roles, and a systematic regime and a mechanism among the organizations concerned.

MWRI's organizations that are responsible for some components of the project under CIWM will include ID, IS, IIS and RGBS. Cooperation among these organizations is a fundamental requirement for realization of CIWM.