7. Water Resources Management Master Plan

Water resources of Jordan is, as described earlier, extremely limited, though water demand is increasing every year due to a recent growth in its population. As a result, the water supply does not meet the demand, which has inconvenienced citizens' daily life. In addition to this, the water level of renewable groundwater has declined due to excessive abstraction and water quality has significantly deteriorated.

In order to tackle the situation, the country needs urgently to use limited water resources effectively, secure water resources in terms of its quality and quantity, and distribute the resources efficiently.

Against the backdrop, we have formulated Water Resources Management Master Plan in this study to solve the problems.

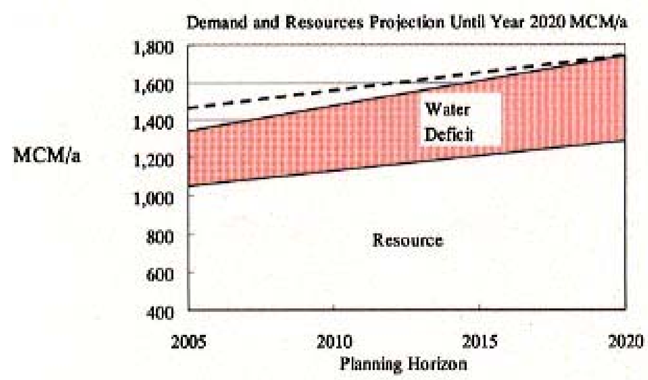
Although development of water resources is discussed in Chapter 5 in this report, it is included in water resources management because it is very important from the viewpoint of quantitative management.

7.1 Gist of the Plan

(1) Basic policy for the formulation of the plan

In this study, Water Resources Management Master Plan has been made, aiming at "unified and comprehensive and sustainable management of water resources" and "strategic development of remaining scarce water resources," while considering a goal of water re-cycling oriented society. In making the master plan, the considerations were made on "development and management of sustainable water resources". Investigation on "cooperation for regional peace water development" and "global climatic change" were recommended as future issues in Jordan.

According to the results of the demand projections Jordan's water demand will increase from about 1,350 MCM in 2005 to about 1,740 MCM in the target year 2020. Regarding the national resources like the safe yield of ground water, surface water and wastewater it becomes obvious that tremendous efforts have to be undertaken to assure the vital needs of Jordan. Total national water resources will be approximately 1,050MCM in 2005 and 1,290MCM in 2020 which includes all the treated wastewater, nonrenewable resources, desalinated water and peace water as well as conventional resources.



The annual deficit will increase from 300 MCM to 450 MCM even considering the potential sustainable resources being fully utilized, which will never be feasible. When the faster realization of target water consumption rate per capita in municipal water supply will be considered, the deficit will drastically increase as shown in broken line in former figure. This scenario underlines firstly the importance of managing demands carefully and secondly the need for developing all available resources including the total share of international resources.

As the projected demand of the country cannot be met by the national resources the demand has to be suppressed to an extent that can be covered by the available resources. With regard to resources a maximized development of ground- and surface water including wastewater reuse, a temporary use of non-renewable water, sea water desalination and Jordan's rightful shares of international resources including Peace Treaty water have to be considered.

In the light of the foreseeable extreme water shortage it occurs to be reasonable to exploit non-renewable water on a temporary scheme to gain the necessary time for the development of sustainable solutions on the long run. The constrained demand is the basis of the water allocation concept followed throughout the study as the required infrastructure has to be tailored according to the resources availability.

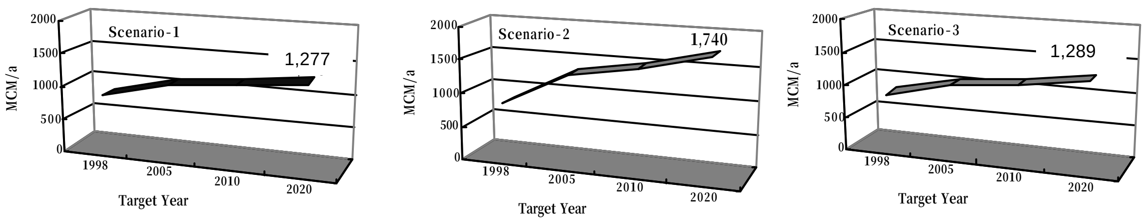
The basic conditions in formulating the Water Resources Management Master Plan are shown in Table7.1-1. Among the basic conditions, most critical issue in managing water resources in a unified, comprehensive and sustainable manner is believed to be the problem of renewable groundwater that is almost drying out due to its excessive abstraction. The most important issue in strategically developing remaining scarce water resources is that most of conventional water resources such as surface water and groundwater are scheduled to be almost fully developed in near future. Thus, in order to meet the water demand that will further increase in the future, it will be critical to develop and use treated wastewater, desalinated brackish and sea water that has been hardly used.

Table7.1-1 Basic Policies for the Formulation of the Master Plan

Management Item		Basic Policies	Existing Policies
Quantitative Management	Improvement of UFW	The present physical loss of 25% shall be reduced to 15% by on-going rehabilitation works by 2010	Policy of UFW Div. of MWI
	Improvement of Institutional System	The necessary improvement plans shall be recommended based on the on-going re-structuring project of the Institutional system in MWI.	Water Strategy, Water Utility Policy, Wastewater Management Policy
	Decline of Groundwater Level Decline	The abstraction of the renewable groundwater shall be reduced to the level of the safe yield. (reduction from 420MCM/a to 275MCM/a by 2020)	Water Strategy, Ground-water management policy, policy of the JICA Study Team
	Development of Conventional Water Resources	The remained potential of the conventional water resources shall be fully developed, the renewable groundwater should not be further developed	Water Strategy, Water Utility Policy, Groundwater Management Policy, Policy of the JICA Study Team
	Development of Non-Conventional Water Resources	Reuse of the treated wastewater should be promoted as an important water resource, the desalination of the brackish and sea water should be restricted for necessary but minimum demand considering the environmental impacts and high cost for processing.	Water Strategy, Water Utility Policy, Water Utility Policy, Irrigation Water Policy, Groundwater Management Policy, Policy of the JICA Study Team
Qualitative Management		The monitoring of the surface water and groundwater quality shall be done for the quantitative management	Water Utility Policy, Policy of the JICA Study Team
Water Allocation Management	Municipal Water	Although the increasing water demand due to the population growth shall be met, the consumption rate shall be kept at almost present level (100lcd to150lcd)	Water Strategy, Water Utility Policy
	Industrial Water	Necessary but minimum demand shall be satisfied considering the importance for the national economy	Water Strategy
	Irrigation Water	The amount of allocation for irrigation shall be kept at almost present level in order to meet the necessary but minimum MIT demand (around 620MCM/a in future)	Irrigation Water Policy、Policy of MWI and World Bank
	Allocation to the Governorates	The demand and supply shall be balanced by the inter-Governorate water transfer	Policy of the JICA Study Team
Risk Management (Measures for Drought)		Special water allocation and urgent water development shall be considered for the drought year of 20 year return period	Policy of the JICA Study Team

(2) Setting of scenarios of water demand

Based on the basic conditions to make the master plan which are shown in Table 7.1-1, three scenarios of projecting water demand were made.



Scenario-1: Demand Control Model based on the base water balance proposed by World Bank
-Municipal Water
High Population, Low Demand
-Industrial Water
About 3times increase by 2020
-Touristic Water
about 11times increase by 2020
-Irrigation Water
Almost table at around 620MCM/a

Scenario-2: High Demand Model based on political target and agriculture development plan
-Municipal Water
High Population, High Demand
-Industrial Water
About 4times increase by 2020
-Touristic Water
about 15times increase by 2020
-Irrigation Water
900MCM/a (300MCM/a increment)

Scenario-3: Variation Model of Scenario-1, different projection parameters were employed
-Municipal Water
Low Population, High Demand
-Industrial Water
About 3times increase by 2020
-Touristic Water
about 12times increase by 2020
-Irrigation Water
Almost table at around 620MCM/a

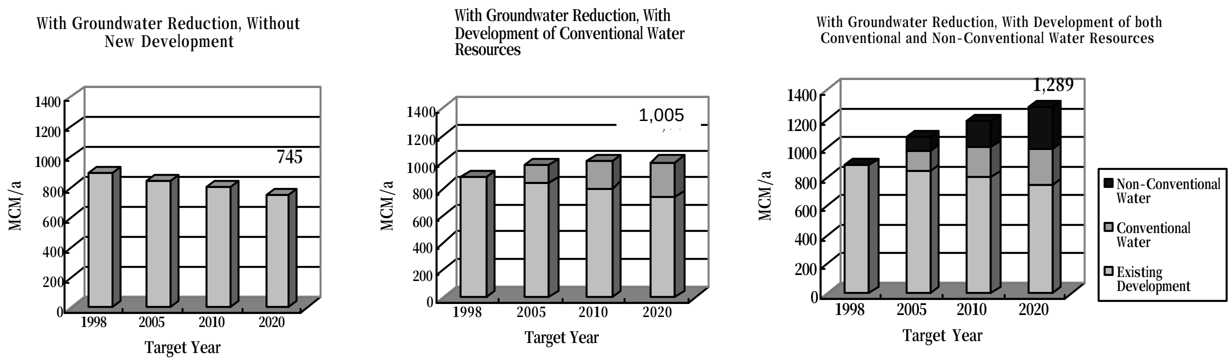
Fig. 7.1-1 Scenarios of Water Demand Projection

The water demand in the scenario-1 is based on the high population increase rate (2.0% to 2.6%) employed by MWI for the planning and low water consumption rate per capita (128l/c/d). It was made in accordance with the basic policies of improvement of UFW, water allocation for MIT and allocation for irrigation shown in Table 7.1-1.

Although the scenario-3 was made almost under the same condition as the scenario-1, the low population growth rate (2.7% to 3.0%) used by the Department of Statistics was adapted and the water consumption rate per capita was set at a high rate (150l/c/d.)

The water demand projection of the scenario-2 was based on the high population growth rate (2.0% to 2.6%) employed by MWI and the high water consumption rate per capita (150l/c/d). It is also in accordance with the basic policies of improvement of UFW, water allocation for MIT and allocation for irrigation shown in Table 7.1-1. As for the water allocation to the agriculture, water demand based on the existing agricultural plan was used instead of taking the policy of maintaining the current volume for irrigation shown in Table 7.1-1.

The Chart 7.1-2 shows future development of water resources.



Note: Existing Development amount will be reduced due to the reduction of groundwater abstraction

Fig. 7.1-2 Amount of Developable Water Resources in Future

As shown in Fig. 7.1-2, if the abstraction of renewable ground water will be restricted without new development of water resources, the total water resources will drop to 745 MCM/a in 2020. If conventional water sources including surface water, peace water and fossil fresh ground water are developed, the total water resources will increase at a small rate to 1,005 MCM/a from the current level (890 MCM/a in 1998) by 2020. If non-conventional types of water, including treated wastewater, desalinated brackish and sea water will be developed in addition to the development of conventional water sources, the total is estimated to increase to 1,289MCM/a by 2020.

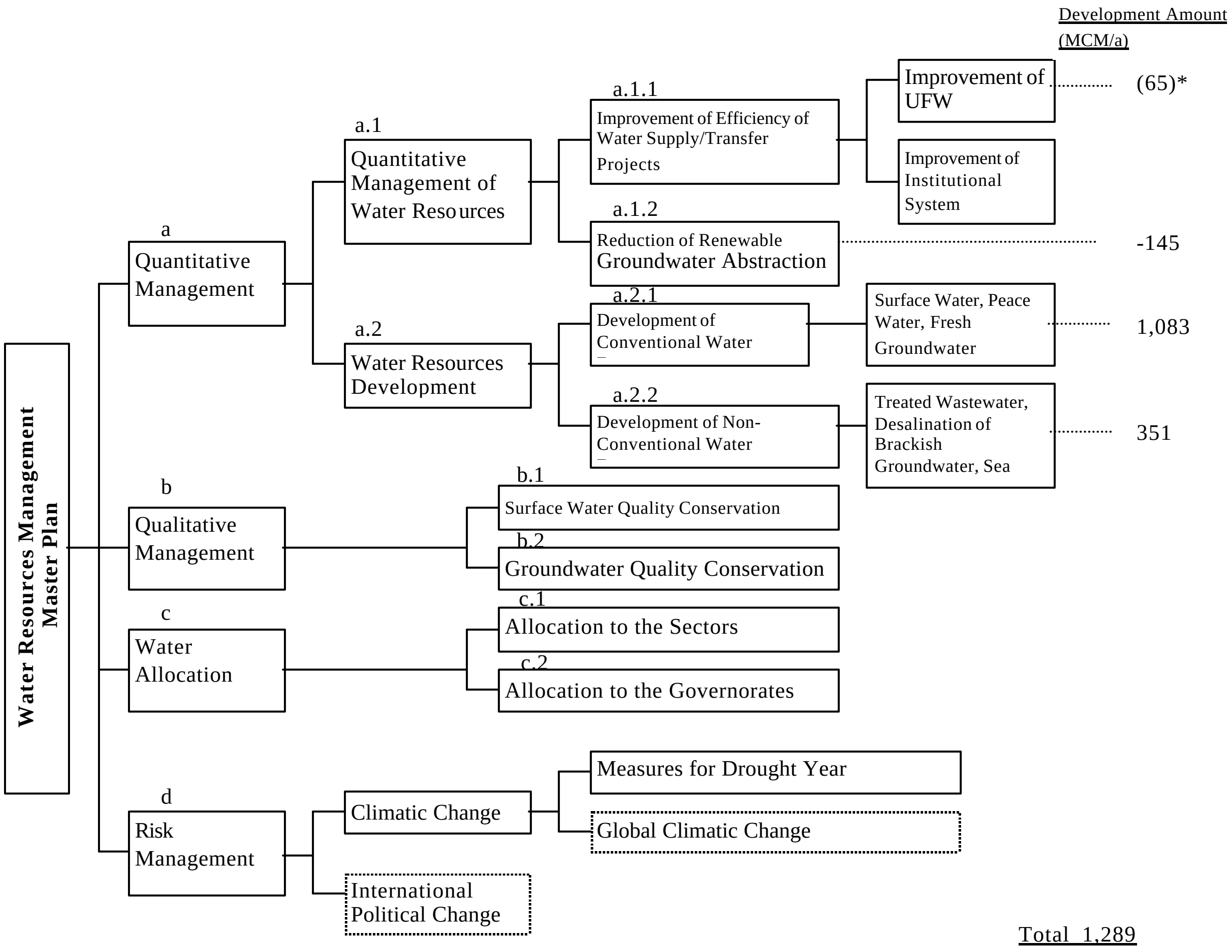
As shown in Fig. 7.1-2, without the development of the non-conventional water sources in addition to the development of the conventional water resources, even the minimum water demand will not be satisfied in future.

Scenario-2 is a targeted demand model assuming the full supply of irrigation water and the higher consumption rate per capita (150l/c/d) which is the ultimate goal of MWI. As shown in Table 7.1-1 and Fig. 7,1-2, the water demand largely exceeds possible water supply in each target year, and thus it can be said that Scenario-2 is hard to be realized.

In cases of scenarios-1 and -3, the water demand is estimated to be within the water supply that can be developed, and thus it can be said that the scenarios can be realized. The major difference between the two scenarios is that future population growth rate is greater and water consumption rate is smaller in Scenario-1, and the population growth rate is smaller and water consumption rate is greater in Scenario-3. Therefore, in making the Water Resources Management Master Plan, Scenario-1 that projects the supply-demand relations based on a high population increase and low water demand is used as the basic scenario in giving consideration to the possibility of the delay of the development projects of water resources.

(3) Basic policy of the plan

The contents of the Water Resources Management Master Plan to satisfy the scenario-1 will be described in this section. The tree structure of the Master Plan is shown in Fig. 7.1-3.



*: Incremental Amount by the improvement of UFW is counted in the reduction of water supply

Fig. 7.1-3 Main Components Forming the Water Resources Management Master Plan

The main policies of the Master Plan shown in Fig. 7,1-3 are explained in the following.

a. Quantitative management

a.1. Quantitative management of water resources

a.1.1 Improvement of efficiency of water supply and transfer projects

- Improvement of unaccounted for water (UFW)

  The plan to improve unaccounted for water is carried out by the section of unaccounted for water (UFW section) established in the Ministry of Water and Irrigation. Currently, a rehabilitation plan of existing water supply system is carried out across the nation. The plan aims to reduce the current rate of water leakage from the water supply system of about 25% to 15%. The Master Plan adopts this plan to reduce the water leakage rate to formulate a water supply plan. It is also planned to educate citizens to save water and establish legal regulations to tackle illegal water use, in addition to the rehabilitation of the water supply system.

  The water resources management master plan also suggests a project to establish water supply control system in an attempt to find out the actual situation of UFW. Because no measures can be taken without understanding the actual situation of UFW, the Master Plan suggests an early establishment of the system.

- Improvement of institutional and management system of water supply projects

  The institutional improvement plan is carried out based on a plan formulated with the cooperation of Canada (CIDA). It has generated some positive results, including the reduction in personnel. The PMU established within the MWI promotes the privatization of maintenance and management for improving the efficiency of the management of water and sewage projects, and the works have been actually privatized in Amman. The Master Plan was formulated with the assumption that such plans would be further promoted.

  On the other hand, as for the projects except for water projects, including sewage projects and water projects for agricultural use, the tariff is set at a low level not to allow to cover the maintenance and management costs. The Master Plan suggests the tariff should be raised to a level that will at least allow to cover such costs in order to improve the management of water projects and to provide sufficient services.

a.1.2. Reduction of the renewable groundwater abstraction

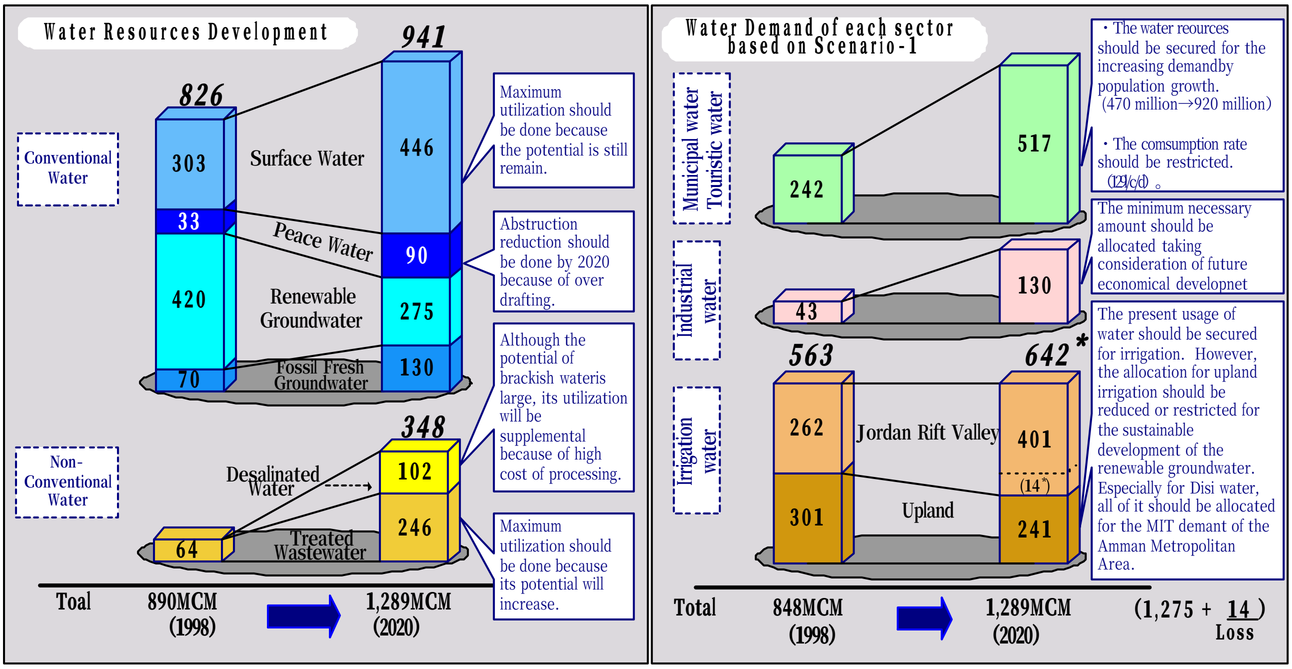
The plan of reducing the renewable groundwater abstraction aims to conserve groundwater sources quantitatively. It aims to reduce the abstraction of renewable groundwater, which is excessively abstracted currently, by about 35 percent (from the current abstraction of 420 MCM/a to 275 MCM/a). The USAID conducted a detailed study on the plan of reducing the renewable groundwater abstraction in Amman/Zarqa basin. It made an action plan consisting of projects of provision of agricultural instruction to improve efficiency of water use of agricultural purposes, purchase of wells and use of treated wastewater. The reduction plan is believed to be applicable in other regions. Therefore, under the Master Plan, it is planned that the action plan is first carried out in Amman/Zarqa basin, and then based on the result, it is to be carried out in other regions. The reduction plan is scheduled to be completed by 2020.

Because the execution of the plant to reduce groundwater abstraction promotes qualitative conservation as well as quantitative conservation of groundwater, it is also proposed as a plan to conserve quality of groundwater.

a.2. Water resources development

In Jordan, most of the conventional types of water resources that are believed to allow sustainable development is to be developed by 2005, and gradual reduction in the abstraction of the renewable groundwater is necessary. New water resources that will allow sustainable development in Jordan are, as shown in Fig.7.1-4, limited to non-conventional water sources of desalinated brackish and sea water and treated wastewater. These non-conventional types of water resources are regarded as important water sources in the Master Plan, and 348 MCM/a of water (85 MCM/a of desalinated brackish groundwater, 17 MCM/a of desalinated sea water and 246 MCM/a of treated wastewater) is expected to be developed by 2020. However, because the use of treated wastewater is limited to certain purposes and cost to desalinate the brackish and sea water is still high, it is difficult to meet the future water demand only with the non-conventional types of water resources.

Therefore, the Master Plan has a policy to aggressively develop the non-conventional types of water sources together with the maximum development of remaining scarce conventional types of water resources including surface water and fossil fresh ground water. However, part of the 1,289 MCM/a of water sources that is scheduled to be developed by 2020 needs to be stored for the next generation, and thus the development should be carried out at a necessary minimum level.



* Loss which will occur in the conveyance of treated wastewater through river and wadis (The treated wastewater will be reused for irrigation in Jordan Valley).

Fig. 7.1-4 Water Balance of the Water Resources Management Master Plan

a.2.1. Development of conventional water

-Surface water

Preparation for the development of surface water is on progress, and most of it is to be completed by 2005. Further large-scale development of surface water will not be possible after 2005. However, development of remaining surface water should be promoted even if it is small in volume, and the Master Plan recommends the implementation of the Water Harvesting Plan. The plan is to store flooded water generated in some regions, although such water is produced rarely, at a dam in the desert area (Badia Region) to use it for the local residents for agriculture and stock breeding. The developable water volume of the plan is projected to be about 15 MCM/a.

-Water from Israel under the peace treaty

Currently, 33 MCM/a of surface water is transported from Israel under the agreement of the peace treaty concluded in 1994. The volume is planned to increase to 90 MCM/a by 2010. The Master Plan includes the "Water Storage in the Jordan River and Side Wadi Plan" as a project to newly develop the increased amount of water under the peace treaty.

-Renewable ground water

As described before, renewable groundwater in Jordan has already been excessively abstracted and the abstraction needs to be reduced. A water allocation plan under which water abstraction is to be reduced both from water for municipal use and agricultural use is formulated in the Master Plan. The WAJ has a plan to prepare alternative water sources to offset the reduced abstraction of municipal water. Improvement of institutional and legislative system is proposed for the reduction of the renewable groundwater for irrigation use is proposed in the Master Plan.

-Fossil fresh groundwater

The development of fossil fresh groundwater in Disi, Ma'an in the southern upland area and Lajoun area in Karak Governorate is proposed in the Master Plan. The water in Disi is being used for municipal purpose in Aqaba and agricultural purpose in the upland area. The amount stood at 66 MCM/a (of which 51 MCM /a was for agriculture) in 1998. The Master Plan includes a project to increase the abstraction to be developed to about 130 MCM/a and transfer it to the greater Amman area (about 300km) by means of pumps in order to convert the fossil fresh groundwater from irrigation water to municipal water.

In the case of the development of fossil fresh groundwater, which is typical mining development, the resources are limited and the period of development is limited to about 50 years, and thus it is not permanently sustainable development. This type of non-renewable water resources should be conserved as water resources for the next generation as much as possible.

a.2.2. Development of non-conventional water

-Treated wastewater

Currently, 64 MCM/a of treated wastewater is generated. The volume is projected to reach 246 MCM/a by 2020, and it is very valuable and important water resources in the future. The Master Plan suggests a plan to promote the use of treated wastewater for agricultural and industrial purposes.

However, because almost no treated water is used directly without being diluted in Jordan, sufficient care needs to be given to hygiene and thus it is necessary to raise public awareness of the promotion of the use of treated wastewater and possible danger of using such water.

-Desalinated brackish groundwater

Brackish groundwater is one of water resources yet to be developed in Jordan. There is a limited number of detailed studies on brackish groundwater and thus there is not enough data to properly evaluate the potential and water quality. However, the Jordan Valley, east coast of the Dead Sea and Karak regions are expected to have great potential. The Master Plan regards brackish groundwater as critical water resources to meet the future water demand, and counts it as a water resource for water demand that has economically high benefit, which includes municipal, touristic and industrial sectors (40 MCM/a by 2010 for MIT use under the Zarqa Ma'in/Zara Spring Project in the east coast of the Dead Sea, 9MCM/a by 2020 for MIT use in Amman area under the Hisban/Kafrein brackish groundwater desalination project and 36 MCM/a by 2020 for industrial use under the Lajoun Oil Shall Project).

However, the desalination of brackish groundwater has disadvantages--high costs for processing and negative environmental impacts to be caused by discharging of brain--and thus the development should be conducted carefully watching the future reduction of cost for processing and advancement of the reverse osmosis technology.

-Desalinated sea water

Under the Master Plan, the use of desalinated sea water is planned at Aqaba located in the southern part of Jordan. The study shows that there is high demand of water for industrial and touristic uses in Aqaba which have enough affordability. In order to meet increasing demand, the development is planned to expand gradually, from 5 MCM/a by 2005 and 17 MCM/a by 2020. Desalination of sea water also has disadvantages--high processing costs and negative environmental impacts same with the desalination of brackish groundwater--and thus the development should be conducted carefully watching the future advancement of the technology.

b. Qualitative management

b.1. Conservation of surface water quality

The Master Plan proposes a formulation of the water quality monitoring system as a project for surface water quality conservation. The monitoring project is to accurately detect the change in surface water quality to prevent the deterioration of the water quality. This allows to take measures to prevent the deterioration of surface water quality prior to its actual occurrence as exemplified in the case of the strange smell of tap water occurred in Amman in 1998. The WQICP project conducted by the USAID includes a surface water quality monitoring project and the Master Plan proposes that this project will be carried out by 2005.

b.2. Conservation of groundwater quality

The Master Plan proposes a water quality monitoring project as a plan for ground water quality conservation as well as a plan to reduce the abstraction of groundwater. The execution of the water quality monitoring project enables to take measures to tackle the rise in the concentration of salinity and nitrate of groundwater at an early stage. The Master Plan includes the water quality monitoring project formulated in

WQICP project conducted by the USAID to be carried out by 2005.

Because the irrigation water in the highland area is believed to be the cause of the deterioration of quality of renewable groundwater in the study, the Master Plan suggests the downsizing of agriculture in the upland area and the reduction in the abstraction of groundwater for irrigation as measures to conserve groundwater quality.

c. Water distribution plan

c.1. Allocation among sectors

Water allocation among the sectors is, as shown in Table 7.1-2, as follows: water for irrigation will remain to be at the current level and water for MIT (municipal, industrial and touristic) uses will be allocated at the necessary minimum level. A water allocation plan among the sectors is shown in Fig. 7.1-5.

Table 7.1-2 Water Allocation among the Sectors

(MCM/a)

		MIT Use		Irrigation Use	
		1998	2020	1998	2020
Conventional Resources	Surface Water	62	182	216	226
	Peace Water	0	40	35	90
	Renewable Groundwater	203	165	211	109
	Fresh Fossil Groundwater	20	130	51	0
Non-Conventional Resources	Desalinated Water (Brackish/Sea Water)	0	102	0	0
	Treated Wastewater*	0	30	50	215
Total		285	647	563	642

* Including Loss which will occur in the conveyance through river and wadis.

Water allocation among the sectors is extremely important for the management for sustainable water use. In order to adjust the allocation, water for agriculture should be partly converted to municipal water, which will be accompanied by the review of agricultural development plan.

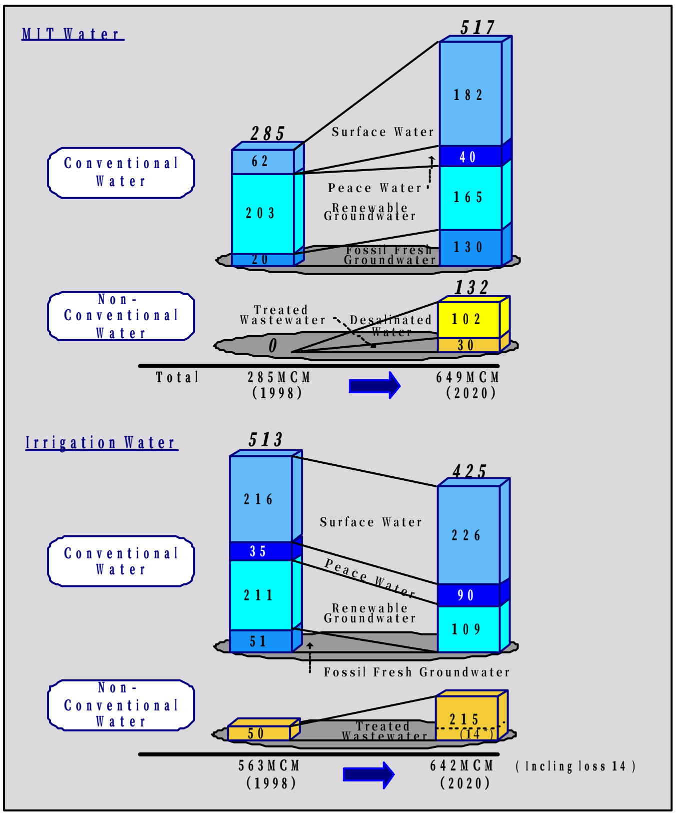
- Securing increasing municipal water demand

The Master Plan follows the national water strategy and adopts a policy of putting priority on water allocation to increasing demand of water for municipal, industrial and touristic purposes and maintaining the current level of water distribution for agricultural purposes, as shown in Fig. 7.1-4.

- Change of water sources and an agricultural development plan

The Master Plan suggests the reduction in renewable fresh groundwater that is currently used for agriculture and, as an alternative, use of treated wastewater, as shown in Fig. 7. 1-5.

The Master Plan also suggests, accompanying the change of water sources, relocation of agriculture conducted in the Upland area to the Jordan Valley in order to financially enable the use of treated wastewater.



* Loss which will occur in the conveyance of treated wastewater through river and wadis.

Fig. 7.1-5 Water Allocation among the Sectors

The Ministry of Water and Irrigation will need to work with the JVA, Ministry of Agriculture and related ministries and agencies in relation to the water allocation, change of water sources and relocation of agricultural land to formulate a national agricultural development plan in accordance with the policy.

c.2. Water allocation among Governorates

Imbalance of water supply and demand that occurs in each region is to be solved by transferring water among the Governorates under Master Plan. The water transfer plan among the Governorates is shown in Fig. 6.4-3, and the Master Plan proposes the construction of main water transfer lines running across the nation after 2005.

d. Risk management (Measures for extraordinarily drought years)

The Master Plan includes a water allocation plan and a plan to urgently develop water resources on assumption of extraordinarily drought years of 20 years return period. As measures to deal with extraordinarily drought years in the field of water resources development, a groundwater development plan in Lajoun in Karak Governorate is assumed. The fossil fresh groundwater that is the water source of the Lajoun wells is almost stagnant, and thus is excellent as a water source for emergencies. Sustainable development of about 11 MCM a year is also believed to be possible in the Lajoun well field. However, because this is not enough to cover the water shortage in extraordinarily drought years (decrease in the development of about 20% of surface water and decrease of 25 MCM/a in total), the Master Plan gives consideration to jointly use a proposal to temporarily stop the execution of a plan to reduce renewable groundwater in extraordinarily drought years.

7.2 Projects in the Master Plan and Implementation Schedule

7.2.1 Projects in the Master Plan

Table 7.2-1 shows the whole water resources management projects that constitute the Water Resources Management Master Plan (Master Plan). Table 7.2-2 shows the water resources development projects of the Master Plan. The locations of the water resources management projects are also shown in Fig. 7.2-1 and the locations of the water resources development projects are shown in Fig. 7.2-2.

Table 7.2-1 Outline of the Main Projects Constituting the Master Plan

Projects				Outline of the Projects	Main Projects	Anticipated Effects
Quantitative Management	Quantitative Management of Water Resources	Improvement of Efficiency of Water Supply and Transfer Projects	Rehabilitation of Existing Supply System (Reduc. UFW)	Replacement of existing old pipeline system	Rehabilitation Projects at main cities such as Amman, Zarqa and Karak, Reduction of 65MCM/a physical loss	Rate of physical loss will be reduced from 25% to 15% by 2010
			Water Supply Control System (Reduc. UFW)	Establishment of Water Supply Control System	Project recommended by the JICA Study	Quantitative detection of UFW will be made possible
			Improvement of Institutional System	Improvement of efficiency through private sector participation and public awareness	Improvement plan of institutional System such as GS, PMU, Concession of Operation & Maintenance, Public Awareness through Mass Media	Improvement of the financial condition, Reduction of UFW, Improvement of Service Level
		Reduction of the Renewable Groundwater Abstraction (Reduction from 420MCM/a to 275MCM/a by 2020)		Reduction of abstraction within safe yield	aImprovement of Irrigation Efficiency (Farmer Education), Well buy-out, Reuse of Treated Wastewater	Saving Renewable Groundwater from Exhaustion,
	Water Resources Development	Conventional Water Resources Development		Surface Water, Peace Water, Fresh Groundwater Development	Wehda Dam, Mujib Dam and other dams, Development of Fossil Fresh Groundwater in Disi-Mudawara Area	1998：826MCM/a 2005：917MCM/a 2010：950MCM/a 2020：941MCM/a
		Non-Conventional Water Resources Development		Construction of TP, Reuse of TWW, Brackish & Sea Water Desalination	Sea water Desalination at Aqaba, Expansion of As Samra TP., Reuse of Treated Wastewater at existing Plants	1998：64MCM/a 2005：137MCM/a 2010：235MCM/a 2020：348MCM/a
Quantitative Management	Surface Water Quality Conservation			Strengthening of the Monitoring System	Formulation of the Comprehensive Monitoring System Proposed by WQICP	Prior detection of the deterioration and Quick Response to it
	Groundwater Quality Conservation			Strengthening of the Monitoring System	Formulation of the Comprehensive Monitoring System Proposed by WQICP	Prior detection of the deterioration and Quick Response to it
				Reduction of Groundwater Abstraction	Same projects mentioned in a above	Water Quality Conservation can be done by 30% reduction
Water Allocation Management	Allocation among the Sectors			Coordination among the Sectors	Securing MIT Water, Changing Water Source for Irrigation	Appropriate Allocation to the Sectors
	Allocation among the Governorates			Construction of Water Transfer lines	Disi-Amman, Wehda-Irbid water Transfer line	Balancing the Demand & Supply in whole Jordan
Risk Management	Measures for Extraordinary Drought Years (20 years return period)			Formulation of Special Water Allocation Plan, Development of Urgent Water Resources	Development of Lajoun Well Field, Suspension of Reduction Program of Groundwater Abstraction, Reduction of Water Supply	Preparation for such emergency cases can be made.

Table 7.2-2 Future Water Development Projects and Development Amount

(MCM/a)

Resource Type	Main Project Name	[1]Existing Develop Amount	Short Term 2001 ～ 2005	Mid Term 2006 ～ 2010	Long Term 2011 ～ 2020	[2]Incremental Develop. Amount during 1998 ～2020	Total Develop. Amount by 2020 (1+2)
Surface Water	Existing Development Amount	303	-	-	-	-	303
	Wehda Dam	-	93	-	-	93	93
	Mujib Dam (including base flow)	-	12	-	-	12	12
	Tanur Dam	-	8	-	-	8	8
	Wala Dam	-	5	-	-	5	5
	Small Dams (Ibn Hamad, Karak, Meddien)	-	-	7	-	7	7
	Feedan Dam	-	3	-	-	3	3
	Water Harvesting	-		-	15	15	15
	Total	303	121	7	15	143	446
Peace Water	Desalination Conveyor to Urban Jordan	33	27	-	-	27	60
	Storage on Jordan River and Side Wadis	-	-	30	-	30	30
	Total	33	27	30	-	57	90
Renewable GW	Reduction of the Abstraction	420	-52	-31	-62	-145	275
Fossil Fresh Groundwater	Disi	70	-5[a]	27	38	60	130
	Lajoun Wells	-	(11)*	-	-	(11)*	(11)*
	Total	70	-5	27	38	60	130
Brackish Groundwater Desalination (including brackish spring)	W. Zarqa Ma'in/Zara Spring Project	-	20**	20**	-	40**	40
	El-Lajoun Desalination Project	-	-	13	23	36	36
	Hisban/Kafrein Desalination Plant	-		-	9	9	9
	Total	-	20	33	23	85	85
Sea water	Aqaba Sea Water Desalination	-	5	-	12	17	17
Reuse of Treated Wastewater	As-Samra TP	46	21	-6[b]	22	37	83
	Wadi Zarqa TP	-	-	40	14	54	54
	Existing 5 TPs	2	2	2	2	6	8
	Other TPs	16	25	29	31	85	101
	Total	64	48	65	69	182	246
Ground Total		**890**	**164**	**131**	**104**	**399**	**1,289**
Total Amount by Target Year		**890**	**1,054**	**1,185**	**1,289**	**-**	**1,289**

Source : Investment Program 2000 to 2010 and JICA Management Plan

a: The water abstraction of the Fossil Fresh Groundwater will be temporarily reduced because the irrigation use of Disi water for irrigation will be restricted.

b. The treated waste effluent will be temporarily reduced from the As- Samra TP because of the completion of the Wadi Zarqa TP

*: It is not included in the Master Plan because it will be used for urgent purposes such as drought.

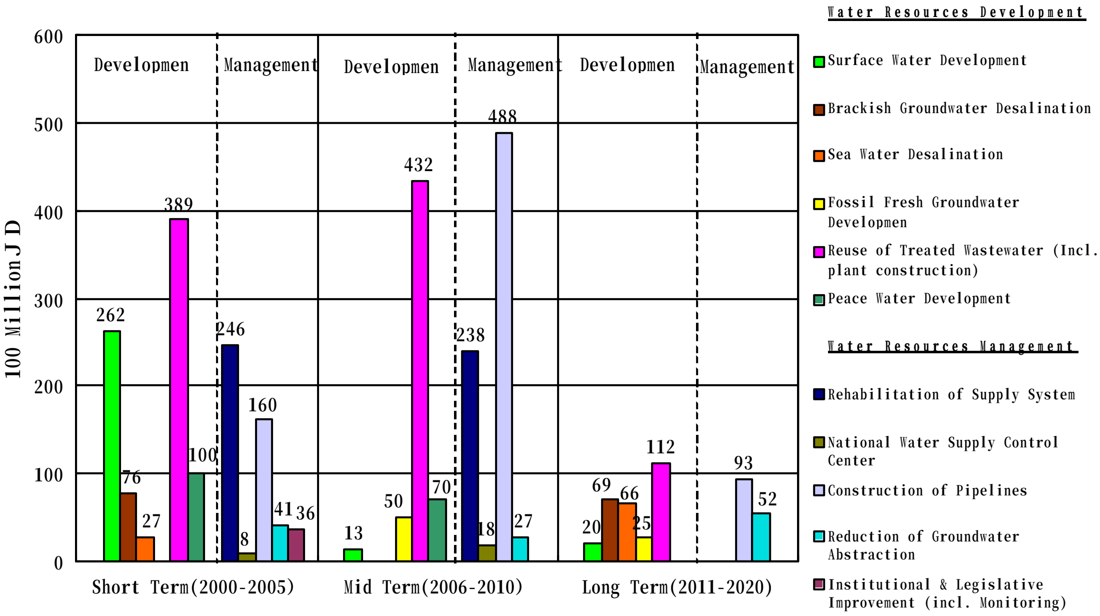
**: It includes desalinated surface water from Wadi Mujib, its amount will be 30MCM/a.

7.2.2. Implementation Schedule of the Water Resources Management Master Plan and Cost Estimation

Fig. 7.2-2 shows main projects of water resources management and Fig. 7.2-3 shows the main projects of water resources development. Table 7.2-1 also shows implementation schedule of the Water Resources Management Master Plan.

As shown in the tables and figures, main new water resources development projects are scheduled to be mostly completed in the short-term target years (2001-2005). In the mid-term target years (2006-2010), monitoring systems of water supply/transfer systems, rehabilitation of existing water supply systems and main transfer lines are scheduled to be mostly completed, and rehabilitation and construction of wastewater treatment plants, reuse of the treated wastewater and measures to reduce the abstraction of the renewable groundwater are expected to be mostly completed in the long-term target years (2011-2020.)

Fig. 7.2-1 shows projected costs for the development and management in short-, mid- and long-term plans. The projection is based on the Investment Program 2,000-2,010, and most of the costs is not actually secured. The short-term projects are roughly estimated to cost 1,350 million JD and mid-term projects are projected to require 1,340 million JD. Please refer to the attachments of the "List of Water-Related Projects" and "Location of Water-Related Projects" at the end of the report to find out the details of each project.



Source: Investment Program 2000-2010 and Evaluation of the Study Team

Fig. 7.2-1 Assumed Cost for the Water Resources Management Master Plan by Target Year

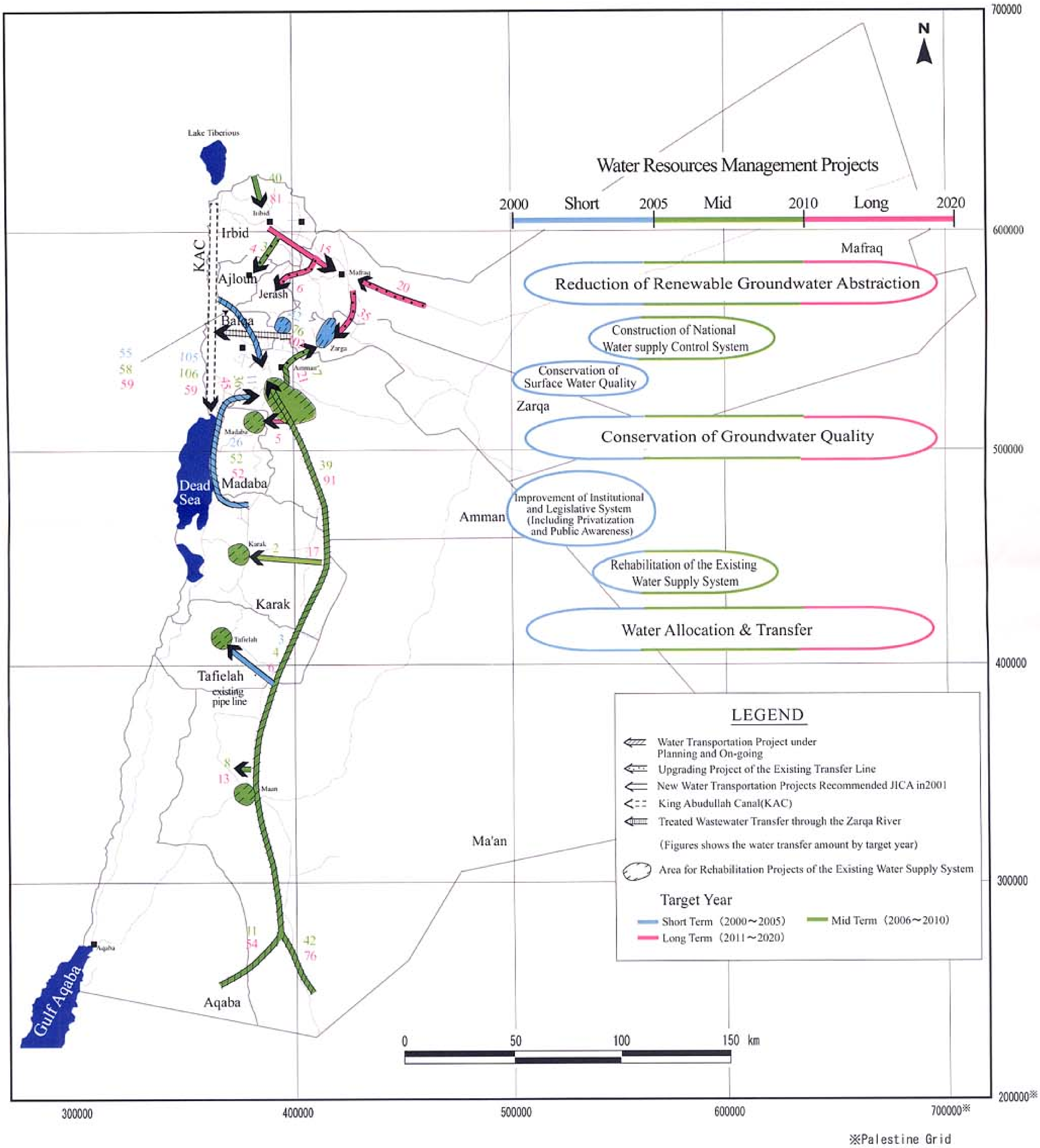


Fig. 7.2-2 Locations of the Main Projects for the Water Resources Management

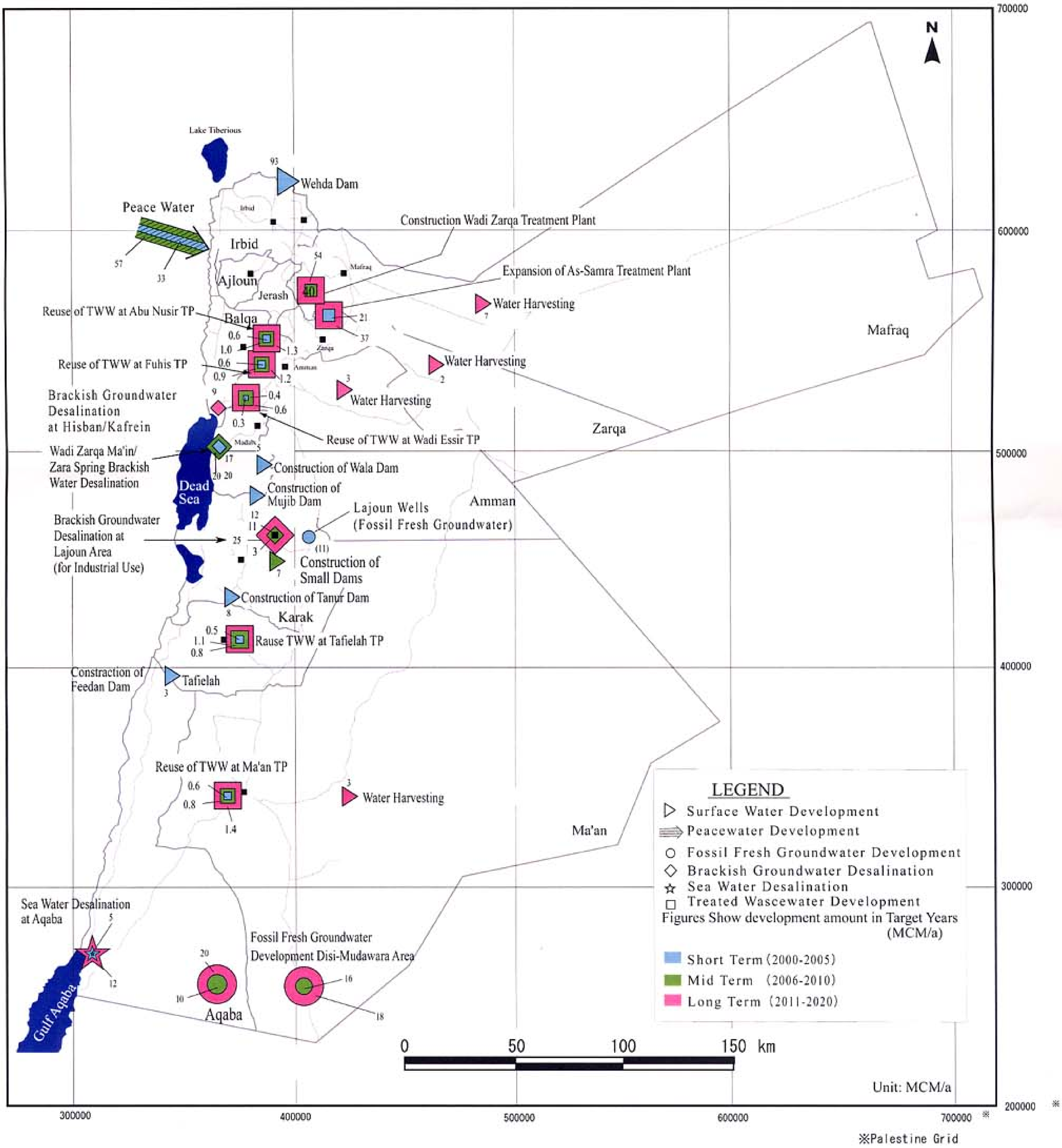


Fig. 7.2-3 Locations of the Main Projects for the Water Resources Development

Management Item	Exist. Develop (MCM/a)	Incremental Yield (MCM/a) Short 2000-2005	Mid 2006-2010	Long 2011-2020	Total	Project No.	Project Cost (Mill.JD/ Mill US$)	Finance	Implementation Schedule Short 2000 — 2005	Mid 2006 — 2010	Long 2011 — 2020
Qualitative Management											
①Rehabilitation of Existing Supply System	-	-	-	-	-	8	484/691	WB,,USAID,EIB, Kfw, HKJ、not secured			
②Construction of Main Transfer Line	-	-	-	-	-	2	26/37	not confirmed			
③Improvement of Institutional System (including education and Public Awareness)	-	-	-	-	-	3	36/51	USAID,EU,GTZ, Kfw			
④Reduction of Groundwater Abstraction	420	-52	-31	-62	275	4	120/171	not secured			
⑤Water Resources Development											
Conventional Surface Water	303	121	7	15	446	7	295/421	Arab F. HKJ			
Peace Water	33	27	30	0	90	2	170/243	not secured			
Fossil Fresh Groundwater	70	-5	27	38	130	2	75/107	HKJ、not secured			
Non-Conventional Desal. of Brackish Water	0	20	33	32	85	3	145/207	USAID, HKJ、Private、not secured			
Desal. of Sea Water	0	5	0	12	17	1	93/133	not confirmed			
Reuse of Treated astewater (incl. construction of TP)	64	48	65	69	246	62	933/1,334	Kfw,USAID,France, Italy,CIDA,Korea, EU,HKJ,Private,not secured			
Total Water Resources Amount at Target Year	890	1,054	1,185	1,289	1,289						
Quantitative Management											
①Surface Water Quality Conservation (Strengthening of Monitoring System)	-	-	-	-	-	1	-	not secured			
②Groundwater Quality Conservation (Monitoring System, Reduction of the GW. Abstraction)	-	-	-	-	-	5	-	not secured			
Allocation Management											
①Allocation and Transfer (incl. water supply)	-	-	-	-	-	10	741/1,058	JICA,GKW,Arab F., HKJ、Private、not secured			
Risk management											
①Measures for Extraordinary Drought Years	-	-	-	-	-	-	-	not secured			
Total	-	-	-	-	-	110	3,118/4,452	-	-	-	-

Source: Investment Program 2000－2010 and other information from MWI、Projects under the conceptual stage are excluded.

8. Evaluation of Water Resources Management Master Plan

8.1 Plan Evaluation

In the Water Resources Management Plan in this Study, the basic policies for demand control and water resources development were set up from the viewpoints of "water environment conservation" and "water recycle" and the demand balance among 12 Governorates was planned with the individual measures as described below. Therefore, the integrity of the entire project was realized.

8.1.1 Demand Control

(1) MIT water

The supply quantities of municipal water were planned as shown in Table 8.1-1 to ensure securing the required quantities which controlling the demands in the Governorates to the minimum levels.

Table 8.1-1 Projected MIT Water Supply per Governorate

(unit: MCM/a)

Govrenorate	2005			2010			2015			2020		
	Municipal	Industrial	Touristic	Municipal	Industrial	Touristic	Municipal	Industrial	Touristic	Municipal	Industrial	Touristic
Amman	99.94	1.14	1.02	136.69	1.33	1.23	167.98	1.48	1.39	191.80	1.56	1.57
Zarqa	38.50	22.42	0.01	53.19	23.64	0.02	65.95	24.59	0.02	76.02	25.13	0.02
Mafraq	18.74	0.30	0.00	21.88	0.35	0.00	22.49	0.38	0.00	20.77	0.40	0.00
Irbid	39.52	8.89	0.02	57.63	9.12	0.03	75.01	9.29	0.03	90.37	9.39	0.04
Ajloun	5.22	0.00	0.00	7.71	0.00	0.00	10.15	0.00	0.00	12.35	0.00	0.00
Jerash	6.14	0.00	0.00	9.16	0.00	0.00	12.17	0.00	0.00	14.90	0.00	0.00
Balqa	20.75	0.59	2.67	26.84	0.69	4.70	31.14	0.77	6.94	33.52	0.81	6.94
Madaba	11.29	0.23	2.35	13.11	0.26	4.41	13.34	0.29	6.55	12.16	0.31	6.56
Karak	10.87	18.39	0.01	14.77	30.64	0.01	18.02	45.57	0.02	20.45	59.67	0.02
Ma'an	7.08	9.32	0.13	8.76	10.86	0.16	9.65	12.05	0.18	9.82	12.72	0.20
Tafielah	3.24	6.75	0.00	4.89	7.86	0.00	6.55	8.73	0.00	8.08	9.22	0.00
Aqaba	11.37	8.05	0.69	12.90	9.38	0.83	12.67	10.41	0.94	11.01	10.99	1.06
Total	272.67	76.08	6.92	367.51	94.13	11.40	445.12	113.55	16.08	501.26	130.21	16.42
		MIT Tota	355.67		MIT Tota	473.04		MIT Tota	574.75		MIT Tota	647.89

(2) Irrigation water

For irrigation water, it was planned to positively reuse treated wastewater for achieving the environmental requirements for reduction of groundwater abstraction. It is, therefore, possible to keep to the policy of maintaining the present gross quantity of irrigation water through the target years. The general irrigation plan (in terms of farm products and cultivated area) based on the water allocation was formulated in 12 Governorates under this Water Resources Management Plan, and the irrigation area and net irrigation requirement by Governorate are as shown in Table 8.1-2.

Table 8.1-2 Agricultural Water Demand in the 12 Governorates

Governorate	2005		2010		2015		2020	
	Area	Demand	Area	Demand	Area	Demand	Area	Demand
	Ha	MCM/a	Ha	MCM/a	Ha	MCM/a	Ha	MCM/a
Amman	3,170	42.1	3,087	41.9	2,865	40.8	2,668	39.1
Zarqa	4,773	65.2	4,417	60.0	4,132	58.0	3,830	53.8
Mafraq	4,936	50.4	4,351	44.6	4,002	41.2	3,509	36.3
Irbid	13,315	146.7	14,464	155.3	14,959	162.1	15,987	163.2
Ajloun	611	6.8	690	7.7	763	8.3	819	8.6
Jerash	1,011	11.6	1,056	11.7	1,009	10.9	1,018	10.7
Balqa	13,381	213.1	15,093	230.9	13,977	210.5	12,730	188.4
Madaba	906	8.1	973	8.9	929	9.2	936	9.5
Karak	9,882	67.8	10,806	71.2	10,763	70.8	10,662	69.2
Ma'an	4,671	46.3	2,496	26.7	2,083	23.5	931	13.4
Tafielah	407	5.4	421	5.7	420	5.7	469	6.3
Aqaba	1,614	19.5	1,242	16.1	612	7.2	664	8.2
Total	58,677	682.8	59,095	680.8	56,513	648.4	54,222	606.7

Note: MWI computation was modified according to the water allocation by JICA.

8.1.2 Water Resources Development

On the water resources development side, each project is reevaluated to finalize the available water resources from both the conventional types, such as surface water, peace water, renewable groundwater, fossil fresh groundwater and from the non-conventional types such as desalinated brackish groundwater, reuse of treated wastewater and use of desalinated seawater as shown in Table 8.1-3. In particular, the existing treatment facilities development plan for treated wastewater was compiled on the national level to be worked out as the treated wastewater reuse plan. For irrigation, excessively exploited groundwater is used at present, and that is the reason why the reduction plan of groundwater abstraction to recover the renewable water quantity was drawn up. This plan is expected to ensure the sustainable development of groundwater.

In the UFW reduction measures, the physical loss rate due to water leakages was set to 15% in each target year in order to reduce the loss to approximately 10% below the present level. By this measure, water resources of about 60 MCM (included in the demand statistics) will be created in 2020.

Table 8.1-3 Water Resources by Sustainable Development (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 Groundwater	20	53	72	85
Desalinated Seawater	5	5	17	17
Treated wastewater	112	177	220	246
Total	1,054	1,185	1,256	1,289

Source: See Table 6.4-1, *: Development will be done for 50 years

8.2 Environmental Evaluation

In the formulated Water Resources Management Master Plan, some improvement to the natural environment on the one hand, and on the other hand some negative impacts on the agro-social environment are foreseen.

8.2.1 Natural Environment

One of the most important issues in the implementation of water resources management is the effect it will generate on the water resources environment. This environmental effect may be categorized as follows:

- Exhaustion of groundwater sources and water quality deterioration
- Surface water quality deterioration

(1) Groundwater

a. Water source exhaustion

In Jordan, excessive groundwater abstraction of renewable groundwater has continued to be practiced in recent years (National total in 1998: 420 MCM/year), resulting in substantial fall in water level. If the abstraction in the current level is continued, some wells dry up sooner rather than later. Thus, the reduction plan of groundwater abstraction is an indispensable project. In this Study, the water resource quantity under sustainable development (national total: 275.0 MCM/year) from the renewable recharge water was calculated to formulate the reduction plan to reduce the groundwater exploitation to the renewable water level in turn by 2020. Groundwater will be used as both irrigation and municipal water, and the reduction quantity should be shared by both uses. As a result, the available groundwater quantities and the groundwater for irrigation water allocations to 12 Governorates are shown in Table 8.2-1.

The reduction of the groundwater abstraction for municipal water to be made by MWI will be implemented under the new water source development plan, but the procedures for reduction of groundwater for irrigation water were formulated as below in reference to the USAID groundwater reduction plan in the Amman-Zarqa basin. These plans will ensure that the reduction is realistically made and may be applicable to other areas in Jordan.

Table 8.2-1 Available Groundwater and Allocation to Agriculture

(Unit: MCM/Year)

Governorate	Current	Reduction Plan of Groundwater Abastraction				Allocation to Irrigation			
	1998	2005	2010	2015	2020	2005	2010	2015	2020
Amman	62.5	53.4	47.0	40.5	34.0	30.4	26.5	19.8	16.6
Zarqa	89.1	75.7	66.1	56.6	47.0	40.4	35.2	26.3	22.0
Mafraq	89.9	85.8	82.9	79.9	77.0	47.9	41.8	31.2	26.1
Irbid	45.1	40.0	36.3	32.7	29.0	17.0	17.0	14.0	13.0
Ajloun	0.7	1.1	1.4	1.7	2.0	0.0	0.0	0.0	0.0
Jerash	3.5	4.9	6.0	7.0	8.0	1.8	1.6	1.2	1.0
Balqa	47.4	38.4	31.9	25.5	19.0	33.1	27.1	19.0	14.0
Madaba	12.9	11.7	10.8	9.9	9.0	1.8	1.6	1.2	1.0
Karak	28.3	22.3	20.4	18.3	16.0	3.1	2.7	2.0	1.7
Ma'an	22.6	19.9	17.9	16.0	14.0	7.6	6.7	5.0	4.2
Tafielah	8.0	9.3	10.2	11.1	12.0	0.8	0.7	0.5	0.4
Aqaba	5.7	6.4	7.0	7.5	8.0	5.1	4.5	3.3	2.8
Total	419.8	368.9	337.9	306.7	275.0	189.1	165.4	123.4	102.7

b. Water quality deterioration

This Study made clear that the groundwater quality deterioration was caused by insufficient wastewater treatment facilities in the city areas and accumulated salts due to irrigation agriculture in the uplands. To eliminate the former problem, the rehabilitation plans for existing wastewater treatment facilities were integrated as a project. The simulation of water quality deterioration due to irrigation was carried out in the Amman south area, and it showed that the water quality problem could be solved by implementation of the groundwater abstraction reduction plan as described in the preceding clause a. The nationwide application of this groundwater abstraction reduction plan will give the effect of keeping the same water quality throughout the country because the hydrogeological conditions are almost identical.

The USAID "WQICP" project has proposed a comprehensive water quality monitoring system for groundwater and surface water, so that this system will be able to offer the complete solution to this problem when it is implemented.

(2) Surface water

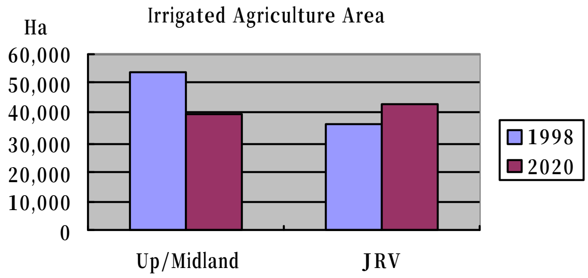
The causes of surface water deterioration can be focused on the insufficient wastewater treatment facilities in the city areas and the algae generated due to eutrophication in water areas. The former problem will be effectively improved because the rehabilitation of treatment plants, especially the projects of As Samra and Wadi Zarqa wastewater facilities have already entered the implementation stage. On the other hand, the eutrophication problem will be solved when the treatment plants are improved and when the nationwide water quality monitoring system as proposed is implemented.

8.2.2 Social Environment

The formulated Water Resources Management Plan generates the impacts on the social environment in the following two points regarding irrigation-based agriculture:

(1) Shift from upland agriculture

The water resources in Uplands/Midlands are limited, but the groundwater reduction to the safe yield quantity and the use of fossil groundwater exclusively for municipal water cannot be avoided in the Master Plan. On the other hand, under the policy of maintaining agriculture at the maximum level, the use of wastewater in the Jordan Valley was planned as an alternative plan, in which the farm products adaptable to the available water sources and water quality as well as some agricultural development projects were proposed. In accordance with this alternative, part of the upland agriculture has to be shifted to the Jordan Valley. This plan requires that about 1/3 of irrigation water and area for the upland agriculture be shifted gradually by 2020 as shown in Fig. 8.2-1. As described above, it was verified technically that the necessary water sources could be secured and that the agricultural land development plan is feasible, but the detailed agricultural shift plan has not been formulated yet. In particular, the shift will have large impacts on the agricultural society, so that full care should be taken on this point.



Source: Plan of JICA Study

Fig. 8.2-1 Changes in the Irrigated Agriculture Areas by Shifting of Agriculture Activities from the Upland to the Jordan Valley

(2) Reuse of treated wastewater

In Jordan, the treated wastewater that flows from the As Samra treatment plant down to the Jordan Valley has been used for irrigation-based agriculture. In this case, no serious problem has been caused because the wastewater flow is diluted with the surface water on its flow downstream and the freshwater from the King Abdullah Canal. However, the proposal in this Study is to directly use the wastewater from the secondary treatment. The environmental assessment including questionnaire survey was implemented in the Pre-FS wastewater reuse project as described in Part B, verifying that 90% of the farmers in the vicinity of Abu Nusir, Fuhis, Wadi Esir, Tafielah and Ma'an treatment plants had willingness to reuse the treated wastewater according to the questionnaire survey of about 100 families. However, it is necessary to take effective social measures deliberate care for through education of residents and implementation of reuse campaigns.

8.3 Economic and Financial Evaluation

Overall financial/economic evaluation for the three groups of proposed projects, namely water development, wastewater treatment and treated wastewater reuse projects was conducted in the master plan study.

The water development projects consists of 16 projects (e.g. Wehda Dam Construction Project) whose objectives are to newly develop or convey surface water/groundwater, out of 24 related projects. The balance are those projects which aim for water saving or keeping the current level of water production through rehabilitation or transference.

The wastewater treatment projects are comprised of 25 projects (e.g. As Samra Wastewater Treatment Plant Expansion), and the treated wastewater reuse projects are made up of 29 projects (e.g. Aqaba Wastewater Reuse Project). The total amount of investment for these projects will reach 1,938 MJD (million JD) by the final target year. It corresponds to about 20% of Jordan's GDP. The breakdown of the amount is shown in Table 8.3-1. The figures in the table are not the same with those in Chapter 7 "Projects in the Water Resources Management" because the projects are different in the scope and definition.

Table 8.3-1 Cumulative Investment Amounts by Sector and Target Year (MJD)

Investment Sector	2005	2010	2015	2020
Water source development and supply	932.1	1,168.3	1,302.2	1,302.2
Wastewater treatment	449.6	600.2	600.2	600.2
Treated wastewater reuse	10.9	21.4	26.2	35.6
Total	1,392.6	1,789.9	1,928.6	1,938.0

It was found that these projects would be financially feasible if the water tariff would be increased in future within the affordable cost of the users according to the financial analysis in case of 6.5% of discount rate.

The water tariff was set aiming the full recovery to the cost based on the concept of Long-Run Marginal Cost (LRMC).
The wastewater project can be divided into wastewater treatment project and treated wastewater reuse project. The former does not have any problems on its financial feasibility. For the latter, the financial feasibility can be obtained if the financial evaluation will be done together with the water resources development project.

(1) Water resources development projects

The overall evaluation of water development projects as a group is that they are in financial terms not feasible with the FIRR of 4%, which is below the assumed discount rate of 6.5% on one hand, and that they are in economical terms highly feasible with the EIRR of 18% (OCC is assumed as 10%) on the other.

Thus, it is necessary to raise the average water prices in future to make this project group financially feasible.

At present the unit prices of municipal, industrial and irrigation water are 341 fils, 1,000 fils and 10 fils per m^3 respectively. According to the analysis, the affordable limits of such prices are 735 fils, 2,740 fils and 283 fils.

Supposing the unit prices of the three types of water are raised by 12%, 12% and 1,680% to 382 fils, 1,120 fils and 178 fils respectively, which are all within their respective upper limits, then, the water development projects will be financially feasible (See Table 8.3-2).

Table 8.3-2 Unit Prices of Water for Sectors

Item	Unit Water Prices (Fils/m^3)			
	Present	Increase Rate	Future	Upper Limit
Municipal Water	341	12%	382	735
Industrial Water	1,000	12%	1,120	2,740
Irrigation Water	10	1680%	178	283

When the unit price of municipal water is raised to 382 fils, the payment for municipal water as the percentage of household income, which is now 1.86%, will go up to 2.08%, while it is generally recognized that the households can afford to pay for municipal water of up to 4% of their income.

Table 8.3-3 Payment for Municipal Water as Percentage of Household Income

Item	Present	Future	Upper Limit
Payment for municipal water as percentage of household income	1.86%	2.08%	4.00%

In short, the project group has a high economic feasibility, and by raising water prices to proper levels in future, it will also be financially feasible.

(2) Wastewater treatment projects

The overall evaluation of wastewater treatment projects as a group is that they are both in financial and economic terms not feasible with an incalculable FIRR and the EIRR of 4%.

It is necessary to raise the average sewerage charges in future to make these projects financially feasible.

At present the unit price of sewerage services can be said to be still considerably low with 147 fils per m^3. According to the analysis, the affordable limit of such price is 368 fils.

Supposing the unit price of sewerage services is raised by 263% to 534 fils, which exceeds its upper limit, then, the wastewater treatment project group will be financially feasible.

Table 8.3-4 Tariff for Wastewater (Municipal Water)

Item	Sewage Unit Price (Fils/m^3)			
	Present	Increase Rate	Future	Upper Limit
Wastewater	147	263%	534	368

If the unit price of sewerage services is raised to 534 fils, the payment for sewerage services as the percentage of household income, which is now 0.80%, will go up to 2.91%, while it is generally recognized that the households can afford to pay for sewerage services of up to 2% of their income.

Table 8.3-5 Payment for Sewage Services as Percentage of Household Income

Item	Present	Future	Upper Limit
Payment for sewage services as percentage of household income	0.80%	2.91%	2.00%

Therefore, it is concluded that these projects will independently be unfeasible in both economic and financial terms.

However, when the financially feasible unit prices of municipal water and sewerage are combined together, they come to 916 fils per m^3, while the combined upper limit is 1,103 fils per m^3. That is to say, the former is less than the latter. It means that the households can afford to pay combined water and sewerage charges in the future.

(3) Treated wastewater reuse projects

The overall evaluation of wastewater reuse projects as a group is that they are in financial terms not feasible under the current treated wastewater unit price on one hand,

and that they are in economic terms remarkably feasible with the EIRR of 37%, which is 3.7 times the assumed OCC of 10%.

It is necessary to raise the unit price of treated wastewater in future to make these projects financially feasible.

At present, the unit price of treated wastewater is as low as 10 fils per m^3. According to the analysis, the affordable limit of such price is 142 fils.

Supposing the unit price of the treated wastewater for reuse in irrigation is raised to 38 fils, which is a fraction compared with its upper limit, then, the treated wastewater reuse projects will be financially feasible (See Table 8.3-6).

Table 8.3-6 Treated Wastewater for Irrigation

Item	Wastewater Unit Price (Fils/m^3)			
	Present	Increase Rate	Future	Upper Limit
Treated Wastewater for Irrigation	10	280%	38	142

In short, the project group has a remarkably high economic feasibility, and by raising the unit price of treated wastewater to proper levels in future, it will also be financially feasible.

(4) Entire project

The overall evaluation of all the projects is that they are in financial terms not feasible with the FIRR of 2%, which is below the assumed discount rate of 6.5% on one hand, and that they are in economical terms feasible with the EIRR of 14% (OCC is assumed as 10%) on the other.

The value of EIRR shows that there are still enough room and potential for raising water/wastewater prices so that all the projects may also be made properly feasible in financial terms.

Fig. 8.3-1 shows the present cost and financially feasible cost of water by water project.

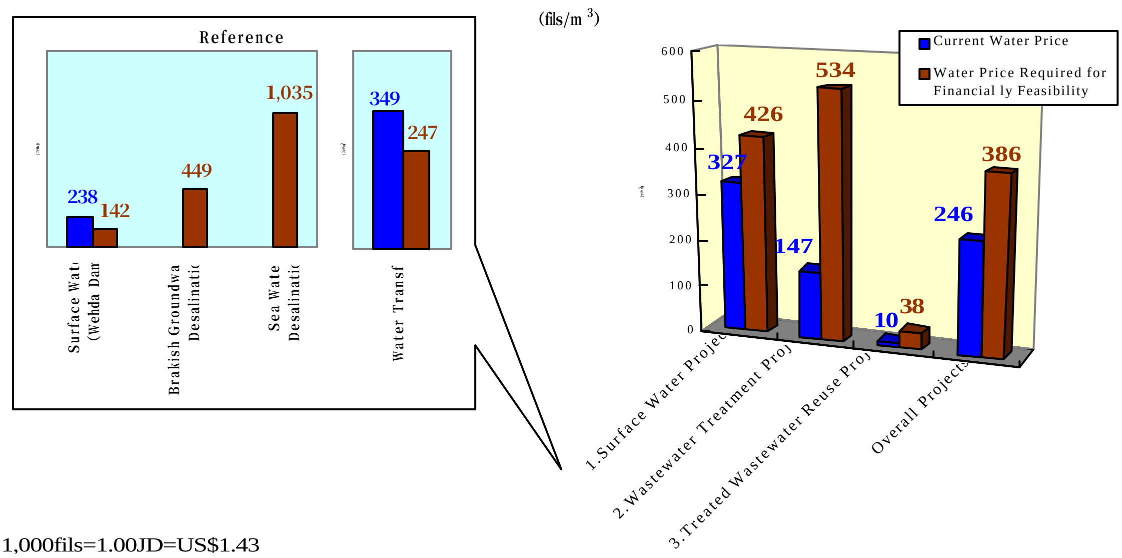


Fig. 8.3-1 Cost by Water Project

8.4 Overall Evaluation

In the overall evaluation of all the projects, the Water Resources Management Master Plan is deemed to be feasible through the demand management and the development of the conventional and non-conventional types of water source.

On the other hand, the M/P involves the future problems such as positive use of treated wastewater, partial shift of the agriculture in uplands to the Jordan Valley and revision of water and sewage service charges. These problems may be solved if there is cooperation between the Government and people of Jordan with each other. Thus, it is desired that the Project be prepared for implementation.

9. Recommendations

Jordan's total rainfall is absolutely little (more than 70 percent of national land has annual rainfall of less than 100 millimeters,) and thus developable water resources are extremely limited. In particular, renewable groundwater faces the danger of drying out and deterioration of water quality due to excessive abstraction.

On the other hand, the population of the country has been increasing in recent years (average yearly increase rate of 3.9 percent in the 1990s,) and, according to the 2000 report compiled by the Higher Council for Science and Technology, water resources per capita, which stood at 327 m^3 a year in 1990 dropped to 170 m^3 in 1999 (when the figure is less than 1000 m^3 a year per capita, it is categorized as absolute shortage in the water resources stress index.) If the population increases at the same level as in the 1990s, the water per capita is projected to drop to 121 m^3 by 2025. Without proper water resources management, the nation will fall into a critical condition.

In order to conduct sustainable water resources management, it will become necessary to curve the water supply and demand by promoting effective use of water resources, water-saving and use of renewable water, and create a society where renewable water is used at a significant level.

In this Study, we formulated a water resources management master plan, aiming to work, by 2020, on "unified and comprehensive and sustainable management of water resources" and "strategic development of remaining scarce water resources," while having in mind the future goal of "Shift to water re-cycling society".

In making the Master Plan, we also gave consideration to "management and development of sustainable water resources," which is unique to Jordan, "regional peace water development" and "global climate change."

The Master Plan includes plans to reduce the total water demand, review water distribution by use and reduce the volume of groundwater abstraction to a proper level as major policies for effective use of water resources and conservation of water quality. It also proposes the promotion of reuse of treated wastewater that is non-conventional water resources as complimentary water source of water for agricultural irrigation.

The following is what the Government of Jordan should urgently work on as an action plan based on the policies mentioned above in order to realize the Master Plan.

9.1 Unified and Comprehensive and Sustainable Management of Water Resources

(1) Management for sustainable water use

1) Reduction of the abstraction of renewable fresh groundwater

The volume of abstracted renewable groundwater in Jordan (420 MCM in 1998) largely exceeds the volume that allows sustainable development (275 MCM/a.) Because prevention of drying out of precious water resources of renewable groundwater is an issue of primal importance to be worked on in water resources management, the government should carry out 35-percent reduction in the abstraction of groundwater for both municipal and agricultural use based on the plan to reduce the abstraction of groundwater toward 2020 proposed in this study.

Although reduction in groundwater abstraction for municipal use is believed to be possible, including the preparation of alternative water sources, not only ministries and agencies that supervise the use of water for agriculture but farmers need to be involved to realize the reduction of abstraction of groundwater for agriculture. Purchase of irrigation wells is believed to a means most likely to be accepted for the reduction.

The government should soon make a concrete plan for allocating budgets and plan and establish organizations and institutions for realizing the reduction, including the means of well buy-out.

Meanwhile, development of renewable groundwater is on progress in the Upland area. The development of renewable groundwater should be regarded as an emergency means to offset the water shortage in extraordinary dry years, and it is necessary to make a comprehensive abstraction plan based on the reduction plan in the study.

2) Change of use of Disi fossil groundwater from agricultural use to municipal use

The national water distribution policy of Jordan has a basic policy to prioritize water for municipal use (people's daily life, industry and tourism), and maintain the current level of water distribution for agricultural use (about 620 MCM/a). In accordance with the policy, the government should convert Disi fossil groundwater most of which is used for agriculture in the southern Upland area to water for municipal use in an attempt to meet the demand of water for municipal use in the metropolitan area. It also should carry out a project to transport water to the metropolitan district.

However, careful observation of changes in groundwater is essential because development of fossil ground water is that of non-renewable water resources, and the government should consider that resources are to be shared by both the current and next generations.

Use of Disi fossil groundwater for agriculture reached 51 MCM in 1998. Thus the conversion should be carried out gradually and social influence from the conversion should be minimum.

3) Use of treated wastewater for agriculture and industry

Treated wastewater generated in the metropolitan area increases in accordance with an increase in population (about 100 MCM/a). It is easy, both financially and technically, to execute a reuse plan at existing five wastewater treatment plants that carried out pre-F/S in the Study, while working for the realization of extensive use of treated wastewater. The government should urgently begin preparation for carrying out the treated wastewater use project, including the plan mentioned above.

Use of properly treated harmless wastewater was considered to cause no problem at a conference of the Council of Leading Islamic Scholars held in Saudi Arabia in 1978, and thus there is no religious restriction on its reuse any longer.

However, there is a possibility that the use of treated wastewater for agriculture may cause health problems to humans due to bio-hazard caused by colon bacilli in excrement in the treated water and that it may include a trace element that affects the growth of farm products. Therefore, it is necessary to have more than one organizations manage and monitor the quality of treated wastewater, appropriately apply legal regulations related to the use of treated wastewater and disclose information and raise public awareness of the promotion of its use.

4) Downsizing of the agricultural development plan accompanying the water resources management plan

a. Review of the agricultural development plan

The agricultural sector (Ministry of Agriculture (MOA) and Jordan Valley Authority (JVA)) has the agricultural development plan outside the framework of water demand adjustment among sectors. Under the plan, the target demand of water for agriculture exceeds 900 MCM/a in comparison to the current 600 MCM/a. As there is structural water shortage, it is impossible to satisfy the demand. Therefore, it is necessary to adjust demand related to the agricultural development plan together with MOA/JVA based on the water distribution plan of the Master Plan in this Study. At the same time, the government needs to explain to farmers who will be directly affected by the demand adjustment.

b. Relocation of farm land

In the Study, we suggested a plan to reduce abstraction of renewable groundwater in the Upland area for the conservation of water sources and conversion of Disi fossil ground water into waster for municipal use. <u>The plans force the downsizing of irrigation agriculture in the Upland area.</u>

On the other hand, it is possible in the Jordan Valley to use treated wastewater generated in the metropolitan area by releasing it down to the valley. By using the treated wastewater as non-conventional water resources, agriculture can be expanded there. Use of alternative water sources is necessary to maintain the current demand for agricultural water while reducing the abstraction of renewable groundwater and changing Disi fossil ground water into one for municipal use. Thus, <u>agricultural land should be relocated from the Upland area to the Jordan Valley.</u> The Ministry of Water and Irrigation has made a plan of agricultural water use by Governorate by using the "Digital Master Plan" tool in accordance with the water distribution plan in the Study.

This shows that appropriate selection of agricultural districts, water sources and farm products enables the relocation of agricultural land. However, because relocation of agricultural land includes serious social issues such as security of farmers' life in the Upland area and approval of the relocation by farmers in the Jordan Valley, <u>measures to reduce influence on social environment should be considered</u> in reviewing the agricultural development plan.

5) Monitoring of water quality for the conservation of surface water quality

In 1998, there occurred contamination of tap water (strange smell) in the Amman metropolitan area. In an attempt to find out possible deterioration of surface water quality to take proper preventive measures, as exemplified in the 1998 case, <u>the government should establish a regular and continuous monitoring system of quality of water in the Yarmouk River and KAC as soon as possible.</u>

However, for effective operation of the system, it is necessary to add items to be monitored, including water ecology (including plankton) in addition to the chemistry of water quality and construct a comprehensive system to manage the environment of water quality under the Ministry of Water and Irrigation, which includes the unification of database.

(2) Formation of a society in which water-saving is promoted

1) Improving efficiency of water supply and distribution projects

a. Improvement of unaccounted for water

Effective use of water resources is a basic policy of water resources management, and it is critical to improve the unaccounted for water (UFW) that accounted for more than50 percent of water supply in 1998. The unaccounted for water is divided into two categories-leakage due to physical causes (physical loss) and water for which tariff is not paid (administrative loss.) Although each type of the loss is believed to account for 25 percent of supplied water, the actual figures are not known. Rehabilitation and improvement projects of the water supply system have been promoted quite substantially with the final goal of 23 percent, mainly in the metropolitan district. However, UFW and PMU sections were just recently established within the Ministry of Water and Irrigation as entities in charge of understanding the actual situations of basic development, supply and the volume of supplied water, and thus the efforts for the improvement of unaccounted for water just began to be made. <u>The government should use the organizations to conduct a study to find out how unaccounted for water is generated (for example, stolen water and illegal use of water for the municipal purpose for agricultural water) in addition to detection of water leakage to establish comprehensive measures against illegal water use, which includes the establishment of a basic legal system.</u>

The government also needs to set up a national water control center for unified and comprehensive control of water transport, which we proposed in this study.

b. Improvement of management of the supply project of municipal water

Because tariff for agricultural water and sewage, including that for water for municipal purpose, remains to be very low, it does not pay for all the maintenance and management costs. Because the budget for the maintenance and management is limited, water supply and distribution services have deteriorated. An increase in the maintenance and management costs per unit of water volume is unavoidable in the development and expansion of new water resources. Against the backdrop, each types of water tariff should be raised drastically. According to the result of the Study, citizens are believed to be able to afford to pay more tariff in comparison with the upper limit of such tariff they can pay from their household income.

The water supply project in Amman is entrusted with the private sector and the efficiency of improving water for unaccounted has increased. Income from water tariff increased from 1,920 million JD (27.4 million dollars) to 2,230 million JD (31.9 million dollars) in two-year period. Learning from this successful example, <u>the government should transfer the maintenance and management of water and sewage facilities that are under the jurisdiction of WAJ to the private sector.</u> In doing so, it is important to privatize local organizations of WAJ currently located in each administrative district without changing the system by changing the system in order to facilitate the transfer. It is necessary for the government <u>to structurally end the deterioration of financial conditions WAJ is experiencing and its inefficient work by introducing the vitality of the private sector.</u>

2) Increase in efficiency of the use of agricultural water

The government also needs to introduce techniques to promote better efficiency of the use of agricultural water, just like municipal water, for the effective use of water resources. For example, the government can introduce irrigation facilities with high efficiency of water use and promote farmers to change farm products they grow to ones that require little water. The agricultural development plan of the Ministry of Water and Irrigation shows that the change of farm products and improvement of irrigation lead to better efficiency of water use.

3) Raising public awareness of water-saving

a. MIT water

According to Jordan's national water strategy, water resources are distributed first for MIT use (municipal, industry and tourism use). Following the strategy, the water for MIT use is increased from 34 percent of the total volume of water to be used in 1998 to 51 percent of the total in 2020 in this study. To restrict the planned volume of supply for MIT use, planned water supply will be restricted. Although MIT use is given priority of water distribution, because the available water resources are limited, the government should continuously carry out campaigns to raise people's and companies' awareness of scarcity and importance of water resources, significance of treated wastewater as water resources and the necessity of water-saving and reuse of water.

b. Agricultural water

Technical training for the introduction of irrigation facilities is extensively provided in order to promote farmers to change farm products they grow to other types of farm products that require little water and improve efficiency of water use for agriculture mainly in the Jordan Valley area. These efforts have yielded some success. The government should provide the same kind of technical training and raise public awareness, including the promotion of the use of treated wastewater, not only in the Jordan Valley but also in the Upland area.

9.2. Strategic Development of Remaining Water Resources

(1) New water resources development

Water resources development plans that are highly reasonable technically and financially are to be carried out toward 2020 under the water resources management master plan. However, because it is also essential to give consideration to water resources for the next generation, detailed study is needed in relation to the following two plans as development from mid-to long-term perspectives.

1) Promotion of development of surface water in the desert area (Water Harvesting Plan)

Although it is rare, the desert area (Badia Region) has torrential rain that results in flood. There is a plan to store the flooded water at a dam to use it for local residents, which is named the Water Harvesting Plan. Developable water volume is estimated to be about 15 MCM/a. The Water Harvesting Plan should be promoted in an attempt to use remaining scarce water resources effectively.

2) Survey and development of brackish groundwater

One type of water resources yet to be developed in Jordan is brackish groundwater and it is believed to have great potential. The Water Resources Management Master Plan formulated in the Study considers the brackish groundwater as important water resources to partially satisfy future water demand. In the Master Plan, desalinated brackish groundwater is regarded as a water source for water demand especially for highly economical industrial development (e.g. Lajoun Oil Shale Project.)

However, use of desalinated brackish water has a problem in terms of its sustainability and economy. It is necessary to carefully watch the future advancement of cost cut and reverse osmosis technology which is the applied technology for the development, from the view point of long-term development. There is a limited number of detailed studies on brackish groundwater in Jordan and thus there is not enough data to properly evaluate its potential, water quality and sustainability. Substantial study on brackish groundwater should be conducted in the east coast of the Dead Sea, where the water is believed to have great potential as major water resources for the next generation.

9.3. Risk Management Involved in Water Resources Management

(1) Climate change

Annual rainfalls in Jordan have far below a long-term average in recent years (since 1998.) Long-term water shortage that has occasionally happened and global climate change that has been pointed out recently are believed to be the main possible causes of the small rainfalls. Although it is impossible to decide which is the real cause in this study, risk management against the change in the usable volume of water resources in water resources management is especially important in Jordan. We refer to the two issues.

1) Measures against extraordinary water shortage

The Master Plan has formulated based on the volume of water resources of years with ordinary amount of rainfalls. However, as seen in the dry weather in recent years, the usable volume of water resources can decrease. In addition to the dry weather, there are some other factors that can have short-term effect on the volume of water resources. It is necessary to establish measures against possible risks such as the delay of carrying out the water resources development plan and the change in water provided under the peace treaty.

The Master Plan assumed a case of serious water shortage due to dry weather in 2005 and studied possible measures to restrict demand and demand management that can be taken under a water distribution plan. Because there are many uncertain factors of water shortage, including the time, place and the volume of shortage, the WAJ needs to prepare for measures against as many assumed patterns of water shortage as possible in advance.

2) Measures to tackle global climate change

A British research institute predicts that rainfalls will decrease by 10 to 15 percent and average temperature will rise by 1.5 °C to 2.5 °C by 2050 in Middle East due to global climate change. Although it is not possible to decide whether the recent decline in rainfalls in Jordan is due to the climate change or not in this study, decline in rainfalls is a serious issue and measures are necessary from the viewpoint of national risk management in relation to water resources management.

a. Monitoring of climate change of wide areas

Global climate change involves a rise in temperature and a wider regional gap of rainfalls. In particular, in order to understand the trend of decrease in rainfalls due to climate change, it is necessary to establish a system to exchange data of meteorological observation and conduct joint study and research with other countries including its neighboring nations, in addition to the continuation and analysis of regular meteorological and hydrological observation to understand extensive climate change at home.

b. Revision of management plan and water distribution plan

It is necessary to review the volume of long-term average water resources in the Study and revise the Master Plan in accordance with the amount of decrease in rainfalls from the viewpoint of demand restriction and proper water distribution, if it is most likely that rainfalls are apparently on a decline trend based on the monitoring result.

(2) Response to changes in the international situation surrounding Jordan

Jordan is currently carrying out two development plans in the Yarmouk River and Side Wadi as part of peaceful use of water resources. The attentions as described below should be paid for the implementation of these projects. The plans require coordination with neighboring nations and thus there is a need for risk management to respond to unpredictable changes during the negotiation process. In case that these projects will not be implemented, the Water Resources Management Master Plan including water allocation plan and etc. should be examined and modified using the tool of GTZ's "National Water Master Plan".

1) Development of surface water in the Yarmouk River

The biggest development project of surface water in the future is the Wehda dam to be built in the Yarmouk River. However, because water resources development is on progress in Syria, where upper stream of the river runs, the basic water flow of the river is decreasing and there are some media reports are concerned about the development of scheduled volume of water. Surface water to be developed as a result of the construction of Wehda dam will be very important water source for Jordan, and thus its government needs to establish a cooperative system with Syria in relation to water use of the Yarmouk River.

2) Peace water from Israel

To-be-developed water volume in the "Storage Plan in the Jordan River and Side Wadi," which is one of peace treaty water projects, is large at 30 MCM a year. It is one of important projects in the Master Plan. However, almost no study on the plan is conducted. There is an urgent need to study the plan substantially and assure the water volume and feasibility of the development.

10. Selection of Priority Projects for pre-Feasibility Study

The selection of the priority projects for pre-Feasibility Study has been done in the following manner:

1. Nomination of Candidate Projects among the Master Plan

2. Setting of Criteria for Selection

↓

3. Establishment of Rankings

↓

4. Selection of Priority Projects for pre-Feasibility Study

(1) Nomination of Candidate Projects

Candidate projects for the pre-Feasibility Study are selected from among the presently planned project which amounts to 135 projects. Nomination of the candidate projects is done based on the following conditions:

-Exclusion of Projects for which Feasibility Study or Detailed Design has been done

-Exclusion of Projects still in the conceptual stage

Twenty (20) projects are nominated from among the Master Plan projects based on the above conditions.

(2) Setting of Criteria for the Selection

Scores are given to the twenty nominated candidate projects from the view-points of :

- -Technical viability
- -Economical viability
- -Environmental viability
- -Political viability

Each criterion has 5 ranks by the point system.

(3) Final Selection of the Priority Projects

Ten (10) projects belonging to the high score group are selected as priority projects for pre-feasibility study.
The general explanation of the ranking given to the selected ten projects are shown in Table 10.1-1.

Table 10.1-1 Ranking of Selected Projects

Project No.	Project Name	Implementation	Technical Viability	Economic Viability	Environmental Viability	Political Viability	Total Score
	Projects for Reuse of Treated Wastewater						
58	Upgrading Ma'an Treatment Plant	Short, Mid and Long Term	**5** Conventional technology can be applied	**4** Investment cost is very low compared with other TP projects (4JD/m^3)	**5** It contributes to improvement of environment	**5** Proper treatment of wastewater is clearly stated in Strategy and Policy, urgent	**19**
58'	Treated Wastewater Reuse Scheme of Ma'an Treatment Plant	Short, Mid and Long Term	**5** Conventional technology can be applied	**4** Investment cost is low (0.1JD/m^3)	**4** No negative impacts, but should be done carefully	**5** Reuse of waste water is clearly recommended in Strategy and Policies, urgent	**18**
W4	Treated Wastewater Reuse Scheme of Abu-Nuseir Treatment Plant	Short, Mid and Long Term	**5** Conventional technology can be applied	**4** Investment cost is low compared with irrigation water (0.1JD/m^3)	**4** No serious negative impacts, but the irrigation in Upland should be done carefully	**5** Reuse of waste water is clearly recommended in Strategy and Policies, urgent	**18**
W5	Treated Wastewater Reuse Scheme of Fuhis Treatment Plant	Short, Mid and Long Term	**5** Conventional technology can be applied	**5** Investment cost is very low compared with irrigation water (0.02JD/m^3)	**4** No serious negative impacts, but the irrigation in Upland should be done carefully	**5** Reuse of waste water is clearly recommended in Strategy and Policies, urgent	**19**
W6	Treated Wastewater Reuse Scheme of Tafielah Treatment Plant	Short, Mid and Long Term	**5** Conventional technology can be applied	**3** Investment cost is not low compared with irrigation water (0.2JD/m^3)	**4** No serious negative impacts, but the irrigation in Upland should be done carefully	**5** Reuse of waste water is clearly recommended in Strategy and Policies, urgent	**17**
W7	Treated Wastewater Reuse Scheme of Wadi Essir Treatment Plant	Short, Mid and Long Term	**5** Conventional technology can be applied	**5** Investment cost is very low compared with irrigation water (0.02JD/m^3)	**4** No serious negative impacts, but the irrigation in Upland should be done carefully	**5** Reuse of waste water is clearly recommended in Strategy and Policies, urgent	**19**
	Construction of Treatment Plant						
W13	Construction of Wadi Zarqa Treatment Plant	Mid Term	**4** Conventional technology can be applied, but it is large scale construction	**5** Investment cost is very low compared with other projects (1.1JD/m^3)	**5** No negative impacts, and contributing to improvement of environment	**4** Proper treatment of wastewater is clearly stated in Strategy and Policy, but initial cost is very high (about 60mil JD)	**18**
	Projects for Reduction of UFW						
M1	National Control System Integrating Surface and Groundwater	Short and Mid Term	**4** Advanced technology should be applied, but it is not difficult	**3** It does not generate direct benefit but it will produce indirect benefit for UFW	**5** No negative impacts, and contributing to reduction of UFW and GW abstraction	**5** Monitoring is emphasized in Strategy and reduction of UFW is emphasized in Utility Policy, urgent	**17**
8	Municipal Water Networks Rehabilitation (Several Cities)	Mid Term	**5** Conventional technology can be applied	**3** Investment cost is no so low compared with other SW. projects	**4** No negative impacts	**5** Reduction of UFW is emphasized in Water Utility Policy, urgent	**17**
	Projects For Water Allocation (Conveyance)						
69	Al Wehda Dam Water Supply Project/Irbid	Mid Term	**5** Conventional technology can be applied	**4** Invest. cost is relatively lower than other supply projects (1.4JD/m^3)	**4** No negative impacts, but not contributing to improvement of environment	**5** Greater Irbid area will seriously suffer water shortage in near future, many people will be impacted	**18**

The ten selected projects can be arranged into five groups of projects by putting together the same kind of projects. The five groups of projects are listed as follows:

I. Projects for Water Resources Development

1) Projects for Reuse of Treated Wastewater from Five Existing Plants

① Treated Wastewater Reuse Scheme of Five Existing Treatment Plants

- Ma'an (including expansion of the treatment plant)
- Abu-Nuseir
- Fuhis
- Tafiela
- Wadi Essir

2) Construction of Wastewater Treatment Plant (Environmental Protection)

② Construction of Wadi Zarqa Treatment Plant

II. Projects for Water Resources Management

3) Projects for Reduction of UFW (Unaccounted for Water)

③ National Control System Integrating Surface and Groundwater

④ Municipal Water Networks Rehabilitation (Karak, Tafielah Ma'an, Madaba and South Amman)

4) Project for Water Allocation (Water Conveyance)

⑤ Al Wehda Dam Water Supply Project/Irbid