The Study on Water Resources Management in The Hashemite Kingdom of Jordan

FINAL REPORT VOLUME X
SUMMARY REPORT

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6. Water Resources Management

The items of water resources management examined in the Water Resources Management Master Plan are as follows:

Quantitative Management (see section 6.1)	Qualitative Management (see section 6.2)
- Improvement Plan of UFW - Reduction Plan of Renewable Groundwater	- Surface Water Quality Conservation Plan - Groundwater Quality Conservation Plan

Institutional & Legislative Management (see section 6.3)	Water Allocation & Conveyance Management (see section 6.4)
- Improvement Plan of Institutional & Legislative System - Promotion Plan of Public Sector Participation	- Water Allocation Plan - Water Transfer & Supply Plan

6.1 Quantitative Management

6.1.1 Improvement Plan of UFW

(1) Present condition of UFW

UFW (Unaccounted for Water) is divided into "leakage from the supply system" and " water for which tariff is not paid". The former is called physical losses and the latter is called administration losses. The rate of UFW has reached 50% to 60% recently. For the countermeasures to the physical losses, rehabilitation of the water supply system and construction of the water supply control system are considered. For the countermeasures to the administration losses, education of staff members, participation of private sectors in the operation & maintenance of the water supply project, public awareness, strict application of law and regulations and construction of the water supply control system are considered. Several projects for the improvement of UFW have been carried out by UFW improvement section established within the Project Management Unit (PMU) of MWI.

(2) Measures for reduction of the physical losses

1) Rehabilitation of the water supply system

The rate of the physical losses is inferred at 25% to 30% of total supplied water amount. MWI has carried out a series of rehabilitation works aiming to reduce the physical losses rate to15% by 2010. As the water gain due to the reduction of the physical losses is counted in the reduction of water demand in the system of the GTZ module, the same manner was employed in the Water Resources Management Master Plan. The reduction amount of the physical losses is estimated at 65MCM/a by 2020.

The rehabilitation works of the existing water supply system have been being carried out in many cities with the cooperation of the several donor countries. In the greater Amman area, where the water supply amount is greatest and also amount of the physical losses is greatest in Jordan, overall rehabilitation of the existing water supply system is on-going by MWI financed by many donor countries and organizations such as USAID, EIB and Kfw. This rehabilitation works are scheduled to be completed by 2004.

The list of the rehabilitation projects of the existing water supply system is shown in Table 6.1-1 and their locations are shown in Fig.6.1-1.

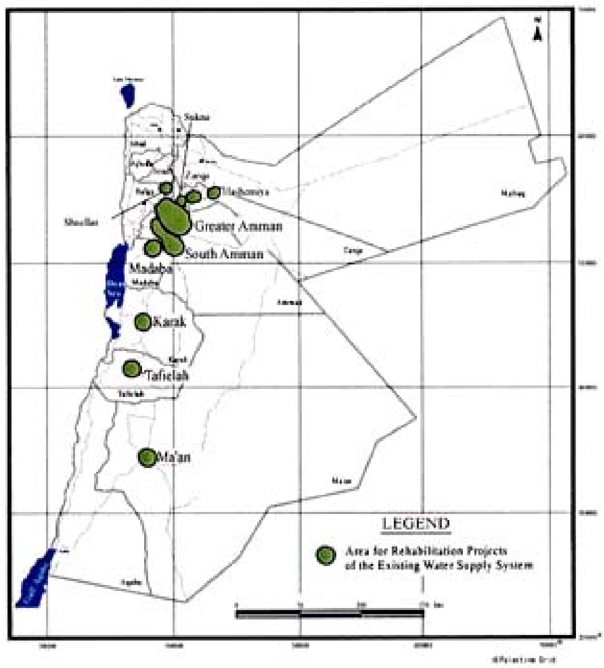


Fig. 6.1-1 Locations of the Rehabilitation Projects of the Existing Water Supply System

Table 6.1-1 List of the Rehabilitation Projects of the Existing Water Supply System

Project name	Cities	Completion Year	Status
1. Rehabilitation of Zarqa Governorate	Zarqa, Russeifa, Hashemiya, Sukna, Shnellar Refugee Camp	2001	on-going
2. Rehabilitation of Southern Ghors Irrigation Stage I	-	2002	Irrigation Project, F/S done
3. Amman Municipal water Network Restructuring Phase I	Greater Amman	2004	on-going
4. Municipal Water Networks rehabilitation (Several Cities)	Karak, Tafielah, Ma'an, Madaba, South Amman and others	2009	Study on -going

Source: Investment Program 2000-2010

2) Construction of water supply control system

Although the water supply control system does not directly reduce the UFW, it is indispensable for the detection of location and quantity of UFW which is the most important basic data for the planning of countermeasures.

Therefore, the construction of the National Water Control Center is proposed in the Water Resources Management Master Plan. The outline of this project is shown in Table 6.1-2.

Table 6.1-2 Outline of the National Water Control Center Construction Project

Construction Stage	Contents of Construction	Target Governorate	Completion Year
Phase 1	Main control center and Sub centers	Amman, Irbid, Mafraq, Zarqa	2004
Phase 2	Sub centers	Ajlun, Jerash, Balqa, Madaba, Karak, Tafielah, Ma'an, Aqaba	2008

(3) Measures for reduction of the administration losses

While the water resources themselves will not be saved by the reduction of the administration losses, it is indispensable for the sustainable and sound operation of the water supply projects

The efforts to reduce the administration losses have been exerted by the UFW improvement section of PMU through the education of the staff members and users, public awareness, inspection of water meters, inspection of the illegal connections and so on. The operation and maintenance works of the water supply have been entrusted to a private sector entity named LEMA and LEMA is also responsible for the reduction of the administration losses. It is MWI's policy to further promote private sector participation, expanding it to other cities.

6.1.2 Reduction Plan of the Renewable Groundwater Abstraction

(1) Present condition of the decline of the renewable groundwater level

As mentioned in section 5.3.2, it is quite obvious that the present abstraction amount of renewable groundwater excessively exceeds the safe yield. The renewable groundwater level decline for these ten years between 1990 to 1999 is shown in Fig. 6.1-2. As shown in this figure, the areas showing severe groundwater decline are located in the Upland extending from north to south in which main well fields and farms are located.

According to the groundwater simulation in South Amman area conducted in the Study, it was expected that the water table of the renewable groundwater would decline up to 300m below the ground surface by 2020 if the present abstraction would be continued without reduction and many existing wells will become dry. In addition, the study results conducted in Amman/Zarqa Basin by USAID (WRPS) indicated that some part of the renewable aquifer would be dried out in the case that the present abstraction would continue for ten years. From these reasons, it is concluded that the renewable groundwater resources will be exhausted without implementation of the reduction measures of the renewable groundwater abstraction.

Therefore, 40% of reduction from the present abstraction amount should be done in order to achieve "Sustainable Water Resources Development"

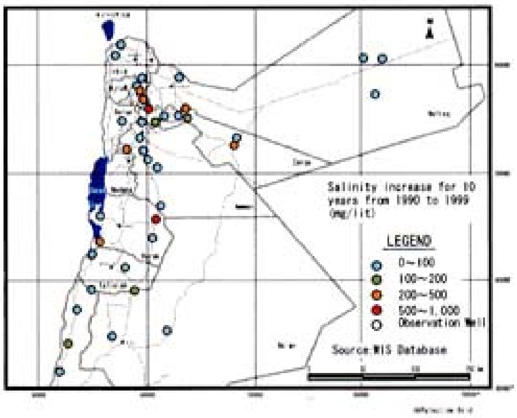


Fig.6.1-2 Distribution of the Renewable Groundwater Level Decline 1990-1999

(2) Reduction measures of the renewable groundwater abstraction

According to the WRPS study mentioned before, several measures for the reduction of the renewable groundwater abstraction were proposed as shown in Table 6.1-3 and the target reduction rate of 40% could be achieved by the combination of these measures. It was recommended in WRPS that the well buy-out was the most acceptable measure. The cost of well buy-outs was estimated based on the annual production amount of the wells and unit cost of buy-out was proposed between JD0.5 to JD1.1/m^3 (about 0.7 to 1.6US\$/m^3).

Table 6.1-3 Reduction Measures of the Renewable Groundwater Abstraction Propose by WRPS

Reduction Measures	Expected Possible Maximum Reduction Rate (%)
1. Irrigation Advisory Services	8
2. Well buy-outs	25 – 33
3. Enforcing Abstraction Limits	25 – 33
4. Exchange of Groundwater to Recycled Water	17 - 25

Source: WRPS by USAID, 2001

The over drafting of the renewable groundwater is mainly done for irrigation in the Upland and the hydrogeological and geographic conditions of the other areas are almost the same with those of Amman/Zarqa Basin. Therefore, it is assumed that the measures proposed in WRPS may be applicable for the other areas.

The action plans for the implementation of these measures in the Amman/Zarqa Basin were formulated in WRPS and the same methodologies will be extended to other areas for the reduction of the renewable groundwater abstraction if the trial in the Amman/Zarqa Basin succeeds.

Fig.6.1-3 shows the reduction plan of the renewable groundwater abstraction by Governorate and by target year.

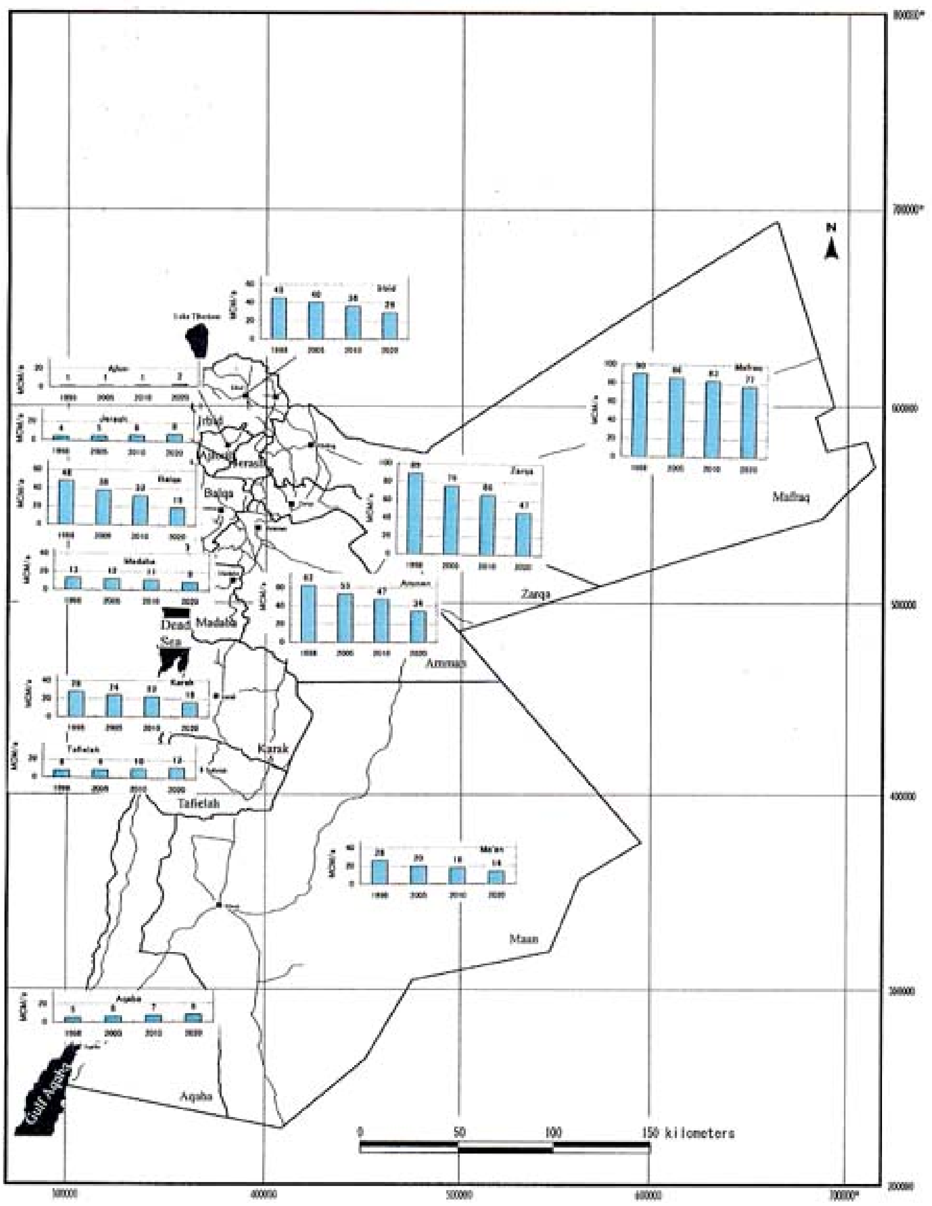


Fig.6.1-3 Reduction Plan of the Renewable Groundwater Abstraction

6.2 Qualitative Management

6.2.1 Surface Water Quality Conservation Plan

(1) Present situation of the surface water quality

The surface water in Jordan can be classified into two categories; the first from outside Jordan which includes Yarmouk River water and Peace Water and the other is inside Jordan in the form of water of wadis.

The water from the Yarmouk River and Peace Water flows into the King Abdullah Canal (KAC) which is the main trunk line for irrigation in the Jordan Valley and for the MIT uses in the Greater Amman area. Water quality of KAC generally meets the standards for potable water from the long term stand point. However, unpleasant smell from the drinking water occurred in the summer of 1998 and it is inferred that the cause of the smell might have originated from the water quality deterioration in KAC. The water quality of KAC in the downstream from the confluence with the Zarqa river cannot be used for domestic purposes because it is mixed with the treated wastewater through the Zarqa River. However, it is good quality for irrigation and can be used without any restrictions.

The water flowing in the wadis is developed by dams and weirs and its quality almost meets the standards for potable water so far excepting the Zarqa River. The King Talal Reservoir (KTR) which is located in the Zarqa River receives the treated wastewater from the As Samra treatment plant and it is mixed with the surface water there. The quality of the treated wastewater flowing into KTR is improved by dilution with fresh surface water and the self purification action of the Zarqa River.

(2) KAC water quality monitoring and conservation measures

The water quality conservation of KAC has become an urgent task because of the occurrence of unpleasant smell in the potable water. In order to strengthen water quality monitoring in KAC, the following measures shall have to be taken.

- Integrated water quality monitoring system under the umbrella of MOWI
- Common database for KAC water quality and incorporate it into the WIS system.
- Monitoring for eutrophication including Algae Growth Potential (AGP) test
- Monitoring for fertilizers, pesticides and other micro-pollutants

Two options are suggested to strengthen the conservation of KAC water quality.

- Option 1: Establish protection belts at the two sides of the canal
- Option 2: Providing cover for the KAC from the north border up to Deir Alla intake

(3) Conservation of the water quality in dams and reservoirs

The contamination of the surface water has not been detected in the existing dams and reservoirs which is supplying the municipal water. However, the water conservation measures should be done in order to prevent unpredictable accidents from occurring in KAC as mentioned above. For the dams and reservoirs for domestic water supply, the following measures have to be taken for water quality conservation.

- Specify protection zones for the reservoir area
- Erase point source of pollution to the reservoir
- Reduce non-point source of pollution to the reservoir
- Strengthen dam management and water quality monitoring

(4) Improvement of surface water quality monitoring and information system

A comprehensive surface water quality monitoring system has already been formulated by the Water Quality Improvement and Conservation Project (WQICP) completed in 1995 with the cooperation of USAID. Monitoring system with 130 monitoring points were planned and recommended in this project and the monitoring system was divided into five categories which were “Municipal Water”, “Industrial Water”, “Potable Water”, “Irrigation Water” and others.

Therefore, it is recommended that the surface water quality monitoring should be implemented based on the WQICP’s program. It is also recommendable that all the data collected by other organizations should be systematically sorted and stored in WIS of MWI.

6.2.2 Groundwater Quality Conservation Plan

(1) Present situation of the groundwater quality

The regional increase of the salinity and nitrate concentration of the renewable groundwater has become a serious problem in Jordan. Such deterioration of the renewable groundwater has mainly been found in the Upland area and salinity and nitration concentration occasionally have not met the standard for the potable water in some areas. The increase tendency is still detected in many areas.

The distribution of the increase of the salinity of the renewable groundwater during 10 years from 1990 to 1999 is shown in Fig.6.2-1. The areas showing prominent salinity increase are located in western Zarqa Governorate where there is intensive highland agriculture.

It is concluded that infiltration of irrigation return water including leaching water is the main cause of the nation-wide tendency of the increase of both salinity and nitrate concentration in the renewable groundwater in addition to the over drafting. Such groundwater quality deterioration is very prominent in the Upland.

According to the groundwater quality simulation in South Amman area done in this Study, it was predicted that the salinity of the renewable groundwater would increase up to 1,300 mg/lit in TDS and the nitrate concentration would increase up to 100mg/lit if the present irrigation continued without reduction of the irrigation water. Such high concentrations of the salinity and nitrate exceed the standard of the potable water. For these reasons, it is concluded that the quality of the renewable groundwater will not allow it to supply municipal demand without implementation of the reduction measures of the irrigation water in the Upland.

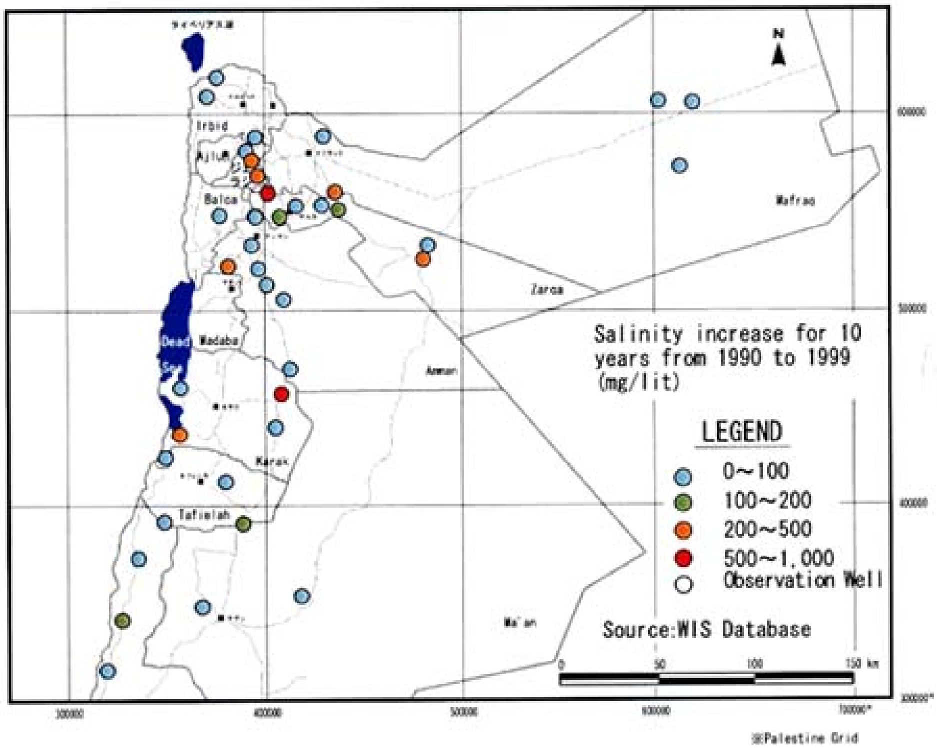


Fig. 6.2-1 Distribution of the Salinity Increase of the renewable Groundwater 1990-1999

(2) Countermeasures for the salinity problem

The groundwater quality deterioration simulation results in the South Amman area indicated that the groundwater deterioration might not further progress if the irrigation water would be reduced by 30%.

Since the hydrogeological conditions and deterioration mechanism may differ from area to area, the simulation results may not be strictly applicable for other areas. However, as the simulated area is one of the severely deteriorated areas of groundwater quality in Jordan, reduction of around 30% of irrigation water might stop the deterioration in other areas.

From the stand point of sustainable development of groundwater (stopping the nation-wide groundwater level decline), groundwater abstraction should be reduced to around 60% of present abstraction (about 40% reduction) throughout Jordan. As the irrigation water in the Upland is fully dependant on groundwater, the reduction of the groundwater abstraction will almost directly reduce the irrigation water use. Accordingly, the 30% reduction of the irrigation water use may be achieved if the groundwater abstraction will be reduced by 40% in the Upland.

According to Water Resources Management Policy Support (WRPS) financed by USAID, around 40% reduction of the renewable groundwater abstraction for irrigation purpose might be possible by implementing several measures such as advisory services, well buy-outs and enforcing the abstraction limits as mentioned in section 6.1.3.

Therefore, the reduction of the groundwater abstraction for the irrigation should be employed as a main measure against the salinity increase of the groundwater.

(3) Countermeasures for nitrate problem

The groundwater deterioration simulation results in the South Amman area also indicate that the increase of the nitrate concentration in the groundwater may not greatly progress if the irrigation water is reduced by 30% in the Upland.

Therefore, the reduction of the groundwater abstraction for the irrigation purpose should also be employed as main measure for the nitrate problem, the same as the salinity problem described in the former section.

(4) Improvement of groundwater quality monitoring and information system

Comprehensive groundwater quality monitoring system has also already been prepared by the Water Quality Improvement and Conservation Project (WQICP). Therefore, it is recommended that the groundwater quality monitoring should be implemented based on the WQICP's program. It is also recommendable that other monitoring items such as biological items, heavy metals and organic compounds will be added.

6.3 Institutional and Legislative Management

(1) Present condition of the institutional and legislative system

As mentioned in section 2.2, the restructuring of the institutional and legislative system of the water sectors is in progress based on the program formulated with the cooperation of CIDA. As a result of the implementation of the program, the number of the staff members of the water sectors has been reduced. The participation of the private sectors to the water sectors and implementation of the project by the BOT and BOO were recommended in the Water Strategy and Water Policies formulated in 1997 to 1998 as a part of the improvement of the institutional and legislative system.

In fact, the operation and management of the water supply and wastewater treatment projects has been entrusted to a private sector entity named LEMA in 1999. It is reported that the income from the tariff collection has increased from 19.2 million JD to 22.3 million JD after the concession to LEMA.

PMU (Project Management Unit) is the responsible agency for the promotion of the private sector participation in the water supply and wastewater treatment projects. PMU is also aiming to extend the private sector participation to the other cities.

For the promotion of public awareness on the severe water shortage condition and education on water saving, the directorate of public awareness of MWI is the responsible agency. This directorate was established based on the recommendation of WQIC project done by USAID in 1995. The activities of the directorate of public awareness are as follows:

- Public awareness campaigns through the mass media such as television, radio and newspapers
- Education at schools and other meetings
- Preparation of advertising posters and video films and others

(2) Improvement plan of institutional and legislative system

The improvement plans of the institutional and legislative system which have been implemented and planned are listed in Table 6.3-1.

Table 6.3-1 Improvement Projects of Institutional and Legislative System

Project Name	Completion Year	Contents of the Project	Donors
1. The Governorate Support Section (GS)	2002	to transfer the experience gained in Amman Water and Wastewater Management Contract and Operations Management Support Project to other cities	GTZ, Kfw
2. Planning and Management Unit	2003	to establish the qualified planning & management unit for appropriate utilization of funds necessary coordination with donors and implementation of rehabilitation program, to improve UFW	EU
3. Amman Water and Wastewater Management Contract	2003	to make performance-based contract with private sector for the provision of water and wastewater services in Amman	USAID

6.4 Water Allocation and Water Transfer Management

For the first step of the water allocation, the total water demand mentioned in chapter 4 was compared and balanced with the total water resources to be developed by the implementation of both of Water Resources Development (refer to chapter 5) and Water Resources Management (refer to section 6.1, 6.2 and 6.3) by target year. If the total demand and supply did not coincide, the basic conditions mentioned in chapter 3 were reviewed and the balance between the demand and supply was repeatedly examined. Such iteration process was continued until the balance was achieved.

For the second step after the achievement of the total balance between demand and supply, the most appropriate water transfer plan was examined to fulfill the water demand of each Governorate by target year in accordance with the basic conditions mentioned in chapter 3.

6.4.1 Water Allocation Plan

(1) Balance between supply/demand and selection of scenario

A total quantity of water resources available from the sustainable development of surface water, groundwater and peace water were re-evaluated and determined as the available quantity in this Study as mentioned in chapter 5. The increase of treated wastewater due to increase of municipal water demand was also predicted. Although the potential quantity of brackish water is high, the use of desalination requires a high processing cost and it will remain supplementary. The available quantities of these water resources are shown in Table 6.4-1. Table 6.4-2 shows the water demand in target years which was estimated based on the demand scenarios described in chapter 4. The total water demands by 2020 by scenario are shown in Table 6.4-3. In addition, the relationship between future supply and demand by scenario is schematically shown in Fig.6.4-1.

Table 6.4-1 Water Resources Development Amount (Supply Amount)

(Unit: MCM/a)

Water Resource	2005	2010	2015	2020
Surface Water	424	431	446	446
Peace Water	60	90	90	90
Renewable Groundwater	368	337	307	275
Fossil Fresh Groundwater	65	92	104	130
Desalinated Brackish Water	20	53	72	85
Desalinated Sea Water	5	5	17	17
Sub-total	942	1008	1,036	1,043
Treated Wastewater (Scenario-1)	112	177	220	246
Treated Wastewater (Scenario-2)	108	177	232	285
Treated Wastewater (Scenario-3)	103	162	207	246
Scenario-1 Total	1,054	1,185	1,256	1,289
Scenario-2 Total	1,050	1,185	1,268	1,328
Scenario-3 Total	1,045	1,170	1,243	1,289

Table 6.4-2 Water Demand Projection by Scenario

(Unit: MCM/a)

Water Use	Scenario	2005	2010	2015	2020
1. Municipal Water	Scenario-1	273	368	445	501
	Scenario-2	273	368	493	587
	Scenario-3	260	341	443	510
2. Industrial Water	Scenario-1	76	94	114	130
	Scenario-2	80	102	134	169
	Scenario-3	72	89	110	132
3. Touristic Water	Scenario-1	7	11	16	16
	Scenario-2	11	17	19	21
	Scenario-3	10	16	17	17
MIT Sub-total (1+2+3)	Scenario-1	356	473	575	647
	Scenario-2	364	487	646	777
	Scenario-3	342	446	570	659
4. Irrigation Water	Scenario-1	694	703	668	628
	Scenario-2	981	1,002	992	963
	Scenario-3	694	703	668	628
Scenario 1 Total (1+2+3+4)		1,050	1,176	1,245	1,277
Scenario 2 Total (1+2+3+4)		1,345	1,489	1,638	1,740
Scenario 3 Total (1+2+3+4)		1,036	1,149	1,240	1,289

Table 6.4-3 Total Water Demand of Each Scenario in 2020

(Unit: MCM/a)

Scenario	MIT Demand	Irrigation Demand	Total	Judgment
Scenario1 (Base Scenario)	648	630	1,277	○:Water demand will remain within possible water supply. It is applicable for all cases because high population growth rate and low consumption rate are adopted in this scenario
	Population: 9,180,000			
Scenario 2 (Target Scenario)	777	963	1,740	:Water demand will extremely exceed possible water supply. This scenario is impossible for its realization
	Population: 9,180,000			
Scenario 3	659	630	1,289	△: Water demand will remain within possible water supply. But, it may not be realistic in case of the rapid population growth because low population growth rate and high consumption rate are adopted in this scenario
	Population: 7,990,000			

○: Applicable, : Not applicable, △: Applicable but accompanied with some uncertainties

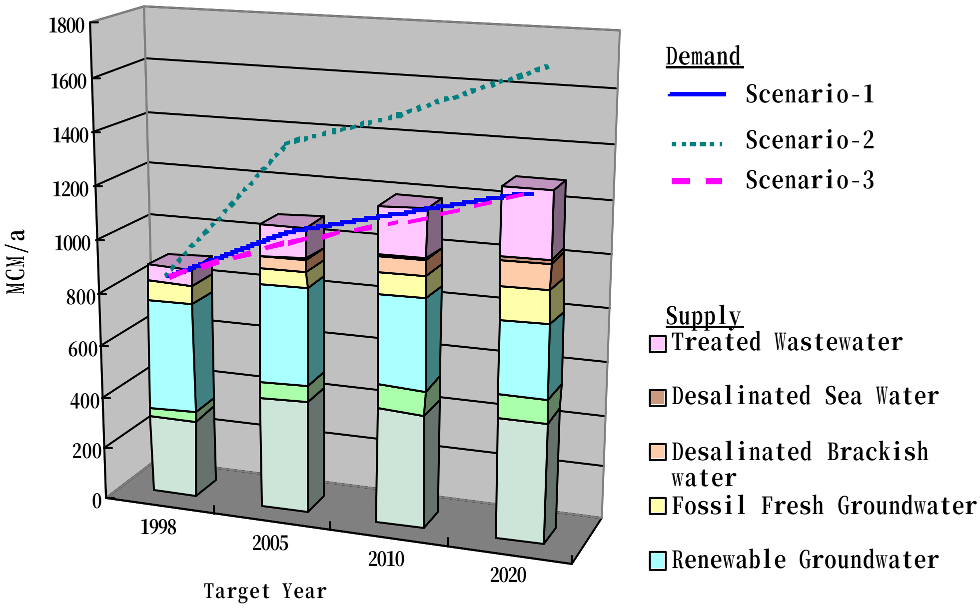


Fig.6.4-1 Balance between Supply and Demand in Target Years by Scenario

Scenario 2 indicates the target water demand which will satisfy the target municipal water demand (150 l/c/d) and target irrigation demand which is estimated based on the future agricultural development schemes. Hence the water demand will extremely exceed the possible supply amount by 422MCM/a in the target year of 2020 as shown in Fig. 6.4-1, it is concluded that the Scenario 2 is impossible for its realization.

For Scenario 1 and Scenario 2, as the water demands of both of them will remain within possible water supply amount as shown in Table 6.4-1 and Table 6.4-2, it is assumed that these are realistic scenarios.

Demand curves of both of Scenario 1 and Scenario 3 are almost coincident each other as shown in Fig. 6.4.1. The main differences between them are that the population growth rate is high and water consumption rate per capita is low in Scenario 1 and the population growth rate is low and water consumption rate per capita is high in Scenario 2 as shown in Table 4.1-1. Therefore, Scenario 1 will be employed for the projection of the water demand in the Water Resources Management Master Plan taking the possibility of the delay of the water resources development into consideration.

(2) Water allocation to Governorates

The available gross quantity of water resources shown in Table 6.4-1 was divided into the individual quantities to be allocated to the 12 Governorates throughout the country. On the other hand, the water demand in each target year (2005, 2010, 2015 and 2020) was calculated by Governorate using the GTZ module.

The balance between supply and demand in each Governorate was taken by the inter-Governorate water conveyance in accordance with the basic conditions mentioned in chapter 3.

These allocated water quantities are based on the planned or normal year's available water resource quantity, but it is foreseen that the actually available quantity may be lower than the planned quantity due to some factors such as the supply of peace treaty water and hydrological drought years. To avoid these problems in case of emergency, the additional plan of emergency water distribution was separately formulated taking into consideration the increase in groundwater abstraction and the acquisition of fossil fresh groundwater (at Lajoun area in Karak).

1) Inter-Governorate water transfer

Present inter-Governorate water transfer is mainly composed of transfer from Irbid Governorate to Balqa Governorate through King Abdullah Canal and transfer from Balqa Governorate to Amman Governorate through the high lift pumping system. The other inter-Governorate transfer lines are small scaled short ones. It is clear that the demand for municipal water will increase in the metropolitan area as the plan years progress and that it would not be satisfied with the water resources within the metropolitan area. The further construction of the inter-Governorate transfer lines will be needed in order to solve this problem. Fig. 6.4-2 shows the amount of water resources and demand in each Governorate by target year and Fig. 6.4-3 shows planned inter-Governorate transfer to fulfill the gaps between supply and demand in the Governorates by target year.

By 2005, it will be needed to both transfer the desalinated water produced by Wadi Zarqa Ma'in, Zara Spring Project from Jordan Valley to Amman Metropolitan area through the high lift pumping system and also to transfer the surface water produced by the Wehda Dam construction project to Greater Irbid by high lift pumping system. By 2010, it will be needed to transfer the fossil fresh groundwater from Disi-Mudawara area to Amman Metropolitan area. In addition, the municipal water will become short in several Governorates in the south region in 2020. Consequently, it will be needed to divide the fossil fresh groundwater for allocation to those Governorates.

2) Water type to be used in each Governorate

Fig. 6.4-4 shows the plan of water uses in the Governorates by target year and Fig. 6.4-5 shows the water allocation to the Governorate by water type in each target year. The distribution of the water allocation in each Governorate by water type at 2020 is shown in page 8 of the attachments at the end of this report.

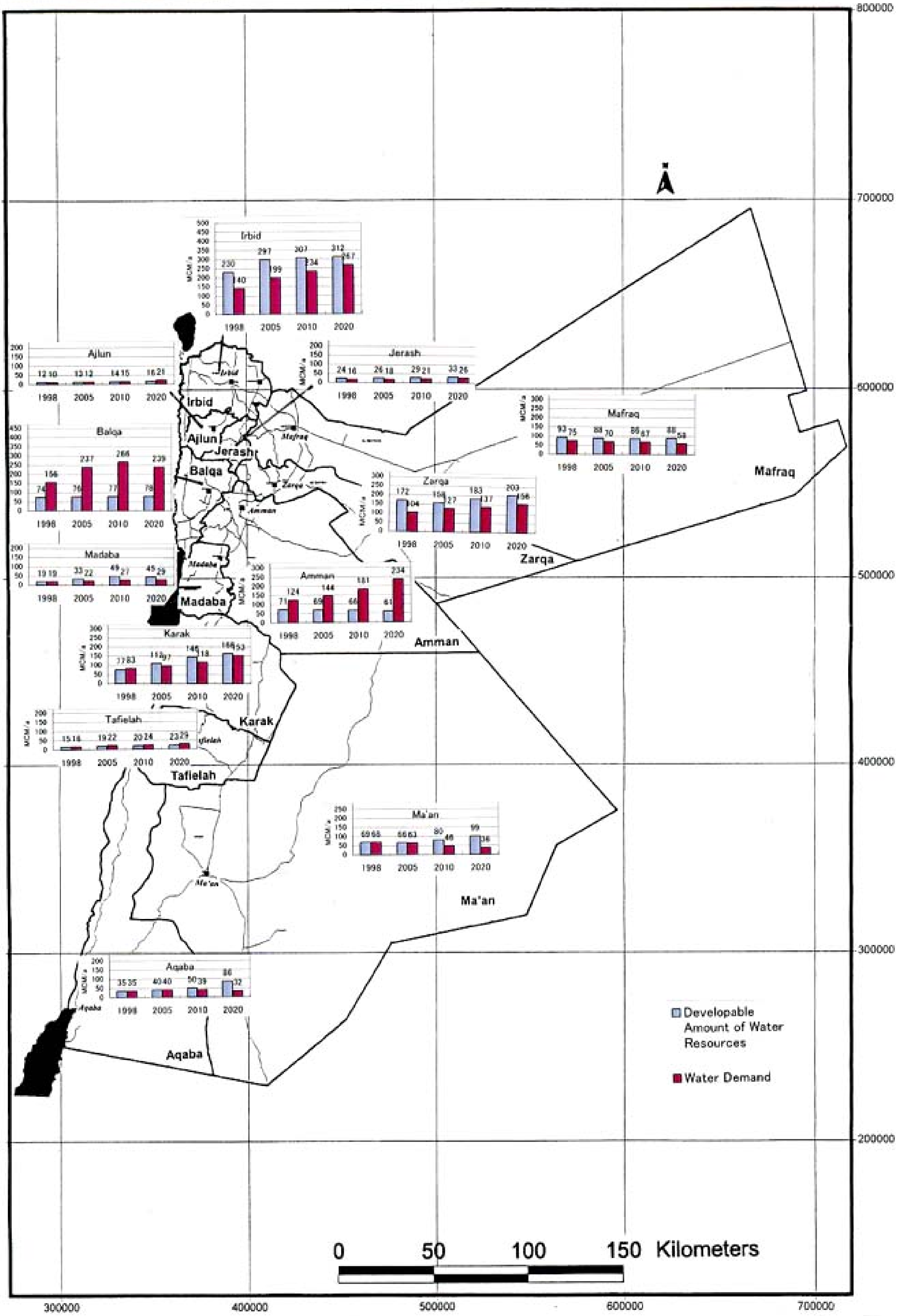


Fig. 6.4-2 Water Resources and Water Demand by Governorate and Target Year

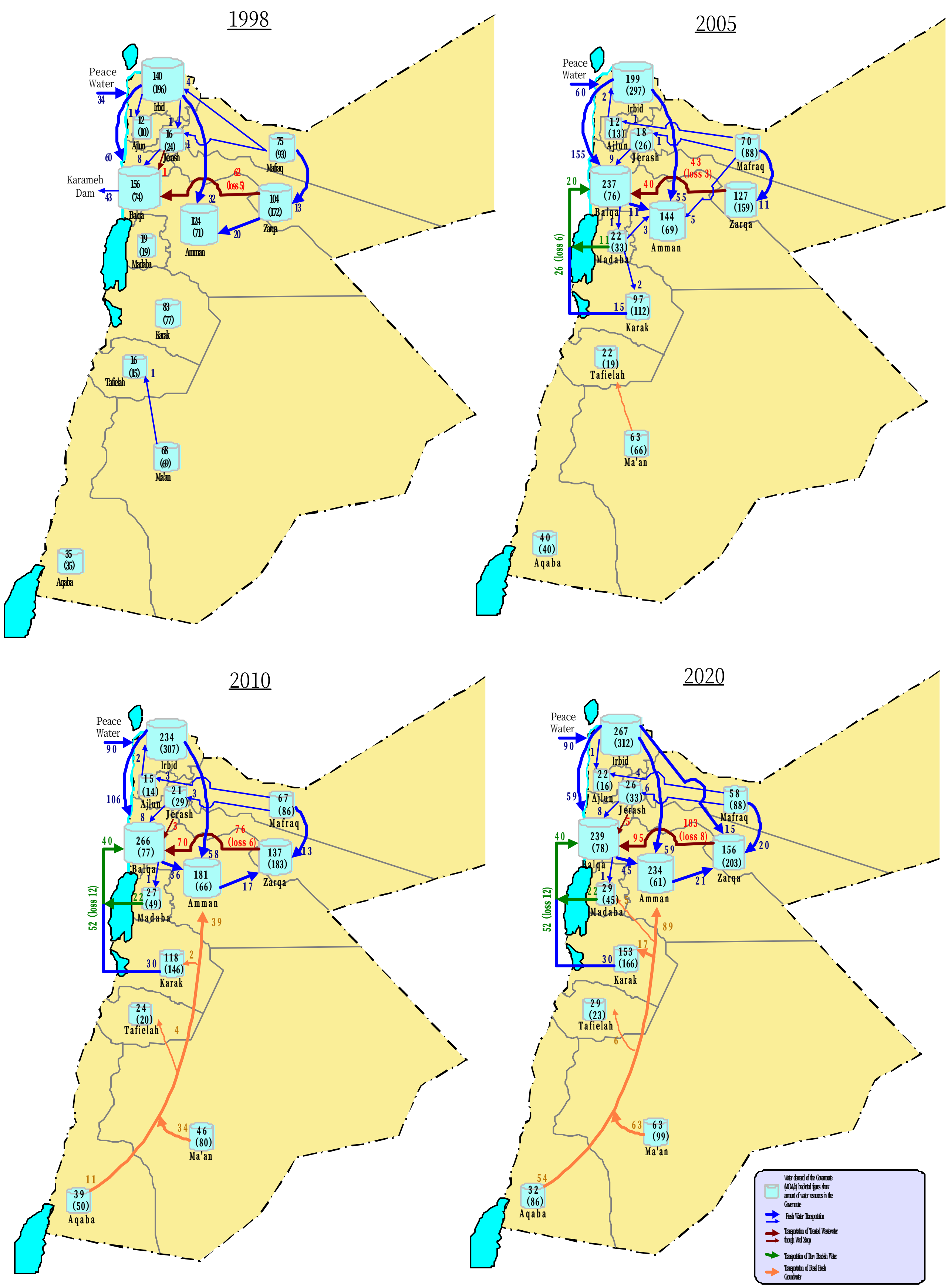


Fig. 6.4-3 Inter-Governorate Water Transfer Plan

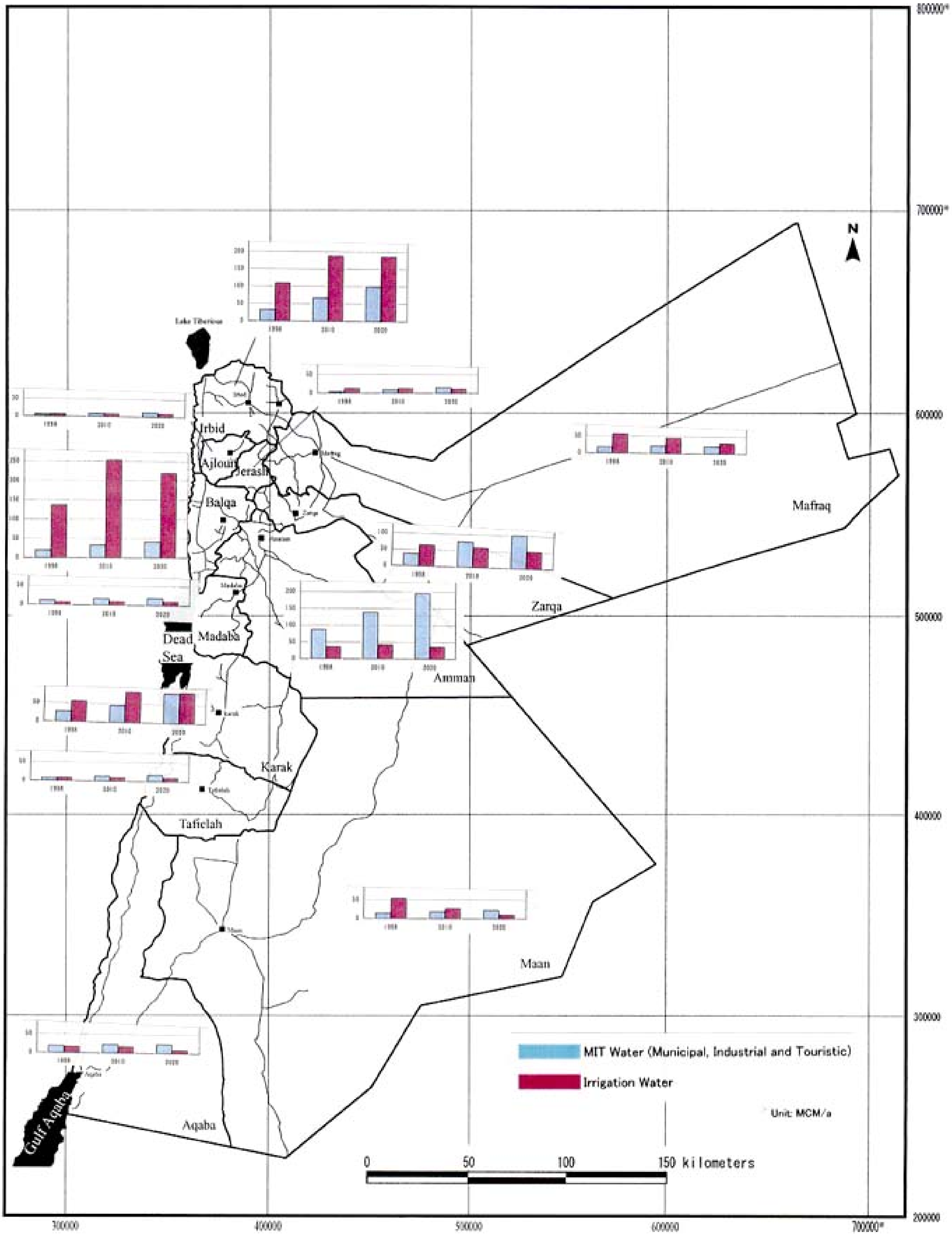
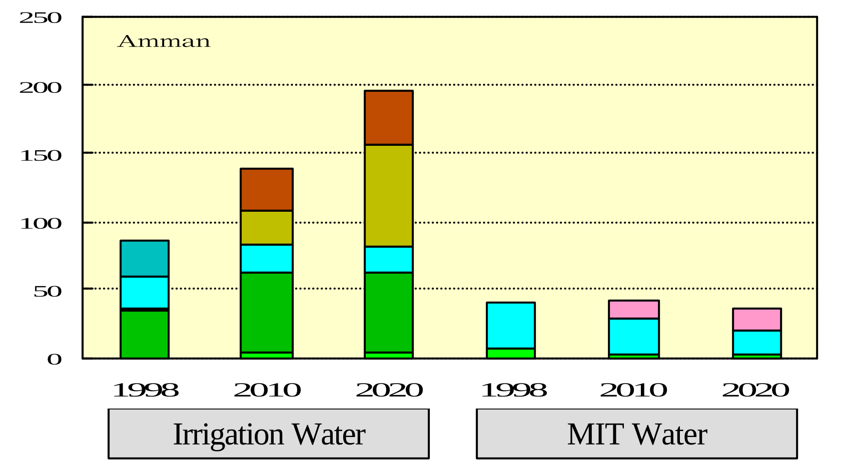
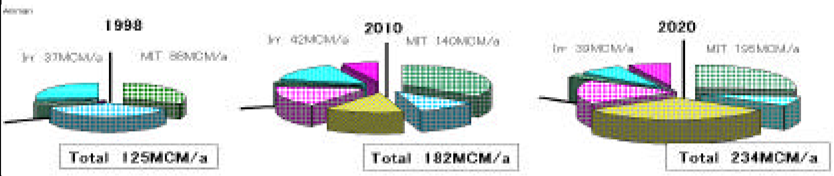


Fig. 6.4-4 Plan of Water Use by Governorate and Target Year

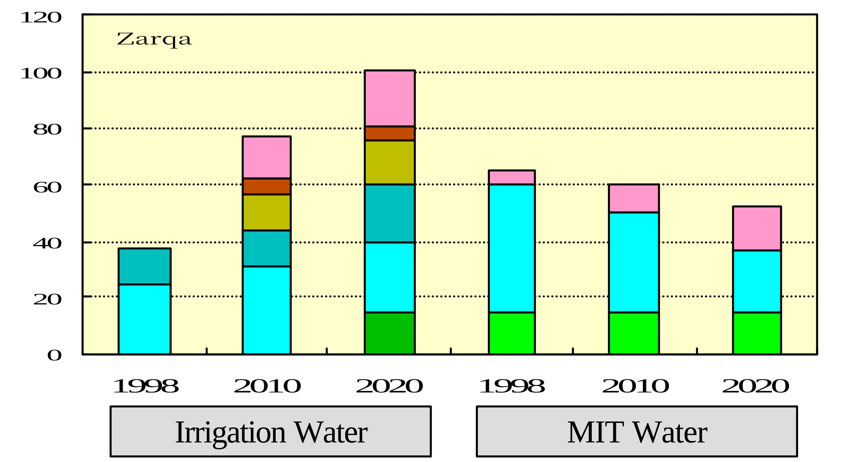


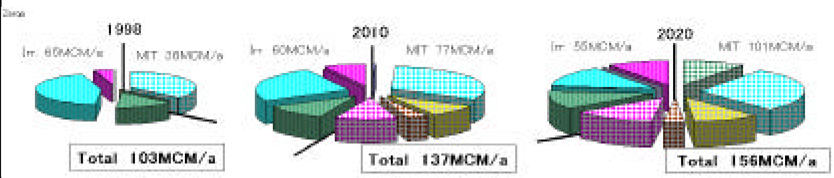


(1) Amman

Population: 1,809,775 (1998)
3,517,600 (2020)
Area of Governorate: 8,231 km^2

Issues in WRM;
- Big metropolitan population and big MIT water demand
- Due to limited water resources Disi fossil and Dead Sea brackish water development are inevitable.
- Upland Irrigation can be maintained with WWTE.





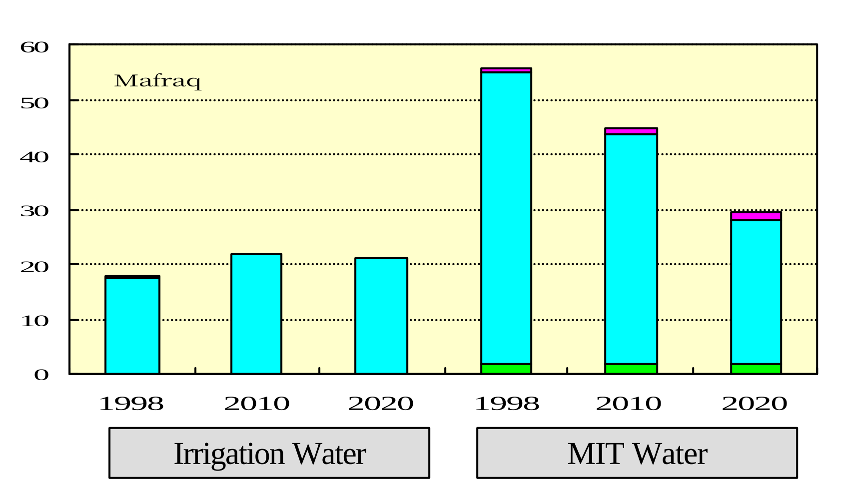
(2) Zarqa

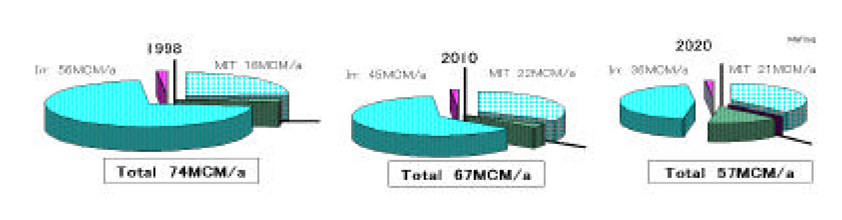
Population: 747,860 (1998)
1,394,100 (2020)
Area of Governorate: 4,080 km^2

Issues in WRM;
- Industrial and agricultural area conforming the greater Amman metropolis
- Current consumption of ground-water is big and reduction shall be implemented.
- Reuse of WWTE is required for both industrial and irrigation water.

Legend

Fig. 6.4-5(1/6) Water Allocation to the Governorate by Water Type in Each Target Year (Amman, Zarqa)



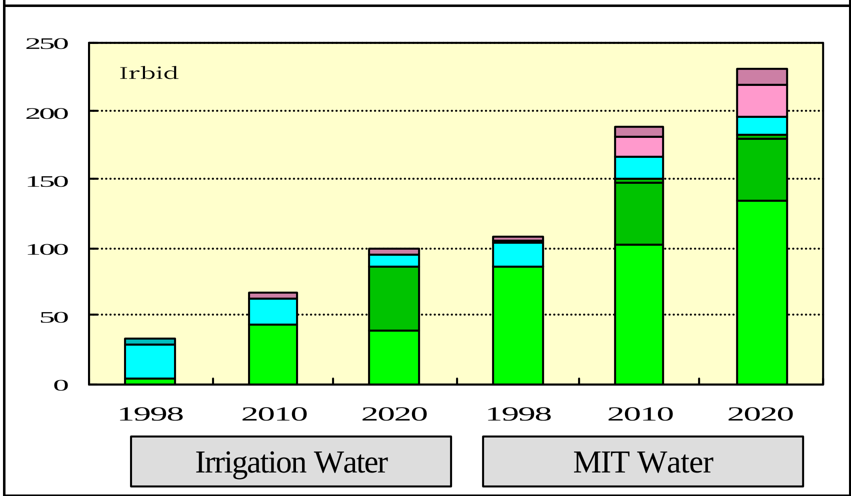


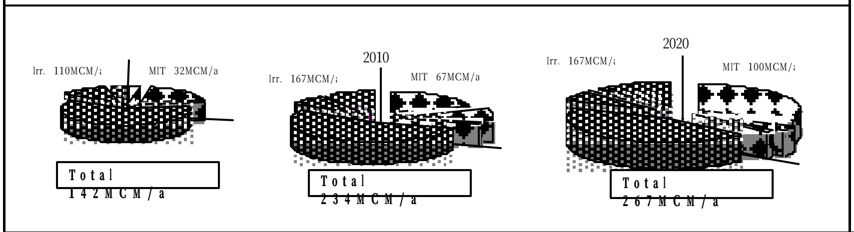
(3) Mafraq

Population: 219,040 (1998)
376,000 (2020)

Area of Governorate: 26,435 km^2

Issues in WRM;
- One of the main groundwater source areas and irrigation agriculture using groundwater is highly activated.
- Reduction of groundwater abstraction to renewable level is essential but available WWTE is quite small.





(4) Irbid

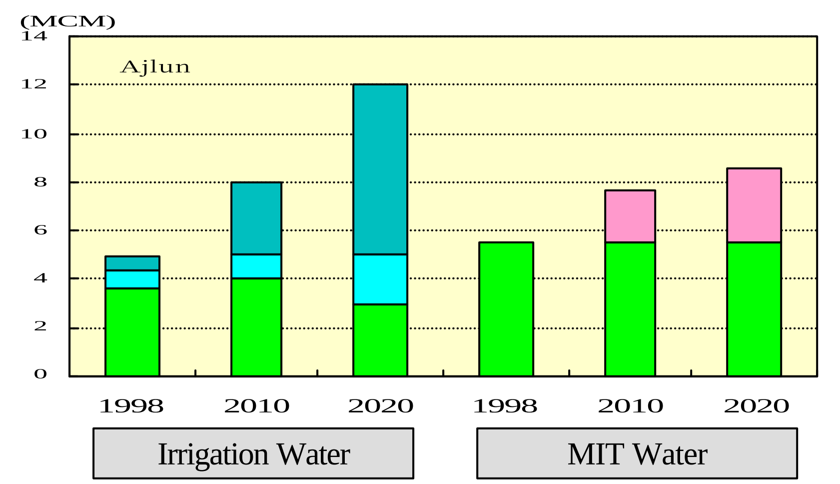
Population: 848,340 (1998)
1,656,000 (2020)

Area of Governorate: 1,621 km^2

Issues in WRM;
- Center city of northern area
- Including large irrigation agriculture in Jordan valley and Upland
- Decreasing groundwater is required but new surface water development and WWTE reuse may enlarge the irrigation agriculture.

Legend

Fig. 6.4-5(2/6) Water Allocation to the Governorate by Water Type in Each Target Year (Mafraq, Irbid)

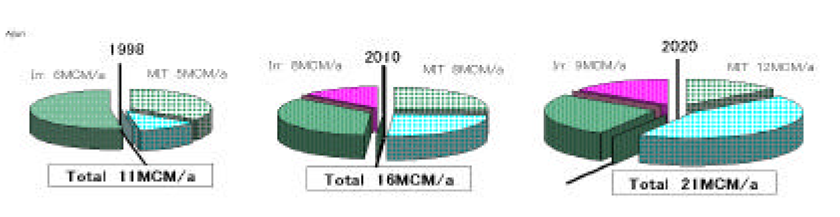


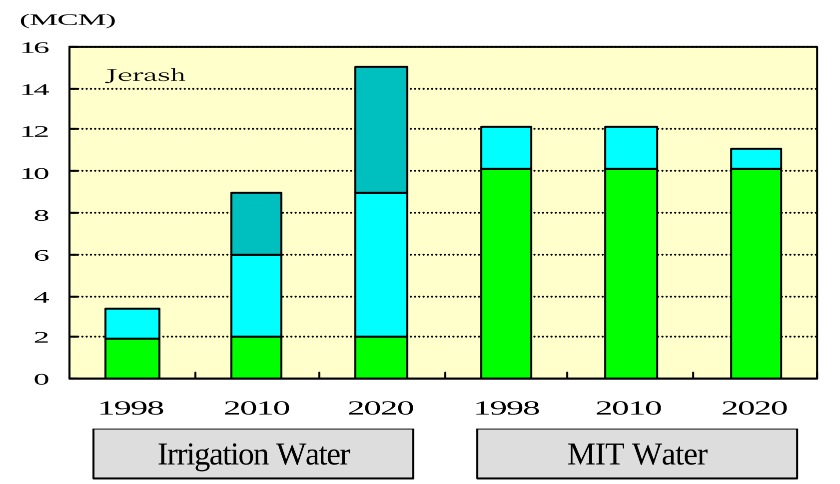
(5) Ajloun

Population: 105,520 (1998)
226,400 (2020)
Area of Governorate: 412 km²

Issues in WRM;

- Olive agriculture area
- Water resource in the Governorate is limited and import from outside is required.
- Reuse of available WWTE may enlarge the irrigation agriculture.



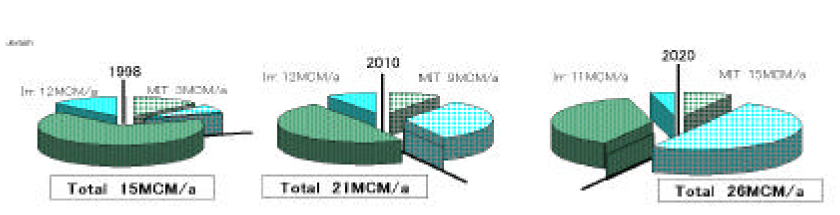


(6) Jerash

Population: 139,815 (1998)
273,100 (2020)
Area of Governorate: 402 km²

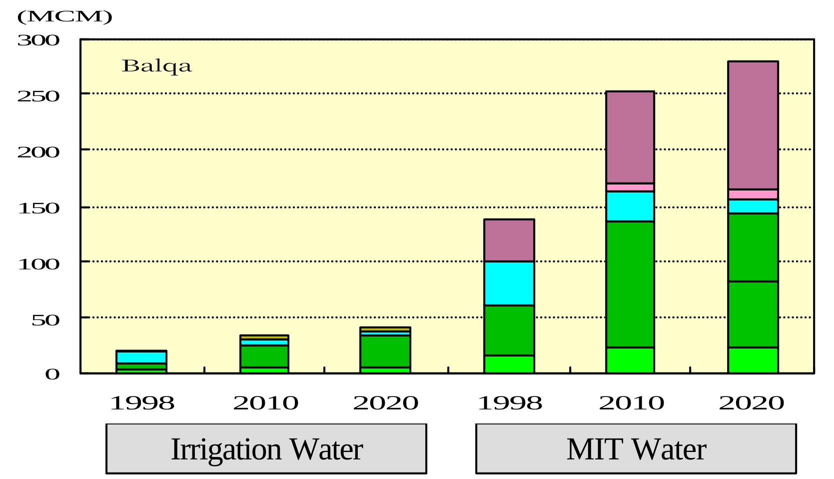
Issues in WRM;

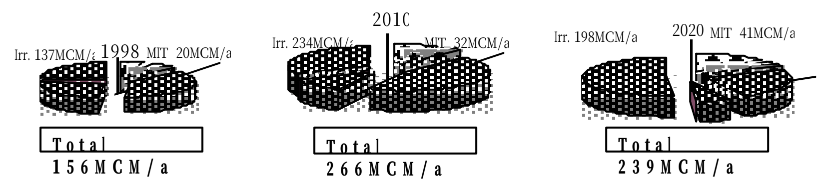
- Tourism and agricultural area with small Governorate area
- Water resource is limited and water allocation from other governorates is inevitable.



Legend

Fig. 6.4-5(3/6) Water Allocation to the Governorate by Water Type in Each Target Year (Ajlun, Jerash)

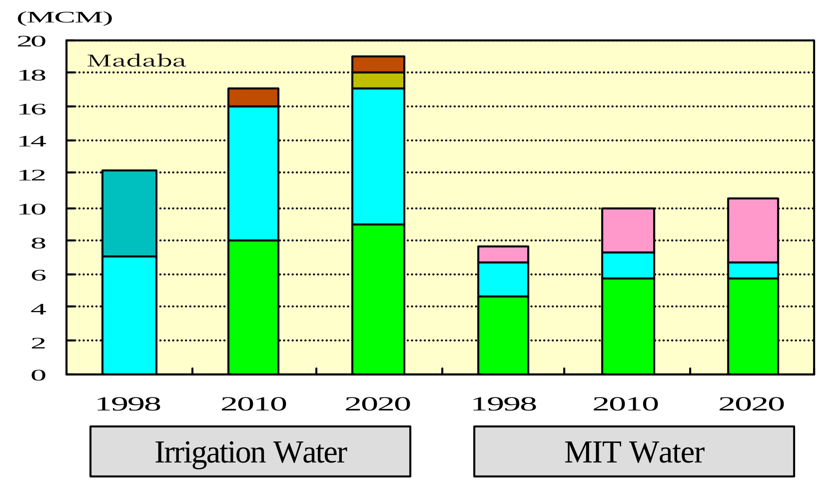


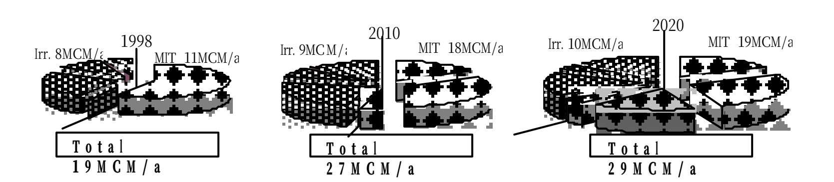


(7) Balqa

Population: 312,155 (1998)
614,300 (2020)
Area of Governorate: 1,076 km²

Issues in WRM;
- Balqa is consisted of agricultural Jordan Valley area and metropolitan Up/Mid land area.
- Reduction of Groundwater use in Up/Midland irrigation is required but abundant WWTE is available for developing the new agriculture.





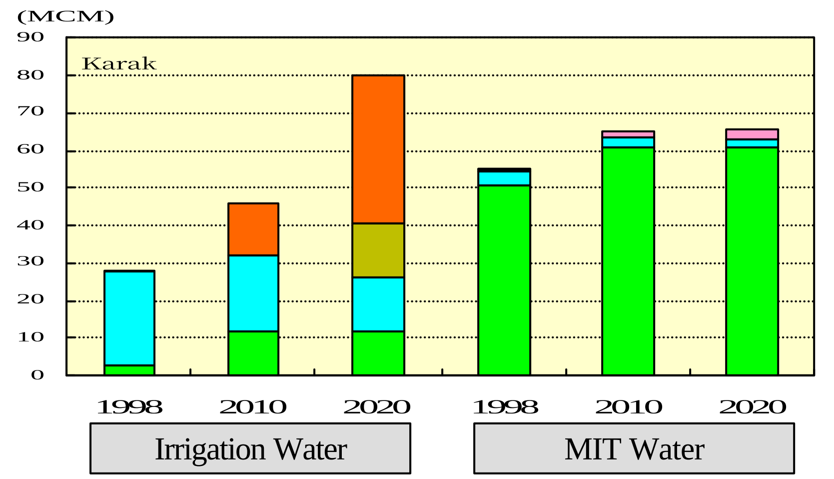
(8) Madaba

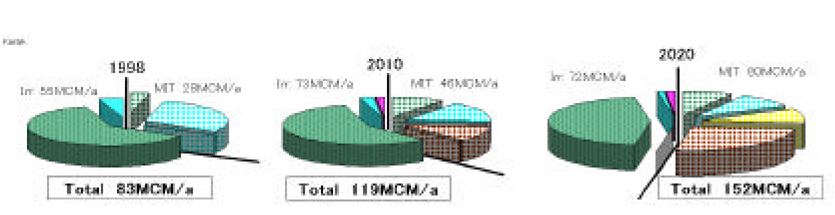
Population: 121,275 (1998)
221,400 (2020)
Area of Governorate: 2,008 km²

Issues in WRM;
- Tourism and agricultural are
- Unaccounted for water is very high (86.2%) comprehensive improvement is necessary.
- Reuse of WWTE may enlarge irrigation agriculture.

Legend

Fig. 6.4-5(4/6) Water Allocation to the Governorate by Water Type in Each Target Year (Balqa, Madaba)



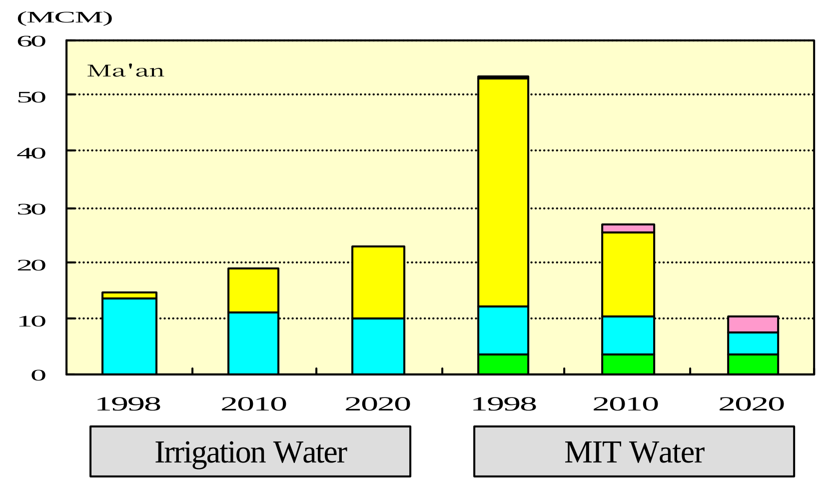


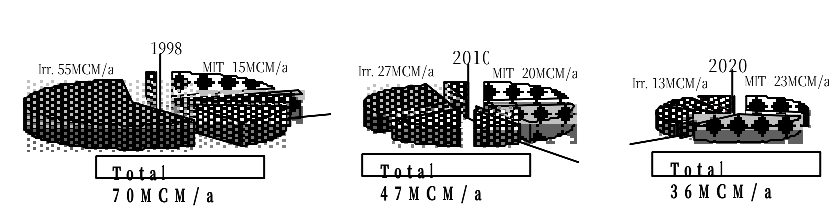
(9) Karak

Population: 191,405 (1998)
374,400 (2020)
Area of Governorate: 3,217 km^2

Issues in WRM;

- Agricultural area
- New surface development is remaining and new agricultural development is prepared.
- New industrial development plan including Oil Shale project is foreseen and large water demand is expected.





(10) Ma'an

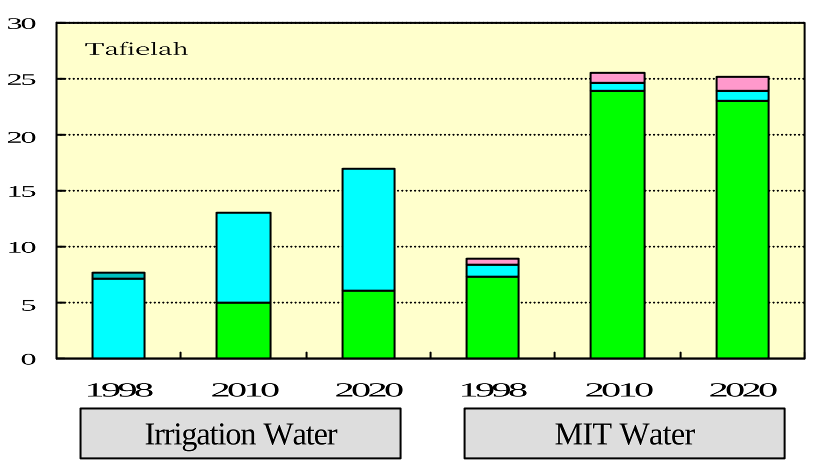
Population: 92,745 (1998)
178,900 (2020)
Area of Governorate: 33,163 km^2

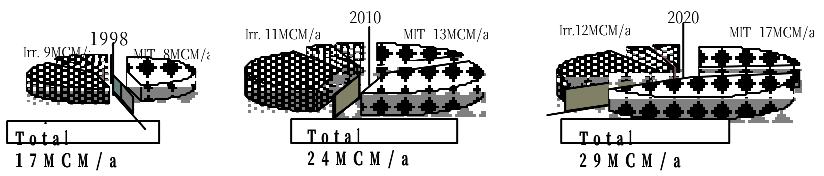
Issues in WRM;

- Area of governorate is large but precipitation is very limited.
- Irrigation agriculture using Disi fossil water is largely done but it shall be changed to MIT use in Amman Metropolitan area.
- WWTE reuse shall be maximized for keeping the irrigation agriculture.

Legend

Fig. 6.4-5(5/6) Water Allocation to the Governorate by Water Type in Each Target Year (Karak, Ma'an)

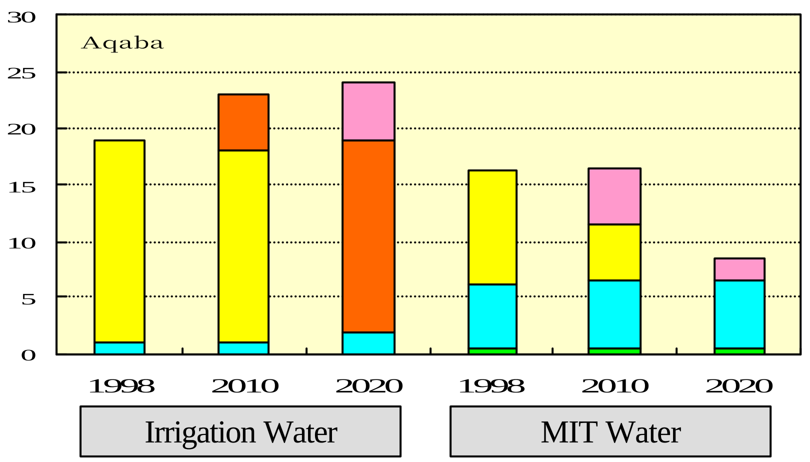


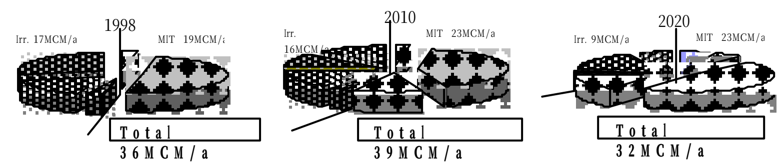


(11) Tafielah

Population: 72,465 (1998)
148,000 (2020)
Area of Governorate: 2,114 km²

Issues in WRM;
- There is phosphate industry in Jordan Valley.
- New surface water development is remaining and new agricultural development is prepared.
- WWTE from existing wastewater treatment plant shall be implemented.





(12) Aqaba

Population: 95,355 (1998)
199,900 (2020)
Area of Governorate: 6,583 km²

Issues in WRM;
- Including tourism and port city
- Disi fossil water is currently used but the source is required to change to sea water desalination.
- In WIS, unaccounted for water is high (69.3%) and comprehensive improvement is necessary.

Legend

Fig. 6.4-5(6/6) Water Allocation to the Governorate by Water Type in Each Target Year (Tafielah, Aqaba)

(3) Measures for drought year

In this Water Resources Management Master Plan, annual average precipitation was adopted. However annual precipitations are fluctuating with a certain range and drought year when the available water resource is decreased shall be considered. Theses years from 1998 are actually categorized into dry years and. At the same time not only the drought years but there are some other factors effecting available water resources such as delaying water resources development projects or rescheduling the implementation of the peace treaty water.

In this Master Plan, groundwater from Lajoun well field which has a yield capacity of 11 MCM/a is proposed as an emergency water source because it is fossil groundwater and possible to store without flowing.

But drought more than that is also expected and for this situation a case study was conducted in order to examine the scale of the effect to water allocation and the possible measures to be taken.

In this case study assumption that drought happens in the year of 2005 and it decreases the surface water in all the country 25% which is expected to happen probably in 20 years according to the hydrological analysis of the study.

Assumptions in the water resources management side are summarized in Table 6.4-4 and are postponing the groundwater reduction scheme one year and so on.

Table 6.4-4 Water Resources Management in Drought Year

Unit: MCM/a

	Alteration	Dry	Average	Dif.
Decrease of Surface Water Flow	75%	450.2	337.7	-112.6
Postponing Groundwater Reduction	1 year	369.9	379.9	10.0
Non-renewable Fossil Groundwater (Lajoun)	100%	0.0	11.0	11.0
Non-renewable Fossil Groundwater (Disi/Ma'an)	100%	61.9	61.9	0.0
Treated Wastewater Reduction	90%	112.3	101.1	-11.2
Peace Treaty	100%	60.0	60.0	0.0
Brackish Groundwater Desalination (Balqa/Karak)	100%	44.0	44.0	0.0
Seawater desalination (Aqaba)	100%	5.0	5.0	0.0
Surface Water Flow Down		1103.2	1000.5	-102.8

Water allocation and required water demand management based on the above drought conditions are sown in country level in the Table 6.4-5 and Figure 6.4-6. It is necessary to reduce the municipal water 10% except in Aqaba where seawater desalination is deployed. Municipal water is decreased 26.1 MCM. On the other hand irrigation water by surface water is required to reduce 15%, and treated wastewater is also decreased according to the decrease of the municipal water. Consequently total irrigation water allocated is decreased 67.8 MCM/a.

This kind of demand management is only implemented by rationing water supply but if it is achieved water supply and use are balanced.

Table 6.4-5 Demand Management in Drought Year

Unit: MCM/a

	Alteration	Dry	Average	Dif.
Total Municipality		272.7	246.5	-26.1
Municipal demand except Aqaba	90%	261.3	235.2	-26.1
Municipal demand for Aqaba	100%	11.4	11.4	0.0
Industrial Water	100%	76.1	76.1	0.0
Tourisric Water	100%	6.9	6.9	0.0
Irrigation Water	91%	717.3	649.5	-67.8
Surface Water	85%	391.1	333.9	-57.3
Groundwater	100%	189.1	189.1	0.0
Disi Fossil Water	100%	44.0	44.0	0.0
Treated Wastewater Reuse	89%	93.1	82.6	-10.6
Total		1073.0	979.0	-94.0

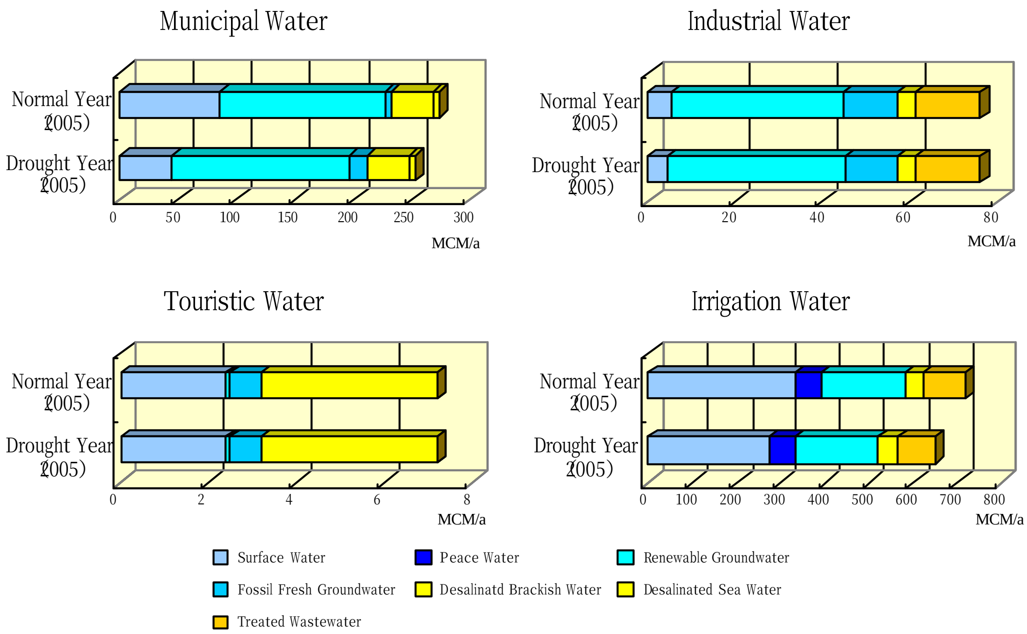


Figure 6.4-6 Demand Management in Drought Year

6.4.2 Water Transfer and Supply Plan

For effective implementation of the water allocation plan examined in section 6.4.1, water transfer and supply plan has been formulated as follows.

(1) Plan for Water Transfer Trunk Line

As a result of examination on required fresh water transfer in future and the current water transfer capacity based on the water allocation plan, new development, construction and upgrading plan for the years of 2000 to 2020 are as shown in figure 6.4-6.

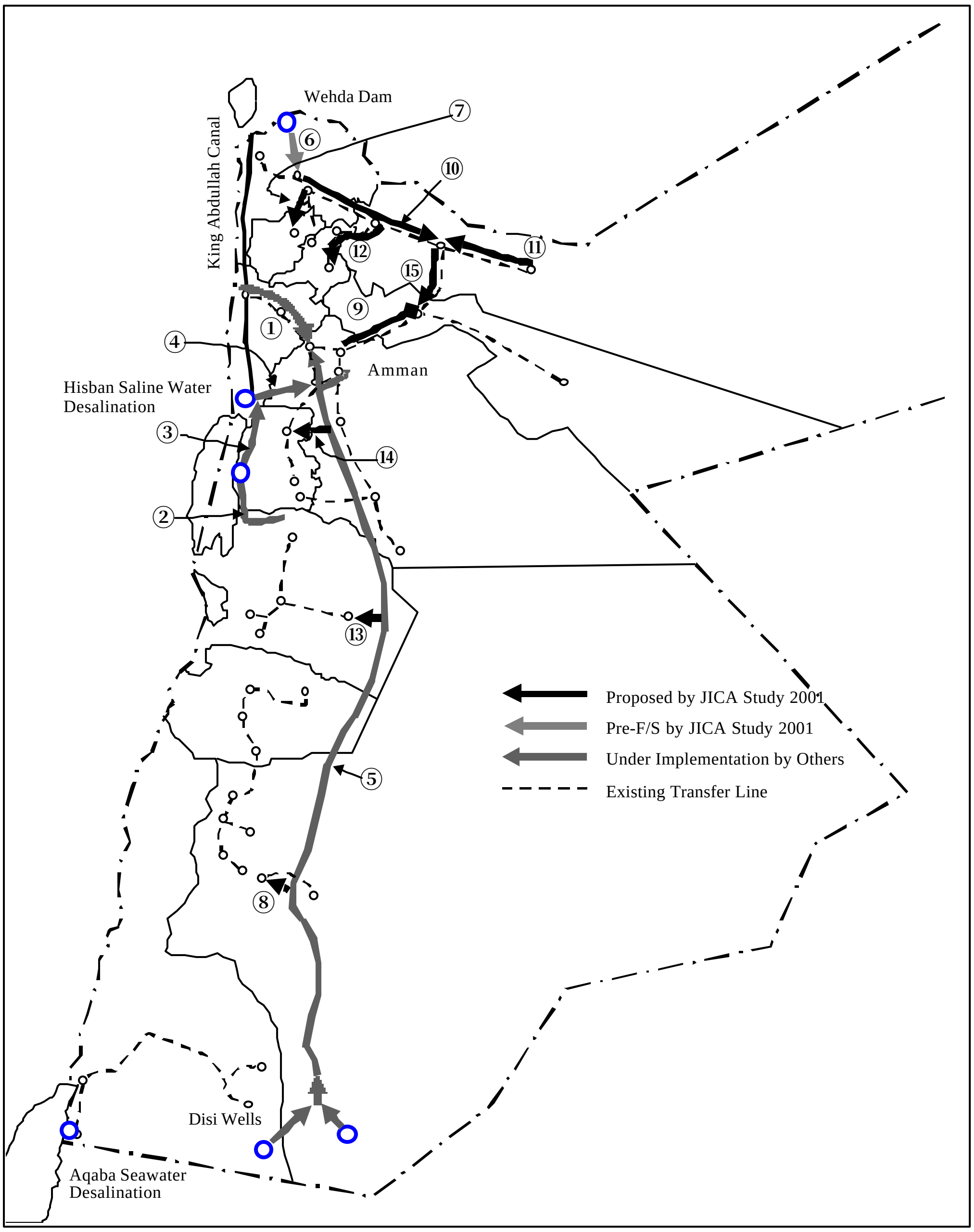


Fig. 6.4-6 General Layout of Inter-Governorate Fresh Water Transfer Lines

Main projects for inter-Governorate transfer line in the whole country are shown in Table 6.4-4. Among the projects in the table, projects ① to ⑤ are on-going development projects. Projects ⑦ to ⑮ are shown in Table 6.4-6 as the future projects that have been proposed by JICA Study in 2001.

Current situation for these projects is as follows.

- Project ① by Germany and projects ② to ⑤ by the United States have already been financed and they are now proceeding from the study stage to implementation stage.
- For Project ⑥ for Wehda Dam-Irbid Water Treatment and Transfer Line developing the surface water of Yarmouk River, preliminary facility plan, EIA and economical/financial analysis have been done in the pre-feasibility study of this study.

Responsible utility for water transfer project in Jordan is Water Authority of Jordan (WAJ).

Table 6.4-4 Main Projects for Inter-Governorate Water Transfer Lines

No.	Plan Name	Expected Completion Year	Remarks
①	Deir Alla－Zai－Dabouq Transfer Line	2002	Under study or implementation by foreign countries' assistance
②	Mujib－Zara/Main Transfer Line	2005	Ditto
③	Zara/Main－Sweima Transfer Line	2005	Ditto
④	Sweima－Muntazah Transfer Line	2005	Ditto
⑤	Disi－Amman Water Conveyor	2006	Ditto
⑥	Wehad Dam－Irbid Transfer Line	2006	Project for which pre-F/S has been done by JICA Study in 2001.
⑦	Houfa－Ajloun Transfer Line	2010	Project that has been proposed by JICA Study in 2001.
⑧	Disi－Ma'an Branch Line	2010	Ditto
⑨	Abu Alanda－Khaw Transfer Lien	2010	Ditto
⑩	Zabda－Houfa－Zatary Transfer Line	2015	Ditto
⑪	KM124－Zatary Transfer Line	2015	Ditto
⑫	Um Lulu－Jerash Transfer Line	2015	Ditto
⑬	Disi－Madaba Transfer Line	2015	Ditto
⑭	Disi－Karak Branch Line	2015	Ditto
⑮	Zatary－Khaw Transfer Line	2020	Ditto

The outline for the above mentioned new projects proposed in this study is described in detail in Table 6.4-5.

Table 6.4-5 Projects for New Inter-Governorate Water Transfer Line

No.	Project Name	Transfer Pipeline Diameter (mm)	Transfer Pipeline Length (m)	Water Reservoir	Pump Equipment
⑦	Houfa-Ajloun Transfer Line	500	15,000		Pump Station :2 nos. Q = 1,120 m^3/hr, H = 200 m Q = 1,120 m^3/hr, H = 220 m
⑧	Disi-Ma'an Branch Line	600	5,500	Balancing Tank x 1 unt Q = 800 m^3	Pump Station :1 no. Q = 1,600 m^3/hr, H = 100 m
⑨	Abu Alanda-Khaw Transfer Line	800	23,000	Pressure Breaking Tank x 1 unit Q = 100 m^3	
⑩	Zabda-Houfa-Zatary Transfer Line	800	57,000		
⑪	KM124 - Zatary Transfer Line	300 600 700	8,500 17,000 8,500	Balancing Tank x 4 units Q = 50 m^3 (1 unit) Q = 400 m^3 (1 unit) Q = 700 m^3 (1 unit) Q = 1,000 m^3 (1 unit)	Pump Station :4 nos. Q = 100 m^3/hr, H = 30 m Q = 780 m^3/hr, H = 50 m Q = 1,450 m^3/hr, H = 50 m Q = 2,120 m^3/hr, H = 100 m
⑫	Um Lulu-Jerash Transfer Line	500	27,000		
⑬	Disi-Madaba Branch Line	600	17,400	Balancing Tank x 1unit Q = 900 m^3	Pump Station :1 no. Q = 1,710 m^3/hr, H = 100 m
⑭	Disi-Karak Branch Line	800	5,000	Balancing Tank x 1unit Q = 900 m^3	Pump Station :1 no. Q = 1,800 m^3/hr, H = 100 m
⑮	Zatary-Khaw Transfer Line	1,000	33,600	Balancing Tank x 1 unit Q = 1,000 m^3	Pump Station :1 no. Q = 3,425 m^3/hr, H = 70 m

Notes 1. Projects No.⑦～⑮ shall be referred to Fig.6.4-2.
2. Piping materials shall be of ductile cast iron.

(2) Implementation Plan for Water Transfer Projects

Implementation plan and project cost to be invested in each year are shown in Table 6.4-6 and 6.4-7 respectively.

Table 6.4-6 Phased Implementation Plan for Water Transfer Projects

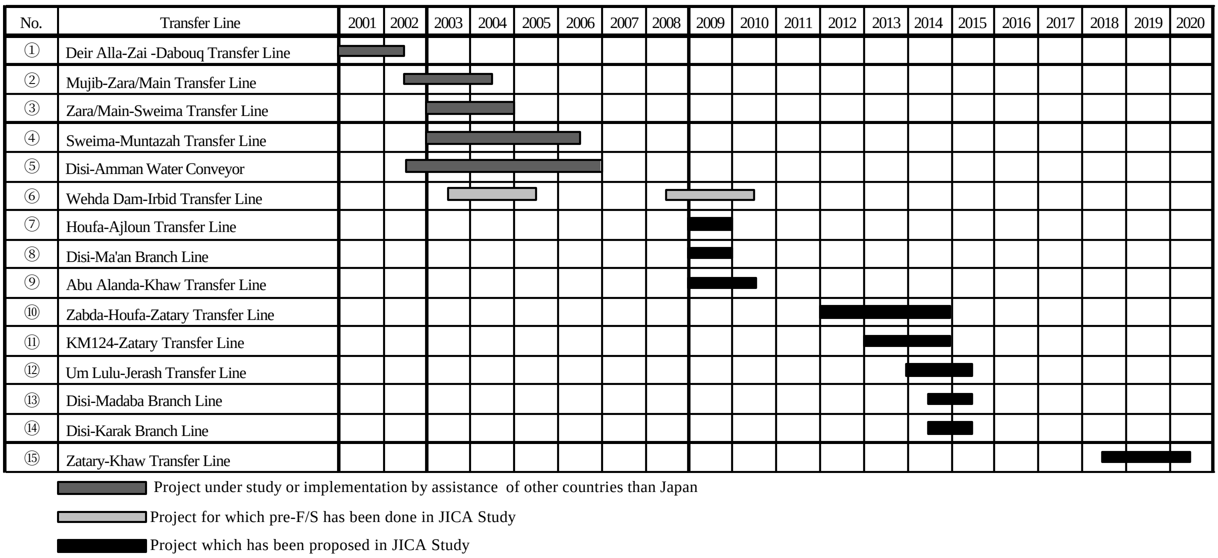


Table 6.4-7 Investment Plan for Water Transfer Project

(Unit : MJD、US$1.0=JD0.7)

No.	Transfer Line	Project Cost	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
①	Deir Alla-Zai-Dabouq Transfer Line	17.0	11.3	5.7																		
②	Mujib-Zara/Main Transfer Line	14.7		3.7	7.3	3.7																
③	Zara/Main-Sweima Transfer Line	13.6			6.8	6.8																
④	Sweima-Muntazah Transfer Line	52.1			14.9	14.9	14.9	7.4														
⑤	Disi-Amman Water Conveyor	437.5		48.6	97.2	97.2	97.2	97.2														
⑥	Wehda Dam-Irbid Transfer Line	58.2			7.7	15.4	7.7			6.9	13.8	6.9										
⑦	Houfa-Ajloun Transfer Line	6.2									6.2											
⑧	Disi-Ma'an Branch Line	4.3									4.3											
⑨	Abu Alanda-Khaw Transfer Line	11.7									7.8	3.9										
⑩	Zabda-Houfa-Zatary Transfer Line	28.6												9.5	9.5	9.6						
⑪	KM124-Zatary Transfer Line	14.1													7.1	7.1						
⑫	Um Lulu-Jerach Transfer Line	6.8														4.5	2.3					
⑬	Disi-Madaba Branch Line	8.6														4.3	4.3					
⑭	Disi-Karak Branch Line	5.2														2.6	2.6					
⑮	Zatary-Khaw Transfer Line	28.6																		7.2	14.3	7.2
	Total for Each Year	707.3	11.3	58.0	133.9	138.0	119.8	104.6		6.9	32.1	10.8		9.5	16.6	28.0	9.2			7.2	14.3	7.2
	Total Accumulated		11.3	69.3	203.2	341.1	460.9	565.5	565.5	572.4	604.5	615.3	615.3	624.8	641.4	669.4	678.6	678.6	678.6	685.7	700.0	707.3

The implementation period for each project is from one year to five years. The whole implementation period of the transfer lines will be from 2001 to 2020. Total investment cost for the period is estimated as 707.3MJD (1,010MUS$).

6.5 Problems and Issues on Water Resources Management

All plans for Water Resources Management are related to "Sustainable Water Resources Management /Development".

(1) Improvement plan of UFW

The reduction of UFW cannot be satisfactory achieved without grasping the conditions of water transportation and supply. However, since the control system of water transportation and supply has not been established yet, it is difficult to identify the locations where UFW happens and to measure the amount of UFW satisfactorily.

It is advisable that the National Water Supply Control System should be established at an early stage.

(2) Reduction plan of the renewable groundwater abstraction

It was determined in WRPS done by USAID that the well buy-outs measure was the most acceptable measure for the reduction of the renewable groundwater abstraction. However, the finance source and responsible organization for the well buy-outs were not clearly stated in WRPS.

Therefore, the finance and organization for well buy-outs should be prepared at early stage because the reduction of the renewable groundwater is essential not only for the prevention of the groundwater resources exhaustion but also for the conservation of the groundwater quality.

(3) Surface water quality conservation plan

Unpleasant smell from the drinking water occurred in the summer of 1998 and it became very big problem and attracted people's attention at that time. It is possible that one of the causes of the smell might originate from algae grown in KAC and such eutrophication of KAC water might be induced by the Peace Water conveyed from the Tiberious Lake to KAC. However, as the water quality monitoring system has not yet been equipped in KAC, the reason of the unpleasant smell still remains unknown and furthermore the urgent mitigation measure against such an accident cannot be prepared immediately.

Therefore, the water quality monitoring system should be equipped in KAC to prevent unpredictable accidents as soon as possible.

(4) Water allocation plan

One of the main findings of the Study is that it will not be possible to meet the water demand of the Amman Metropolitan Area by its own water resources inside of the area. It will be necessary to transport the water from outside using high lift pumping system. On the other hand, the Upland irrigation has been intensively carried out in the vicinity of the Metropolitan Area and large amount of the limited renewable groundwater resource has been abstracted and used for the Upland irrigation. This fact means in other words that the Upland irrigation has been supported by very expensive water from outside the area transported by high lift pumping exceeding 1,000m. In case of Amman and Zarqa Governorates, present water use for the Upland irrigation has farther exceeded the imported water amount from outside (imported water: 41MCM, water used for the Upland irrigation: 79MCM in 1998).

The water for the Upland irrigation in the vicinity of the Amman Metropolitan Area is solely dependant on the limited renewable groundwater as mentioned above and the abstraction amount has exceeded its safe yield causing the serious groundwater level decline and water quality deterioration. Therefore, the reduction of the renewable groundwater abstraction and shifting of the irrigation water from the renewable groundwater to the treated wastewater are essential for the prevention of the exhaustion of the renewable groundwater resource and conservation of its quality.

As mentioned above, the reduction of the Upland irrigation area will be needed in future because of both economic and environmental aspects. It will accordingly be necessary to shift part of the irrigation area in the Upland to the Jordan Valley. Needless to say the Water Resources Management Master Plan will not be able to achieve its main targets without the implementation of these policies.

However, the shift of the irrigation area will obviously generate many negative social impacts such as loss of farmers' jobs in the Upland, farmers' anxieties in leaving their family lands for new areas, unforeseeable factors to be caused by the shifting such as unacceptability of the new lands, non-welcome by existing farmers in the new land, reduction in incomes, abrupt changes in life styles and so on.

The basic plans for agriculture including the reduction of the renewable groundwater abstraction for irrigation, reuse of the treated wastewater for irrigation and shifting the irrigation area from the Upland to the Jordan Valley were recommended in the Water Resources Management Master Plan. The action plans including the mitigation measures for the negative social impacts to be caused by the implementation of the basic plans should be formulated at an early stage.

(5) Water Transfer/Supply Plans

The inter-Governorate water transfer and supply to the each demand center have not yet been satisfactorily understood and many problems have taken place for the control of water transfer and supply because the measurement and control system has not been established yet.

Therefore, It is recommended again that the National Water Supply Control System which was proposed in the Water Resources Management Master Plan should be established at an early stage in parallel with the construction of the water transfer and supply systems.