JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF ENERGY
TEHRAN REGIONAL WATER BOARD
THE ISLAMIC REPUBLIC OF IRAN

THE STUDY ON WATER MANAGEMENT IN THE WESTERN AREA OF THE CAPITAL TEHRAN IN THE ISLAMIC REPUBLIC OF IRAN

FINAL REPORT

MAIN REPORT

NOVEMBER 2001

SANYU CONSULTANTS INC.

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PREFACE

In response to a request from the Government of the Islamic Republic of Iran, the Government of Japan decided to conduct a study on Water Management in the Western Area of the Capital Tehran and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Shoichiro Higuchi of SANYU CONSULTANTS INC. to Islamic Republic of Iran, two times between May, 2000 and August, 2001. In addition, JICA set up an advisory committee headed by Mr. Hidetomi Oi, Development Specialist between April, 2000 and September, 2001, which examined the Study from Specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Islamic Republic of Iran and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Islamic Republic of Iran for their close cooperation extended to the Team

November 2001

Takao Kawakami
President
Japan International Cooperation Agency

October 15, 2001

Mr. Takao Kawakami
President,
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Mr. Kawakami,

We are pleased to submit hereby the Final Report of the Study on Water Management in the Western Area of the Capital Tehran in the Islamic Republic of Iran. This report incorporates advises and suggestions of authorities concerned of the Government of Japan and your good agency as well as the comments made by the Tehran Regional Water Board (TRWB) of the Ministry of Energy and other responsible agencies of the Government of Iran on the formulation of the project during technical discussions on the draft final report, which were held in Tehran.

In the light of urgent importance of solving water shortage problems prevailing over the western area of the capital Tehran, the Study is to supplement and strengthen the Master Plan Study on the National and Regional Water Resources initiated already by the Government of Iran.

Potential resources of both surface water and groundwater are limited in the Tehran capital area and the use of available water resources has been stretched to the limits. Almost river may be the last source of surface water remained unused within the territory of water allocation of the area. Groundwater has tended to decrease showing annual imbalance of more than 700 MCM toward the final drying up unless proper measures are taken immediately. In order to expect the sustainable development of the area within the available resources, such resources are to be managed and operated properly and effectively. Important issues of management and operation includes 1) establishment of operation rule of water source facilities to allocate necessary volume of water among water users within the minimum risk of water deficit, 2) combination use of surface water and groundwater to allocate water effectively and rationally, 3) establishment of water allocation rule for reasonable and equitable water use among users and 4) improvement and maintenance of water use manners and facilities to minimize losses of water.

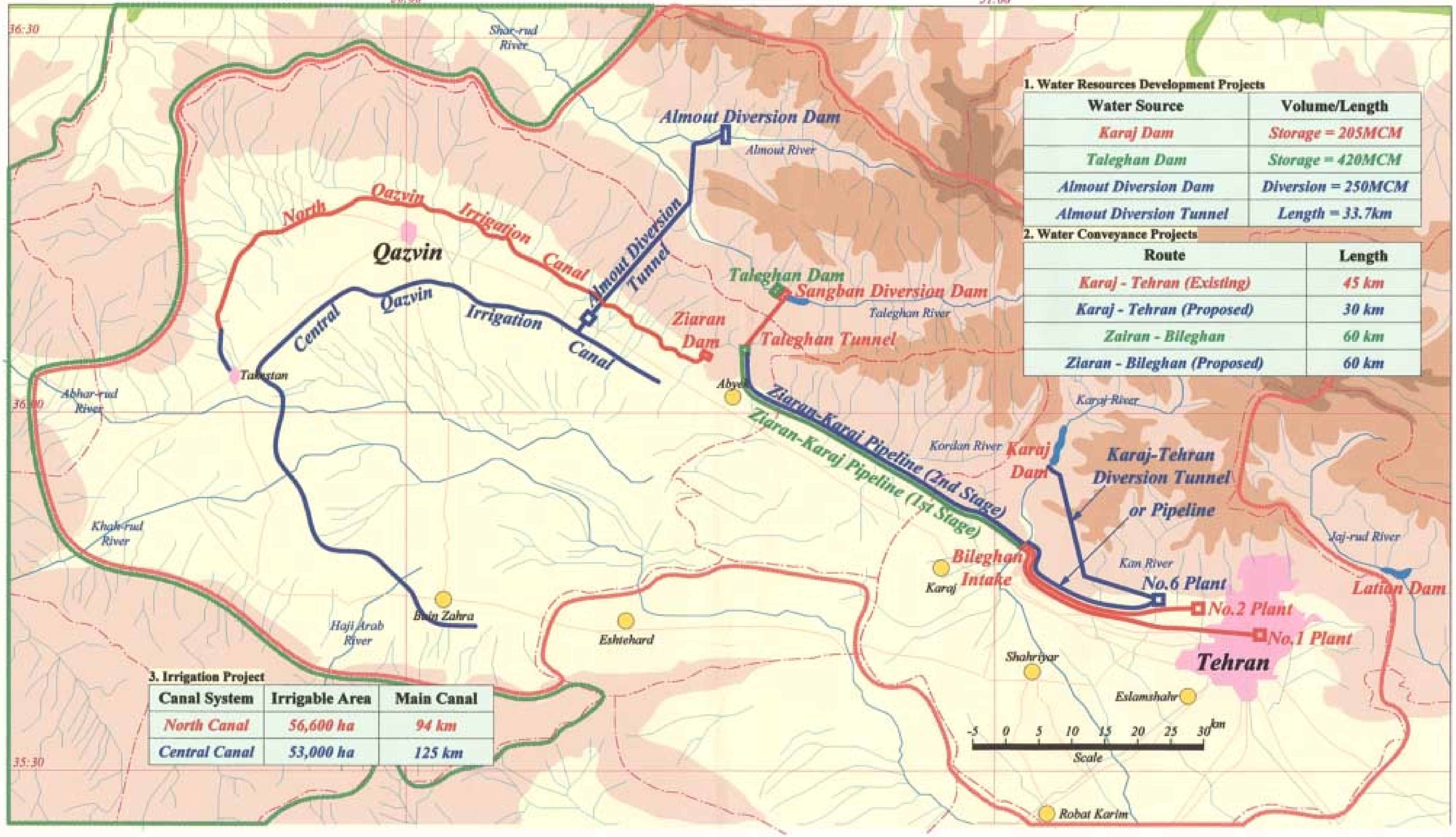
In view of critical condition of balance between demand and supply of water and of need for sustainable development of the capital area as a whole, the Study aims to furnish full information regarding the demand and supply of water so that the Government of Iran can make decision for further implementation of the Project under due consideration of not only technical aspects but also economic and other situation of the country. The magnitude of environmental influence that might be caused by Project would not be considerable.

We wish to take this opportunity to express our heartfelt gratitude to your Agency and other authority concerned of the Government of Japan as well as to the TRWB and other agencies of the Government of Iran for close cooperation and assistance extended to us during the course of our investigations and studies.

Very truly yours,

Shoichro Higuchi
Leader of the Study Team

General Location Map



1. Water Resources Development Projects

Water Source	Volume/Length
Karaj Dam	Storage = 205MCM
Taleghan Dam	Storage = 420MCM
Almout Diversion Dam	Diversion = 250MCM
Almout Diversion Tunnel	Length = 33.7km

2. Water Conveyance Projects

Route	Length
Karaj - Tehran (Existing)	45 km
Karaj - Tehran (Proposed)	30 km
Zairan - Bileghan	60 km
Ziaran - Bileghan (Proposed)	60 km

3. Irrigation Project

Canal System	Irrigable Area	Main Canal
North Canal	56,600 ha	94 km
Central Canal	53,000 ha	125 km

LEGEND OF PROJECTS	
(red line)	Existing Project
(green line)	Project under Construction
(blue line)	Proposed Project

LEGEND OF BOUNDARIES	
(red line)	Study Area (Part)
(green line)	Related River Basins (Part)

ABBREVIATION AND LOCAL TERMS

A. ABBREVIATION OF MEASURES

(1)	Length	mm	=	millimeter		
		cm	=	centimeter		
		m	=	meter		
		km	=	kilometer		
(2)	Area	m^2	=	square meter		
		ha	=	hectare	=	104 m^2
		km^2	=	square kilometer	=	106 m^2
(3)	Volume	lit.	=	liter	=	1,000 cm^3
		cu.m	=	cubic meter	=	m^3
		MCM	=	million cubic meter	=	106 m^3
(4)	Weight	mg	=	milligram		
		g	=	gram		
		kg	=	kilogram	=	1,000 gram
		t, ton	=	ton	=	1,000 kg
(5)	Time	s	=	second		
		min	=	minute		
		h, hr	=	hour		
		d	=	day		
		yr	=	year		
(6)	Currency	Rls	=	Rial		
		US$	=	US Dollar		
		¥	=	Japanese Yen		
(7)	Electricity	kv	=	kilovolt		
		kw	=	kilowatt		
		MW	=	megawatt	=	1,000 kw
		kwh	=	kilowatt-hour		
		MWh	=	megawatt-hour	=	1,000 kwh
		GWh	=	gigawatt-hour	=	1,000 MWh
(8)	Discharge	cu.m/sec	=	cubic meter per second	=	m^3/sec
(9)	Others	mmho	=	micromho	=	conductance
		ppm	=	parts per million		
		%	=	percent		
		pH	=	scale of acidity		
		‘	=	minute		
		“	=	second		
		℃	=	Celsius		

B. OTHER ABBREVIATIONS

GDP	=	gross domestic product
GRP	=	gross regional product
GBP	=	gross basin product
El.	=	elevation
HWL	=	high water level
LWL	=	low water level
FOB	=	free on board
CIF	=	cost, insurance and freight
M/P	=	National and Regional Water Resources Master Plan

C. ABBREVIATION OF ORGANIZATIONS

EOJ	=	embassy of Japan
IMO	=	Iranian Meteorological Organization
JICA	=	Japan International Cooperation Agency
MOE	=	Ministry of Energy
PBO	=	Planning and Budget Organization
TRWB	=	Tehran Regional Water Board

D. Local Terms

Far	=	Farvardin	=	21 March to 20 April
Ord	=	Ordibehesht	=	21 April to 21 May
Khr	=	Khordad	=	22 May to 21 June
Tir	=	Tir	=	22 June to 22 July
Mor	=	Mordad	=	23 July to 22 August
Shr	=	Sharivar	=	23 August to 22 September
Mhr	=	Mehr	=	23 September to 22 October
Abn	=	Aban	=	23 October to 21 November
Azr	=	Azar	=	22 November to 21 December
Dey	=	Dey	=	22 December to 20 January
Bah	=	Bahman	=	21 January to 19 February
Esf	=	Esfand	=	20 February to 20 March

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Executive Summary

Western Area of the Capital Tehran

The western area of the capital Tehran comprises Tehran City and four regions of Tehran, Karaj, Hashtgerd and Qazvin that extend westward of Tehran City. Tehran City, the capital of the Islamic Republic of Iran, is the center of the national activities such as politics and socio-economy. Tehran and Karaj regions lie adjacent to Tehran City holding numbers of satellite cities of Tehran and neighboring agricultural zones. Hashtgerd region is located between Karaj and Qazvin where residential and industrial developments of large-scale are under progress designated by the government as the new development area. Qazvin region of Qazvin Province holds a vast agricultural area of about 350,000 ha forming a supply center of food to the capital area and has been expanding as a new industrial zone.

Population and Water Demand

Total population of the western capital area is 11.7 million in 2001 and is projected to increase to 17.4 million in 2021. On the other hand, the present water demand of 4,675 MCM is forecasted to increase to 5,630 MCM in 2021 accompanied by increasing population and industrial, urban and agricultural development of the area. Domestic and industrial water demand of 1,595 MCM at present is projected to increase to 2,320 MCM in future while agricultural water demand is estimated to increase to 3,310 MCM from the present demand of 3,080 MCM. In Tehran City, present water consumption of 910 MCM will increase to 1,230 MCM in future providing a serious anxiety of water shortage in the area.

Potential and Available Water Resources

(1) Surface Water

Major sources of surface water in the area are Karaj, Latian and Lar dams under operation at present and Taleghan storage dam and Almout diversion dam that are going to be developed in near future. Small streams originated from Taleghan mountains are also providing surface water in the area. Total potential resources of such water are evaluated at 2,460 MCM, of which 1,390 MCM are being utilized at present and available resources in future are estimated at 1,965 MCM including the present use. Potential and available water resources are absolutely insufficient against the demand of water in the western capital area, and as high as 80% of the potential resources are to be utilized in order to satisfy the demand, requiring strict management of water developed.

(2) Groundwater

There lies a large scale groundwater aquifer with the storage capacity of 42,000 MCM underneath the plain of 8,200 km^2 in the western capital area. Presently about 3,300 MCM of groundwater are extracted from 26,000 deep and shallow wells and utilized for domestic, industrial and agricultural purposes. Recharge of groundwater from precipitation and surface flow in the area is, however, not adequate as compared with extraction and over-extraction becomes obvious in many places showing draw-down of groundwater tables and reduction of groundwater production, providing serious problems on the management of groundwater resources.

Water Allocation Plan

On the basis of increasing water demand due to population growth and urban, industrial and agricultural development, water allocation plans of short-term in 2006, medium-term in 2011 and long-term in 2021 are prepared. Comparison between the present situation and the long-term plan is summarized as below;

Use of Water	Present Situation in 2001			Long-term Plan in 2021		
	Surface Water	Ground Water	Total	Surface Water	Ground Water	Total
Domestic/Industrial	640	955	1,595	980	1,340	2,320
Agricultural	750	2,330	3,080	1,335	1,975	3,310
Total	**1,390**	**3,285**	**4,675**	**2,315**	**3,315**	**5,630**

Present use of surface water of 1,390 MCM will increase to 2,315 MCM in future with a increment of 925 MCM supplied by Taleghan dam, Almout water diversion and re-used water from sewage treatment plant. Use of groundwater in future is restricted at the present level in consideration of impending and critical conditions of groundwater resources.

Water Sources and Water Resources Development Projects

The existing and proposed water sources and water utilization projects that will be managed in future are summarized in the next table.

It is, however, necessary to carry out urgently the study and implementation for the following projects, in order to achieve the projected water allocation plan:

- Rehabilitation works of existing Taleghan tunnel and Qazvin north irrigation canal system, which have been under operation for a long period of more than 25 years and partly deteriorated.
- Study and implementation of the new water conveyance facility connecting the Karaj river downstream of Karaj dam and proposed No.6 water treatment plant in Tehran City in order to realize the utilization of the Taleghan water of 150 MCM in 2011 and 310 MCM in 2021.
- Feasibility study of Almout water diversion project should be carried out together with the study for Qazvin central irrigation project because both projects are closely related each other.
- Inventory survey for the existing shallow and deep production wells to identify their pumping function, extracted amount of groundwater, necessity of rehabilitation, etc together with implementation of rehabilitation program and construction of new production wells.

Outline of Existing and Proposed Water Sources and Water Utilization Project

Project	Status	Outline
1. Water Sources Project		
Karaj Dam	Operation	Arch dam H=180m, V=205MCM, A.W 4.35MCM
Taleghan Water Diversion	- do -	Sangban weir, Tunnel 9km, Ziaran dam A.W 200MCM
Taleghan Dam	Construction	Fill dam H=104m, V=420MCM, A.W 450MCM
Almout Water Diversion	Plan	Almout weir, Tunnel 33.8km, A.W 250MCM
2. Water Conveyance Project		
Karaj-Tehran No.1, No.2	Operation	L=40km, Q=2.7m^3 in No.1, 8.0m^3 in No.2
Karaj-Tehran No.6 Plant	Plan	L=24km, Tunnel or Pipeline Q=15m^3/sec
Ziaran-Karaj, Stage 1	Construction	Steel Pipeline L=60km, Q=5m^3/sec
Ziaran-Karaj, Stage 2	Plan	- do - L=60km, Q=5m^3/sec
3. Tehran Water Work Project		
Water Treatment Plant	Operation	No.1～No.4 Capacity 18.7m^3/sec, Annual Yield 535MCM
- do - No.5	Construction	Capacity 6.75m^3/sec
- do - No.6	Plan	Capacity 12.0m^3/sec
Sewerage Plant	Plan	No.1 Capacity 9.5m^3/sec, No.2 Capacity 13.9m^3/sec
4. Irrigated Agriculture Project		
Karaj Irrigation	Operation	Area 20,000ha, Main Canal L=38km,
Kordan Irrigation	- do -	Area 5,000ha, Weir, Main canal L=12km,
Qazvin North Irrigation	- do -	Area 48,200ha, Main Canal L=94km,
Qazvin Central Irrigation	Plan	Area 53,000ha, Main Canal L=125km,
5. Groundwater Development		
Shallow and Deep Wells	Operation	Shallow well 15,000, Deep well 11,000 A.W 3,300MCM
Groundwater Recharge	Plan	Recharging pond/dam, underground dam
6. Rehabilitation Projects		
Qazvin North Irrigation	Plan	Concrete structure and gates in canal system
Taleghan Water Diversion	-do-	Taleghan tunnel, Ziaran dam and telemeter system
Water Pipeline in Tehran City	-do-	Prevent of water leakage through pipeline of 8,000km

Note: V;=Reservoir Capacity, A.W=Available Water, H=Height and L=Length

Improvement of Water Management

Potential resources of both surface water and groundwater are limited in the Study Area and the use of available water resources has been stretched to the limits. Almout river may be the last source of surface water remained unused within the territory of water allocation of the capital area of Tehran. Groundwater has tended to decrease showing annual imbalance of more than 700 MCM toward the final drying up unless proper measures are taken immediately. In order to expect the sustainable development of the area within the available resources, such resources are to be managed and operated properly and effectively. Important issues of management and operation includes 1) establishment of operation rule of water source facilities to allocate necessary volume of water among water users within the minimum risk of water deficit, 2) combination use of surface water and groundwater to allocate water effectively and rationally, 3) establishment of water allocation rule for reasonable and equitable water use among users and 4) improvement and maintenance of water use manners and facilities to minimize losses of water. Necessary activities of water management may be categorized into seven definite items classified as 1) watershed management, 2) river flow management, 3) water source management, 4) water allocation management, 5) groundwater management, 6) irrigation water management and 7) domestic water management.

Almout Water Diversion Project

In order to satisfy the urban water demand of Tehran City in future, the Taleghan water of 310 MCM per annum is necessary to be conveyed to Tehran in 2021. As the Taleghan water has been planned and used for Qazvin irrigation since 1970s with the program of future expansion of irrigation area in Qazvin plain, the Almout Water Diversion Project becomes necessary to compensate for the Taleghan water and to supply irrigation water to Qazvin plain. The project includes the tunnel with a long distance of 33.8km having the high viability to be implemented. The outline of project is as follows;

- Diversion Water Amount — 250 MCM
- Downstream Release — 60 MCM
- Almout Diversion Dam — Concrete weir H=10m, L=56m
- Almout Water Pipeline — Steel pipe, L=6.0km, Q=22.5m^3/sec
- Almout Tunnel — D=4.0m, L=33.8km
- Project Cost — US$123.6 million
- Water Cost — US$0.05/m^3

Qazvin Irrigation Project

(1) Outline of Irrigation Project

The existing irrigation area is estimated at 81,000ha or 23% of total farm area supplied by the Taleghan water of 200 MCM in combination of groundwater. In future irrigation area will be expanded supplied by the Almout water, small river waters and groundwater to be exploited, etc. Conceptual plan of Qazvin irrigated agricultural development is as shown below.

Outline of Qazvin Irrigation Canal System

Item	Existing North Area		Proposed Central Canal	
1. Irrigable Area (ha)	North, Higher Takestan	38,600 9,000	North, Lower Central	38,100 60,900
	Total	**47,600**	**Total**	**99,000**
2. Net Irrigation Area (ha)	North, Higher Takestan	28,900 6,700	North, Lower Central	28,500 45,500
	Total	**35,600**	**Total**	**74,000**
3. Irrigation Intensity (%)		75		75
4. Available Irrigation Water (MCM) Talegan water Almout water Groundwater		 140 - 260		 - 210 610
Total		**400**		**820**
5. Recharging Water		-		40
6. Irrigation Canal System Main Canal Secondary Canal	 Q=30m^3/sec, L = 94km 12 units, L = 220km		 Q=22.5m^3/sec, L=125km 10 units, L=150km	
7. Production Wells		800units		1,600units

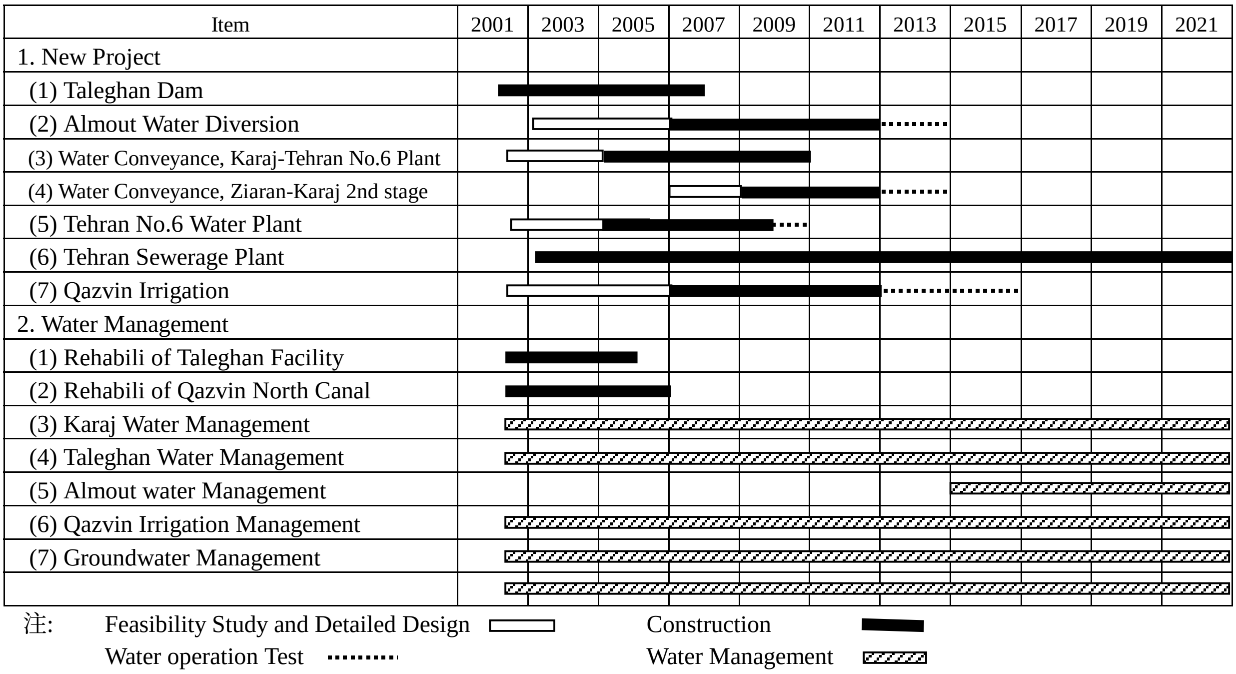
The project cost for irrigation canal system is estimated at US$41.5 million. Total project cost including the Almout water diversion project is US$165.1 million (123.6 million + 41.5 million).

Project benefit is estimated at Rls 81 billion (about US$10 million) on the financial basis and Rls 147 billion (about 18.4 million) on the economic basis. Economic Internal Rate of Return (EIRR) estimated based on the project cost and project benefit shows relatively high value of 15%. The investment cost per ha is estimated at US$5,900.

Implementation Schedule of Water Resources Development and Management Program

As mentioned in the above, it is necessary to implement the various water resources development and water management projects to achieve the water allocation plans proposed in the Master Plan and to satisfy the increasing future water demand in the western capital area. The implementation schedule for the development and management is proposed as follows;

Implementation Program of Water Resources Development and Management Projects



Conclusion and Recommendation

(1) Integrated Water Management Program

Total available water for domestic, industrial and agricultural uses in the Study Area is estimated at about 5,600 MCM in 2021, consisting of the surface water of 2,300 MCM and groundwater of 3,300 MCM. This volume of available water is not thoroughly sufficient to satisfy the future water demand when the per capita value of available water, 320 cubic meter only, is taken into consideration, because this value is considerably smaller as compared with the world average. Accordingly, the integrated water management program to use and allocate the developed water properly and effectively among various water demands becomes inevitably necessary and is to be implemented urgently. In this concern, it is recommendable to pay the particular attention 1) reservoir operation and reservoir water use, 2) combination water use for surface water and groundwater, 3) evaluation and management of groundwater resources, 4) water allocation rule with reasonable and equitable use, and 5) water use on the service area level to minimize the water losses.

(2) Surface Water Sources Development

Potential surface water in the Study Area is evaluated at 2,460 MCM, of which 1,965 MCM could be developed and available to cover the proposed water demand toward 2021 in the area. However, the following study and implementation for the water sources development are to be carried out properly and on schedule.

- The new Karaj water conveyance project to convey the Karaj water to the proposed No.6 water treatment plant through a tunnel under gravity or a pipeline with pumping station has to be urgently studied and implemented.
- It is important to complete the Taleghan dam project just on schedule. It is also urgently necessary to survey, study and implement the rehabilitation of the existing Taleghan tunnel.
- As for the Almout surface water, it is very important and urgently necessary to implement the Almout Water Diversion Project to divert the Almout water to Qazvin irrigation.

(3) Groundwater Management

Present use of groundwater of 3,300 MCM is judged to be the maximum limit taking into account the available recharging water in the area such as rainfall, surplus surface water in rivers, return flow from irrigation and domestic and industrial water supply, etc. It is recommendable to study and implement the groundwater management in order to carry out the effective and sustainable use of groundwater, including 1) establishment of monitoring and evaluation system including the rehabilitation of monitoring wells and the provision of new organization to evaluate and control the groundwater properly and accurately, and 2) study and implementation of groundwater recharge program by recharging dam and dike in the Khah-rud river basin in Qazvin plain and the Kordan river basin in Hashtgerd region.

CHAPTER 1.

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background

Tehran City has expanded rapidly and largely westward after the revolution with its population increased from about 5 million in 1979 to 7.5 million in 2001, that are projected further to grow to 10.7 million in 2021 indicating 200% of growth during 40 year period. Being located in the western border of the capital Tehran, Karaj and Hashtgerd have also been expanding as the satellite cities of Tehran with increasing population from 0.5 million at the time of revolution to 3.4 million in 2001 with a projection of 5.5 million in 2021.

This expansion urged the improvement of social infrastructure such as highway, railway, power transmission lines, gas pipeline and communication network together with development of residential areas. Development of water sources and provision of water use facilities are still outdistanced by other public sectors, providing major source of anxiety about serious water shortage in near future.

At the time of revolution, approximately 400 MCM of municipal water were consumed annually in Tehran, of which 150 MCM were supplied from Latian dam constructed on Jaj-rud river located in the east of Tehran city and 250 MCM were provided from Karaj dam on Karaj river in the west of Tehran. Both dams are multi-purpose for water supply and irrigation, however, rapid increase of demand for municipal water supply due to migration of urban population and industries has forced conversion of water use from irrigation to municipal water supply. As a result of such a conversion, both dams have been supplying 300 MCM of annual water to Tehran after 1993 showing a critical level that cannot accommodate any further increase in additional water to Tehran, except some 100 MCM of Karaj water that are utilized for agricultural purpose at present. To cope with increasing demand of water supply in Tehran, consumption of groundwater has increased rapidly from approximately 100 MCM in 1993 to 300 MCM in 1997 showing obvious over-extraction. Currently, consumption of municipal water in Tehran is about 910 MCM, of which 340 MCM are provided from Latian and Lar dam, 300 MCM from Karaj dam and 270 MCM from groundwater. Accordingly in the western capital area, surface water of Karaj river has been fully developed together with excessive development of groundwater by means of deep and shallow wells. Remaining sources of surface water are the Taleghan and Almout rivers, located adjacent north to the western capital area, and increasing demand of water accompanied with growing population and industry will require much more water in future in order to support socio-economy including urban, industrial and agricultural development of the area.

Shortage of irrigation water from surface resources resulted in connection with conversion of agricultural water to municipal water has forced the scale-downs of irrigation as well as dependence on groundwater in the agricultural areas of southern Tehran plain and downstream reaches of Karaj and Jaj-rud rivers. Decreasing progress of production as well as levels of groundwater together with contamination of water quality due to waste-water from municipal areas has become serious social problems in the area.

Demand of municipal water supply in Tehran in 2021 is estimated at 1,230 MCM corresponding to the projected population of 10.7 million with an increase of 320 MCM against the present demand of 910 MCM.

About 350,000 ha of agricultural area extend in the Qazvin plain located adjacent to the western area of the capital Tehran, where wheat, sugar beet, orchard and vegetable are planted and chicken, sheep and cattle are raised forming the center to support the food security of the capital Tehran. In the northern Qazvin plain where about 77,000 ha of farmland extend, the irrigated agricultural development project was completed in the early 1970's with water diverted trans-basin from the Taleghan river combined with groundwater in the plain. Since then irrigated agriculture has been practiced in the area for more than 30 years forming plentiful rural communities. At present about 48,000 ha are being irrigated with a potential irrigable area of 77,000 ha whenever irrigation water is available.

Taleghan river traverses the Taleghan valleys located to the north of Qazvin plain from east to west emptying finally into the Caspian sea. Annual potential water of the river is about 480 MCM that is the largest among all of rivers in the area. A part of river runoff has been diverted at the existing Sangban diversion dam and transported to northern Qazvin plain through the Taleghan diversion tunnel of 9 km long constructed in 1972. Annual usages of the Taleghan water in the northern Qazvin plain are 150 to 200 MCM.

In the light of urgent needs of additional source of water for the western area of the capital Tehran, the government of Iran has formulated as the national strategy the following plans of water resources development and allocation:

- To construct a water pipeline of about 60 km long connecting the outlet of existing Taleghan tunnel with Karaj river in order to utilize a part of Taleghan water for irrigation purpose in Karaj area. It is estimated that about 120 MCM of water can be conveyed to Karaj area after providing current amount of Taleghan water to the northern Qazvin plain. The project is at present under construction and will be completed within a year. Formulation of a proper management plan to allocate water between irrigation in the northern Qazvin plain and irrigation use in Karaj area is one of the major subject of the Study, since no definite plan has been established yet. This plan will be categorized as the "Short-term Water Management Plan".
- Potential surface water resources of Taleghan river at the site of proposed Taleghan storage dam/reservoir is evaluated at 480 MCM/year, and approximately 160 MCM of additional

amount of water diversion, from 290 MCM under the Short-term Plan including 170 MCM to be allocated to the northern Qazvin plain for irrigation and 120 MCM for irrigation use in Karaj area to 450 MCM after controlled by the proposed dam/reservoir, would be expected. It has been recognized under the existing plan of proposed Taleghan storage dam construction that 300 MCM of water are to be allocated to irrigation in Qazvin plain while 150 MCM are to domestic purpose in Tehran city. In view of rapid growth of water supply demand at present and in future in the western capital area, the government of Iran has envisaged a plan to allocate all of stored water in Karaj dam to water supply in Tehran city and to use Taleghan water for compensation purpose to irrigation purposes in Karaj area. Possibility of this plan is to be studied, and this plan will be categorized as the "Medium-term Water Management Plan".

In this connection, construction of the proposed Taleghan storage dam has been determined as the urgent project by the cabinet with the presidential order of immediate action in 1998, and the dam construction was just commenced at the middle of 2001 by the Tehran Regional Water Board. Completion of dam construction is expected in 2006 to 2007.

It is however projected that additional supply of 160 MCM by the construction of Taleghan storage dam is not sufficient to fulfill the future demand of water supply in the western capital area, and new water resources development plan to divert Almout river water has been under consideration by the Tehran Regional Water Board. Almout basin is located adjacent to Taleghan basin having about 250 MCM of water diversion that can be supplied to Qazvin plain. About 140 MCM of Taleghan water will be allocated to Qazvin plain and 310 MCM of Taleghan water will be conveyed to the western capital areas of Tehran, if this Almout water diversion plan is practicable. Under this plan, new irrigation system will be consolidated and the water diverted from Almout river will be distributed to serve irrigable areas in the central and southern Qazvin plain. This plan however requires construction of a long distance tunnel of about 34 km underneath the mountains of 3,000 m level, and a pre-feasibility survey for this plan is one of the main issues to be included in this Study.

On the basis of comprehensive understandings on the existing and future developments of the area focusing especially on appropriate projection of demands of water required in various water user sectors, existing situation of impending balance of water between demand and supply, exhausting resources of surface and groundwater, it is inevitably necessary and urgent to set up an integrated water management plan consisting of proper and timely water resources development plan, effective and stable water use management plan and reasonable and rational water allocation plan for sustainable growth of the area toward the target year of 2021.

The National and Regional Water Resources Master Plan (the Master Plan), being prepared since 1996 by the Ministry of Energy, was completed in 2000. The Tehran Regional Water Board

(T.R.W.B) under the Ministry of Energy has a deep concern to the Master Plan study on the Central Region, especially for the Tehran capital area that is the most important area in the country and suffered from chronic water shortage problems. The Master Plan was prepared based, however, on the socio-economic and hydrological data up to 1993/94 with analyses starting from 1996 as the present conditions showing a slight time lag when compared with the actual situation. The Master Plan is also open to charge of emphasizing the logical plans of allocation of water between increasing demands and possible supplies, without focusing too much on the engineering measures to realize such allocation plans.

Under these circumstances, T.R.W.B requested the Japanese Government to carry out the Study on Water Management in the Western Area of the Capital Tehran, on the basis of the Master Plan and including engineering study on the viability of the water diversion plan from Almout river on a pre-feasibility study level, under the technical cooperation of the Japanese Government. In response to the request of the government of Iran, the government of Japan has made efforts towards extending technical cooperation to establish a rational and practical water management plan including water diversion plan from the Almout basin to the Qazvin plain, and dispatched experts through Japan International Cooperation Agency (JICA). A preliminary Study Team was sent and the Scope of Works was consented and signed by both the governments in December 1999. In March 2000, JICA decided to send a Study Team consisting of eleven (11) experts of various field headed by Mr. S. Higuchi to conduct “the Study on Water Management in the Western Area of the Capital Tehran in the Islamic Republic of Iran (the Study)”

1.2 Objectives of the Study

The objectives of the Study are 1) to make a long-term projections of increasing water demands for various water uses in the western area of the capital Tehran up to the project target year of 2021, 2) to grasp potential surface and ground water resources in the Study Area and to evaluate present and future surplus or deficit of water on the basis of water balance between demand and supply, 3) to formulate short-term and medium term plans of management/allocation of water to be diverted from the Taleghan river, 4) to conduct a pre-feasibility study on the water diversion plan from the Almout river to cope with a long-term solution of water allocation and management in the Study Area, and 5) to carry out technology transfer to the counterpart personnel in the course of the Study.

1.3 Study Area

The Study Area covers 16,100 sq.km as the Direct Study Area inclusive of 1) the western area of the capital Tehran involving Tehran city, surrounding Tehran area, and Karaj and Hashtgerd areas, 2) entire Qazvin plain, 3) river basins of Taleghan, Almout and Shar-rud upstream of Shiahdasht, and 15,500 sq.km as the Related Basin involving 4) Shah-rud river basin upstream of Manjil dam in view of environmental aspects and. 5) three river basins of Abhar-rud, Khah-rud and Haji Arab that are watershed of the southern Qazvin plain. Figure 1.3.1 illustrates the boundary of the Study Area.

1.4 Scope of the Study

In order to achieve the Study objectives in the Study area, the Study covers the following study items:

(1) To evaluate the potential and available surface water resources of the rivers and tributaries such as Karaj, Taleghan and Almout in the Study Area.

(2) To collect and compile the available data related to groundwater, and based on these data, to evaluate present consumption and recharging capacity and to make water balance study between potential recharge and consumption of groundwater resources.

(3) To set up water allocation plans of short, medium and long terms toward the project target year of 2021 in the Study Area dividing into Tehran City and other four regions of Tehran, Karaj, Hashtgerd and Qazvin, on the basis of projected water demands for various water user sectors and availability of water from surface and groundwater resources.

(4) To set up operation rules of Karaj and Taleghan storage dams for sustainable supply of water programmed in the water allocation plans to meet requirements from urban water supply of Tehran City with a priority and irrigation in Karaj and Qazvin regions.

(5) To identify existing and proposed water development and management projects in the Study Area in order to achieve the water allocation plans.

(6) To carry out the pre-feasibility study on the Almout Water Diversion Project taking into account the requirement of water in irrigation systems of either existing and proposed in Qazvin plain and evaluation of possible environmental impact of the water diversion plan on the water use in downstream areas together with its mitigation plans.

(7) To prepare a conceptual plan of irrigated agricultural development in Qazvin plain, on the basis of availability of surface water to be diverted from Taleghan and Almout rivers in combination of groundwater to be extracted from Qazvin aquifer, including the rehabilitation plan of existing northern Qazvin irrigation system and expansion of irrigation area in the central and southern Qazvin plain.

(8) To prepare a proper rule of management of groundwater resources including monitoring, evaluation and control systems.

(9) To prepare an implementation program for water resources development and management projects in the Study Area.

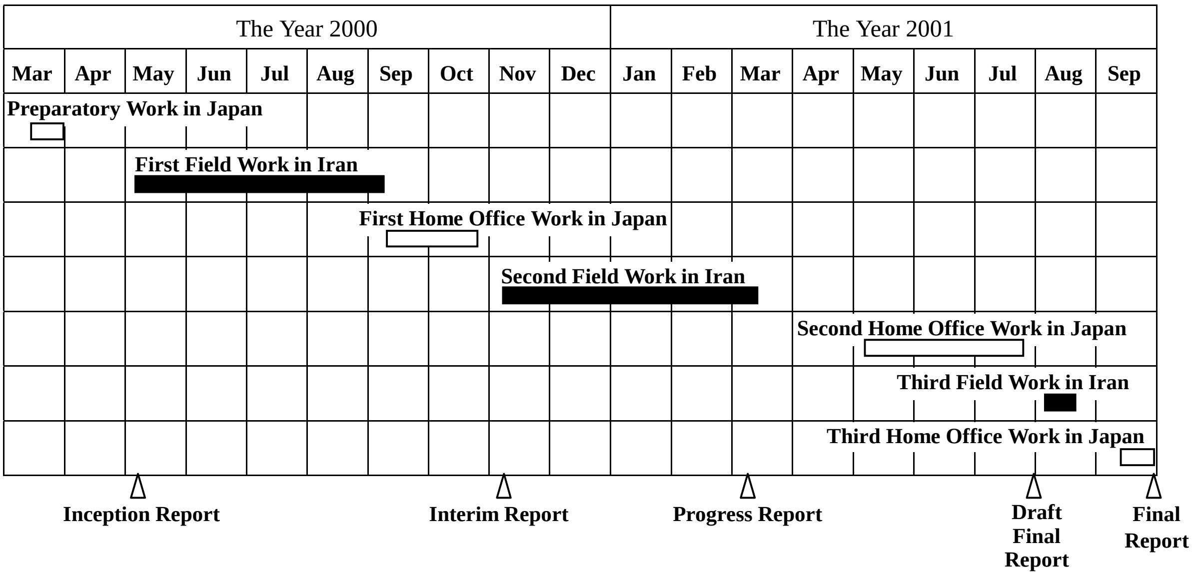
Above studies are made on the basis of findings and proposal given in the National and Regional Water Resources Master Plan as of the end of 2000, prepared by the Ministry of Energy entrusted to

Jamab Consulting Engineers.

1.5 Overall Working Schedule of the Study

The Study has been and will further be implemented in seven (7) stages of three (3) phases as shown below:

Phasing of the Study



Stage 1: Preparatory Works in Japan (End of March, 2000)

Stage 2: First Field Survey in Iran (May to Early September, 2000)

Phase I Study (Basic Survey)

Collection of basic data/information and field survey/investigation was made during this stage of the Study, in order to grasp the existing conditions of the Study Area. Aero-photo survey including mapping, leveling survey to connect benchmarks between Ghazvin and Almout basin, profile survey at alternative sites of the Almout dam/reservoir construction, core drilling investigation and inventory survey for rehabilitation of existing water use facilities mainly in the north Ghazvin plain was entrusted to the companies/groups in Iran.

Phase II-1 Study (Preparation of Water Resources Management Plan)

Overall management plan of existing water resources development projects and their facilities was prepared in this stage of the Study, based on the potential of surface and groundwater resources and existing situation of water management in the study area. Necessity of the Taleghan dam construction was clarified and preliminary study on the Almout water diversion including environmental aspects will be conducted.

Stage 3: First Home Office Work in Japan (Phase II-1 Study continued)

A plan of water resources management was finalized in this stage of the Study inclusive of rehabilitation plan, costs, benefits and organization plan for operation and maintenance of existing water use facilities. Selection of an optimum plan from alternatives of Almout water diversion was made and TOR for EIA study will be prepared. All of these findings was compiled in the Interim Report.

Stage 4: Second Field Survey in Iran

Phase II-2 Study (Pre-feasibility Study for Almout Water Diversion)

Supplemental field survey was conducted for the development of Almout basin together with Environmental Impact Assessment which was entrusted to the Iranian company. Preliminary design of Almout dam and water diversion tunnel was also executed during this stage of the Study, and the Progress Report was prepared at the end of the stage.

Stage 5: Second Home Office Work in Japan (Phase II-2 Study continued)

A pre-feasibility study on the Almout water diversion was finalized in this stage of the Study.

Phase III Study (Reporting and Technology Transfer Seminar)

The Draft Final Report was prepared compiling all of findings obtained since the beginning of the Study.

Stage 6: Third Field Survey in Iran

The Draft Final Report will be presented and the technology transfer seminar will be held in Tehran.

Stage 7: Third Home Office Work in Japan

Final Report will be prepared on the basis of the comments of Iranian government on the Draft Final Report.

1.6 Personnel Engaged in the Study

JICA has organized the Study Team comprising twelve (12) experts for the implementation of the Study. JICA also set up an Advisory Committee for the purpose of providing technical advices to the Study Team as listed below:

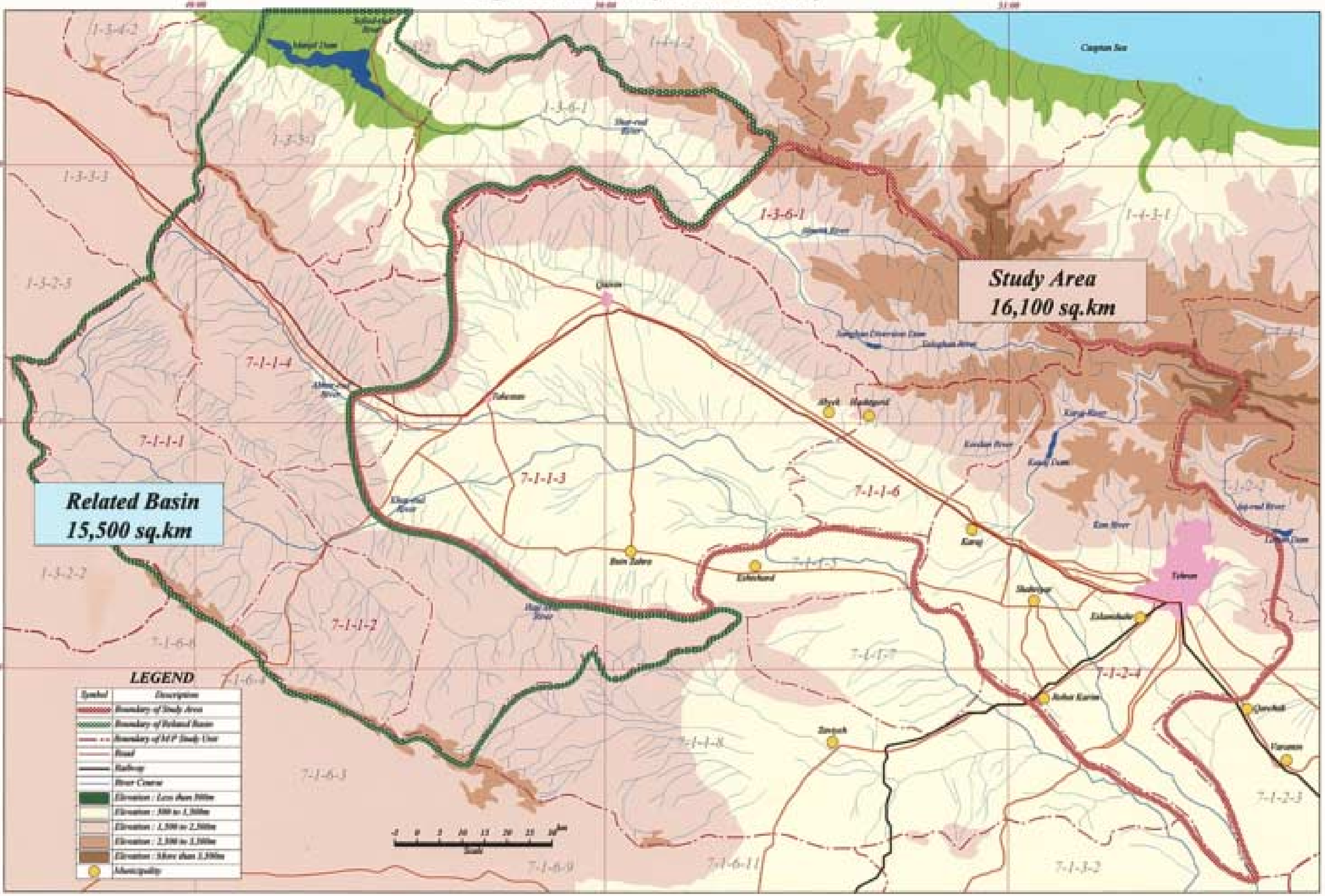
Organization of the JICA Study Team

Designation/Field	Name of Experts
Team Leader/Water Management Plan	Shoichiro HIGUCHI
Deputy Leader/Hydrology/Hydraulics	Yoshiaki KIMURA
Land Use/Irrigation Plan	Takanori TAKATSUKA
Dam Construction Plan	Hiroshi MORIYAMA
Water Diversion Plan	Masaru MATSUYAMA
Environment	Mitsuaki INO
Water Demand Projection	Shigeru TAKARA
Survey Supervision	Hossein MALEKINEJAD
Construction Plan/Cost Estimate	Kasaku CHICHIBU
Groundwater Development Plan	Izumi KATO
Topography/Geology	Masuud SIROVYA
Economic and Financial Evaluation	Nobuki TOYOOKA
Interpreter	Goramhosin SHOKOHIFAD
Coordinator (1)	Eichi SHIBATA
Coordinator (2)	Akemi KUNO

Organization of JICA Advisory Committee Team

Assignment	Name	Position
Chairman	Hidetomi OI	Senior Advisor, Disaster Prevention, Water Resources Development, JICA
Member	Shinichi SHIBUYA	Deputy Director of River Improvement and Management Division, River Bureau, Ministry of Land, Infrastructure and Transport

Figure 1.3.1 Study Area Boundary



CHAPTER 2.

PRESENT CONDITIONS OF THE STUDY AREA

CHAPTER 2 PRESENT CONDITIONS OF THE STUDY AREA

2.1 Scope of the Study Area

2.1.1 Division, Acreage and Outline of the Study Area

The Study Area, located at the western area of the capital Tehran, involves two river basins of Taleghan and Almout, Tehran city and four regions of Tehran, Karaj, Hashtgerd and Qazvin according to the classification of water management study units employed in the Master Plan. The boundary of river basin is shown in Figure 2.1.1.1 together with location of major cities included in the Study Area.

Coverage of These basins and regions area is estimated approximately on the topographical map of scale 1 to 250,000 as summarized in the following table.

Area Division of the Study Area

Unit; km^2

Basin & Region	Total Area	Mountain Area	Plain Area
Taleghan & Almout Basin	2,445	2,445	0
Tehran City	530	0	530
Tehran Region	2,150	860	1,290
Karaj Region	2,370	1,430	940
Hashtgerd Region	1,350	570	780
Qazvin Region	7,255	1,965	5,290
Total	**16,100**	**7,270**	**8,830**

(1) Taleghan and Almout River Basin

The Taleghan and Almout rivers are located on the northwest of Tehran city, originate from the Alborz mountain and empty finally into the Caspian Sea. Both river basins have very important water resources amounting to available water of 700MCM, which could be conveyed to Tehran capital area. There are the existing Taleghan water diversion project, Taleghan dam project under construction and Almout water diversion project under planning.

(2) Tehran City

Tehran City is the capital of Iran forming the center of politics and socio-economy in the country. The city holds a large urban population of 6.8 million at present (1996) and uses the urban domestic water of 870MCM being supplied from Lar, Latian and Karaj dams and groundwater. Shortage of water due to limited availability of water from those water sources is the serious problem in this area at present and more in future.

(3) Tehran Regions

Tehran region locates adjacent to Tehran city and is mainly formed with Eslam Shahr and Qarchak, the bed towns of Tehran city, and has a population of 720,000 in 1996, 410,000 in urban area and 310,000 in rural area. Agricultural area of 48,900ha is existing in the region and has produced various 48,900ha is existing in the region and has produced various products and supplied them to Tehran market.

(4) Karaj Region

The Karaj region has developed as the satellite area of Tehran city and holds the large population of about 1.7 million in 1996, 1.4 million in the urban and 0.3 million in the rural. Agricultural area is estimated at 44,500ha, of which 85% is irrigated at present. Agricultural area, however, has been decreased in recent years due to conversion of farm land to urban and industrial area. The region has faced serious water shortage problem due to increasing the domestic and industrial water demand and the transfer of Karaj dam water to the urban water supply in Tehran city from the irrigation water in Karaj area.

(5) Hashtgerd Region

Hashtgerd region locates at the western corner of the Teheran province adjacent to Qazvin province and new urban and industrial development has been progressed at present. Present population of as small as 200,000 is expected to increase to 800,000 in 2021. Water is not sufficient within the region to cover the proposed urban, industrial and agricultural development in future.

(6) Qazvin Region

Qazvin region has a population of 800,000 at present and a large agricultural area of 350,000ha and has fulfilled the important role to support the food security in the capital area. The region is blessed with a plenty of water sources such as the Taleghan and Almout rivers, a number of tributaries flowing into the Qazvin plain and groundwater aquifer with a large recharging capacity. Accordingly the region is the area with a large potential for agricultural development over a vast expanse of farmland supplied by rich available water.

2.1.2 River Basin related to the Study Area

River basins related to the Study Area can be divided into two category, one is basin of three rivers, Abhar-rud, Khah-rud and Haji Arab, being expanded in the south plateau area of Qazvin plain and the other is the Sefied-rud basin including the Shah-rud river located at the downstream of the Taleghan and Almout rivers.

(1) Three River Basins in Qazvin South Plateau

Three rivers in Qazvin south plateau produce the annual runoff of more than 250MCM in total, flow down in the area of Takestan, Shal and Buin and finally empty into the salt marsh. As the surface water of those three rivers has been used for irrigation and for recharge of groundwater in the southern Qazvin plain, it is necessary to identity the possibility to use those surface water for irrigation project in the southern Qazvin Plain.

(2) Sefied-rud River Basin

There exists Manjil dam with its reservoir capacity of 1,600MCM providing water to the large Giran irrigation area of about 230,000ha in the basin. The Manjil dam is constructed at the conjunction point of Shah-rud and Qezel Ozan rivers, and has been under operation for more than 30 years. Proposed water diversion plans from the Taleghan and Almout river to Qazvin plain and western area of the capital Tehran will reduce the flow in Shah-rud river and in turn will give some influence of the operation of the Manjil dam. Irrigation service area of Giran plain will be suffered from some water shortage problem, and hence it is necessary for the Study to cover the basin, to make study of the Manjil dam operation and to evaluate impact of the proposed water diversion plans.

2.2 Natural Conditions

2.2.1 Topographical Conditions

The Study Area has an area of 16,100km^2 consisting of two river basins of Taleghan and Almout covering 2,445km^2 and a large plain area of 13,655km^2 involving Tehran City and four regions of Tehran, Karaj, Hashtgerd and Qazvin. The topographical condition of the Study Area being classified by the elevation is shown in the Figures compiled in the Database Map.

(1) Taleghan and Almout Basin

The Taleghan and Almout rivers originate from the Alborz mountain range with the elevation of 3,500 to 4,000m, flow down along the deep valley, join at Shir Kooh site and change their name to the Shah-rud river, which empties into the Manjil reservoir in the Sefied-rud river.

The Taleghan river reach is about 15km from the conjunction point with Almout river to the site where the proposed Almout diversion tunnel crosses the river. Along this reach, river forms a V-shape valley and is steep with a river-bed slope of 1 to 50, and therefore access is very difficult.

The length of Almout river is about 40km from the origin to the conjunction of the Taleghan river. The river course between the middle to downstream reach forms a U-shape valley with the river width of more than 200m and the slope of 1 to 60. The river-bed elevation is 1,400m to 1,100m at the middle reaches of the river.

(2) Tehran City and Tehran Region

The northern part of Tehran City and Tehran region is formed with the high mountainous area elevated between 2,000m and 3,500m, while the plain is lying on the elevation of 1,700 to 1,200m and formed with undulated topography. There are many streams flowing down from the northern mountains area, passing through the plateau area in Tehran City and surrounding region and disappearing at the southern desert area. Kan river is one of the large river in the region.

(3) Karaj and Hashtgerd Region

The northern part of Karaj and Hashtgerd region also is formed with the high mountainous area elevated between 2,500m and 4,000m, where the Karaj and Kordan rivers and many streams originate and flow down to the southern plain. The upper reaches of the Karaj river is formed with a deep V-shape valley consisting of consolidated rock layers, while the lower reaches is formed with alluvial plain with the elevations ranging from 1,300m to 1,000m, being used for agriculture.

The Kordan river basin also is formed with the V-shape valley in the upper reaches and a large alluvial plain in the lower reaches. The river flows down the alluvial plain and empties into the salt marsh located at the eastern margin of Qazvin plain. The plain is formed with very flat topography and the slope is 1 to 100 directed from north to south.

(4) Qazvin Region

The Qazvin region is composed of a large plain with the area of more than 5,000km^2, enclosed by the mountainous area on the north, west and south. The northernmost part is called as the Taleghan mountains, which has the area of 1,650km^2 elevated between 2,000 to 2,500m forming an important watershed to supply the surface water to Qazvin plain.

Originating from the Taleghan mountains, the Ziaran river is one of famous tributaries where the Ziaran regulating dam is constructed to regulate the water diverted and conveyed from the Taleghan river. The western and southern mountainous area is about 600km^2, which is formed with the elevation of 1,500 to 2,000m. Three rivers of the Abhar-rud, Khah-rud and Haji Arab originate from those mountains, flow down the plain and empty into the salt marsh lying at the depression in the eastern corner of Qazvin plain.

The plain is quite flat with the elevation 1,300 to 1,200m and has been used for agriculture. The surface and groundwater being supplied or recharged by many small rivers is available for agriculture in the plain.

The salt marsh with the area of about 500km^2 extends on the eastern depression of the plain with the elevation of 1,200 to 1,150m. The surplus surface and ground water is flowing into the salt mash and lost due to evaporation and the outflow to the Shoor river which collects saline water also from the southern plain of Karaj and Tehran regions and convey to the desert area.

2.2.2 Geological Conditions

Study Area featured by geology is classified into two sections of “Mountain catchment” and “Plain area”. “Mountain catchment” stands with on the Alborz Mountains and is bounded in the north by the Almout basin. “Plain Area” dominates the southern half of Study Area and includes broad area of Qazvin to the Tehran. Lithology represented in these sections is comprising of various Formations of Precambrian to Recent age as shown in Figures 2.2.2.1 to 2.2.2.3 and 3.4.1.1.

“Mountain catchment (Mountains)” straddles on an part of the Alborz mountains are represented by a rugged ridges and with high altitude exceeding EL.4000 m Highest peak is Mt. Alam kuh (EL.4860 m) locating at the eastern edge of the Mountains. On northern slopes of these high mountains, small glaciers are nourished by permanent snowfields. Due to heavy snowing in the winter season, annual precipitation reaches 400 to 1,000 mm. The Mountains therefore are deeply dissected and forming the down-cutting valleys, such as “Taleghan”, “Almout” and “Shah-rud” rivers. By the rivers, three (3) ridges, namely as Takht-e-Soleyman, Hessarchal, and Taleghan ridges, are isolated as distinct sub-parallel ranges.

Lithostratigraphic sequences overlain the terrain include various formations dated from the Precambrian until the Neogene rock. The most common lithological types being variably volcanic rocks and congregates, marl, mudstone, sandstone and evaporates. A brief description of the main units is given hereafter:

[Precambrian]
The oldest units at the watershed are the late Precambrian rock consist of red and green sandstone and shale (Pe) with layers of stromatolite limestone, dolomite (Ped).
[Lower Carboniferous]
Lower Carboniferous Mobark limestone rests unconformably on late Precambrian sediments. This formation consists of mostly well-bedded gray or dark limestone in part shalely (Cm) and massive, feature-forming limestone (Ccml).
Dorud Formation [Lower Permian]
Dorud Formation is of Lower Permian, and gray sandstone and quartzite mostly, with layers of mudstone, siltstone and in middle part with thick bedded limestone with fusulinides fossil (Pd).
Ruteh Formation [Middle Permian]
Ruteh Formation is grey or dark limestone with medium bedded to massive and locally dolomite. Muddy or silty layers in upper part (Pr), rests conformity on the Dorud formation.
Elika formation [Lower Triassic]
Elika formation in lower part consist of platy limestone to shalely limestone yellowish grey with vermiculite limestone in upper part mostly buff dolomite. This formation rests unconformably on Ruteh formation.
Shemshak formation [Jurassic]
Shemshak formation, resting disconformably on Triassic strata is Shemshak formation (Js) which consists of mostly grey or grey brown mudstone, and siltstone with layers of sandstone.

Karaj formation [Eocene]
Karaj formation, the Paleogene sequences comprises two major parts. The lower part consist of tuffs (Ekta) and tuffaceous sediments (Ektm) including nummulitic limestone (l). The upper part consists of mainly sub-aerial basic lava flows, of probable upper Eocene to Oligocene age. Agglomerates, a layer of nodular gypsum, dark basalt (EKV), basanite and andesite type (VP) exits partly. The surrounding of intermontane of Alamout and the area of Taleghan Rud and tunnel route area is located in this formation.
Upper Red formation
Upper Red formation is the deposits of intermontane basin of Tleghan and Alamout which are believed to belong mainly to the upper red formation, having a complex stratigraphy owing to lateral interchange free mudstone and siltstone and gypsiferous mudstone. The oldest deposit of Neogene is conglomerate gypsiferous beds is interbeded partly.
[Quaternary]
Pleistocene and Recent deposit during the Quaternary, minor volcanism and many land-slips have occurred in the mountain country and moraines have been formed by glaciers established on some of the highest ground. It carries trachyte lava which issued from low volcanic cone. Recent deposits include the alluvium and alluvial fan deposit of Alamout and Taleghan valleys also scree and talus and moraines In many cases the resultant deposits show that the failure was recurrent and occurred partly as mud flows or by solifluction.
Intrusive Rock
Basic and intermediate dykes, probably feeders to minor volcanic episodes, cut pre-Paleogene formations. Coarse olivine monzonite - lenses (Im) intrude Paleogene.

In the Mountains, faulting is not widespread, but apparently limited to some major faults. It is possible to have old buried faults at deeper depths inherited from past tectonic evolution. Several major faults represented by Fishan and the Shahrak faults are passing in E-W to WNW-ESE trend. In accompany with these faulting system, large earthquakes occur repeatedly such as Rudbar-Tarom earthquake (M_0 8.8×10^{19} Nm, M*7.2,.20th June 990).

“Groundwater Basin” lying on the southern foot of the Mountains is stretching 190 km long from Qazvin plain to the south of Tehran, and is geomorphologically divided into three parts: “Marginal Area”, “Flat Plains” and “Salt Marsh”.

“Marginal Area” is located along the northern mountains, and is characterized by the sloppy terrain with the granulation of disconnected deposits and rivers. The terrain is overlain by various sizes of deposit becoming smaller towards the central and terminal parts of the plains. “Flat Plains” are of very monotonous features, and is extending over the Qazvin-Buin and Hashtgerd areas. Salt Marsh is the terminal of a number of surface and groundwater streams distributed in the south of Tehran and Qazvin plain, which are draining far southeastwards end up to “Salt marsh in the Central Iranian Plateau”.

“Neogene Formation” are dominated in the Plains area. These sequences are of conglomerates, breccias, evaporite free mudstone and siltstone and gypsiferous mudstone, and are mostly belonging to aforesaid "Upper Red Formation", having a complex stratigraphy structure owing to lateral interchange of the lithological divisions. The broad pattern of lithological variation is common to all basins and typical geologic-sequences classified are descriptive as follows:

Geologic Members
Conglometates: They are consisting of rock fragment of basic lava, sandstone and limestone, and are classified into three horizons. Among three(oldest, second layer and younger conglomerates). Yonger conglometrates are correlative with "Harzardarreh Formation" of Qazvin Plain, which comprises poorly sorted, weathering breccias and subordinate sand/silt.
Evaporite-free mudstone and siltstone: mostly dull red in colour and free from gypsum, may exposed in the deep section of the Plain. It often includes the grey or red fine grained clastics: sandstones, conglomerates and pebbles.
Gypsiferous mudston eand Halite: They are of white-pale-yellowish gray gypsum and hlalite interbeds. They are often found at basement of intermontane basins of Taleghan na Alamout as being sources of saline spring, but their existance in the Plain area is not confirmed.

In Qazvin plain, Neogene rocks is belonging to entirely to the "Hezardarreh Formation", cropping out at dissected low hills along the western and northern fringes of the Plain, Generally, they have at least 1,000 m thickness, and comprising of pale purple-gray conglomerates, breccias, sandstone, red-brown siltstone. Thick conglomerates layer was accumulating in the alluvial fans, where streams or rivers draining flanking mountains debauched in to basins. While far from drainage, the fine clastic deposits were deposited in hypersaline-lagoonal condition. in Oligocene-early Miocene marine transgression. In the central part of Qazvin plain near by Salt marsh, Recent silt or silty clay is submerged by floodwaters during parts of most winters, and even in late summer the water table lies close below the surface. Crusts of halite are developed during the summer months in places where capillary rise of saline groundwater maintain the superficial sediments.

2.2.3 Climate Conditions

Iran has a variable climate. In the northwest, winters are cold with heavy snowfall and subfreezing temperatures during December and January. Spring and fall are relatively mild, while summers are dry and hot. Being located in the northern part of the country, the Study Area belongs to the semi-arid climatic zone. The Study Area is located, in a macroscopic view, in the depression surrounded by areas of the great Alborz mountain massif, west Zagros highlands and the western part of the Kaveer salt desert, specified by its altitude ranging from 800 m to 4,300 m above mean sea level. The climate of the area is Mediterranean with air mass brought from west in winter and from east in summer. Pluvial air mass visits the area from west or north with humidity which changes to precipitation on the way when crossing Azerbaijan, Zagros and Alborz mountains, decreasing its influence as it invades further towards east and south. For this reason, intensity and amount of precipitation of the area is under a close relation with latitude and altitude indicating 700 to 800 mm in the western and northern highlands and 100 mm or less in the southern and eastern border near the Kaveer salt desert.

Precipitation in the Study Area is also Mediterranean. Summer is completely dry and precipitation occurs only in winter season. Nearly 90% of annual precipitation is brought in the months from October to June with the maximum amount corresponding to 15% of the annual total in the months February, March and April to June. Remarkable part of precipitation is presented as snow.

Average Annual and Monthly Precipitation at Selected Stations

Unit: mm

Code(M/P)	Station	MEH	ABN	AZR	DEY	BAH	ESF	FAR	ORD	KHR	TIR	MOR	SHA	**YEAR**
136550	Galinak	21.5	50.9	55.3	42.0	52.7	73.7	74.5	76.6	23.4	5.5	3.2	3.9	**483.3**
136564	Baghkalyeh	23.4	42.2	49.6	36.0	45.8	60.1	60.1	57.5	20.9	7.1	3.3	1.9	**407.8**
136568	Loshan	8.3	17.6	20.1	21.0	17.6	21.8	28.1	27.2	4.9	1.7	1.9	0.3	**170.5**
711586	Abegarm	11.2	21.8	26.5	24.3	26.6	36.4	37.4	41.1	10.0	3.0	1.3	1.7	**241.5**
711626	Takestan	16.5	31.4	37.2	28.1	32.2	41.3	41.0	46.1	11.6	2.1	2.3	2.7	**292.4**
711694	Ziyalan	13.2	35.6	49.5	38.1	49.2	57.3	57.0	50.5	13.7	3.3	2.2	2.8	**372.3**
711696	Abyek	13.6	24.5	33.8	31.1	37.3	43.5	39.4	36.2	9.7	1.3	2.0	1.6	**274.2**
711700	Karimabad	14.8	18.2	29.6	22.9	25.9	30.9	32.0	26.8	8.3	3.1	3.8	4.8	**221.3**
711776	Qazvin	18.4	33.8	42.8	41.5	45.0	58.3	52.0	56.1	14.8	3.1	2.5	2.8	**370.9**
711778	Roudak	11.6	23.8	31.9	32.9	38.6	50.5	36.2	43.4	8.3	2.8	2.7	1.7	**284.4**
712718	Sira	26.5	54.2	81.0	68.2	84.2	103.2	95.6	82.3	22.9	5.9	3.9	7.0	**634.9**
712722	Bileghan	12.5	30.8	41.4	42.9	48.4	50.5	47.3	45.6	11.3	1.8	1.6	2.4	**336.4**
712762	Latian	16.1	34.7	54.3	51.9	63.6	68.1	55.4	47.7	12.4	4.8	2.3	2.6	**413.8**
712792	Varamin	13.8	13.3	17.5	10.5	14.3	10.6	8.8	10.1	4.4	4.8	4.0	9.2	**121.3**

Source of Data: Ministry of Energy and Iranian Meteorological Organization

Monthly distribution of precipitation is moderate in most regions in the Study Area with annual values ranging from 150 mm at the southeastern corner to 700 to 800 mm at the northeastern corner of the Study Area.. About 65% of annual rain or snow is concentrated in winter season from October to March, however, spring and summer season from April to September still keeps 35% of annual precipitation.

Annual evaporations of either measured or estimated, since direct measurement is usually impossible in freezing months, range from less than 1,500 mm at stations located on relatively higher mountainous areas to 2,100 mm at stations located on flat plain of relatively lower elevation. As for monthly distribution of evaporation, the maximum value is observed in July while minimum is measured in December and January.

Average Annual and Monthly Pan-Evaporation at Selected Stations

Unit: mm

Code (M/P)	Name of Station	MEH	ABN	AZR	DEY	BAH	ESF	FAR	ORD	KHR	TIR	MOR	SHA	**YEAR**
136550	Galinak	71.6	27.4	14.2	15.0	17.0	24.8	38.5	82.5	159.1	281.2	288.2	186.4	**1,205.5**
136564	Baghkalyeh	197.7	111.4	60.9	43.6	44.8	55.6	110.5	183.0	290.1	365.1	343.7	292.6	**2,099.0**
712720	Karaj Dam	138.8	69.7	34.1	24.3	25.7	45.6	90.1	144.8	235.7	290.1	279.8	224.0	**1,602.7**
711626	Takestan	204.2	84.4	43.5	28.3	25.3	41.2	90.6	173.8	267.4	389.3	396.6	360.3	**2,105.0**

Data Source: Tehran Regional Water Board

Average annual and monthly air temperatures are also collected at major meteorological stations of which some are summarized in the following table. In Tehran city, coldest month is January with the maximum daily temperature of 7 degree Celsius and the minimum daily temperature of –3 degree Celsius, while the hottest month is July with the maximum of 37 degree and the minimum of 22 degree Celsius. It is noted here that at the stations located in mountainous area of higher elevation where implementation of transbasin water diversion plans are proposed, absolute minimum temperature falls below –10 degree Celsius during winter season, with the lowest temperature of –27 degree Celsius observed at Karaj dam in February. Special attention will be needed for preparation of facility construction plan.

Average Annual and Monthly Air Temperature at Selected Stations

Unit: ℃

Code (M/P)	Name of Station	MEH	ABN	AZR	DEY	BAH	ESF	FAR	ORD	KHR	TIR	MOR	SHA	**YEAR**
136550	Galinak	11.1	3.9	-0.5	-2.9	-2.9	0.3	5.6	10.8	15.0	20.9	20.4	17.4	**8.2**
	(Abs. Min)	0.2	-12.4	-13.7	-19.3	-20.4	-12.7	-3.7	1.4	5.2	6.8	6.2	4.4	
136564	Baghkalyeh	17.5	11.7	6.0	2.4	2.4	6.0	12.0	16.9	21.7	25.2	25.5	23.0	**14.2**
712720	Karaj Dam	11.0	4.2	-1.4	-7.4	-5.2	-1.6	6.2	10.5	14.1	19.2	18.0	16.0	**7.0**
	(Abs. Min)	-1.5	-7.0	-15.5	-24.5	-27.0	-21.0	-15.0	-4.5	0.5	6.0	7.0	3.5	

Data Source: Tehran Regional Water Board

It is commonly recognized in Iran that average monthly temperature has a close correlation with altitude where station is located. Such relations are extracted from the Master Plan report as described below.

Average Monthly Temperature by Altitude

Unit: mm

Altitude	Item	MEH	ABN	AZR	DEY	BAH	ESF	FAR	ORD	KHR	TIR	MOR	SHA
1500m	Average Max.	24.8	17.7	10.6	6.4	6.6	11.0	17.7	23.4	29.8	34.3	34.4	31.3
	Mean	16.8	10.8	4.7	0.9	1.0	5.2	11.2	16.3	21.7	25.6	25.8	22.6
	Average Min.	8.4	3.9	-1.1	-4.5	-4.6	-0.6	4.6	9.1	13.4	17.0	17.2	13.8
2000m	Average Max.	22.6	15.3	8.0	3.7	3.9	8.6	15.4	21.0	27.8	32.7	32.8	29.5
	Mean	14.3	8.2	2.0	-2.0	-1.8	2.7	8.9	13.8	19.3	23.6	23.7	20.3
	Average Min.	5.8	1.2	-3.9	-7.5	-7.6	-3.2	2.2	6.6	10.8	14.5	14.6	11.0
3000m	Average Max.	18.2	10.6	2.9	-1.6	-1.4	3.8	10.8	16.3	23.7	29.5	29.5	25.8
	Mean	9.3	3.1	-3.3	-7.7	-7.4	-2.3	4.3	8.9	14.6	19.5	19.5	15.7
	Average Min.	0.2	-4.2	-9.4	-13.5	-13.6	-8.4	-4.5	1.6	5.6	9.5	9.4	5.4

Data Source: Tehran Regional Water Board

2.2.4 Land Use

The Taleghan and Almout river basin is formed with the high mountainous and plateau areas and the important watershed to foster the surface water resources. The mountainous area is not covered with forest and vegetation and not used for agriculture and other purpose, but the plateau area is covered with natural shrub and grazing and used for feeding place of sheep. Some villages are spreading in the plateau and alluvial plain along the river and their inhabitant has engaged in agriculture. The regions consisting of Tehran, Karaj, Hashtgerd and Qazvin also are divided into the mountainous area as explained in 2.1.1.

The mountainous area of 4,825 km^2 in the region is located mainly at the upper basin of the Kan river in Tehran region, the Karaj river in Karaj region, the Kordan river in Hashtgerd region and many small rivers in Qazvin region, and has supplied the important surface water to agriculture and groundwater recharge. There are existing Karaj big reservoir dam, Bileghan weir and intake, Kordan weir, Ziaran regulating dam, etc. and a number of wells and Qanats to supply the domestic, industrial and agricultural water. The mountainous area and plateau in the region also is covered with natural grazing and has been used for feeding places of sheep.

The plain area in the region is 8,830 km^2 and its land use is shown in the following table.

Land Use at Plain in Region

Unit: km^2

Region	Agricultural Area			Other land including urban/rural area	Total
	Irrigated farming	Dry farming	Total		
Tehran	409	81	490	1,339	1,820
Karaj	378	66	444	496	940
Hashtgerd	214	142	356	424	780
Qazvin	1,159	2,351	3,510	1,780	5,290
Total	**2,160**	**2,640**	**4,800**	**4,039**	**8,830**

Note : Irrigated farming area is based on the 1998's data

As for the agricultural area, Qazvin region has the largest area of 350,000 ha occupying 73 % of total agricultural area in the region but its irrigation area is not large as 116,000 ha or 40 % of total agricultural area in Qazvin region. Tehran, Karaj, and Hashtgerd regions have not a large agricultural area compared with that in Qazvin region but the agricultural area is mostly irrigated. The irrigation area of 100,000 ha in those three regions is located near the Tehran city and has supplied many kinds of agricultural products to Tehran market. The winter crops of wheat and barley are cultivated at the dry farming area, while summer crops of sugar beet, beans, maize, feeder crops, vegetables, etc. are cultivated at the irrigation area.

The large scale urban and industrial development has been promoted and achieved in Tehran city and Tehran, Karaj and Hashtgerd regions, and as a results the land use for urban and industrial purposes has been escalated in recent years. Some of new area in Qazvin region also is expanding as the urban and industrial area in addition to the expansion of the existing urban area of Qazvin, Takestan, Buin, etc.

In accordance with the large urban and industrial and agricultural development in the Tehran western capital area, the land use for economical infrastructures such as the high way, provincial roads, railway, power stations, electrical lines, water supply facilities, etc., also has been expanding. Accordingly, unused land in the western area will be disappeared near future and the land cost has been escalated year by year.

2.3 Socio-economic Conditions

2.3.1 National Economy

Although Iran enjoys a relatively high per capita GDP (US$ 1,650 in 1376: 1997/98) among Middle East countries, and exhibits healthy social indicators including life expectancy (71 years in 1376: 1997/98), literacy (80% in 1375: 1996/97), primary enrollment (90% in 1375: 1996/97), and access to safe water (90% in 1376: 1997/98), record-low prices in the international oil market have actualized expansion of fiscal deficits, deterioration of international balance of payments, high unemployment rate, acceleration of inflation and economic stagnation.

Iran is OPEC’s second largest oil producer and accounts for roughly 5% of global oil output. The country holds 9% of the world’s oil reserves and 15% of its gas reserves. However, the Iranian economy depending entirely upon oil and gas exports is facing acute problems, exacerbated by record-low oil prices in 1377 (1998 and early 1999).

(1) GDP Growth Rate and Inflation Rate

Real GDP growth rate (1361: 1982/83 constant prices) in 1377 (1998/99) was constrained to 1.6% as a result of slumping productivity in the construction sector (-6.9% growth during 1375-77: 1996/97-1998/99) and record-low international oil prices (-3.1% growth for the same period), compared to an average growth rate of 4.6% experienced during the period 1370-76 (1991/92-1997/98) (see Table 2.3.1.1 in the Supporting Report). Other macro-economic indicators are summarized in the Database Map Table 2.2.1.

Since the Islamic revolution, the annual rate of inflation has averaged 22%, with a peak of 59% in May 1995, and a low of 3% in June 1990. Thus, inflation has not only been high but also fairly volatile. One of the major goals of the Second 5-year Economic, Social and Cultural Development Plan was to bring down inflation to a consistent single digit level. The rate of change in the consumer price index declined sharply from 49% in 1374 (1995/96) to 23% in 1375 (1996/97). In 1376 (1997/98), the prices of water, electricity and gas exhibited the largest rise at 49%, compared to the general index of producers' prices accounting for 16% (see Table 2.3.1.2 in the Supporting Report).

(2) Sectoral Structure of the GDP

Sector-wise contributions to the GDP in 1375 (1996/97) were 26% for agriculture, 17.5% for oil, and 15.8% for manufacturing, while in 1377 (1998/99), these shares of the GDP were, respectively, 27.7%, 15.6%, and 17.1%, reflecting slumping activity in the oil sector on the one hand, and conversely a modest growth in the agricultural sector. Therefore, the agricultural sector still remains the mainstay of the industrial structure of the country (see Table 2.3.1.3 in the Supporting Report).

(3) National Budget

Despite that the achievement of a balanced budget, defined as zero borrowing from the banking system, was one of the primary goals of the Second 5-year Economic, Social and Cultural Development Plan, Iran suffered from a national budget deficit in 1376 (1997/98) and 1377 (1998/99), relying on oil and gas sales as an important funding source (51.3% of the total revenue in 1376 down to 43% in 1377). This fiscal position was further aggravated by a large shortfall in oil export earnings, and lower-than-expected non-oil revenue (comprising tax and non-tax revenue, and earmarked revenues). The fiscal deficit was widened from 2.4% of GDP in 1376 (1997/98) to 3.8% of GDP in 1377 (1998/99).

In 1377 (1998/99), the water resources sector and the agriculture and natural resources sector were the recipients of only 0.6% and 0.9% of the total government development expenditure, respectively (see Table 2.3.1.4 in the Supporting Report).

(4) Exchange Rate

The government maintains a dual official exchange rate system and a free market rate system. The two official rates, which comprise the floating rate at 1,750 rials per U.S. dollar and the export rate at 3,000 rials per U.S. dollar, have remained unchanged since May 1995, while the present free market rate is around 8,000 rials per U.S. dollar. Consequently, the official exchange rates have become increasingly overvalued in real effective terms, and have been adopted to protect domestic industries. In general, the floating rate applies to oil and gas export receipts, imports of essential goods (wheat, barley, rice, maize, soybeans, sugar, hybrid seeds, edible oil, fertilizers, pesticides, meat, tea, detergent, vitamins, medicine for livestock, tractors, agricultural equipment, etc.) and services, to public sector debt services, and to the export rate for all other official current account transactions, including non-oil export, imports of industrial goods, spare parts, raw materials, and service receipts.

Since May 1995, the authorities have been implementing a phased strategy aiming at unifying the exchange rates in the context of liberalizing the trade regime, and also in accordance with the Second 5-year Economic, Social and Cultural Development Plan. In this context, the import coverage of the more appreciated floating exchange rate has been gradually reduced and a market for import certificates has been created through the Tehran Stock Exchange.

(5) Government Subsidies

A number of goods and services are subject to price controls and subsidies, which have mainly been determined by the Consumer and Producer Protection Organization (CPPO). Subsidies can be divided into three categories: (a) income subsidy, which is a kind of subsidy paid in cash to increase the incomes of low income groups; (b) value subsidy, which is subsidy paid in the form of special coupons with certain monetary values for consumption of basic goods by low income groups; and (c) indirect subsidy, which is subsidy paid to reduce the prices of basic goods lower than their real market prices. CPPO has performed the functions of determining administered prices and paying subsidies for basic goods. The price-setting function of CPPO covers goods that are subsidized and made available through the coupon system (wheat, rice, sugar, edible oil, milk, cheese, meat, fertilizers and pesticides); related goods and services (flour, labour used for production of sugar cubes, sugar beet waste to feed animals, etc.); goods produced by monopolies (e.g. paper, agricultural machinery, petrochemicals, etc.); and other goods imported at the exchange rate of 1,750 rials per U.S. dollar. Coupons are issued by the Ministry of Commerce through the banking system.

Budgetary subsidies in 1375 (1996/97) amounted to 5,980 billion rials, with wheat subsidies accounting for about two-thirds of the total. Imports of subsidized goods are made mainly by the government trading corporations at the exchange rate of 1,750 rials per U.S. dollar. Imports of these goods can also be made by the private sector at 3,000 rials per U.S. dollar, which is profitable in situations when demand is not met by the subsidized supply. Large subsidies stem from under-pricing domestic consumption of petroleum products such as oil and gas in comparison with the international price level of these products, thereby leading not only to negative impacts on the optimization of resource allocation and on efficiency of economic investment in this sector but also an uncontrolled increase in the consumption of the products.

Table 2.3.1.5 in the Supporting Report exhibits government subsidies paid to CPPO, indicating the huge amount of subsidies paid to consumers and producers in the country, and causing a bias in the price mechanism of commodities under free competition. The amount of subsidy in 1377 (1997/98) totaled to 4,579 billion rials, of which 74% were for wheat, followed by 11.4% for chemical fertilizers, and 9.6% for milk and cheese. Subsidized food items in quantity and price are summarized in Table 2.3.1.6 in the Supporting Report.

(6) Third 5-year Economic, Social and Cultural Development Plan

Iran embarked on the Third 5-year Economic, Social and Cultural Development Plan, covering the period 1380-84 (2000/01-2005/06) (fiscal year ending March 20). Policies undertaken in the plan include structural adjustments in governmental administration and public enterprises, promotion of free market-oriented economic competitiveness by removing non-tariff trade barriers, budget and tax reforms, and establishment of a comprehensive social safety net to protect the most vulnerable segments of the population. These policies are aimed at a number of important objectives; in particular, a GDP growth rate averaging 6% over the period and the creation of 765,000 new employment opportunities annually.

Quantitative economic targets contained in the plan are shown below.

Quantitative Economic Targets

Macro-economic Indicators	Second Development Plan	Third Development Plan
Real GDP Growth	5.1%	6.0%
Real Gross Domestic Investment Growth	6.2%	7.1%
Rate of Inflation	12.4%	15.9%
New Employment Opportunities	479,000 (annually)	765,000 (annually)

Source: “Third Five-year Economic, Social and Cultural Development Plan”, Plan and Budget Organization.

Strategic policies for the areas of water resources and agricultural development are outlined below.

(a) Water Resources Development

1) to achieve sustainable development in water resources;
2) to develop surface water resources to increase agricultural production together with rehabilitation of the existing irrigation networks;
3) to promote the re-use of waste water, and to strengthen water resources conservation management in respect of quantity and quality; and
4) to strengthen water demand management by taking into account appropriate water allocation to different users.

(b) Agricultural Development

1) to attain self-sufficiency in food production by effective utilization of various resources available in the country;

2) to achieve sustainable development in agriculture;
3) to promote agricultural investments and agro-industry activities;
4) to create employment opportunities in the agricultural sector; and
5) to accelerate development in rural areas to solve the problems inherent to urban areas such as excessive population pressure, high unemployment, high water consumption, etc.

As mentioned above, the water resources and agricultural policy initiatives are aimed at freeing the utilization of water resources from substantial dependence on the limited ground water resources and turning it to newly-exploited surface water resources. In this respect, the major objective of this Project conforms to the strategic policies of the plan.

2.3.2 Administrative Divisions

(1) Administrative Divisions

Administrative divisions of Iran in 1376 (1997/98) comprised 28 provinces (Ostan), 261 sub-provinces (Shahrestan), 703 counties (Bakhshe), 673 cities, and 2,222 rural communities (Dehestan) as shown in Table 2.3.2.1 in the Supporting Report, while the Study area covers the 2 provinces of Tehran and Qazvin, 10 sub-provinces (7 sub-provinces of Savojbolagh, Eslamshahr, Tehran, Varamin, Rey, Shahriyar and Karaj in Tehran province, and 3 sub-provinces of Qazvin, Buin Zahra and Takestan in Qazvin province) as shown in Table 2.3.2.2 in the Supporting Report. It should be noted that the present Qazvin province was included in Zanjan province during the census year 1370 (1991/92), and in Tehran province during the census year 1375 (1996/97), excepting that Takestan sub-province remained in Zanjan province.

(2) Socio-economic Characteristics of Major Cities

The western area of the capital Tehran can be broadly categorized into two regional features: (a) an industrial zone centering on Karaj Bozorg, Hashtgerd, and New Hashtgerd where urbanization and industrialization are acute, providing an engine for future economic growth for the country; and (b) an agricultural zone centering on Qazvin plain which is agronomy based, functioning as a food supply base for the capital Tehran and its environs. Development in the western area together with Qazvin plain, therefore, plays a key role not only in achieving sustainable economic growth of the country by rectifying skewed economic levels between urban and rural areas, but also in enhancing self-sufficiency in food production to meet the increased population pressure in major cities.

(a) Tehran

Tehran is the most densely-populated city in Iran with a population of 6.8 million (11.3% of the total population), located at the foot of the Alborz ranges. It is the country's largest commercial and industrial center and the base for small to large modern technological and industrial establishments, constituting a primary engine of economic growth in the country. This is evident from the fact that the industrial production value in Tehran sub-province in 1375 (1996/97) accounted for 13.8% of the national total. There are satellite cities of Karaj, Shahriyar, Eslamshahr, Rey, Robatkarim, Varamin, Damavand and Shemiranat scattered around the capital of Tehran, providing the important trade and marketing linkages. Karaj, Latian and Lar dams together with groundwater resources are the principal source of water for domestic, industrial and agricultural uses, and also produce part of the country's electrical power.

(b) Karaj

Karaj with a population of 941,000 is situated 30 km west of Tehran. A majority of people are commuters to Tehran. It is an economic central base for transportation of various products between Tehran and the Caspian Sea due to its proximity to Tehran. Agro- and agro-processing industries (fertilizers, vegetable and fruit preservation, etc.) and mineral industries (iron, copper, aluminum, etc.) are predominant in Tehran province. It exhibited a marked population increase from 442,000 in 1370 (1991/92) to 941,000 in 1375 (1996/97) at an annual growth rate of as high as 16.3% during the same period (0.9% for Tehran). It is forecast that with further advancement in urbanization, Karaj's capability of accepting population inflow would reach a critical level, thereby resulting in the possibility that some existing agricultural land would be converted to residential area, i.e. a gradual decrease in the agricultural land. The metro line which links Tehran to Karaj is now operational and transports a heavy commuter load to Tehran. The existing Karaj irrigation area is located south of Karaj city.

(c) Hashtgerd Jadid (New Hashtgerd)

Hashtgerd Jadid (25km west from Karaj) is a new residential town fully equipped with public utilities, adjacent to a new industrial complex and the existing Hashtgerd industrial area. The present population is about 10,000, and is forecast to increase by 50-fold to 500,000 in 1395 (2016/17). In conformity with the prevalent law that new industrial establishments should be restricted to locations more than 120 km away from Tehran, there is large potential for industrial development in this area, combined with the existing industrial area in Hashtgerd. The Tehran – Karaj metro line is expected to be extended up to this new town in the near future. The existing Kordan irrigation area is located nearby.

(d) Qazvin

Qazvin lies to the north-west of Tehran on the important freeway between Tehran and Tabriz (125 km from Tehran) with a population of 291,000 in 1375 (1996/97) (its annual growth rate at 0.9% during the period 1370-75: 1991/92-97). It provides a pivotal commercial center for the surrounding agricultural regions, and has the following comparative advantages: (i) geographic location for marketing of agricultural products is favorable given the fact that the largest consumption center of Tehran is only 2 hours away by road; (ii) the existence of the all weather highway from Qazvin to Tehran facilitates trade and marketing of agricultural products, as well as transport of agricultural inputs; (iii) Qazvin province, due to its advantageous location and access, has become a food supply base for Tehran and its environs, which comprise major consumption centers for cereals, vegetables, fruits and livestock products produced in the province; and (iv) through the prevailing rural-urban trade and marketing linkages, the largest consuming area, Tehran, and its satellite cities comprise the greatest potential for increased demand for agricultural products due to ever increasing urbanization and population pressure.

In addition to the above, Qazvin province has large potential not only for agricultural development but also for industrial development, reflecting the fact that agro- and agro-processing industries are widespread in the province.

2.3.3 Demography

(1) Population

Total population in the Study Area in 1375 (1996/97) was 11.2 million, being 18.7% of the national total. Of the total, Tehran sub-province amounted to 6.8 million (60.6% of the total) due to inclusion of the highly-populated urban area of Tehran, Qazvin accounting for 0.99 million (8.9%), and Shahriyar accounting for 0.86 million (7.6%) (see Table 2.3.3.1 in the Supporting Report).

The urban population as a proportion of the total population in the Study Area averaged 83.9% in 1375 (1996/97), exhibiting a relatively high degree of urbanization compared to the national average at 61.3%, while the 3 sub-provinces of Savojbolagh, Rey and Shahriyar are characterized as being rural.

The average annual rate of population growth for the period 1370 (1991/92) to 1375 (1995/96) in the Study Area was 2.26% (2.34% for urban areas, and 1.89% for rural areas), being highest at 11.06% for Shahriyar sub-province, and lowest at 0.17% for Savojbolagh sub-province (see Table 2.3.3.2 in the Supporting Report).

As shown in Table 2.3.3.3 in the Supporting Report, the working population in the Study Area averages 32.3% of the total population (10 years of age and over), being highest at 34.8% for Shahriyar, and lowest at 30.2% for Eslamshahr. In terms of agriculture, Qazvin enjoys substantial agricultural manpower resources at 28.1% (the national average is 23.1%), while Eslamshahr and Karaj suffer a scarcity of the same with the exception of Tehran.

According to FAO (Food and Agriculture Organization) projections, agricultural population during the period 1379-1389 (2000/01-2010/11) is forecast to decrease at an annual rate of 0.51% for the country due to continued rapid urbanization and industrialization.

As shown in Table 2.3.3.4 in the Supporting Report, population density in 1375 (1996/97) averaged 387.7 persons/km^2 (exceeding the national average of 36.8 persons/km^2), ranging from 64 persons/km^2 for Qazvin to 4,037 persons/km^2 for the most densely-populated Tehran.

(2) Population Projections

Population projections for years 1380 (2001/02), 1385 (2006/07), 1390 (2011/12), and 1400 (2021/22) have been made based on the average annual rate of population growth for the period 1370 (1991/92) to 1375 (1996/97), and also by taking into due consideration consistency with the National Water Master Plan (1377: 1998/99) as shown in Table 2.3.3.5 in the Supporting Report. It should be noted that Varamin and Rey sub-provinces comprise only Qarchak and Hasanabad, respectively; and that the rural population in Eshtehard is excluded from Karaj sub-province.

The population of the Study Area is forecast to grow at an annual rate of 1.77% (the national growth rate is 1.64%) during the period 1375-1400 (1996/97-2021/22), comprising 2.14% for urban areas (2.25% for urban areas nationwide) and –0.99% for rural areas (0.43% for rural areas nationwide). The projected rural population decrease is further supported by the fact that the rural population in Savojbolagh sub-province declined by 29.3% during the period 1370-75 (1991/92-1996/97) at an annual growth rate of –6.69%, and –1.66% and –0.52% growth rates were also recorded for Qazvin province, and the whole country, respectively. Furthermore, this predicted trend is deemed well justified when consideration is given to the huge number of migrants coming from rural areas in Tehran and other provinces to Tehran province itself, e.g. about 430,000 inter- and intra-city migrants resided in Tehran province during the period 1365-75 (1986/87-1996/97). It is worth noting that this tendency cannot be fully explained only in terms of significant population inflow in search of employment opportunities in urban areas. It is also due to the acceleration of the pace of urbanization and industrialization in rural areas in general, and when the capacity of such urban centers to absorb migrants reaches a critical level, migrants are reluctant to opt for residing in the more remote rural areas.

(3) Households and Average Family Size

The number of households and average family size in the Study Area in 1375 (1996/97) are shown in Table 2.3.3.6 in the Supporting Report. As indicated in the table, the number of households in the Study Area in 1375 (1996/97) accounted for 20.9% of all households in the country. Of this, Tehran accounts for 60.6% of the population and 64.3% of the households in the Study Area, respectively. Average household size in the Study Area is 4.3 persons, which is slightly smaller than the national average of 4.8 persons. In general, household size tends to be smaller in urban areas than in rural areas, and this trend is expected to remain unchanged in the future.

(4) Unemployment

As a result of the direct impacts of the recent record-low international oil prices on the Iranian economy, the unemployment situation has worsened not only in urban areas but also in rural areas, constituting an important social issue for the Government. The effects of this unemployment are particularly serious in urban areas. Given the fact that most employment opportunities are created in urban or industrial areas, inter- and intra-immigration is considered a crucial determinant in increasing unemployment in urban areas owing to differences in income levels and other factors. Regional imbalance, limited employment opportunities in rural areas, and other economic, social and cultural factors caused migrants to increase by 430,000 persons during the period 1365-75 (1986/87-1996/97). Most of these migrants were youth.

Additionally, the youth population amounted to 36.6 million in 1375 (1996/97) and is forecast to increase by 38.3% to 50.6 million in 1385 (2006/07). The Third 5-year Economic, Social and Cultural Development Plan, therefore, includes creation of new employment opportunities of 765,000 annually during the plan period to overcome the current unemployment situation. It is, accordingly, essential and urgent to control huge population inflow into urban areas by appropriate measures to develop rural areas through promotion of agricultural development and/or industrialization. In this respect, implementation of this Project is vital, guaranteeing creation of new employment opportunities, and adequate and stable water supply for the agricultural and industrial sectors in rural areas.

Table 2.3.3.7 in the Supporting Report indicates unemployment rates by sub-provinces for 1375 (1996/97). The unemployment rate for the Study Area in 1375 (1996/97) averaged 6.1% (compared to the national average at 9.1%), being highest at 8.2% for Karaj, and lowest at 4.4% for Rey. Reasons for this result include theworsening unemployment situation in Tehran for the former case; and Rey's geographical location in rural area where agriculture is predominant for the latter case.

2.3.4 Regional Economy

(1) Industry

The industrial sector has continued to be dominated by relatively few but large public enterprises that account for approximately 70% of the GDP in the manufacturing sector. Public enterprises have relied on relatively capital-intensive production while the private sector has been characterized by labour-intensive production. Real growth in the industrial sector in 1377 (1998/99) reached 4.9% while the share of industrial contribution to the GDP continued to increase, having reached 17.1%. The construction sector was the most dynamic sector in 1375 (1996/97), having significantly grown by 10.6% due to the expansion in both housing and commercial construction in Tehran, partly as a result of local government policies to relieve shortages of housing and office space.

As shown in Table 2.3.4.1 in the Supporting Report, the industrial production value in the Study Area in 1375 (1996/97) amounted to 12,538 billion rials, being 15.1 % of the national total. The share of the value in the Study Area is highest at 91.4% for Tehran, and lowest at 0.2% for Savojbolagh where the fledgling industrial cities, Hashtgerd and Hashtgerd Jadid are located. Nevertheless, Hashitgerd, Hashitgerd Jadid and Alburz have large potential for rapid industrialization in the near future.

The manufacturing sector in the Study Area is summarized in Table 2.3.4.2-3 in the Supporting Report. Based on base-structure and employment pattern in the manufacturing sector, the characteristics of each major city are mentioned below.

(a) Tehran and Karaj

Of 12,872 billion rials (the total industrial production value in the Study Area in 1373: 1994/95), Tehran and Karaj enjoy a predominant position in industrialization at 98.3% of the total. The major industries include machinery and equipment (32.9% of the total value in Tehran and Karaj), chemical products (21.0%), food products (16.6%), textile and leather products (11.3%), and non-metallic mineral products, e.g. cement, quarrying, etc. (6.7%), with a total of 4,420 factories employing about 300,500 persons, and providing the primary engine for economic growth in the country as a whole. However, in consideration of the industrial law limiting new industrial establishments to be located over 120 km away from Tehran, and in light of the deceleration of the earlier rapid pace of industrialization and urbanization in these areas, it is forecast that no significant change will occur in terms of base-structure and employment pattern in the industrial sector. According to the National Water Master Plan (1998), industrial establishments are expected to increase from 4,420 units in 1373 (1994/95) to 6,880 units in 1400 (2021/22) with employment increases from 300,500 persons to 378,600 persons in the same period.

(b) Hashtgerd

Hashtgerd accounted for only 0.2% of the total industrial production value in the Study Area in 1373 (1994/95), providing an indicator of the area as being industrially underdeveloped. In this area, paper and printing constitutes a primary industry at 38.2% of the total industrial production value in Hashtgerd, followed by machinery and equipment at 19.9%, metal products at 16.1%, food products at 12.9%, and textile and leather products at 8.1%. Based on comparative advantages in its location (being in the neighborhood of a new industrial complex in Hashtgerd Jadid, a new residential town with population forecast at 500,000 persons in 1395: 2016/17 and irrigated areas in Kordan and Karaj), access (being located along the main freeway extending from Tehran to Tabriz), as well as land availability, Hashtgerd has large potential for industrial development especially in the food processing industry. The food processing industry is forecast to increase production facilities from 1 unit in 1373 to 524 units in 1400, and from 11 persons to 14,900 persons in terms of employees.

(c) Qazvin

Qazvin accounted for only 1.5% of the total industrial production value of the Study Area in 1373 (1994/95). The primary industries in Qazvin comprise machinery and equipment (32.8% of the total industrial production value in Qazvin), food products (23.4%), chemical products (18.3%), non-metallic mineral products (15.7%), and metal products, e.g. steel and iron, copper and aluminum (1.0%). The food industry includes production of meats and diary products, fruit and vegetable preservation, and sugar and wheat flour milling. Qazvin where an agronomy-base economy is predominant plays a pivotal role as a food supply base for the largest consuming area, Tehran and its environs, due to its advantageous geographical location and access. In order to cope with future food demand increases in Tehran and its satellite cities due to increasing urbanization and population pressure, it will be necessary to pursue year-round irrigated agriculture (directed at crop diversification in conformity with regional climate) in light of the large potential for expansion of farmland and achievement of high cropping intensity given adequate irrigation water availability to secure a sufficient food supply and generate new employment opportunities in both the agricultural and agro-industrial sectors. The role of these sectors as a base industry can accordingly be expected to increase in economic importance. Referring to the National Water Master Plan (1998), industrial production facilities are forecast to increase from 103 units (5,455 employees) in 1373 (1994/95) to 1,710 units (78,400 employees) in 1400 (2016/17) with full development of the Alborz industrial complex closely located to Qazvin city, while the food industry is expected to significantly increase from 18 units (772 employees) to 200 units (8,100 employees).

(2) Agriculture

(a) Agriculture in the Study Area

(i) Crop Cultivation

Agriculture continues to play an important role in the Iranian economy, contributing 27.7% of the GDP (1375: 1996/97) and accounting for 23.1% of the working population. Rural areas in the Study Area are characterized by a predominantly subsistence agricultural economy with severe irrigation water shortage, small land holdings (e.g. 2.5 ha for the Karaj and Kordan irrigation areas and 3.0 ha for the Qazvin irrigation area). Agriculture in the Study Area is generally not commercialized and exhibits low productivity. Disparities in income and employment opportunities are wide and persistent due to small land holdings and unavailability of adequate irrigation water throughout the year. Apart from the disadvantaged segment of the rural population, food security is guaranteed in the case of higher income groups who are practicing a multiple cropping system along the irrigation networks based on comparative geographical advantages. Given the fact that the irrigation networks in the Karaj and Kordan irrigation areas have recently dried up completely, making the comparative geographical advantages ineffective, the viability of regional agriculture is severely threatened.

Cropped area, production and yields of major crops in Tehran and Qazvin provinces in 1377 (1998/99) are shown in Table 2.3.4.4 in the Supporting Report. Major crops in the Study Area comprise wheat, barley, industrial crops (sunflower seeds, cotton and sugar beets), tomatoes and potatoes. As of 1377 (1998/99), irrigated farming accounted for as high as 93.6% of wheat cropped area in Tehran province, while the same proportion for Qazvin province was as low as 48%, indicating inadequate irrigation facilities in the Qazvin plain. Wheat cropped area in the Study Area in 1377 (1998/99) was 106,920 ha (4.8% of the national total), with an average yield at 3,437 kg/ha (national average: 3,423 kg/ha).

(ii) Crop Prices

Essential food crops in the Study Area are purchased from farmers by private marketing agents/dealers at free market prices, and also by the Ministry of Commerce at guaranteed procurement prices as shown in Table 2.3.4.5 in the Supporting Report.

(iii) Chemical Fertilizer Prices

Generally speaking, low prices for agricultural inputs (chemical fertilizers and agro-chemicals) combine with stable prices for agricultural products to provide production incentive to farmers, in turn spurring increased consumption. In the case of Iran, however, high government subsidies for agricultural inputs have become subject to the pressures for tightening government expenditure. Agricultural inputs in the Study Area are marketed through the Agricultural Support Services Company organized under the Ministry of Agriculture at uniform prices (guaranteed prices) with limited quantity, and through private traders at free market prices. The prices for the former are much cheaper than the latter as shown in Table 2.3.4.6 in the Supporting Report.

(iv) Self-sufficiency in Food Production

The government plans to continue to support the agricultural sector through a number of policy interventions, with the view to promoting food self-sufficiency as envisaged in the Third Five-year Plan (1380-84: 2000/01-2005/6). To help meet this objective, the government is continuing to take necessary steps to ensure adequate supplies of chemical fertilizers and agro-chemicals at subsidized prices, and prices for internal procurement (guaranteed procurement prices) of wheat, rice and other essential food items are continuing to be set to cover the cost of production and a profit margin, though at a substantially heavy burden to the government budget.

As shown in Table 2.3.4.7-8 in the Supporting Report, a food gap of 6.5 million tons of wheat between availability (12.07 million tons) and requirement (18.57 million tons) emerged in 1378 (1999/00) with a wheat self-sufficiency rate at 45.8%, and the gap was covered by government and private imports. Wheat imports are forecast to increase from 5.65 million tons (self-sufficiency rate at 59.2%) in 1379 (2000/01) to 6.76 million tons (self-sufficiency rate at 59.5%) in 1388 (2009/10), causing a heavier burden to the budget. Wheat subsidies in 1377 (1997/98), for instance, accounted for about 74% of total budgetary subsidies amounting to 4,579 billion rials.

Province-wise self-sufficiency rates in food production have been estimated on the assumptions that ① Tehran province comprises the sub-provinces of Savojbolagh, Eslamshahr, Tehran, Varamin (Qarchak only), Rey, Shahriyar and Karaj, while Qazvin province consists of Qazvin, Takestan and Buin Zahra, based on the population mentioned in Table 2.3.3.6 in the Supporting Report; ② crop production has been fixed at the average for 1377/78 (1998-00) in the whole Tehran and Qazvin province and remains unchanged over the period 1375 (1996/97) to 1400 (2021/22); and ③ per capita crop consumption has been determined as the average for 1366 (1987/88), 1371 (1992/93) and 1376 (1997/98) and taking into account feed and seed uses, and waste (see Table 2.3.4.9 in the Supporting Report), and are summarized in Table 2.3.4.10 in the Supporting Report wherein the self-sufficiency rates are approximate and may be somewhat overvalued.

The self-sufficiency rate of wheat in Tehran province in 1375 (1996/97) was estimated at 10.3%, and is expected to decline to 6.5% in 1400 (2021/22) due to high population pressure and scarcity of farmland, while that in Qazvin province is forecast to decrease from 106.4% in 1375 to 76.3% in 1400 if the present farming practices remain unchanged in the future. The crops for which self-sufficiency was possible in 1375 were barley and tomatoes for Tehran province, and wheat, barley, maize, beans, potatoes, tomatoes and grapes for Qazvin province where agriculture is predominant. Barley and maize are used mostly for animal feed.

In these circumstances, it is deemed essential to promote further agricultural development, including livestock and poultry with the view to reducing the heavy dependence on the government subsidies for wheat and other basic food imports and eventually attaining food grain self-sufficiency in the country. Consequently in this regard, the implementation of this Project is highly important.

Although the Government emphasizes self-sufficiency in food production in the Third 5-year Economic, Social and Cultural Plan, agricultural productivity cannot be raised without a perennial irrigation water supply. It is, therefore, essential to secure stable irrigation water supply and increase the productivity and cropping intensity of existing farmland to maintain and strengthen the important role of regional agriculture, especially in the Qazvin plain, providing a food supply base for Tehran and its environs. As the regional agricultural sector continues to be one of the major sources of employment and income, and is overwhelmingly dominant in terms of labour force absorption, introduction of market-oriented multiple cropping to the Study Area constitutes a major potential for generating substantial seasonal employment and income opportunities, especially for subsistence farmers.

(v) Livestock and Poultry

Livestock and poultry breeding, and the production of dairy products are important sources of supplementary income and employment opportunities in the Study Area, as well as contributing to improved nutrition for the increasing population in Tehran and its environs. Table 2.3.4.11 in the Supporting Report indicates the production of livestock and poultry products in the Study Area. Production of red and poultry meats in the Study Area in 1377 (1998/99) accounted for 29.0% of the national total, hen eggs at 37.7%, and milk at 11.1%. In terms of self-sufficiency in such production within the Study Area itself, this was 130.6% for the production of poultry meats and 275.7% for eggs; especially that in egg production in Qazvin was as significantly high as 761.9%. In particular, Qazvin province clearly enjoys full self-sufficiency in the production of the above-mentioned products.

(b) Agriculture in Qazvin Plain

The characteristics of the prevalent farming practices in the Qazvin plain are summarized as follows.

- The agricultural sector comprising cultivated agriculture, horticulture, and livestock and poultry breeding, together with agro-based industries in Qazvin province continues to occupy a predominant position in the regional economy, providing a primary engine for rectifying regional economic imbalances. It also has the capacity to provide immediate locomotive effect on stimulating the regional labour market, and a high capacity to absorb labour. Consequently, the role of this sector as a base industry can be expected to increase its importance in the future.

- Agriculture has already attained a shift from subsistence agriculture to commercialized or specialized agriculture with crop diversification including high value crops. Nevertheless, it has been adversely affected by a severe two-year draught, causing in particular production of food grains to decrease substantially. Therefore, it is essential that adequate irrigation water is secured through maximized water use efficiency when needed and that productivity and cropping intensity of existing farmland be increased to maintain and strengthen the role of agriculture in this region.
- Fruit growing is an important source of household income. Particularly, grapes in Qazvin province are popular in Tehran, and solid demand for exists. Commercial fruit production is significant due to relatively good marketing network and processing facilities.
- Farmers raise cattle, sheep, goats and chickens. These are primarily for home consumption with surplus being shipped to market. Livestock and poultry raising is popular in the Qazvin plain due to the high availability of animal feed crops, such as barley, maize, alfalfa and clover. There may be a considerable additional potential as well as the current need for promoting livestock and poultry breeding, and production of dairy products as an important source of income and employment opportunities in this region.
- The Qazvin plain functions at present as a food supply base for the major consumption area of Tehran and its environs by effective use of the existing rural – urban marketing linkages. This reflects the comparative advantages (geographically favourable location, and high development potential to ensure adequate and stable food supply) which the plain has over other producing areas with regard to food production destined for Tehran and its environs.
- Given completion of the Qazvin – Buin Zahra road segment currently under construction to augment the existing road network extending through the benefit area, transport of agricultural products and inputs can be accomplished more smoothly thereby reducing transport time and cost. This will in turn enable reduced shipping cost and more advantageous price structure for commodities.
- Improved and hybrid seeds are mainly distributed to the farmers of the benefit area via the Qazvin Agricultural Supporting Services Company, but not in adequate quantities. It is, therefore, recommended that a seed production structure be established whereby

small farmers who are particularly in a socio-economically disadvantaged position specialize in profitable seed cultivation. This will enhance and stabilize their income, and simultaneously assure timely and stable seed supply to the farmer groups/organizations. To accomplish this, it will be necessary to avail of agricultural technology support from the Qazvin Agricultural Organization, together with provision of agricultural credit from the state-owned commercial banks.

- Chemical fertilizers are distributed to the farmers via the Qazvin Agricultural Supporting Services Company, as well as private traders. Nevertheless, it is reported that supply of fertilizers in a timely manner and in appropriate quantities is not be carried out. In order to rectify this, the government is encouraging the participation of the private sector in the fertilizer market; however, since private traders are not eligible for government subsidy which enables the agricultural supporting services company to maintain a uniform price throughout the country, there is concern that retail prices by private sector entities would show regional variations with higher prices. Accordingly, in order to ensure timely and adequate supply of chemical fertilizers, it is essential that the Qazvin Agricultural Supporting Services Company formulate a fertilizer demand plan based on each year's cropping plan in close collaboration with the Qazvin Agricultural Organization. In addition, it is necessary to extend credit to small farmers to assist them in achieving the economic independence to purchase fertilizers.
- Low farmer awareness about quality control and consumer emphasis on cheap price rather than quality are principal factors in the lagging introduction of a standardization and grading system for agricultural products in the benefit area; and thereby forcing farmers into the weak position of price-takers rather than price-setters. It is, accordingly, necessary to cultivate such awareness about the importance of quality control at the producer, or farmer end. Appropriate quality control will ensure an advantageous farm-gate price for farmers, as well as a more attractive margin for collection and shipping agents and millers.
- Crop storage and post-harvest losses can be seen at a substantially high rate. Therefore, a storage and post-harvest loss reduction program should be initiated with the aim of modernizing food storage at the farm level. This program to transfer appropriate food storage technology to the farmer is an important step in improving the self-sufficiency rate of food production in the benefit area.

Considering the above characteristics of the Qazvin plain, it will be necessary to pursue irrigated agriculture (directed at crop diversification in conformity with the regional climate) with a view to coping with future demand increases in Tehran and its satellite cities due to increasing urbanization and population pressure (rural – urban migration). There exists large potential for expansion of arable land to reinforce the role of Qazvin plain as a food supply base and generate new employment opportunities. Accordingly, this Project which ensures perennial irrigation water supply will promote in the Qazvin plain more commercialized or specialized agriculture and development of a market /export-oriented multiple cropping system best suited to the local environment through effective use of land resources, improved agricultural technology, and appropriate fertilizer inputs. This is essential for generating gainful employment and income opportunities in the region. This will, in turn, lead to further promotion of directly linked agri-businesses and a diverse range of related agro-based industries.

2.3.5 Regional Infrastructure

(1) Roads and Highways

Road and highway networks play a pivotal role in the rural-urban trade and marketing linkages. A freeway extends through the Study Area, facilitating the movement of commuters and commodities. Table 2.3.5.1 in the Supporting Report indicates the density of road and highway networks in the Study Area. Density of roads and highways in the Study Area in 1375 (1996/97) was 0.14km/km^2 on average (the national average of 0.05 km/km^2), being highest for Eslamshahr at 0.42 km/km^2, and lowest for Savojbolagh and Varamin at 0.11 km/km2.

(2) Water Supply

Water production in the Study Area was 1,212.55 MCM in 1377 (1998/99), being 30.5% of the national total; and of the total, 68.6% were sold to consumers as shown in Table 2.3.5.2 in the Supporting Report. Despite that Tehran's water supply is currently groundwater (40%) and surface water (60%) conveyed from Karaj, Latian and Lar dams, the area has recently experienced its worst water crisis in decades due to excessive water consumption by Tehranis and poor rainfalls during the winter of 1998 and spring of 1999. This situation will be further aggravated not only by the impacts of uncontrolled immigration to the capital city of Tehran along with its own inherent rapid population growth but also by uncontrolled pumping up of groundwater. Appropriate measures are thus required to exploit new surface water resources, as well as maximum the effective use of available water resources including a legal framework and institutional strengthening to limiting groundwater use..

(3) Electrification

In 1377 (1998/99), the Tehran region generated 19,282,000 MWh of electricity, of which 97.9% were from thermal plants. As shown in Table 2.3.5.3 in the Supporting Report, electricity consumption in the Study Area in 1377 (1998/99) was highest at 41% for households, followed by

27.6% for industry, and 15.5% for commerce; and the Study Area overall consumed electricity at 23.7% of the national total. It is worth noting that industrial consumption of electricity in the Qazvin region is significant at 51.5%.

(4) Education

In rural areas, failure of children to enroll for primary education is a serious problem. Causes for this are the use of children for agricultural labour and low incomes. As shown in Table 2.3.5.4 in the Supporting Report, area coverage for elementary schools in the Study Area averages 6 km^2 per school(national average is 26 km^2), being highest at 15 km^2 for Qazvin sub-province, and lowest at 1 km^2 for Eslamshahr and Tehran sub-provinces. For secondary education, the Study Area averages an area coverage of 15 km^2 per school (compared to the national average of 43 km^2).

Literacy rate in this country is significantly high compared to neighboring countries. Reasons for this include (a) the Government's strong awareness of the importance of education that would be anticipated to encourage greater private sector participation in the marketplace, thereby strengthening and energizing the Iranian economy which has suffered from rising government deficit, worsening international balance of payments, and growing unemployment and inflation, and (b) a huge budget allocation to the educational sector (23.5% of the total current expenditure in 1377: 1998/99).

Literacy rate in the Study Area is as high as 88.1%, compared to the national average at 79.5%. The highest literacy rate is in Tehran sub-province at 90.6%, and the lowest at 79% in Rey province as shown in Table 2.3.5.5 in the Supporting Report. In general, the literacy rate for males is higher than that for females.

(5) Medical Services

The higher disease rate in rural areas compared with urban areas is the central most pressing issue under the Government's health and medical services policy. The current administration is pushing for increased fiscal investment in the health and medical services sector (9.7% of the total current expenditure in 1377: 1998/99) aimed at reduction of the outbreak rate for preventable diseases and establishment of a base level of medical service throughout rural areas.

As shown in Table 2.3.5.6 in the Supporting Report, the area coverage of hospitals in the Study Area in 1375 (1996/97) averaged 205 km^2 per hospital (the national average is 2,380 km^2), being the densest at 15 km^2 for Tehran, and the least dense at 2,785 km^2 for Savojbolagh where the industrial cities of Hashtgerd, Hashtgerd Jadid and Abyek are located. The area coverage for health and medical centers averaged 71 km^2 (the national average is 281 km^2), being the densest at 10 km^2 for Tehran, and the least dense at 199 km^2 for Qazvin. In general, hospitals are concentrated in urban areas; while health and medical centers are more sparsely scattered in rural areas.

Table 2.3.5.7 in the Supporting Report exhibits the area coverage of physicians and dentists in the Study Area in 1375 (1996/97). This result is, needless to say, correlated to the area coverage of hospitals, and health and medical centers. The area coverage of physicians, for instance, averages 2 km^2 per physician in the Study Area (the national average at 32 km^2), being the densest at 0.12 km^2 for Tehran, and the least dense at 121 km^2 for Savojbolagh, indicating skewed levels of regional development.

With full awareness of the fact that regional imbalance is attributed to disparities in socio-economic development which in turn relies heavily on the good availability of water resources, it is deemed necessary to achieve sustainable industrial and agricultural development through implementation of this Project to rectify skewed socio-economic levels among regions in the Study Area.

2.4 Existing Urban, Rural and Industrial Water Use

Data related to the existing urban, rural and industrial water use are collected mainly from the Master Plan and supplementary from the other sources such as Tehran Water and Sewerage Company and JAMAB consultant which has prepared the Master Plan.

2.4.1 Organization

As for the urban water supply, the water supply company at each urban area is exiting and manage the operation and maintenance of the water facilities. However, the industry water and rural domestic water is managed by the Water Board under Ministry of Energy and the Rural Water Counsel in Ministry of Jahad. The classification of organization for water use in the Study Area is summarized in the following table.

Table 2.4.1 Water Management Organization

Area Classification	Water Use Category	Ministry of Energy (Water Board)	Water and Sewerage Company	Ministry of Jahad (Rural Water & Sewerage Counsel)	Municipality
Urban Area	Domestic Water				
	Public Water		○		
	Greenery Water		○		
	Sewerage Water		○		○
Rural Area	Domestic Water		○		
	Greenery Water			○	○
Industrial Area	Ground Water	○			
	Surface Water		○		

Urban Water Supply

The largest organization in the Study Area is Tehran Water and Sewerage Company (W.S.C), which manages the urban water dividing Tehran city into six districts. The companies at six districts manage the operation and maintenance for the water facilities including treatment plan, water supply pipeline networks, deep wells for groundwater use, etc and collection of water fare under the control of the Tehran Regional Water Board (T.R.W.B) which manages the water sources of urban water supply and irrigation. Each W.S.C has three board members consisting of the representatives from Ministries of Energy and Finance and Plan and Budget Organization. The west Tehran W.S.C manages the water supply in Karaj and Hashtgerd urban area and the Qazvin W.S.C manages the Qazvin urban water supply.

Rural Water Supply

By 1983, the Ministry of Health managed the rural water supply for villages with families of less than 150 and Jahad managed the villages with more than 150 families. After 1991, Jahad has full responsibility to manage all rural water supply. The Rural Water and Sewerage Counsel managing the rural water supply has been set up at each province under the control of Jahad.

Industrial Water Supply

The industrial water supply from the surface water sources is managed by W.S.C, but the supply by groundwater for Tehran, Karaj, Hashtgerd and Qazvin industrial area is managed directly by T.R.W.B.

Greenery Water Supply

Greenery water is supplied generally by groundwater and its management is carried out by municipalities of Tehran, Karaj and Qazvin. This water supply is separated from the urban, rural and industrial water supply.

2.4.2 Present Urban Water Supply

(1) Urban Area (City)

The urban area belonging to Tehran city, Tehran, Karaj, Hashtgerd and Qazvin region is classified as follows taking into account the water sources for water supply and irrigation.

Tehran; Eslamshahr, Qarchak and new city to be supplied by groundwater in Tehran

Karaj; Qods, Robat Karim, Hasanabad, Akbarabad, Shariyar, Karaj Bozorg, Mahdasht, Malard and new cities to be supplied by Karaj surface water and groundwater in Karaj.

Hashtgerd; Hashtgerd, Nazarabad, New Hashtgerd and new city to be supplied by groundwater

Qazvin; Abyek, Alvand, Qazvin, Eqbalieh, Buin, Danesfahan, Shal, Esfarvarin and Takistan to be supplied by the Taleghan water and groundwater in Qazvin

(2) Urban Water Consumption and Water Sources in 1996

The urban water consumption in 1996 and its water sources in the Study Area is summarized as shown in the following table based on the data in the Master Plan.

Domestic Water Consumption in Urban Area 1996

City		Population (10^3)	Water Consumption 1996 (MCM)	Per Capita con-sumption (lcd)	Water Sources
1. Tehran City					Surface, 640
	Sub-total	**6,785.8**	**870.0**	**353**	Ground, 230
2. Tehran	Eslamshar	265.4	28.2	291	Ground
	Qarchak	142.7	14.9	286	- do -
	Sub-total	**408.1**	**43.1**	**289**	- do -
3. Karaj	Qods	138.3	14.1	280	Ground
	Robatkarim	36.5	3.6	270	- do -
	Hasanabab	11.2	1.1	259	- do -
	Akbarabad	85.1	8.3	268	- do -
	Shariyar	40.1	4.0	271	- do -
	Karaj Bozorg	941.0	102.7	268	- do -
	Mahdasht	29.0	3.2	300	- do -
	Malard	88.1	8.6	268	- do -
	Sub-total	**1,369.3**	**134.9**	**270**	- do -
4. Hashtgerd	Hashtgerd	32.8	2.9	245	Ground
	Nazarabad	69.0	6.3	249	- do -
	Sub-total	**101.8**	**9.2**	**248**	- do -
5. Qazvin	Abyek	32.8	2.8	231	- do -
	Alvand	60.8	3.2	144	- do -
	Qazvin	291.1	27.8	262	- do -
	Egbalieh	31.5	1.7	148	- do -
	Buin	10.0	1.2	316	- do -
	Danesfahan	8.1	0.8	295	- do -
	Shal	14.1	1.1	213	- do -
	Esfarvarin	11.9	1.0	230	- do -
	Takistan	54.2	4.9	247	- do -
	Sub-total	**514.4**	**44.4**	**237**	- do -
	Total	**9,152.4**	**1,101.6**	**330**	

Data source; the Master Plan

Tehran city consumes a large urban water of 870MCM per annum or 78% of total urban water in the Study Area. Karaj urban area, the satellite town area of Tehran city, also consumes relatively high water amount of 134.9MCM per annum.

(3) Water Sources and Water Supply Facilities

The water sources of urban water supply in Tehran city are the surface water being conveyed from Karaj, Latian and Lar dams and the groundwater brought from the Jaj-rud river basin and wells extracted in Tehran city. The using rate of surface and groundwater is 70% and 30%. The water sources of the other urban area in Tehran, Karaj, Hashtgerd and Qazvin regions are mostly groundwater. Some surface water in the Karaj river is used for Karaj city.

Four water treatment plants are under operation in Tehran city and the western area of city is covered by No.1 and No.2 plants receiving the Karaj water, while the eastern area by No.3 and No.4 plants using the Latian and Lar water. No.5 plant to receive additional Lar water is under construction. The groundwater in all urban area in the Study Area is treated with simplified system, lifted to the elevated tank, and supplied to service area by pipeline system.

The design capacity and annual production of Tehran treatment plant is shown in the following table;

Item	No.1 Plant	No.2 Plant	No.3 Plant	No.4 Plant	No.5 Plant
Year of Construction	1955	1963/70	1968	1984	Under construction
Maximum Capacity (m^3/sec)	3.0	9.5	5.25	5.25	7.50
Normal Capacity (m^3/sec)	2.7	8.0	4.0	4.0	6.75
Annual Production in 1999 (MCM)	55.6	226.5	123.0	129.7	10.0
Source of Raw Water	Bileghan & Well	Bileghan	Latian/Lar	Latian/Lar	Jajrud & Lar

Source; Tehran Water and Sewerage Company

Annual water production by four existing plants with total normal design capacity of 18.7cu.m/sec is estimated at about 590MCM under 24 hours operation.

The design capacity and annual production of Karaj treatment Plant is 0.15cu.m/sec and 4.7MCM respectively. As for the groundwater, number of deep wells, design pumping yield and annual production at each city are summarized in the following table

Design Capacity and annual production of Wells in Urban Water Supply

City		No. of wells	Pumping Yield Per Well (m^3/hr)	Total Pumping Yield (m^3/hr)	Operating Time (hr)	Annual Production (MCM)
1. Tehran City		172	166	28,550	24	250.1
2. Tehran	Eslamshar	25	180	4,500	18	29.6
	Qarchak	24	85	2,040	18	13.4
Sub-total		**49**				**43.0**
3. Karaj	Qods	10	103	1,030	18	6.8
	Robatkarim	7	57	400	18	2.6
	Hasanabab	2	80	160	18	1.1
	Shariyar	17	91	1,550	18	10.2
	Karaj Bozorg	134	87	11,600	18	76.2
	Mahdasht	6	75	450	18	3.0
Sub-total		**176**				**99.9**
4. Hashtgerd	Hashtgerd	4	70	280	18	1.8
	Nazarabad	9	72	650	18	4.3
Sub-total		**13**				**6.1**
5. Qazvin	Abyek	4	140	560	18	3.7
	Alvand	4	135	540	18	3.5
	Qazvin	35	128	4,480	18	29.4
	Buin	2	130	260	18	1.7
	Danesfahan	2	80	160	18	1.1
	Shal	2	115	230	18	1.5
	Esfarvarin	2	120	240	18	1.6
	Takistan	5	132	660	18	4.3
Sub-total		**56**				**46.8**
Total		**466**				**445.9**

- Deep wells in Tehran city and Eslamshar in Tehran region show the high pumping yield of 160 to 180cu.m/hr because cities locate at the north mountain foot area which can recharge easily rainfall and mountain stream water to the groundwater.
- Deep wells at Qods, Shariyar, Karaj Bozorg, etc. in Karaj region being located at the mountain foot area also show the high pumping yield of 80 to 100cu.m/hr. However, Robat Karim being located at the south low area in Karaj region shows the low pumping yield of 57cu.m/hr because of less recharging rainfall and stream water.

- Deep wells in Hashtgerd region show relatively low pumping yield of 70 to 72cu.m/hr due to less mountain stream water to recharge the groundwater.
- Deep wells operated at many cities in Qazvin plain has the high pumping yield of 120 to 140cu.m/hr because many mountain streams empty into the Qazvin Plain and recharge the groundwater.
- Groundwater in Tehran city, Tehran and Qazvin has been extracted generally keeping the water balance between recharging and pumping yield. However serious drop of groundwater level has occurred in Karaj and Hashtgerd region due to decreasing surface water to recharge and over pumping groundwater. The drawn down depth at deep wells reaches 40 to 50m at some area in Karaj region due to decreasing of the Karaj surface water to recharge groundwater by Tehran water supply of Karaj dam.

(4) Per Capita Water Consumption

The per capita water consumption (lcd) in each city of the Study Area consisting of domestic use, other public use and water loss is shown in the following figure,

Per Capita Water Consumption in Cities 1996

Region	City	Per Capita Consumption (lcd)		
Tehran	Tehran City	175	121	353
	Eslam Shar	138	129	291
	Qarchak	153	101	286
Karaj	Qods	168	102	280
	Robat Karim	108	129	270
	Hasanabab	140	85	259
	Shariyar	145	101	271
	Karaj Bozorg	140	92	268
	Mahdasht	157	113	268
Hashtgerd	Hashtgerd	140	76	245
	Nazarabad	127	108	249
Qazvin	Abyek	165	32	231
	Alvand	95	37	144
	Qazvin	162	69	262
	Eqbalieh	95	42	148
	Buin	160	126	316
	Danesfahan	156	96	295
	Shal	165	18	213
	Esfarvarin	134	72	230
	Takistan	132	90	247

Domestic Use Public Use Water loss

- Per capita consumption in Tehran city shows the high value of 353 lcd but includes a large water loss of 121lcd (34% of total consumption), which occurs by leakage through water distribution pipeline, accident, illegal connection, etc. Tehran W.S.C has surveyed the pipeline with total length of more than 20,000km in Tehran city and continued to prevent the water leakage by improvement of pipe connection and replacement of deteriorated pipes.
- Per capita water consumption of Mahdasht in Karaj region and Buin in Qazvin region shows the relatively high value of 300 to 320 lcd as compared with that of the other cities with 200 to 250 lcd, while Alvand and Eqbalieh in Qazvin region shows the low value of 140 to 150 lcd. These reason is seemed that no actual measurement data are available and the water consumption is estimated based on number of wells, pumping capacity of well/hr and operation time of 18hr as shown in the above table. Of course, Mahdasht and Buin locate at the southern part in the Study Area, present very hot climate and require a large water consumption, while Alvand and Eqbalie are new cities expanding near Qazvin city in recent years and their water consumption is still low due to insufficient water supply system.
- The other cities except Tehran city also have suffered from many water losses in the water supply system and intend to improve the system.

2.4.3 Water Supply for Other Use

(1) Rural Water Supply

No precise data are available in the rural water supply neither for production nor consumption. All of these productions are computed multiplying the pump-up capacity of all the pumps by the operation time. No data are available neither for leakage nor accountable rate. Water production in 1996 is estimated as follow:

Rural Population and Water Consumption in 1996

Study Unit	Population (10^3)	Water Consumption (MCM)	Per Capita Demand (lcd)
Tehran	625.8	43.0	187
Karaj	312.9	21.4	187
Hashtgerd	112.1	4.8	118
Qazvin	297.9	11.2	103
Total/Average	**1,348.7**	**80.4**	**163**

(Source: the Master Plan in Sept. 2000)

According to the report “Global Criteria for Design, Supply and Distribution in Rural Area No.3”,of the Ministry of JAHAD, published in 1989, the reasonable domestic water demand in rural area is ranging from 80 lcd in cold weather to 100 lcd in hot weather. The water consumption mentioned in the above table shows reasonable value of 187 lcd in Tehran and Karaj including the sufficient other public water use and water losses but small value of 118 to 103 lcd in Hashtgerd and Qazvin region taking into account the public water uses and water losses.

(2) Industrial Water Supply

Existing industrial area is expanding at Tehran, Karaj and Qazvin region and has used groundwater developed by deep wells. New factories, however, are not allowed to install at the site within 120km from Tehran city according to new government law. Two sites of Alborz in Qazvin region and new Hashtgerd in Hashtgerd region are nominated as the industrial area to install new factories.

The industry water sources are groundwater developed by deep wells under control of the regional Water Board and its water consumption in 1996 is estimated in the following table based on the data in the Master Plan.

Area	Water Consumption (MCM)
Tehran	49.8
Karaj	199.1
Hashtgerd	0.2
Qazvin	4.5
Total	**253.6**

(3) Water Supply in New Cities (New Urban Water Supply)

Some new cities will be set up in Tehran, Karaj and Hashtgerd regions. The water consumption data for those cities are not available at present.

(4) Greenery Water

Greenery water is the water used for green belt and garden yard in cities. A municipality controls most of the greenery water exploited from the wells, but its consumed volume is not measured precisely.

The estimation has been made multiplying the pumping capacity of all wells available, by the operation time of 5000 hours a year. The consumed water of Tehran City in 1986 was estimated at 63.4 MCM with 73 wells and 85 MCM with 8 additional wells in 1992. The rate of the greenery consumption to the raw water inflow for urban use is likely constant being more or less 10%. The following is the data for greenery consumption in Tehran City.

Greenery Water Consumption

Year	1983	1986	1987	1992
Greenery Consumption (MCM)	27.4	63.4	70.1	85
No. of Wells for Greenery		73		91
Raw Water for Urban Consumption (MCM)	517	542	576	714

(Source : Municipality)

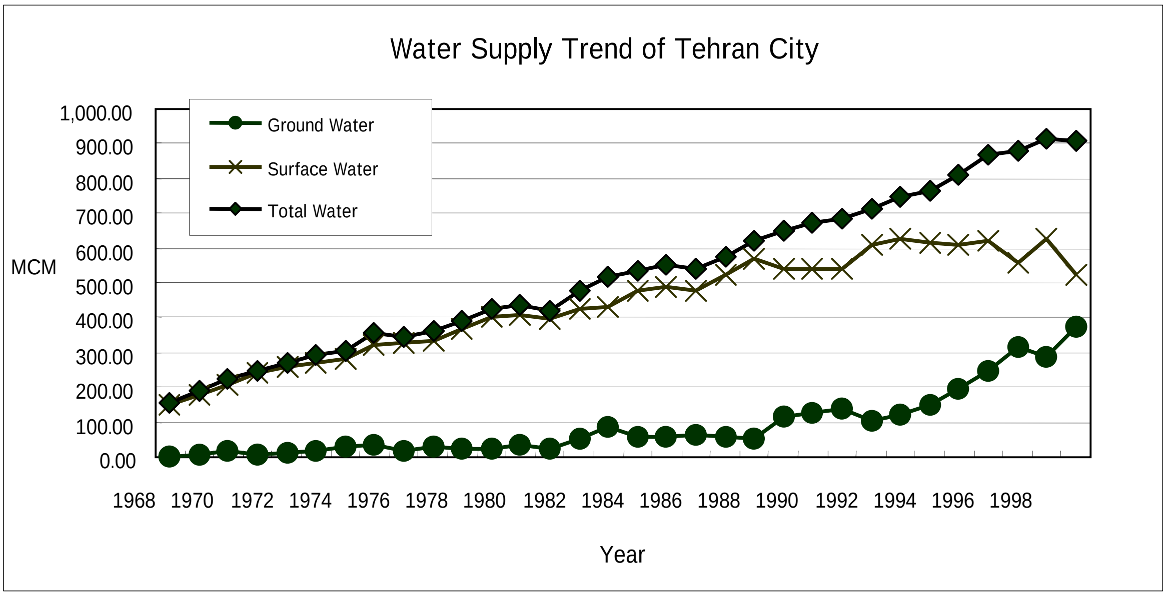
2.4.4 Water Supply in Tehran City

The water consumption in Tehran city is 870MCM in 1996 occupying the large portion of 80% for total urban water of 1,100MCM in the Study Area. Accordingly the water supply conditions in

Tehran city are studied as follows;

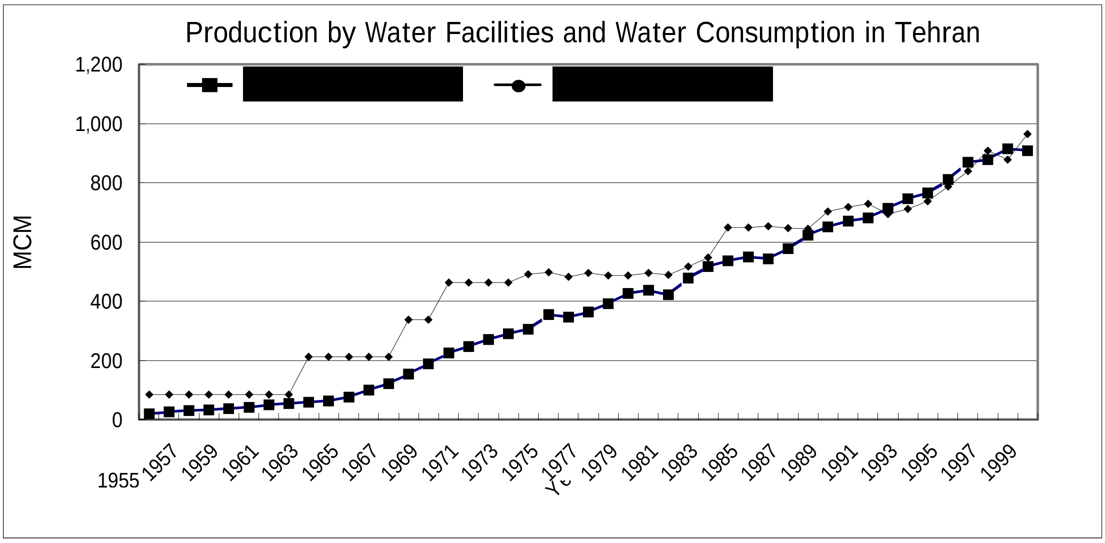
(1) Water Supply Trend

The average increasing rate for the water supply volume in Tehran city is 3.5% in the past 10 years. Since 1992, the supply of surface water from Karaj and Latian dams has not increased due to limit of the surface water in both dams, while ground water use has increased considerably in recent years as shown in the following figure.



(Source: Tehran Province Water Supply Company Data Basis)

The water consumption is much closer to the limit of normal maximum operation capacity of all plants, as shown in the Figure below. The capacity was simply calculated adding the normal production capacity of 4 treatment plants to the extracted capacity of groundwater by wells. Tehran water supply in recent years has been supported by the extracted groundwater due to limitation of surface water. The following figure shows the comparison between production volume and approximate normal maximum plant capacity in Tehran.



(Data Source: The Tehran Water and Sewage Company)

(2) Water Sources

Before 1927, Tehran residents had received water from 26 Qanats at about 1m^3/s. In 1927, due to the increment of the population in Tehran City, the water diversion has been realized from the Karaj river to Tehran. Present water in Tehran is supplied from the Karaj, Latian and Lar dams and ground water of Tehran city. The water flow diagram is shown in the Database Map.

<u>Surface Water for Tehran Urban Water Supply</u>

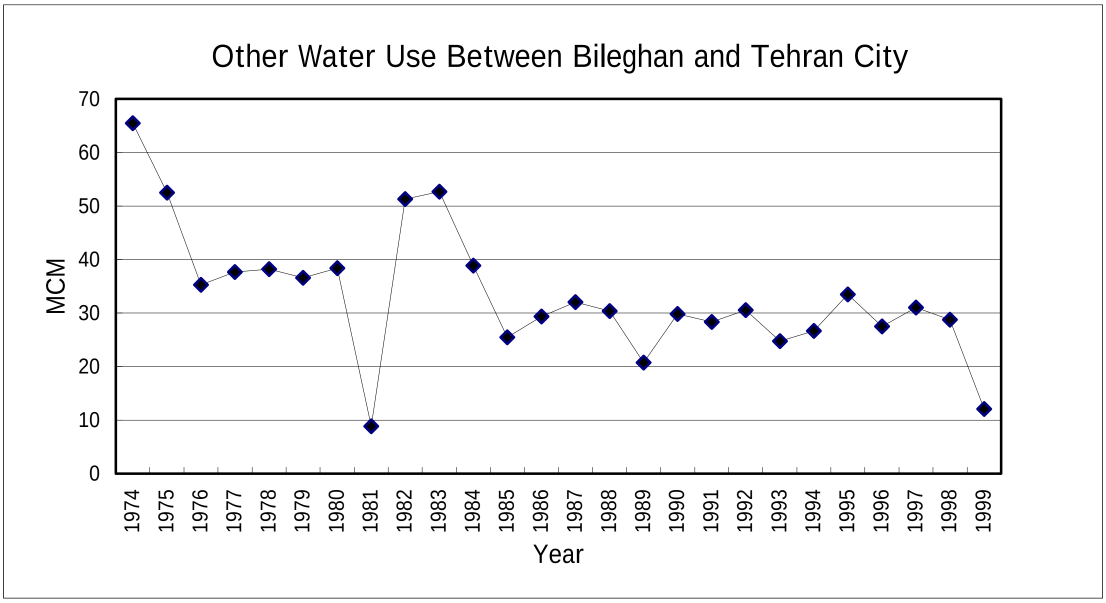
The Tehran Water and Sewerage Company under the control of the Ministry of Energy operates four complete water treatment plants with the capacity of 18.7 m^3/s (Normal Maximum Capacity) and the simplified systems to ground water for the population of 6.8 millions people in 1996. The plant capacity will be expanded 22.45 m^3/s soon in 2001, and 26.2 m^3/s, equivalent to 826 MCM per year in 2002 with the installation of Phase–1 of No. 5 water treatment plant (No. 5 W.T.P).

At present, the WTP-5 receives the water from the wells along the Jaj-rud river tentatively, and waits for the completion of the Lavarak-Sohanak water diversion tunnel which is scheduled to be completed in 2002 (the project is now facing some difficulty, and might be delayed.) and the Lar Dam Pump Station Project which also will be completed in 2002. The pump station will contribute the increment of approximately 60 MCM per year. Presently one pump is under operation with the capacity of 1.8m^3/s, another two will be scheduled to start operation in 2001.

Groundwater is being supplied after simple chlorination, separately processed from surface water. In the year of 1996, the rate of water sources was 71 % from surface and 29% from ground water.

No.1 & 2 plants receive the water from Bileghan Intake in the Karaj river. The water from the Bileghan Intake is diverted through the steel pipe line which runs into the WTP-1 in Tehran, supplying some amount of water to Karaj in the course, at 100-150 litters/sec, and the concrete pipe line which goes straight to the WTP-2. Some amount of the water supplied by Karaj is used for forestation and industry amounting to more or less 20 MCM, as explained and shown below.

In 1996, the total annual raw water transmitted from all sources was 870.0MCM, and the total produced water was 842.4 MCM including the amount of 250 MCM of the exploited ground water. The consumption in the course of transmission and plant process, namely being the balance, is 27.5 MCM. This volume is consumed for about 50 factories which located along the pipe lines, forestation, and portable water supply in Karaj. This annual variation of water consumption in Tehran is shown in the following figure:



(Source: The Tehran Water & Sewerage Company)

No. 3 & 4 plants are located at the east site of Tehran and receive the water only from the Latian dam including the water from the Lar Dam. The normal maximum capacity of the plants is 8.0 m^3/s, of which 400 litters/s is utilized for the forestation and greenery in the vicinity according to the explanation of the Plant Manager. This volume is likely adjusted depending upon water demand in Tehran.

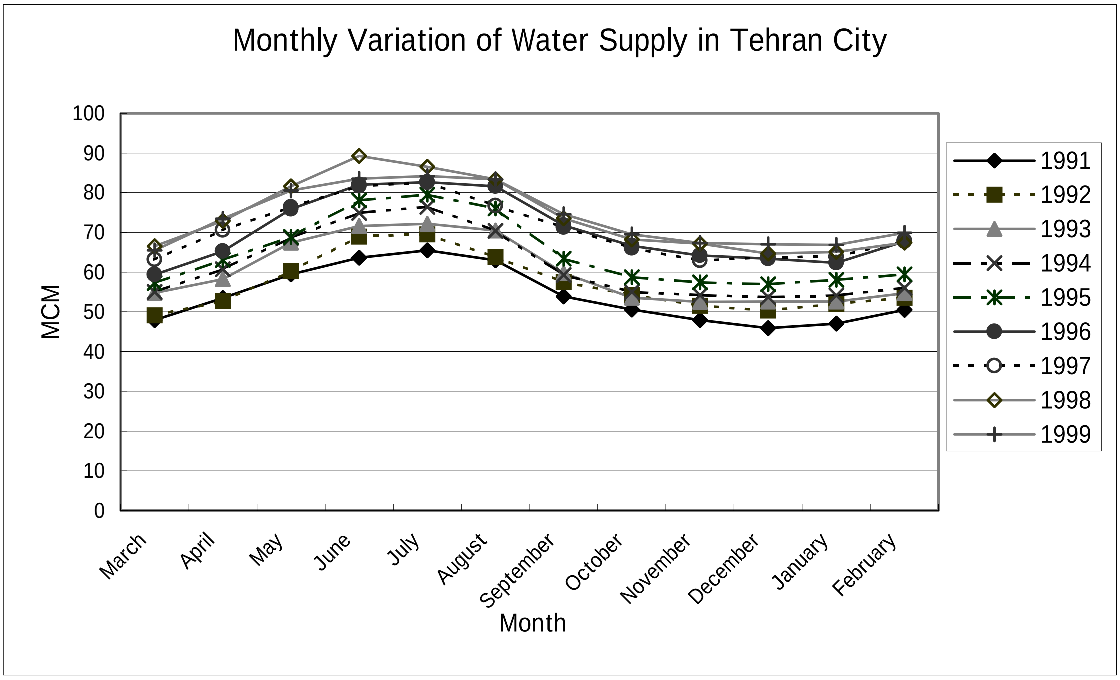
A WTP-5 is planned to utilize water from the Lar Dam. At present, the overall facilities are not ready for the use of water from the dam through the Lavarak-Sohanak water diversion tunnel, but due to urgent demand in the Tehran City, the facilities which have been already constructed, such as Ghochak free flow diversion tunnel, and temporarily installed facilities in the plant and ten wells along the Jaj-rud rivers, are in use to satisfy the urgent need of Tehran.

In the original plan, the water from the Lar reservoir is to be brought into Latian reservoir but owing to the short of the regulation capacity and the significant increase of the sediment arisen from the erosion occurred at the edge of the Latian reservoir, the plan has been reviewed to bring the water from the upstream tributaries of the Latian reservoir.

Phase-1 of No.5 Water Treatment plant is under construction, as explained above, and the implementation of the Phase-2 with the capacity of additional 7.5 m^3/s is also scheduled and the land acquisition seems to have been made already.

Monthly Variation of Water Consumption

Monthly consumption shows the steady variation in a year. The highest demand is in June and July, while the lowest is in December and January.

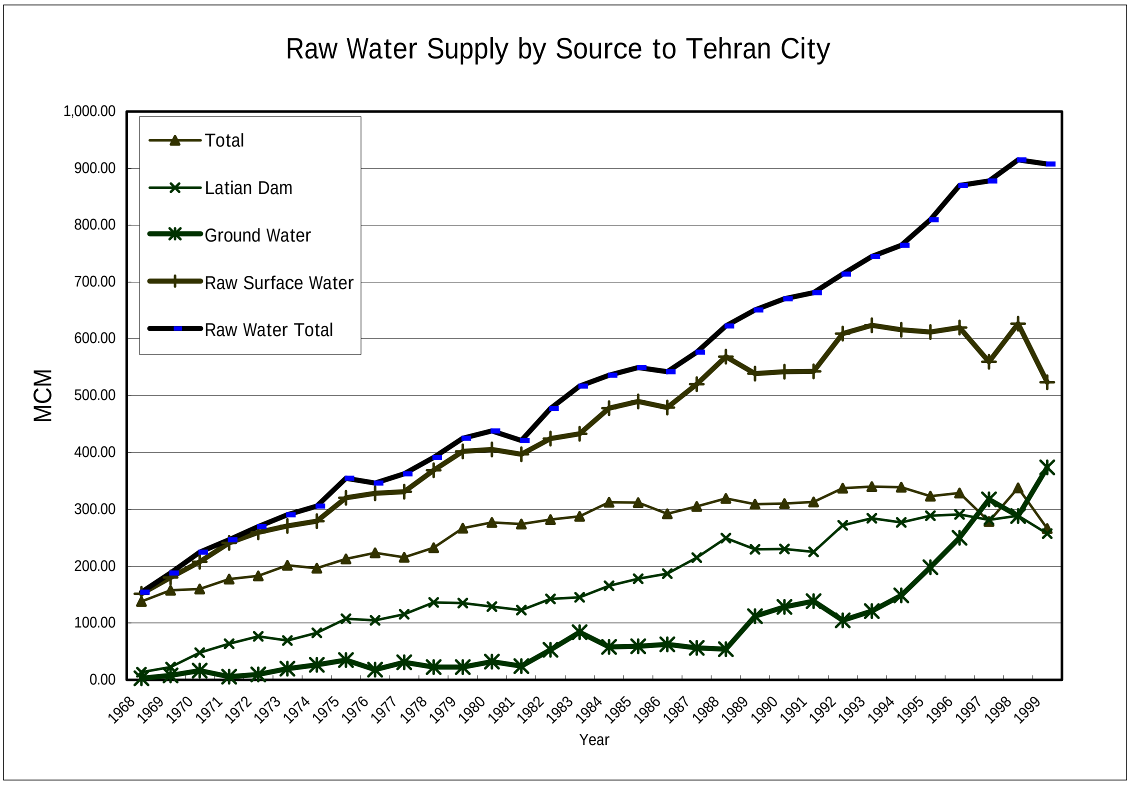


(Source: The Tehran Water and Sewerage Company)

Maximum monthly consumption rate is 10.4% of annual water consumption in the past 10 years and the maximum monthly consumption is higher than the one of the minimum month by approximately 40%.

Source Share

In the past several years, supplied volume from each source has been almost constant except ground water which shows drastic increase. As for the Karaj water, the conveyed water to Tehran city has increased largely, while irrigation water supply to Karaj agriculture area decreased.

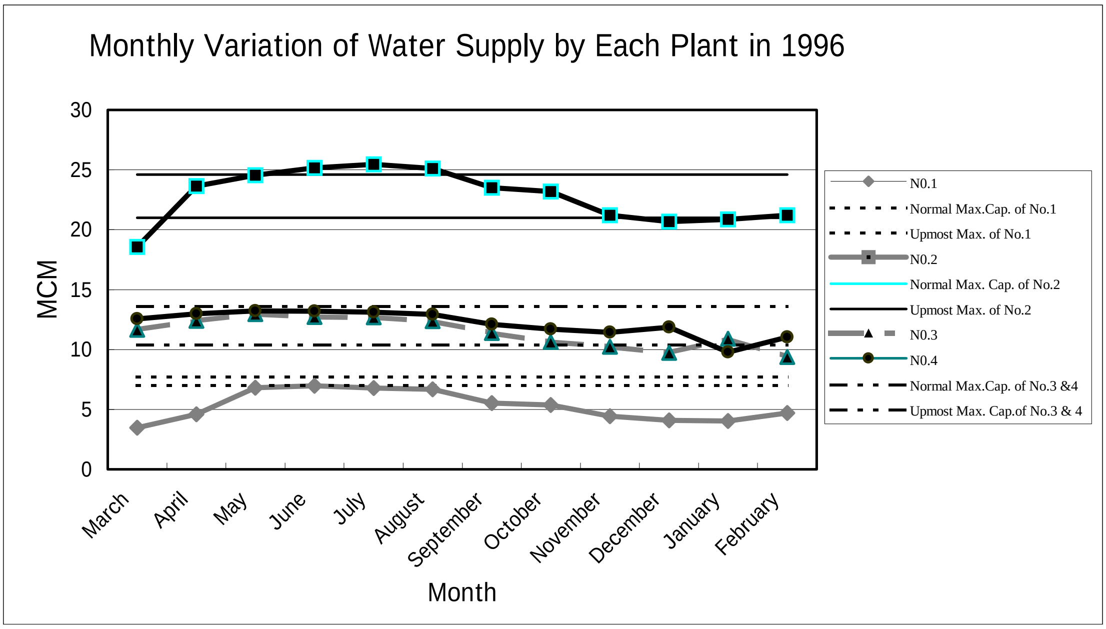


(Source : the Tehran Water and Sewerage Company)

Water Supply Facilities in Tehran

(Water Treatment Plant)

Monthly variation of water supply to each treatment plant in 1996 is described as follow:



(Source: The Tehran Water & Sewerage Company)

The complete system includes elimination of suspended solids by strainers, pre-chlorination, coagulation and flocculation with ferric chloride and lime, sludge sediment and clarification, and sand filtration processes.

In 1996, No.2 W/T plant is close to the ultimate maximum capacity, especially from June to August and the rest of a year is also mostly over the normal operation capacity as observed on the above figure. No.2 plant is designed with the capacity of $4.0m^3/s$ on 200NTU of turbidity, this condition could be applied to all the plants for normal operation. During March and April, the river water is high in turbidity and low in October and November. The maximum turbidity raises upto 2,500 NTU.

No.2 Plant is not acceptable to increase the treatment volume in the peak of demand, and No.1 plant have neither significant marginal capacity in the peak season of demand. No.6 Plant should be installed with the highest priority for the raw water from the Taleghan river. However, the water conveyance system from Karaj to No.6 plant is not studied yet, although the Taleghan raw water is available at Karaj site in 2001.

(Pumping Station)

The following pump station is in operation in the year of 1998:

No. of Pumping Station	26
Installed Pumping Capacity	33 m^3/s
Maximum Height of Pump	525m
Pumping Stage	6

(Length of Distribution Pipes Lines)

The following distribution pipeline is installed in the year of 1998. Presently, the remedy works for water leakage is being undertaken with the target of 1000km per year and to complete the works within 9 years.

Ductile Iron Pipes	8,680km
Gravity Flow (%)	50%
Distributed by Booster Pump (%)	50%
Subscriber	Over 800,000

(Reservoir)

The location of the reservoirs is shown in the Database Map.

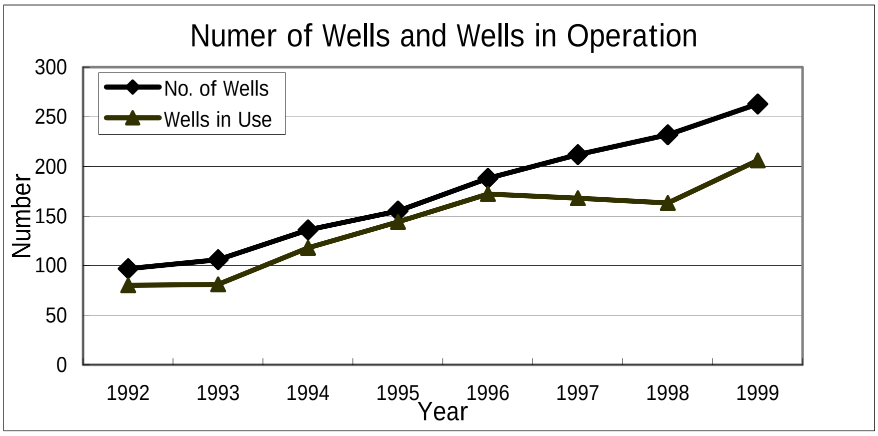
No. of Reservoir	50 in Operation
Total capacity	1,550,000 m^3

(Source: "A Glance at Water and Wastewater Province of Tehran, 1998)

Ground Water Supply in Tehran

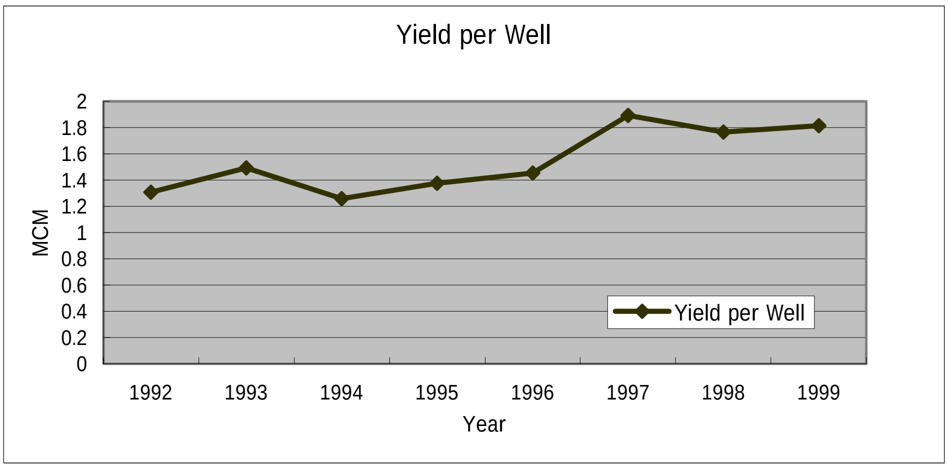
It can observe constant increase of number of wells in past several years. In 1992, there were 97 wells and increased to 263 in 1999. In proportion to the number of the wells increased, the exploited volume has also increased from 105 MCM in 1992 to 374 MCM in 1999. It is likely that Tehran aquifer has raised the ground water level in 1980's than the level of 30 years ago by 10 m, due to the diversion water from Latian and Karaj dam into Tehran, but after significant excess exploitation of ground water, the ground water came down by 2 to 3 m in the year of 1994. Further lowering is accelerated after 1994 due to the serious and drastic increase of exploitation of ground water in these several years.

The status of increasing wells in Tehran city in recent years is shown in the following figure;



(Data Source : The Tehran Water and Sewerage Company)

In the year of 1996, the number of the wells installed was 188, of which 172 were in operation. The average yield of each well in Tehran is fairly increased, in spite of increment of new well as shown below. This means that the water consumption shouldered by ground water is growing faster than the construction speed of wells in Tehran:



(Data Source : The Tehran Water and Sewerage Company)

Water Use Management

Loss of water occurs in the raw water reservoir and in the course of water transmission, water treatment process and distribution.

(a) Loss in Distribution for Urban Water Supply

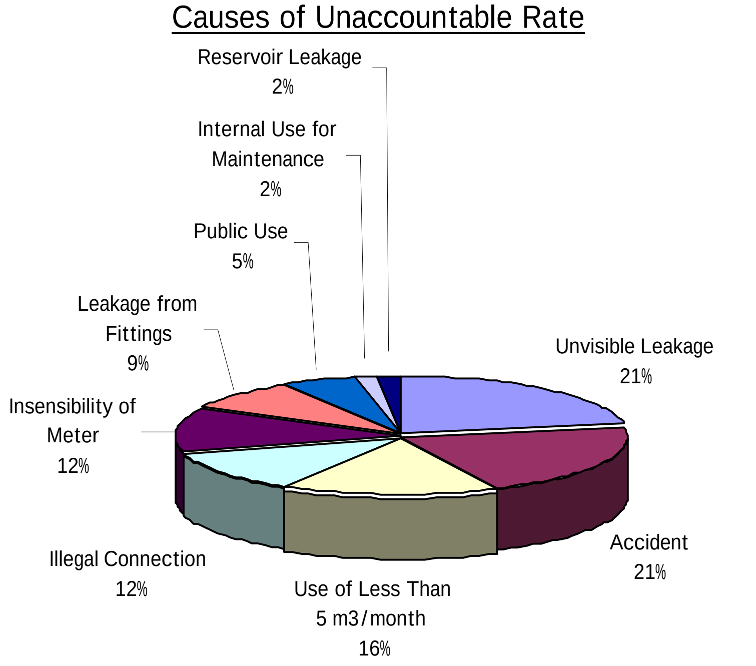
Unaccountable volume is derived from the loss in transmission lines and networks, insensibility of a counter, and illegal connection etc. No precise data are available for leakage. The unaccountable volume is reckoned on the balance of production and billed volumes. The average of unaccountable rate is 34% in the urban area in the year of 1996 and 35% in 2000, according to the data of "the Technical Bureau of Water & Sewerage Company". The breakdown of unaccountable rate of each zone is mentioned in Table below "lcd in the urban Area in 1996". In Tehran, it is likely that center of town, namely old town areas, has rather bigger value of unaccountable rate, due to the deterioration of network. Shemiranate area is rather new town but the accountable rate is high. This might be due to the high pressure brought from water transmission load. The per-capita-demands for the covered areas by six Water and Sewerage Companies in Tehran are as follows:

Per Capita Demand in Tehran

	Domestic Use (lcd)	Others (lcd)	Unaccounted (Leakage and Other Loss) (lcd)	Total (lcd)	Unaccountable Rate (%)
South of Shahret(6)	157	67	88	312	28
South West of Tehran(5)	160	69	123	352	35
Hasanabad & Bazar Area(4)	158	115	127	353	36
West of Tehran & Kan-Tehran-Pounek(3)	168	72	80	320	25
Lashkarak- Tehran Pars(2)	162	79	89	330	27
Shemiranate(1)	165	71	101	337	30

(Source: The Master Plan)
Note: "lcd" stands for "Litter Per Capita Demand ".

The Iranian Water & Sewerage Engineering Company has been established in the area of No.4 Water & Sewerage Company where is a central area of the Tehran city for the implementation of the pilot project of leakage prevention. The minimum guarantee of the improvement is 0.6% of the total water production. They aim at checking and remedying 1,200km of pipeline for the purpose, and to accomplish the project in 7 – 8 years time. According to the information of the project result, the following result has been obtained, though the sum of the figures shows slight difference of the precedent data of the unaccountable rate.



(Source: Technical Bureau of the Tehran Water and Sewerage Company)

(b)Loss in Other Categories of Water Use

In rural area and for industrial and greenery uses, no actually measured data of water consumption are available. The volumes are calculated according to the pumping capacity and operation time. The unaccountable rates in these areas are supposed to be small due to rather small unity and less variation in altitude. No loss is counted for greenery and industrial water use, since the length of the network is negligible.

2.4.5 Sewerage System

In the Master Plan, reuse of treated water is proposed suddenly at about 499 MCM in 2021. This capacity and schedule should be carefully studied, since this reuse has an important role in water allocation.

Traditional sewerage system is an independent system with a natural soaking well at an individual house without collection network of wasted water. Such traditional system is adopted at the rate of 80% in the country, 14% for traditional system with the collection network but without treatment system. The complete system is 6% in nationwide urban areas, in population.

The complete sewerage systems are only in Tehran, Karaj and Hashtgerd with small scale, where the permeability of ground condition is very low or bed rock being very shallow, within the Study Area.

In Tehran, there are six small sewerage networks, of which treated volume and number of the subscribers' connections are as follows:

Sewerage System in Tehran

In 1996

No. of the System	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	Total
Connection	1,231	1,547	512	6,160	1,743	1,645	12,838
Treated Vol. (x 1,000 m^3)	565	710	235	2,825	799	755	5,889

(Source: the Tehran Water and Sewerage Company)

The systems of networks are located at Saheb Gheranieh, Gheitarrieh, Zargandeh, Gisha, Shahr-Ara, and Shush in Theran, and five treatment plants, Ekbatan, Shush, Saheb, Gheitarrieh and Zargandeh, cover those areas. The treated water is released into the river or waterway adjacent to the system, then flow down to Tehran south. The family members are 8.46 persons on an average for a connection. The coverage of sewerage is approximately 1.5% in Tehran.

There is a project of sewerage system under construction in Tehran with the loan of World Bank, for the treatment plant, transmission line and networks. The target population of the project on the phase-1 is 2.6 million, this coverage being 150km^2 equivalent to one fifth of Tehran city, and at the end of the plan, the total covered population to be 10.5 million in the year of 2023. The treated water is scheduled to divert to irrigation area in Tehran South, Karaj and Valamine.

2.4.6 Water Tariff Collection

Domestic water supply in the Study Area is by water service facilities in urban areas and by shallow and deep wells in rural areas. The principal source of water is a mixture of groundwater and surface water, producing from the scare natural resources. Rural water supplies are now being improved as part of a rural development program being carried out by the Ministry of Jahad.

Water tariff collection is taken place by different regional agencies. Water tariffs for domestic and industrial uses are generally collected by the corresponding regional water and sewage companies except for specific industrial areas of Hashtgerd Jadid and Shahr-e-Sanati Alburz, while collection of that for agricultural purpose is done by the corresponding regional irrigation networks operation and maintenance companies as well as regional water boards.

Water tariffs are determined at an annual meeting of the National Economic Council comprising the Central Bank of Iran, the Plan and Budget Organization, and relevant ministries such as the Ministry of Finance, the Ministry of Agriculture, the Ministry of Construction, the Ministry of Industry, and so forth to subsidize the tariffs. Water tariffs are classified according to different water users and water sources as shown in the following table. In the case of monthly urban water consumption rated at 30 m^3, for instance, it charges 284 rials/m^3 for Tehran province, and 203.84 rials/m^3 for Qazvin province.

Water Tariffs (1378: 1999/00)

Water User	Tehran Province (rials/m^3)	Qazvin Province (rials/m^3)
Urban Households (water service facilities)		
Monthly Consumption		
① less than 4.99 m^3	Free	Free
② 5	40	52.67
③ 10	42	55.17
④ 15	45	59.48
⑤ 20	66	65.71
⑥ 25	203	184.27
⑦ 30	284	203.84
⑧ 35	394	228.73
⑨ 40	481	258.96
⑩ 45	613	316.59
⑪ 50	704	357.90
⑫ 55	795	404.60
⑬ 60	886	456.70
⑭ 65	979	517.40
⑮ 70	1,236	838.70
⑯ over 75	1,512	1,183.00
Rural Households (groundwater)	5 + 2,080* (Karaj & Kordan areas) or 75 (Jihad rate)	5 + 2,080* or 75 (Jihad rate)
Industry (water service facilities)	720 (Tehran & other satellite cities) 800 (Karaj Bozorg)	1,001 (Qazvin city) 936 (other cities)
Industry (groundwater)	5 + 10,420* (Karaj & Kordan areas)	5 + 10,420*
Specific Industrial Area	169 (Hashtgerd Jadid)	420 (Alburz)
Agriculture (canal water)	4% of crop production value (28 rials/m^3)	4% of crop production value (28 rials/m^3)
Agriculture (groundwater)	2.6 (Karaj & Kordan areas)	4.3
Agriculture (groundwater & surface water)	-	30

Note: * monthly rate.

Source: 1) Tehran, Karaj, and Qazvin Water & Sewage Companies.
2) National Water and Waste Water Engineering Company.
3) Qazvin Irrigaiton Networks Operation and Maintenance Company.
4) Karaj and Qazvin Regional Water Boards.
5) Hashtgerd Jadid Development Company.
6) Rural Water & Sewage Council of Jihad.

2.5 Existing Irrigation Water Use

2.5.1 Existing Irrigation Area

In accordance with the available data by Jamb consultant and agricultural organization in each region, the suitable farm land area, the existing cultivation area and irrigation area are summarized as follows;

Suitable Farm Area, Cultivation Area and Irrigation Area

Unit : ha

Region	Suitable Farm Area①	Cultivation Area		Irrigation Area (1998)	
		Area②	Rate (%) ②/①	Area③	Rate (%) ②/①
Tehran	69,000	49,000	71	40,900	83
Karaj	62,900	44,400	71	37,800	85
Hashtgerd	38,100	35,600	93	21,500	60
Qazvin	370,000	351,000	95	115,800	33
Total	**540,000**	**480,000**	**89**	**216,000**	**45**

(1) Suitable Farm Area

According to the land classification data in the Study Area, there is existing the suitable farm area of 540,000ha belonging to class Ⅰ, Ⅱ and Ⅲ. Qazvin region holds especially a large suitable farm area of 370,000ha equivalent to about 70% of total suitable area in the Study Area and has a large potential of irrigated agricultural development.

(2) Cultivation Area

The suitable farm area in Hashtgerd and Qazvin, regions is mostly cultivated as shown in the cultivation rate of 93 to 95%. However the cultivation area in Tehran and Karaj region has decreased year by year due to conversion of farm land to urban and industrial area.

The following figure shows the changing rate of cultivation area at each region from 1983 to 1999.

The irrigation area of grain crops such as wheat and barely occupies 40 to 50 % of the total irrigation area in every region. Although wheat and barely are winter crops and do not require irrigation water in winter season, they require it at grain mature season from Farvaldin to Khordat (April to June). In case of sufficient irrigation water is available at the mature season, they get the high yield of more than 3.5 ton/ha as compared with the low yield of less than 1.5 ton/ha in dry farming.

Industrial crops are sugar beet, sunflower, bean, etc, and mostly cultivated in summer season. Qazvin region cultivates the large sugar beet area because the sugar processing factory is existing in Qazvin region.

Feeder crops are alfalfa and forage which are used for livestock breeding in the region. Every region has cultivated the feeder crops with 10 to 20 % cropping intensity.

Vegetable and orchard plantation is dominant and their area covers 30 to 40 % of total irrigation area because the farm lands are locating near Tehran capital area which consumes a large volume of fresh vegetables and fruits through the year.

(3) Irrigation Area

Irrigation area in the Study Area is always changed every year depending on the available irrigation water and reaches 250,000ha in the wet year with sufficient water but 200,000ha in the drought year presenting scarce water. The irrigation area in 1998, the drought year, is reported at 216,000ha in the Study Area. The irrigation intensity at Tehran and Karaj region shows the high value of 83 to 85% because both regions locate adjacent Tehran city and have been developed as the important agricultural area of Tehran city since the beginning of 1900. Irrigation intensity in Qazvin region is still low as 33% because irrigation development in the region was commenced in 1960s but has not been accelerated up to now. Present conditions of irrigation area in each region is described as follows;

- Irrigation area in Tehran region is mostly expanding at Eslam shar and Rey districts in the south of Tehran city. The area has been irrigated by mountain stream water flowing down through Tehran city and the Kan river in spring season and groundwater extracted by shallow and deep wells and Qanat.
- Irrigation area in Karaj region is divided into two parts, one is shariyar and Robatkarim districts which have been irrigated by Karaj irrigation canal system using the Karaj dam water, the other locates at the west and south district of Karaj city and has been irrigated by groundwater extracted by many wells.

  The former irrigation area was 25,000ha in the year 1960s to 1970s but has decreased to 15,000 to 20,000ha in recent years due to decreased Karaj dam water, which has transferred to Tehran urban water supply. The latter area also has decreased year by year due to variation of land use from the farm area to urban and industrial area.
- Irrigation area in Hashtgerd region is consisting of the Kordan irrigation project area at the north high land, the other is the south low land area being irrigated by groundwater. The Kordan irrigation project area is expanding to 5,000 to 6,000ha in 1999 by the new weir and canal project but the south area has decreased due to conversion of farm land to industrial area.
- Qazvin irrigation area is mostly formed with the existing north irrigation area developed by the Taleghan water, the central area being irrigated by groundwater and the south high land area using the surface water of three rivers of Abhar-rud, Khah-rud and Haji Arab-rud.

(4) Major Crop Area under Irrigation

Major cropping area under irrigation in each region is shown in the following table;

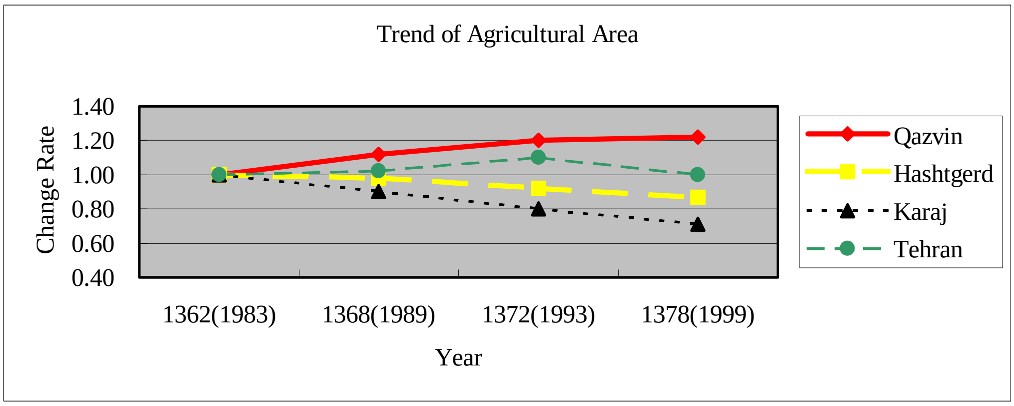
Major Crop Area under Irrigation

Unit: ha

Crop	Tehran	Karaj	Hashtgerd	Qazvin	**Total**
(1) Irrigation Area					
Grain	19,340	16,270	10,830	51,810	**98,250**
Industrial crop	100	370	850	5,290	**6,610**
Feed crop	7,180	5,680	3,380	14,170	**30,410**
Garden/vegetable	7,090	5,390	850	11,390	**24,720**
Orchard	7,220	10,080	5,550	33,200	**56,050**
Total	**40,930**	**37,790**	**21,460**	**115,860**	**216,040**
(2) Cultivation Area	48,900	44,500	35,600	351,000	480,000
(3) Irrigation Intensity (1)÷(2)%	82	85	60	33	45

Source; Estimation by JICA Study Team. Basic data is from Jamab consultant based on the statistic data of agricultural organization and related agencies.

Trend of Agricultural Area (year 1983 basis)



Source; Jamab consultant, based on the statistic data, related study/projects

As is cleared in the above figure, Karaj and Hashtgerd region has decreased 30 % and 15 % farm land against the land in 1983 during past 15 years, while Qazvin region increased 22 % farm land.

Karaj region has lost a large farm area caused by the conversion of farm land to residential area of overflow population in Tehran city and the decreasing irrigation water from Karaj reservoir due to transfer to Tehran city.

Although agricultural area has been decreasing, the area of summer crops with high marketability is not changed but will increase according to the market demand in Tehran capital area.

2.5.2 Irrigation Water Demand

(1) Standard Unit Irrigation Water Requirement

As for the standard unit irrigation requirement, theoretical requirement and actual requirement are studied in the Master Plan. Theoretical requirement is estimated based on the FAO's standard method using the modified Penman method by using regional meteorological data and crop factor of each crop. Actual requirement is estimated based on the actual diversion requirement at the irrigation canal system, which includes crop water consumption, irrigation losses on farm level, distribution and diversion water losses in canal system and operation losses in the water sources such as reservoirs and canals. In accordance with the study result in the Master plan, actual irrigation requirement shows the high value as compared with the theoretical one as shown in the following table.

Unit Irrigation Requirement for Major Crop

Unit : m^3/ha

Area and crop	Qazvin		Hashtgerd		Tehran-Karaj	
	Theoretical	Actual	Theoretical	Actual	Theoretical	Actual
Wheat	4,443	10,017	4,543	8,496	5,146	8,312
Barley	4,443	7,686	4,543	6,055	5,146	5,923
Maize	6,528	11,326	6,674	10,423	7,094	10,518
Sugar beet	9,315	15,672	9,525	17,383	8,701	17,006
Alfalfa	9,715	20,608	9,933	23,254	9,268	22,746
Forage (low Yield)	6,545	11,591	6,691	11,591	5,152	9,136
Pulses	5,356	11,960	5,477	12,108	6,222	11,894
Cash crop (melon/onion)	8,098	12,991	8,279	13,897	8,964	12,991
Potato	7,746	16,179	7,919	17,116	8,451	16,746
Orchard (orange)	9,667	14,120	9,884	13,800	11,238	13,502
Other fruit	10,906	18,541	11,151	18,595	11,914	18,191

In accordance with the explanation in the Master Plan, the actual irrigation requirement shows very low irrigation efficiency of 30 to 40 % because large water losses on farm level and in canal system take place by the poor water management.

Although the actual irrigation requirement in the above table is judged to be fairly large as compared with the international standard, this requirement is based on the actual irrigation value in each region and will be applied for estimation of the present used irrigation demand.

(2) Current Irrigation Water Demand

In accordance with the existing irrigation area of 216,000 ha in 1998 and the average irrigation requirement per hectare which is estimated based on the actual irrigation requirement and the irrigated cropping area, the current irrigation water demand is summarized in the following table.

Summary of Current Irrigation Demand in 1998

Area	Irrigated area (ha)	Total	
		Unit Requirement (m^3/ha)	Demand (MCM)
Tehran	40,930	11,300	463
Karaj	37,790	11,800	446
Hashtgerd	21,460	11,600	249
Qazvin	115,860	12,500	1,448
Total	**216,040**	**12,100**	**2,606**

Total irrigation water demand in the Study Area reaches a large amount of 2,600 MCM, of which Qazvin occupies 1,450 MCM corresponding to 56 % for total demand.

Unit irrigation requirement in Qazvin is 12,500 m^3/ha that is a little high value as compared with the other values because of a large orchard area and a large water losses by deteriorated irrigation canal system.

2.5.3 Existing Irrigation System

(1) Irrigation Water Sources

Irrigation water is supplied by the surface and groundwater sources and their supply amount in each region is summarized in the following table based on the data in the Master Plan.

Surface and Groundwater Sources for Irrigation Demand in 1998

Unit: MCM

Region	Irrigation Demand	Water Source	
		Groundwater	Surface Water
Tehran	465	365 (78 %)	100 (22 %)
Karaj	445	335 (75 %)	110 (25 %)
Hashtgerd	250	190 (76 %)	60 (24%)
Qazvin	1,450	1,150 (79 %)	300 (21 %)
Total	**2,610**	**2,040 (74 %)**	**570 (26 %)**

Note: Share of water source in Hashtgerd and Karaj-Tehran is assumed by referring to the Master Plan by Jamab consultant. In Qazvin, groundwater is firstly balanced based on data from Qazvin Regional Water Board, secondary, remaining is assumed as surface water.

Irrigation water in Tehran region is supplied by mountain stream water and groundwater. Although surface water sources such as the Kan river and tributaries being originated from the north mountain in the region are existing, they appear in only spring season from Farvardin to Tir (3 to 4 months) and have been used for irrigation for winter crops summer irrigation water is depend on groundwater.

Irrigation water in Karaj region also is mostly depending on the groundwater. Although the farm land at Shahriyar and Robatkarim was mostly irrigated by the Karaj irrigation canal system receiving Karaj reservoir water in the past, the present irrigation area and water demand are largely decreased caused by the conversion of Karaj water to Tehran city.

The available irrigation water from Karaj reservoir was more than 200 MCM per annum in 1970s and 150 MCM in 1980s but decreases to 80 MCM only in 1998. Groundwater use for irrigation in Karaj region has increased remarkably year by year to recover the deficit of irrigation water from the surface water and as the result its water level and yield has decreased in recent years.

Irrigation water in Hashtgerd also is mostly used from groundwater except some surface water in the Kordan irrigation system. Although the Kordan river has a relatively rich surface water of 120 MCM per annum, the irrigation water has been used at the limited area in the upper basin and shows the amount of 60 MCM. Main farm land in Hashtgerd region is lying on the lower alluvial plain of the Kordan river and has been irrigated by groundwater to be recharged by the surplus surface water in the Kordan river. Groundwater level and yield in the region also have been decreased by over pumping from deep wells for not only irrigation use but also urban and industrial use.

Qazvin irrigation water using surface water is a large amount of about 300 MCM per annum, of which 200 MCM is diverted from the Taleghan water and conveyed by Qazvin north canal system. The remaining 100 MCM is mostly brought from mountainous stream and has used for irrigation overall Qazvin plain. Groundwater in Qazvin plain is fairly stable due to many recharging water from mountainous streams, Taleghan water and return flow of irrigation. In addition, the surface water of 80 to 100MCM has been used at the area along the tributaries but managed by the local people.

(2) Karaj irrigation canal system

The Karaj canal irrigation system was constructed in 1962 and has been operated and maintained since 1964 by Karaj Irrigation Company.

The canal network is consisting of two main canals of right bank and left bank. The left bank canal starts from Bileghan and continues to Saeid abad village, total length is about 26 km, including tunnel section of about 4 km. It has not any secondary canals, but, in several parts of the canal is possessed by factories and gardens along the canals.

The right main canal starts from Bileghan passes Karaj old town and Arkanno and then goes to Andishe and Razi abad. Main canal length is about 12 km and has three secondary canals, one is the Farrakh abad canal ("FC4") and the others is the Fardis canal and the Shahriyar and Robatkarim canals that have not been made over to the Irrigation Company yet. Total length of the secondary canals is about 46 km.

The left bank canal is connected with the right bank canal at the nearest downstream of Bileghan where a fish culture pond is provided. The canal network covers the town of Robatkarim and Shahriyar in addition to the upstream area of the Karaj river. The canal is the trapezoid or box shaped concrete lining typed canal. The canal network is summarized as follows.

Canal Length and Design Capacity

Main canal	Secondary canal	Capacity (m^3/s)	Length (km)
Left canal		6.0	26
Right canal		12.0	12
	Frrakh abad (FC4)	4.5	8.5
	Fardis	5.5	15
	Shahriyar and Robatkarim	4.5	22.5

Source; Karaj Irrigation Company. The length is estimated on the 1/50.000 map based on the interview survey with the company.

The organization of Karaj Irrigation Company is consisting of the two sections, canal operation section of 6 staffs and repairing section of 2-3 staffs, but has no maintenance equipment. The company operates and manages the 95 control gates of 55 at main canals and 40 at secondary canals.

(3) Kordan irrigation canal system

There are old and new irrigation canal systems in the upstream of Kordan river. In the past, two weirs had been constructed in the Baraghan and Aghsht rivers in the tributary of Kordan river, and a old canal system had been provided to supply irrigation water into the surrounding of Kordan town. In 1999, besides the old canal system, one weir and canal system have been newly constructed as the new canal system to supplement the old canal system. At present, some additional related facilities are under construction and planning. After the completion of construction of new canal system, water supply is operated together with both of old and new canal systems. Main canal runs along the Kordan river up to the site beside the highway and secondary canal is being constructed after crossing the Kordan river by siphon.

Canal Length and Design Capacity

Canal	Length (km)	Design capacity (m^3/s)	Remark
Old canal system			
Main Canal	4	Form 3.0 to 4.0	Earth canal
New canal system			
Main canal	8	6.0	Lining (Average B=1.0, H=1.2)
Secondary canal	13	3.0	Under construction, earth type
Left branch			Under planning
Right branch			Under planning

Note: Based on the interview survey with the related offices.

Artificial recharge ponds with the surface area of about 6.0 ha are under planning in the area between the highway and the railway. According to the plan, runoff during flood season is conveyed into the ponds, which are expected to produce the annual recharging amount of 10 to 15 MCM.

There is no available data on irrigated area since the new canal system has been just constructed. According to the interview survey, present irrigated area under the canal system would be about 5,000 to 6,000 ha and has used the surface irrigation water 60 MCM per annum.

(4) Qazvin irrigation system

Qazvin north canal system

Qazvin region has been recognized as a center of agriculture having potential area of about 350,000 ha. However, agricultural activities have been always restricted under irrigation water limitation. To solve shortage of irrigation water, Taleghan water diversion project was constructed at 1970s. The project is consisting of the weir in the Taleghan river, the diversion tunnel to deliver irrigation water from Taleghan to Ziaran, Ziaran regulating dam and the irrigation canal in the plain.

An irrigation canal network has been provided to convey irrigation water from Ziaran to Qazvin north area covering about 76,700 ha of irrigation area. The construction started in 1969 and completed in 1976. The outline of canal system is shown in the following table.

Outline of Irrigation Canal System

Canal	Length (km)	Design capacity (m^3/s)	Remark
Main canal	94	30.0 - 3.0	A=76,700 ha
Secondary canal	220	7.4 - 0.6	12 canals
Tertiary canal	270	1.0 - 0.17	
Quarterly canal	540	0.34 - 0.17	
Total	**1,124**		**63 composite wells**

Source: Qazvin Irrigation Company

Artificial recharge ponds and composite wells are also incorporated in the canal network to recharge and to withdraw the groundwater for supplement irrigation water supply and demand.

Major function of the canal network is generally recognized as follows.

Annual Irrigation Water being Used in North Qazvin Area

Unit : MCM

Water diverted from Ziaran	Distribution Water			Withdrawal from Composite Wells
	Selling to Farmers	Artificial Recharge	Assumed Loss	
200 (100%)	140 (70%)	30 (15%)	30 (15%)	10

Source; Qazvin Irrigation Company. Note; water volume is dependent on diverted water from Ziaran.

Although water distribution largely fluctuates depending on the diverted water amount from Ziaran, it is said that about 70 % of the diverted water is conveyed into farm fields, about 15 % is counted as the water loss including evaporation and infiltration in the course of canal to fields and remained 15% for groundwater recharge.

Recharging pond

Concerning the artificial recharge in the area, ten (10) ponds were constructed along the canals. According to the interview survey with the Company, enough number of ponds were provided in the eastern part of the existing canal area, however, in the western part, they were eliminated during the construction stage of the canals even though they are needed at present. Artificial recharge from the canal network is largely dependent on the available diversion water. In the past eight years from 1990 to 1998, annual amount of recharge from the canal network is fluctuated from 3 MCM to 99 MCM. Average annual amount is 31 MCM.

Composite well

Total 63 deep wells with 8 to 10 inch diameter are constructed as the composite well besides the canals and withdraw groundwater and supplement to the canal water. Though annual extracted water amount from composite wells were 100 to 150 MCM in the past, present amount is only 10 to 20 MCM because most of wells are not fully operated at present due to deteriorated wells and broken pumping equipment.

Operation and maintenance

In general, governmental irrigation canal system is operated and managed by Irrigation and Agriculture Management Organization under the Regional Water Board. Qazvin north canal system has been operated and maintained by Qazvin Irrigation Company which holds total number of 35 staff (1999) and 5 units of heavy O/M machines.

Deep and shallow wells

To supplement irrigation water demand in summer season and to meet necessary water demand of the other water uses, about 5,000 private wells are dug in the plain. Out of them, about 3,500 wells are used for only irrigation, about 1,300 wells for drinking and rural irrigation. The extracted mount for irrigation is estimated at 1,100 MCM.

According to the legal act ratified and enforced in 1991 by Ministry of Energy, all state-run and governmental wells have been assigned and transferred to related farmers. As the result, all of the wells are now operated and managed by owner-farmers.

Water Use on Farm Level

In the beneficial area, various traditional irrigation systems with spring, qanat and private well, and modern irrigation canal system constructed by the government are mixed due to topographic conditions and availability of water sources. The flood, furrow and basin irrigation method has been applied for on farm irrigation.

- Flood and Border Irrigation

  Flood and border irrigation is carried out so as to cover overall farm area by water. This method is generally applied for irrigation of winter crops in spring season, which can introduce a rich water from mountain streams to farm area. This method has some advantage to minimized the land preparation cost on farm level but its irrigation efficiency is low as 40 to 30% due to many water losses on farm. It is necessary in this irrigation method to prepare the irrigation farm block with a proper length and slope and well grading.

- Furrow irrigation

  Furrow irrigation is carried out so as to supply irrigation water after preparing small ditch. This irrigation is generally applied for industrial crops, oil seed crops and vegetable, which require slightly larger irrigation requirement than winter crops. Irrigation efficiency in this method shows the higher value of 60 to 65% as compared with flood and border irrigation because the irrigation water is supplied through farm ditches.

- Basin irrigation

  Basin irrigation has been applied for orchard such as grape, apple, pestatio, etc. Orchard plantation area is enclosed by dike with the height of more than 50cm to store a rich surface water in spring. The stored water is gradually infiltrated into root zone and used for orchard. This basin method is effective to use the rich spring flood brought from many small rivers.

  As the other irrigation methods, sprinkling and drip irrigation have been taking place among particular farmers who can plant crops with the high value and marketability and agro-business enterprises. However, it is only applied in the small limited parts of the area.

2.5.4 Irrigation Fee

(1) Qazvin canal system

Irrigation water fee is collected from beneficial farmers who subscribed to the Qazvin canal network and contracted with the Irrigation Company. Although amount of water fee to be collected is depending on the kind of planted crops, it is set to be equivalent to 3 % of the production of planted crop. According to the Irrigation Company, water fee is from 20 to 50 Rials per m^3. A criteria on the water operation method such as diversion requirement and irrigation schedule is also prepared for each crop. Annual irrigation water requirement is from 7,000 m^3/ha to 15,000 m^3/ha and monthly requirement is from 1,000 m^3/ha to 3,000 m^3/ha. Collected water fee is used for operation and maintenance expenses of the canal system. However, its amount is insufficient to cover the operation and maintenance expenses and as a result the existing canal system is deteriorated. Total amount of the collected water fee in 1999 was 1,597 million Rials.

(2) Karaj canal system

Based on the cropping program, Karaj irrigation Company manages and operates the canal system, and collects the irrigation water fee that corresponds to supplied water volume through the canals. The amount of irrigation water fee to be collected is dependent on the kind of planted crops. According to the Irrigation Company, the fee is from 5.5 to 27.5 Rials/m^3, and higher than that of the Qazvin plain. Size of irrigation service area covered with the canals is limited depending on the released water from Bileghan. According to the 1998-99' data, for example, it was only 3,460 ha and water distributed into farmers was only 9.4 MCM, although the year of 1998-99 is considered as a drought year. Less amount of water supply in the dry year would cause to the decrease of crop production. Therefore, different irrigation water fee in normal and drought years is provided by the Irrigation Company.

2.6 Existing Total Water Demand

The existing total water demand and its water supply sources in 1996 are summarized in the following table based on 2.4 "Existing Urban, Rural and Industrial Water Use" and 2.5 "Existing

Irrigation Water Use".

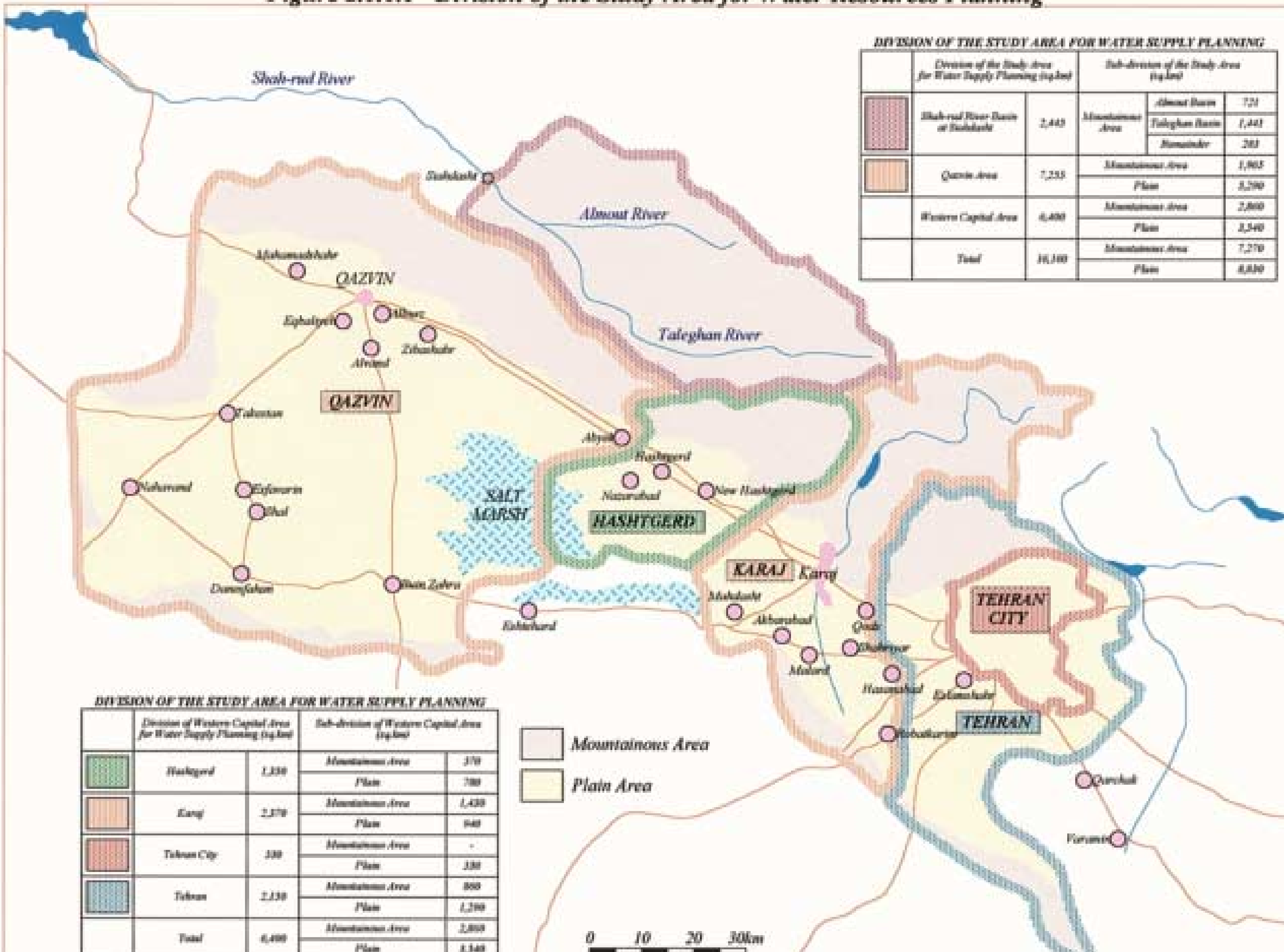
Existing Total Water Demand and Its Water Supply Sources (1996)

Unit: MCM

Region	Domestic Water Use			Industrial Use	Agricultural Use	Total
	Urban	Rural	Total			
1. Tehran City						
Surface Water	640	0	640	0	0	640
Groundwater	230	0	230	0	0	230
Sub-total	**870**	**0**	**870**	**0**	**0**	**870**
2. Tehran Region						
Surface Water	0	0	0	0	100	100
Groundwater	43	43	86	50	365	501
Sub-total	**43**	**43**	**86**	**50**	**465**	**601**
3. Karaj Region						
Surface Water	0	0	0	0	110	110
Groundwater	135	21	156	199	335	690
Sub-total	**135**	**21**	**156**	**199**	**445**	**800**
4. Hashtgerd Region						
Surface Water	0	0	0	0	60	60
Groundwater	9	5	14	0	190	204
Sub-total	**9**	**5**	**14**	**0**	**250**	**264**
5. Qazvin Region						
Surface Water	0	0	0	0	300	300
Groundwater	44	11	55	5	1,150	1,210
Sub-total	**44**	**11**	**55**	**5**	**1,450**	**1,510**
6. Total						
Surface Water	640	0	640	0	540	1,210
Groundwater	461	80	541	254	2,070	2,830
Total	**1,101**	**80**	**1,181**	**254**	**2,610**	**4,045**

- Total water demand in the Study Area is 4,045MCM, of which 1,210MCM is supplied by surface water and 2,830MCM by groundwater. The use of groundwater is large as 2.4 times of the surface water.
- The water use for agriculture reaches the large amount of 2,610MCM, which is equivalent to 65% of the total water use.
- The urban water use also reaches the large amount of 1,181MCM corresponding to 29% of the total water use.

Figure 2.1.1.1 Division of the Study Area for Water Resources Planning



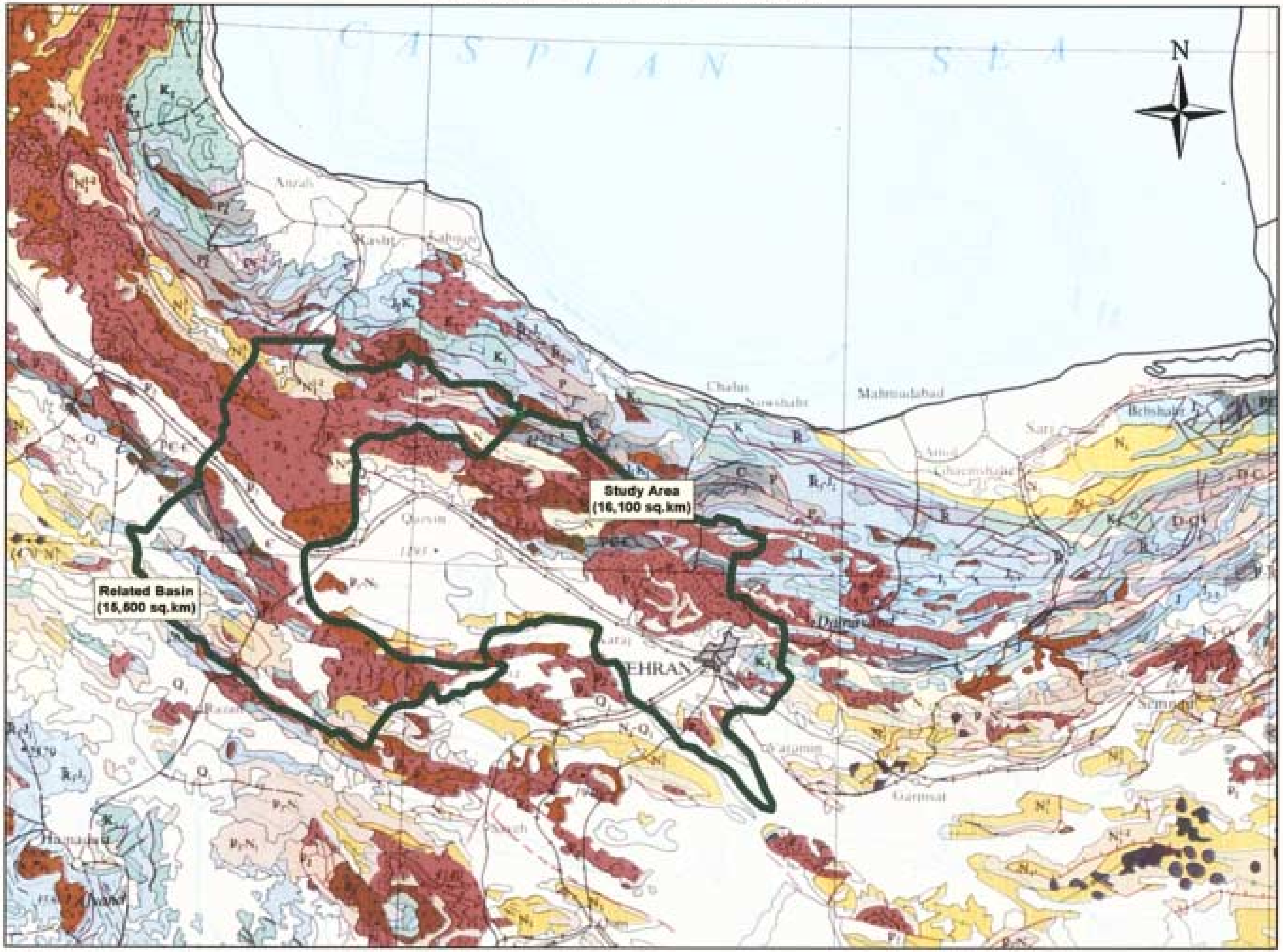
DIVISION OF THE STUDY AREA FOR WATER SUPPLY PLANNING

	Division of the Study Area for Water Supply Planning (sq.km)		Sub-division of the Study Area (sq.km)		
	Shah-rud River Basin at Siahdasht	2,445	Mountainous Area	Almout Basin	721
				Taleghan Basin	1,441
				Remainder	283
	Qazvin Area	7,255	Mountainous Area		1,965
			Plain		5,290
	Western Capital Area	6,400	Mountainous Area		2,860
			Plain		3,540
	Total	16,100	Mountainous Area		7,270
			Plain		8,830

DIVISION OF THE STUDY AREA FOR WATER SUPPLY PLANNING

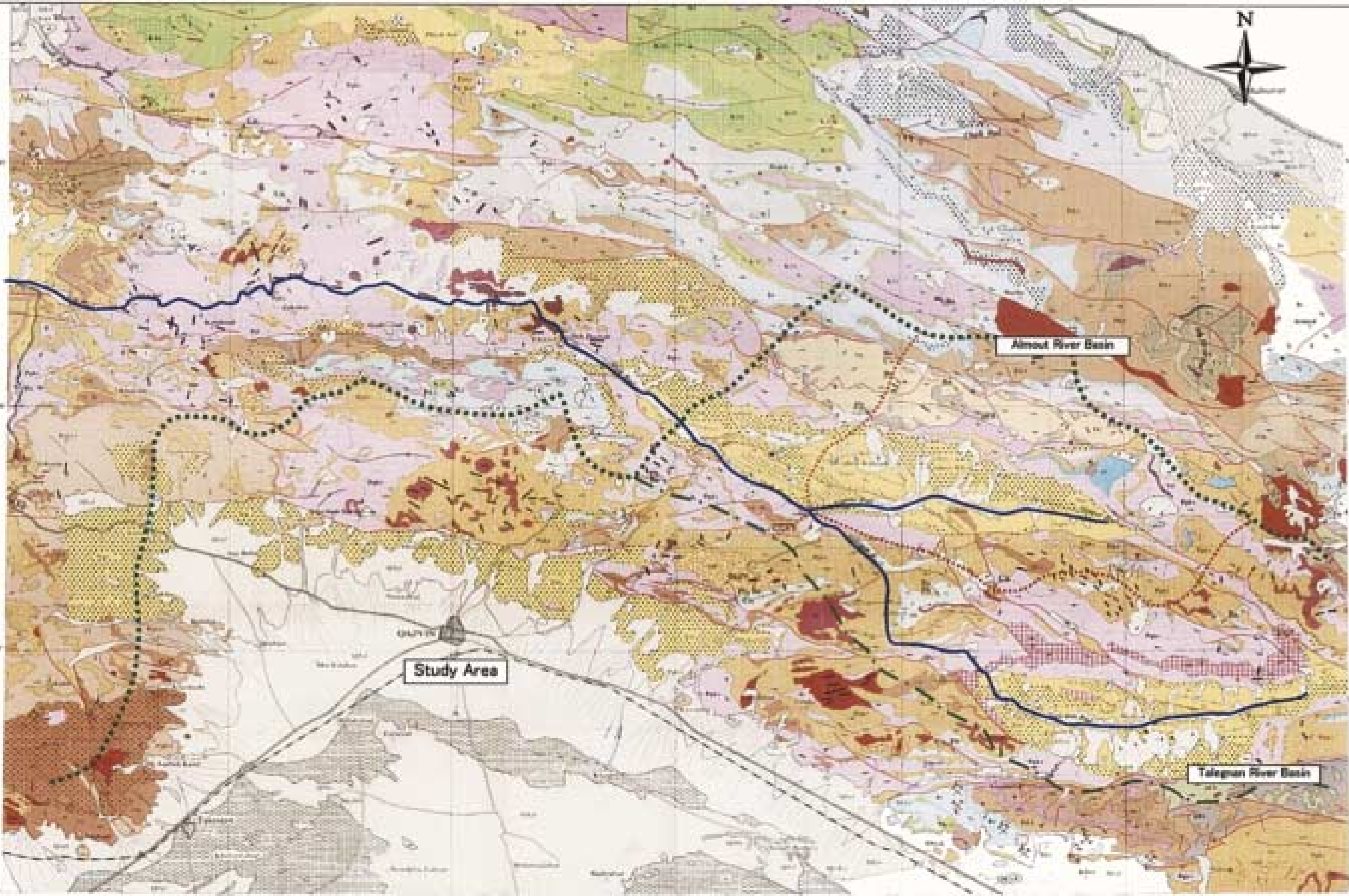
	Division of Western Capital Area for Water Supply Planning (sq.km)		Sub-division of Western Capital Area (sq.km)	
	Hashtgerd	1,350	Mountainous Area	370
			Plain	780
	Karaj	2,370	Mountainous Area	1,430
			Plain	940
	Tehran City	330	Mountainous Area	-
			Plain	330
	Tehran	2,150	Mountainous Area	860
			Plain	1,290
	Total	6,400	Mountainous Area	2,860
			Plain	3,540

Figure 2.2.2.1 Geologic Map of the Study Area



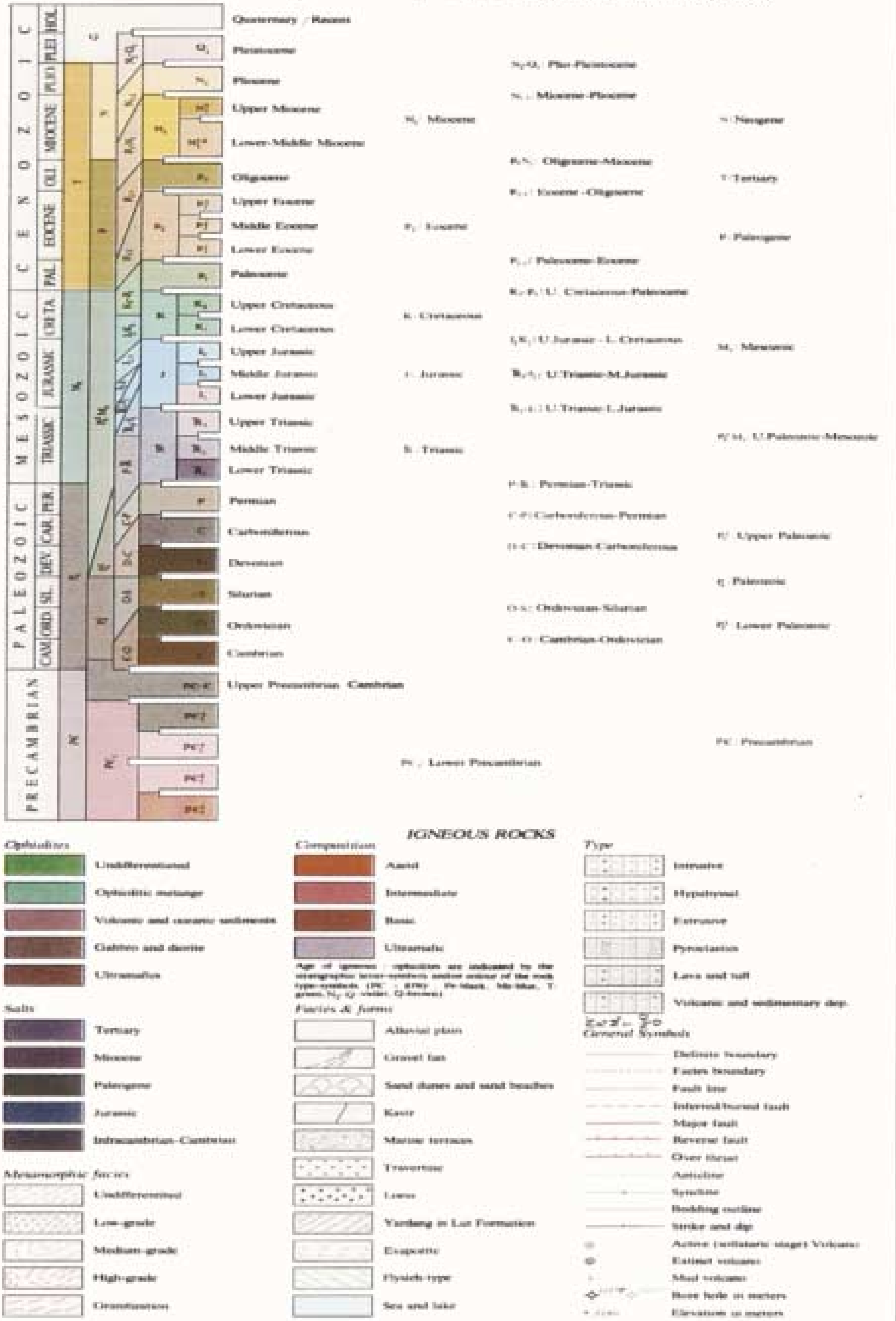
Note: The geologic classification used in Map is refferred to the "Geological Map of Iran (1989, SC=2,500,000)" prepared by Geoogical Survey of Iran

Figure 2.2.2.2 Geologic Map of Taleghan-Alamout Basin



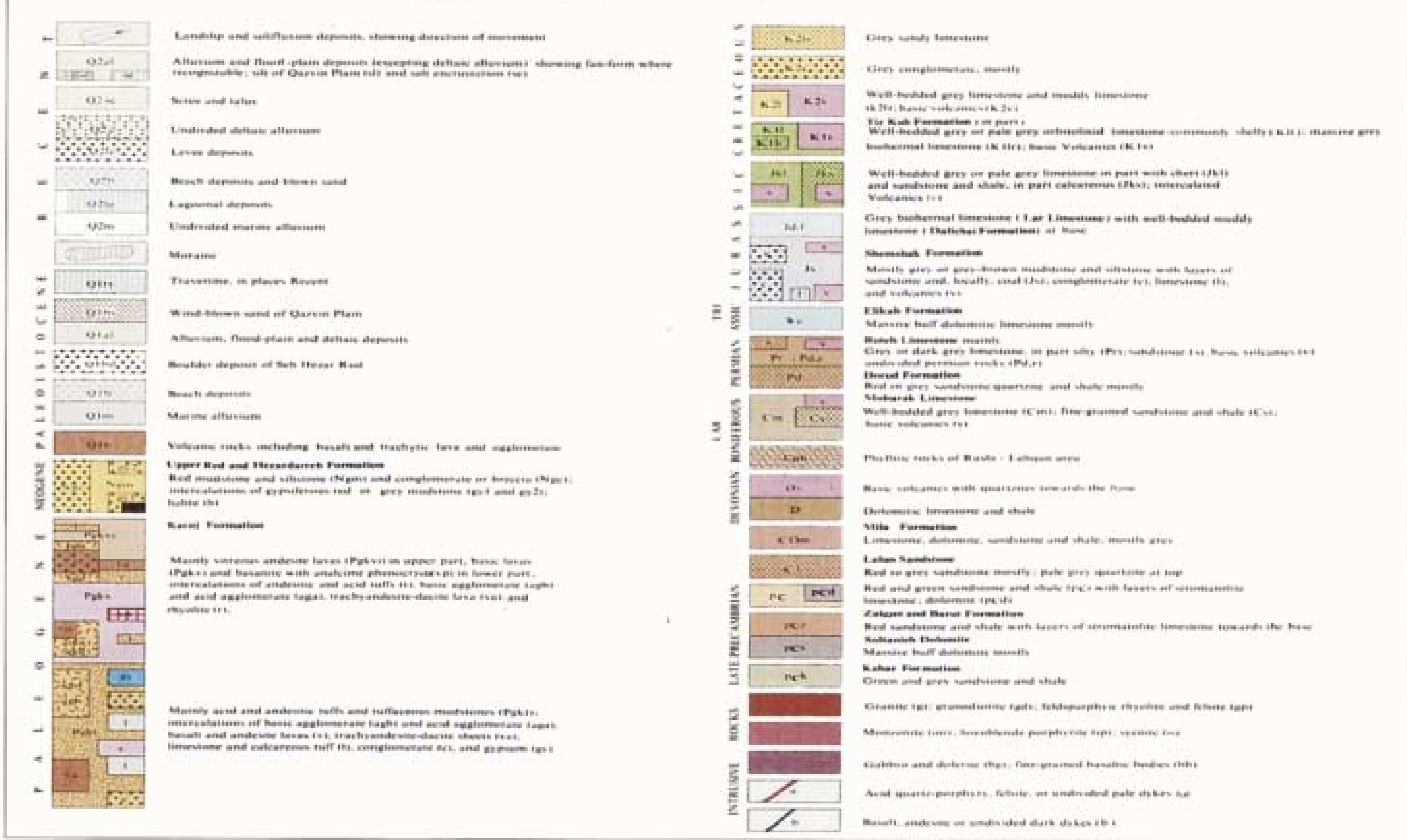
Note: The geologic classification used in Map is refferred to the "Geological Map of Gazvin and Rasht (1976, SC=250,000)" prepared by Geological Survey of Iran

Figure 2.2.2.3 Legend of Geologic Map (Geologic Map of the Study Area)



Note: The geologic classification used in Legend is reffered to the "Geological Map of Iran (1989, SC=2,500,000)" prepared by Geological Survey of Iran

Figure LEGEND



Note: The geologic classification used in Legend is refferred to the "Geological Map of Qazvin and Rasht (1975, SC=250,000)" prepared by Geoogical Survey of Iran