THE ISLAMIC REPUBLIC OF IRAN
MINISTRY OF AGRICULTURE

THE FEASIBILITY STUDY
ON
THE IRRIGATION AND DRAINAGE DEVELOPMENT PROJECT
IN
THE HARAZ RIVER BASIN

MAIN REPORT

JULY 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of Islamic Republic of Iran, the Government of Japan decided to conduct a feasibility study on the Irrigation and Drainage Development Project in the Haraz River Basin and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Iran a study team headed by Mr. Satoshi Kadowaki, Sanyu Consultants Inc.,4 times between November, 1990 and October, 1993.

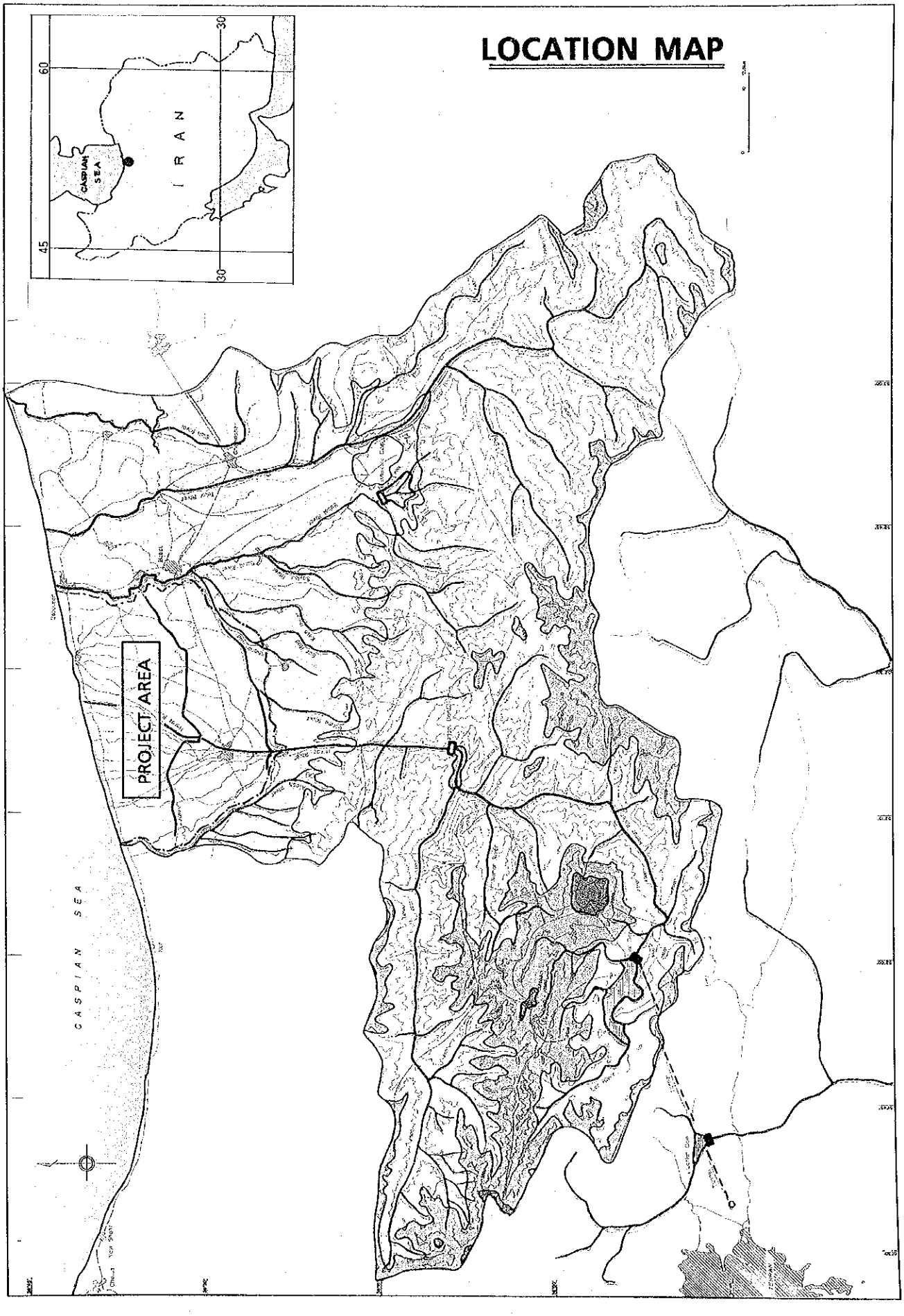
The team held discussions with the officials concerned of the Government of the Islamic Republic of Iran, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

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

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency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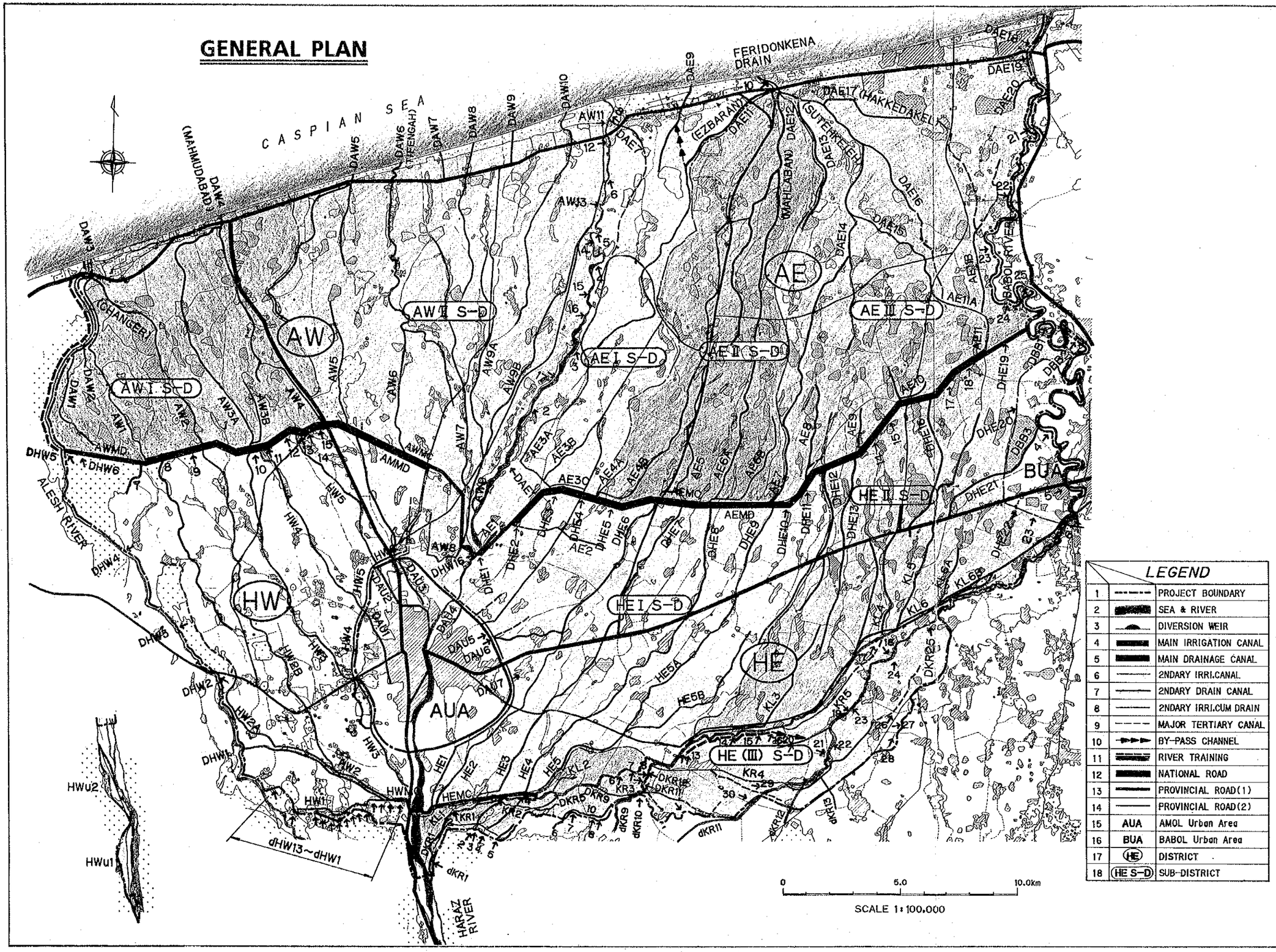
GENERAL PLAN



	LEGEND	
1	----	PROJECT BOUNDARY
2	▬▬	SEA & RIVER
3	⌒	DIVERSION WEIR
4	▬▬	MAIN IRRIGATION CANAL
5	▬▬	MAIN DRAINAGE CANAL
6	——	2NDARY IRRI.CANAL
7	——	2NDARY DRAIN CANAL
8	——	2NDARY IRRI.CUM DRAIN
9	- - -	MAJOR TERTIARY CANAL
10	▬▸▬▸	BY-PASS CHANNEL
11	▬▬	RIVER TRAINING
12	▬▬	NATIONAL ROAD
13	——	PROVINCIAL ROAD(1)
14	——	PROVINCIAL ROAD(2)
15	AUA	AMOL Urban Area
16	BUA	BABOL Urban Area
17	(HE)	DISTRICT
18	HE S-D	SUB-DISTRICT

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ABBREVIATIONS AND TERMS

International Agencies

ADB	Asian Development Bank
FAO	Food and Agriculture Organization of United Nations
IBRD	International Bank for Reconstruction and Development
IRRI	International Rice Research Institute
JICA	The Japan International Cooperation Agency
UNESCO	United Nations Educational, Scientific and Cultural Organization
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
SCS	Soil Conservation Service

Iranian Government

MOA	Ministry of Agriculture
MOE	Ministry of Energy
MORT	Ministry of Roads and Transportation
MOCJ	Ministry of Construction Jihad
MOPB	Ministry of Plan and Budget
MOH	Ministry of Health
MPG	Mazandaran Provincial Government

GDA of Mazandaran	Mazandaran General Department of Agriculture
RWB of Mazandaran	Mazandaran Regional Water Board
AO of Amol	Amol Shahrestan Agriculture Office
ARTSC of Babol	Babol Shahrestan Agriculture, Rural and Tribal Service Center
ANDWO	Amol Nur District Water Office
BDWO	Babol District Water Office
CAPIC	Caspian Sea Coastal Area Agricultural Development Project - Pilot Implementation Center
IMO	Iranian Meteorological Organization
NCC	National Cartographic center
SWESC	Soil and Water Engineering Service Cooperation

Unit of Measurements

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer
ha	:	hectare
cm^2	:	square centimeter
m^2	:	square meter
km^2	:	square kilometer
lit	:	liter
m^3	:	cubic meter
MCM	:	million cubic meter
lit/sec	:	liter per second
m^3/sec	:	cubic meter per second
cms	:	cubic meter per second
m/sec	:	meter per second
ppm	:	part per million
abdang	:	Iranian unit of discharge, 1 abdang = 0.25 m^3/sec
g	:	gram
kg	:	kilogram
ton, t	:	metric ton
EL	:	elevation above mean sea level
MSL	:	mean sea level
FWL	:	full water level
HWL	:	high water level
LWL	:	low water level
PGD	:	Persian Gulf Datum
sec	:	second
min	:	minute
hr	:	hour
No.	:	number
HP	:	horse power
EC	:	electric conductivity
ET	:	evapotranspiration
HYV	:	high yielding variety
O & M	:	operation and maintenance
IRR	:	internal rate of return

B/C	:	benefit cost ratio
FY	:	fiscal year

Administrative Division

Ostan	Province
Shahrestan	Township
Bakhsh	District
Dehstan	Village District

Glossary of Iranian Terms

rud	river
band	weir
abbandan	farm pond
chah	well
cheshmeh	spring
mirab	water master

SUMMARY

A. OBJECTIVE OF THE STUDY AND NATIONAL DEVELOPMENT PLAN

A. 1: Objective of the Study

01 : Objective

The Government of Iran has planned to increase rice production, by improving irrigation / drainage systems, and expanding crop diversification in winter crop season within the on-going Five-Year Plan (1988 ~ 1993). In order to realize the above mentioned target, this study was conducted to evaluate the feasibility of irrigation / drainage and agricultural development in the Haraz River Basin.

02 : Development Target

The annual report of the Central Bank of Iran reported that the gross national products in 1987/88 (1366 of Iranian Calendar) was about 18,681.2 billion rials, and the formation factors of GDP were 59.8% of Personal Consumption, 16.2% of Public Expense, 30.7% of Investment/Stock Holding and -6.6% of Foreign Trade.

The recent 5-year Plan was started on March 21, 1989 with optimum investment of 34,632.3 billion rials, equivalent to 480.87 billion US dollars at the official exchange rate in 1989. The target investment during this 5-year Plan was estimated as 27,620 billion rials. The required foreign currency expenditure was estimated as 119 billion rials, but foreign currency income in the period was estimated as 103.6 billion dollars expecting 27.4 billion dollars from foreigner's investment or loans.

The main target of the recent 5-year Plan lies in the establishment of social justice, accordingly the development of poverty stricken regions have higher priority of investment. This means that improvement of social infrastructure in rural areas, irrigation and other agricultural facilities, transportation/communication facilities, educational facilities, etc. have higher priority. The planned growth index was 8% per annum by the GDP, and per capita growth rate of production was set at 4.8%.

A. 2: National Development Plan

03 : Agricultural Sector

According to the Agricultural Census in 1988, total area of agricultural land in Iran was 16.9 million ha, 32% or 5.4 million ha of which was fallow. In annual cropping land, 5.6 million ha was irrigated, but the other 5.9 million ha was cropped as dry farming.

On the other hand, the number of farming families was 2.8 million households or 68% of the total households in the country. Self supply ratio of staple food such as wheat and

rice are 76% and 71%, respectively, and large portion of vegetable oil, mainly soya bean or sunflower oil, are dependent on importation.

To improve such situation, it is possible to guess from the recent 5-year Plan that the plan is aiming to achieve the following goals:

To expand the irrigated farmland to 6.3 ~ 6.7 million ha it is imperative;

- To increase usable water resources from 89 billion to 92.36 billion cu.m. Simultaneously, the reservoir capacity of storage dams is to be increased from 22.1 billion to 22.4 billion cu.m, and;
- To improve irrigation networks for 750,000 ha and to execute land leveling works for 50,000 ha within the period of 5-year Plan.

Consequently;

- It was targeted to increase production of wheat at a rate of 5% per annum or to increase total production of wheat from 7 million to 11.05 million tons. This goal was achieved in 1990, but the production of wheat in Iran is rather unstable due to application of dry farming for large portions of wheat farm. Expansion of irrigated farmland is very important to stabilize the production of cereal grains.
- 3.8% of annual rate of production increase was expected for paddy, and total production is to be increased from 1.7 million to 2.06 million tons. This target was also achieved in the case of 1990, however the imported quantity of rice is still remaining at a high rate.
- The annual rate of production increase for forage crop was set at 10.6% to increase total production from 9.06 to 15 million tons of dry material. This target will be achieved by means of expanding production of alfalfa and other forage crops, but large portion of demand of maize will still be dependent on importation.
- The increase rate of red meat; mutton and beef were expected to be 3.4% per annum or to increase the total production from 525,000 to 620,000 tons. Simultaneously, the increase rate of production of white meat, different kinds of poultry meat, was expected to be 11.6% per annum.

B. THE PROJECT AREA

B. 1: Natural Features

04 : Location

The Project Area is located in the eastern part of the coastal area of the Caspian Sea. As shown in the location map, the Project Area of about 108,000 ha in gross lies in an alluvia plain bounded by the Caspian Sea to the north, by the Kari Rud Canal and its canals to the south, by the Babol river to the east, by the Alesh river to the west, and extends from 35° 24' N to 36° 43' N, and 52° 12' E to 52° 40' E and is about 40 km east to west and 25 km north to south.

05 : Climate

Compared to the central plateau which is a typical arid zone, the Project Area receives much rainfall, reaching 788mm of annual mean precipitation. Most of the precipitation occurs in autumn, winter and in spring, but less in summer which is the rice growing season. Precipitation is derived from aqueous vapor evaporated from the Caspian sea and carried mainly by the Siberian or north wind during winter. Most of the precipitation occurs as rainfall but rarely in the form of snow in the Project Area. However, most of it falls as snowfall in the Alborz range, the catchment area of the Haraz basin.

The mean annual atmospheric temperature is 16.3°C, with the maximum monthly mean of 25.7°C in August, the minimum of 7.2°C in February. Humidity is high throughout the year with an average of 83%. April to August are the drier months.

06 : Rivers

Major rivers related to the project locate in and around the beneficial area and regimes of the river are summarized below:

River Regime

River	Gauging Station	Drainage Area (km^2)	Annual Runoff (MCM)			Extreme Daily Discharge (cms)
			Max.	Mean	Min.	Max.
Haraz	Karehsang	4,061	1,817	1,085	572	311
Babol	Babol	1,643	785	479	196	700
Alesh	(Nur-Amol Bridge)	163	-	-	-	-
Garma Rud	(Kari Junction)	116	-	-	-	-
Sadjjad Rud	Bandpai	260	82.5	67.4	42.6	42
Kela Rud	Diva	136	80.5	60.5	26.5	46

07 : Caspian Sea

Excess water of the Project Area is drained into the Caspian sea (about 371,000 sq.km of surface area). According to the long term records since 1926 on the sea water level fluctuation, the difference between minimum (-)28.5 PGD and maximum (-)25.3 m PGD is about 3.20 m. The sea water level by June, 1992 was around (-)26.10 m PGD in rising time, and careful consideration to prospect design maximum sea water level shall be made from the viewpoint of surface drainage plan and groundwater utilization for the project.

08 : Environmental Conservation

The present environment conservation restrictions found in and around the Project Area are as follows.

Environmental Conservation Areas Related to the Project Area

Environmental Conservation Areas Within the Project Area
(1) Feridon Kenar Conservation Area
(2) Amol Conservation Area
(3) Southern Caspian Coastal Line Conservation Area
Garma Rud Basin Conservation Area
(4) Baliran Conservation Area
Haraz River Basin Conservation Area
(5) Sang Chal Conservation Area
(6) Namarestagh Conservation Area
(7) Baladeh Conservation Area

Among the three areas directly related to the Project Area, only Feridon Kenar Conservation Area is of concern in the study. In this area a pond (Abbandan: AE88) has already been reserved as of international importance, and likewise no development has been proposed in the study. For other ponds, no particular restriction on development has so far been imposed.

B. 2 : Social and Economic Aspect

09 : Population and Household

The Project Area consists of administratively three Shahrestans of Amol, Babol and Babolsar with 490 villages. The population and households in the Project Area are estimated at about 425,000 and 76,300, respectively. Rural population shares about 64.5% of total population.

10 : Regional Industry

It is obvious that the prosperity of economy of the Project Area is still continuing under the present high price of rice. However, more than 40% of employed are engaged in rice-culture oriented agriculture and, furthermore, the ratio of employment in rice-milling, storage-keeping, whole sale of rice and other rice related sectors share large portion. In other words, the regional economy of the Project Area is greatly dependent on the paddy rice-culture. Other than those rice related industries, there are some small scale manufactories of furniture, agri-machinery, etc., construction, transportation, etc., but their portion of the regional gross product is not comparative to that of rice related industries taking their operational scale into account.

Taking the availability of land resources into consideration, further expansion of agricultural land is hardly possible. On the other hand, the population increase rate was rather high in recent decades. This means that rice-culture oriented economy of the Project Area will encounter serious problems of employment, except otherwise introducing new industries.

The introduction of new industries requires proper supply of material and/or production/marketing advantage to other regions. Unfortunately, the Project Area has no such advantage to be emphasized.

B. 3 : Present Land Use

11 : Land Use

The total gross area of the project covers 108,009 ha, of which cultivated area shares 84,498 ha, or 78% of the total. The share of paddy field represents 82,834 ha, or 77% of total or 98% of the cultivated land.

Water for paddy irrigation is currently diverted from the Haraz river through a number of canals and distributed by way of gravity irrigation system.

Tracts of paddy field extend from higher altitude areas of valleys and piedmont or mountain foot to dune hinterland on the Caspian coast, on which paddy covers the entire field in summer. As to second crops, winter crops are planted in parts of areas with high elevation in beneficiaries on both west and east districts of Haraz Diversion Dam, where better drainage condition prevails to cope with rainy winter climate.

Upland field occupies only 0.2% of the total area, while orchards covering 1.3% of it are mainly located in well-drained areas on alluvial fans and in the vicinity of living quarters, on which mainly citrus trees are grown.

B. 4 : Water Resources

12 : Precipitation

Mean annual precipitation is 788 mm. Seasonal distribution varies from a minimum of around 140 mm (18% of annual) in a quarter from May to August, a maximum of about 400 mm (50%) in autumn and winter beginning from September to December.

13 : River Runoff

The Haraz river originates in the Alborz Mountains lying in the south of the Project Area. The Haraz river is found with the tributaries such as the Nur river and the Lar river. Catchment area of the Haraz river is 4,061 km^2 at Karehsang gauging station. The Lar dam was completed in the Lar river for diverting water to Tehran Water Works in 1980. The Lar dam is, however, not fully operational yet.

On the other hand, storage reservoirs for the Project Area are Lar dam and small ponds scattered in the beneficial area. The total available water in those reservoirs is 276 MCM.

14 : Groundwater

The estimation of the final amount of groundwater draft obtained as a provisional calculation indicates more than 200 MCM annually containing the 6,000 wells in the whole Project Area.

Available groundwater for irrigation is around 145 MCM consisting of 137 MCM of shallow wells and 8 MCM of spring. Major groundwater drafting area is located mainly in low land area and the area of near Haraz river.

B. 5 : Agriculture and Livestock

15 : Land Holding

Due to the execution of land reform in 1960s most of the farmers in the Project Area have become land-owners, viz., the ratio of land owner farmer in Amol, Babol and Babolsar districts are about 85%, 65% and 60%, respectively. The average size of land holding is 1.72 ha in Amol, 1.55 ha in Babol and 1.53 ha in Babolsar districts. The mean holding size of whole Project Area is 1.66 ha.

16 : Cropping Pattern

Rice paddy is by far the predominant crop currently found in the Project Area, while upland and orchard crops are minor ones accounting for only 2.3% of the total cropping acreage.

Rice varieties are roughly grouped into the local and the improved, and the former is further classified into long grain and short grain varieties. Most of the local ones currently cropped have long grain, represented by Tarom. It is an early maturing variety that has kept fairly stable yield performance. Besides, it's taste suits consumer's preference which makes its market price stabilize at higher price levels, leading it to the top share of the total cropping acreage in the Project Area. Among representative improved varieties strains of Amol-3 and Khazar are popular.

Berseem clover has been recommended to be introduced as a secondary crop in rice fields as a strategy of promoting livestock sector since the middle of eighties, but the acreage under berseem tends to level off due to various constraints such as limited supply of seed, poor drainage during winter on paddy fields and customary grazing of cattle in the paddy field after harvesting rice crop.

17 : Farm mechanization

The farm mechanization of paddy rice cultivation has been steadily developed, covering plowing, puddling, spraying, threshing and carrying out works at the rate of 66 hours per ha.

18 : Livestock

Livestock herd presently kept by farmers in the Project Area is estimated at about 53 thousand heads of sheep/goats as well as 96 thousand heads of cattle, of which 10% of above of cattle herd constitutes pure milch cows or hybrids.

Sheep and goats are chiefly fed in the villages located in highland, grazed within highland extended in Piedmont area of the Alborz mountains during rice cropping season and then are migrated into plains after rice harvest and pastured in paddy fields or in coastal rangeland feeding on rice straw, roughage/fodder or concentrates as supplemental.

The objective of keeping sheep/goats herds in the Project Area is solely for redmeat production, though dairy products like butter, cheese and yogurt may also be obtained, and almost all of these are oriented to domestic consumption.

The objective of keeping cattle mainly lies in milk production for home consumption, but for commercial purposes only a few large-scale livestock farms produce dairy products and beef meat for meeting consumer's demand within the area. In most cases male calves are sold before weaning to livestock farms etc. where they are fed as beef cattle. In case of cattle steers the live animals are bought by butchers to be slaughtered in municipal slaughtering houses.

19 : Farm Economy

The gross income of farmers by the farm land holding size of less than 1.0 ha, 1.0 to 2.0 ha and more than 2.0 ha are about 2.7 ~ 2.8 million rials, 4.7 million rials and 7.1 million rials, respectively, however the portion of disposable income is limited.

B. 6: Irrigation and Drainage

20 : Available Water Resources

Since the topography, soil and climate are congenial to paddy growth and water for irrigation is available from the streams diverting from the Haraz river, paddy cultivation has been practiced since hundreds of years ago, and present irrigated area of paddy is totally about 83,000 ha.

Availability of the water resources at the present condition was evaluated as following table. Several volumes of water shortage have occurred even in a normal year.

Water Resource	Available Water Resources					
	Haraz West		Haraz East		Total	
	Amount (MCM)	Area (ha)	Amount (MCM)	Area (ha)	Amount (MCM)	Area (ha)
Surface Water	238	18,867	404	32,126	642	50,993
Wells	47	4,086	88	7,588	135	11,674
Spring	3	266	5	454	8	720
Abbandan	10	904	26	2,323	36	3,227
Return Flow	19	1,692	32	2,880	51	4,572
Sub Total	317	25,815	555	45,371	872	71,186
Shortage	63	4,591	108	7,057	171	11,648
Total	380	30,406	663	52,428	1,043	82,834

Note: Unit water requirement = (1,033 + 10) MCM + 82,834 ha ≒ 12,600 m^3/ha

21 : Characteristics of Drainage

Drainage characteristics of the area can be summarized as follows:

- Well Drained Area: Area in the highland region where drainage of rainfall and excess irrigation water is easy, and the groundwater level is low.
- Poorly Drained Area: Area in the middle and lowland regions where drainage of rainfall and excess irrigation water is difficult, and the groundwater level is high.
- Hardly Drained Area: Exceptionally low-lying area, (-)24.0 m and below, in the lowland region, especially in the hinterland of Feridon Kenar, where drainage is obstructed by rising of Caspian sea level and outfall (estuary) blockade due to bar formation. Groundwater level in this area is usually high and the area is

inundated during irrigation period. Water drafted from shallow wells is sometimes saline.

- Coastal Sand Dune Area: Highly percolative sand dunes are formed in the coastal region, which drain directly into the Caspian Sea. No drainage improvement is required.

22 : Operation and Maintenance

Management of water distribution is performed by the chief mirab, one each assigned by MOE for Amol and Babol Sharestan. The chief mirab enjoins the 116 zone mirabs who are responsible for management of secondary canals. In the terminal level, about 286 village mirabs operate water allocation in the tertiary and fourth canals.

Any water measurement facility is not equipped to the existing intakes and turnouts. Water distribution is practiced using a traditional measuring unit, namely "Abdang". Abdang means the distribution ratio of water, and it is given to and fixed at all intakes and turnouts. Depending on a given abdang, intakes and turn-outs are operated empirically by mirabs to keep a fixed distribution ratio regardless of discharge.

23 : Canal Network

The main facilities in the Project Area are those that divert and convey water from the Haraz river into the secondary canals. The three diversion works in the Alesh river are functionless in the latter half of the irrigation period due to exceptionally low discharge. The Kari Rud, diverting from the Haraz river at the southern part of the Project Area, is utilized to irrigate the northeast region. Subjected to the influence of rural development, relocation and changes, about 100 secondary canals are now in function.

Since most of the rainfall occurs in autumn and winter and this does not greatly affect crop production, except for the seven drainage main canals in the low-lying area in the north, drainage facilities are less developed compared with irrigation canal. The role of most of the secondary canals are less trenchant and often function as irrigation cum drainage canals.

No clear distinction is made for canals smaller than the tertiary level. Water is supplied to the field from secondary canals through a network of still smaller canals. These canals also serve to catch excess water and convey it to be stored in the farm ponds or reused.

24 : Water Right

The Project Area has a complex traditional water right system. It came into being when the division ratio between the Haraz river and the Kari Rud was decided at 7 : 5.

When water is abundant in canal, all farmers use it for irrigation regardless of whether they have water right or not. In dry year, water is allocated only to those with water right.

Based on 1985 survey, the paddy area with water right is estimated to be 64,300 ha. The survey conducted by Amol and Babol Water Offices in 1990 shows that it has been increased to 66,500 ha.

B. 7 : On-Farm Facility

25 : Present Condition of On-farm Facility and Farmers Intention

From the field survey, the conditions of on-farm irrigation and drainage systems are grasped as follows:

- Diversion works are made of earth bags, brushwood or concrete to raise the water level of canals, secondary or tertiary ones.
- Irrigation water is led to the upper point of a terminal irrigation block (TIB), which is about 110 ha in average, through an irrigation-cum-drainage ditch.
- In TIB, irrigation and drainage systems are plot-to-plot-mode.
- Drainage water is discharged into an irrigation-cum-drainage ditch finally.
- On the other hand, it can be said that the present irrigation method is effective from the viewpoint of re-use of return flow.

With the above systems, following problems are observed:

- Inundation is caused in the downstream fields during wet period, making second cropping difficult.
- Ineffective and irrational water distribution during drought period.
- Washing away of applied fertilizers and chemicals due to plot-to-plot irrigation.
- It is impossible to control water depth in an individual lot.
- It is difficult to harvest the early matured rice when different varieties are planted together in a plot-to-plot irrigation unit.

C. DEVELOPMENT PLAN

C. 1: Major Constraints

26 : Land Resources

Thus, it seems that the area has already reached the limit from land resources point of view, however, the land use still remains at as low as or below 120% from cropping intensity point of view. Therefore, it is indispensable for the development of local agriculture to consolidate basic infrastructure including soil improvement as well as to raise cropping intensity, though the ambient conditions in the background have been left behind.

Averaged acreage in land holding is estimated at 1.66 ha in area on one hand, small holders including landless households account for 32% of the total holdings on the other, and hence one can be hardly deny that these situations have hampered rationalization of farming.

27 : Water Resources

The Project Area has been developed as an agricultural area heavily oriented to rice production, in a way completely relying its water source on surface flow in the Haraz river. However, seasonally occurring water shortage has become chronic as the acreage under rice crop has been expanded. Though the total water amount as mean annual discharge counts 1,086 MCM, available flow during irrigation period for rice crop accounts for about 60% of this total, and current water control effectively regulating water conveyance is made without counting 240 MCM expected in Lar Dam located in the upper-most stream of the Haraz.

Water resources other than the above are 36 MCM of abbandans water and 153 MCM of groundwater.

28 : Irrigation and Drainage Facility

Progress in alignment or improvement of canals lagged behind, and there were no permanent structures in water intakes along the Haraz river. Lately, however, a construction plan of an intake weir into Kari-Rud, a main canal was launched and it is now under construction. Yet, almost no turnout diversion structures have been equipped at the points from main canals to secondary or from secondary to tertiary, nor particular operation and maintenance facilities to cater canals have been provided either.

Issues of drainage have rarely been considered hitherto by the reason of predominant mono-culture of rice crop, and up to date no systematic improvement in drainage

facilities has been conducted. A part of canals located in and below the middle part of the Project Area play a role of drainage during off-season of rice crop (rainy season), but the function is limited to prevention of water logging in roads or residential areas by inundated rain water from the surface of rice fields, thus causing water logging condition over them for a large tract of paddy area.

29 : On-farm Conditions

Majority of farm plots have been gradually developed by a reclamation process from swamps or deforested land to dried fields, they mostly have irregular boundary along natural topographic contour or gradient, with the average area of a plot ranging most frequently between 0.1 and 0.3 ha. However, smaller size plots with less than 0.1 ha are more often observed in highland with steeper topographic gradient. Such smaller sized plots often aggregate to form a block of plot-to-plot irrigation as a unit with several hectares to several tens of hectares.

As evident from the distribution pattern of canals, the Project Area virtually consists of plot-to-plot irrigation blocks, hence the majority of rice plots are not equipped with direct access roads. Besides, bunds of rice plots as a pathway have narrow width barely providing passage for a single person, and as a result farm machinery is very often carried in from adjacent plots.

30 : Agricultural Supporting Service

Agricultural cooperatives serve as a farmers organization linked with production activities, but they do not have autonomous activities in spite of long experience in their activities over 20 years. The fact that the contribution from a member to cooperative fund amounts only to some 40 thousand Rials or so indicates too low level judging from current monetary value, and deficit of running fund resources is also considered to be a cause limiting their activities.

Also, experimental, research and extension activities in the agricultural sector have been hitherto for the most part confined to varietal improvement for rice, and supporting systems for diversification and rationalization of farming have not been well provided. In livestock sector in particular, veterinarians, extension specialists, technicians for artificial insemination and other staff as well as service facilities have not fully met the requirement of the area.

31 : Environment

Within the Feridon Kenar Protected Area, only a single abbandan (AE88) has been designated as a protected area. This reservoir was designated as a wetland of international importance for migratory fowls, to which any development activity has

been prohibited. Whereas, in the abbandans designated as protected reservoirs in the Amol Protected Area only hunting is banned but no other restrictions on development activities have so far been imposed. Judging from these situations, it is vital to implement works in these abbandans with special consideration on the protection of fish species.

C. 2 : Basic Concepts of the Development

32 : Development Concepts

The objectives of agricultural development in the Haraz river basin are to up-grade the living level of beneficiary farmers and to contribute to the stabilization and development of the national economy by means of increased of food production under the given conditions at the Project Area solving those constraints.

33 : Expansion of Cropping Intensity

The improvement of soil by means of drying of paddy field and expansion of potential cropping area of second crops are the main objectives of drainage improvement for the Project Area.

- To remove any damage to paddy due to standing water or inundation.
- To avail mid-summer drying in paddy field to accelerate the growth of paddy, and
- To remove inundation damage to berseem which will be cultivated in the rainy season.

In principle, the whole Project Area is subject to such improvement, except the area where the topographical or other conditions limit such improvement. The optimum development scale is planned after detailed examination of practical potential of implementation, cost/benefit ratio, and other technical or economical factors.

34 : Irrigation and Drainage Facility

Taking the two diversion dams of Haraz and Amol as well as trunk canals therefrom which have been planned by the MOE into account, and using the existing canals as far as possible, the most appropriate plan of improvement of secondary and tertiary canals are to be provided so that rational water management may be applicable in future.

35 : Land Consolidation and Agri-Extension

The improvement plan of on-farm facilities is to avail farm machinery for mechanized farming of high efficiency and water management at on-farm level in future. Most of existing paddy farms do not have direct approach road to the village road, therefore introduction of farming machines of larger scale is rather difficult. On the other hand, the prevailing plot-to-plot irrigation system is not only hindering the mid-summer drying of paddy field, but there is considerable wash-out loss of fertilizer and agri-chemicals.

Taking such present conditions into account, the on-farm facilities improvement is to be designed in such a manner that each plot of paddy field is in contact with the farm road. Simultaneous separation of irrigation and drainage canals is to be applied as far as acceptable from economical point of view.

36 : Effective Use of Water Resources

The effect of improving works of basic farmland facilities will be materialized when a stable water supply is available.

Some 40% of annual runoff of the river is flowing in non-irrigation period, viz., about 400 MCM of river water is discharging into the sea uselessly.

Considering such actual conditions, the effective use of discharging runoff at the non-irrigation period is the sole solution to obtain stable water resources in the Project Area. Accordingly, the feasibility study on the Mangol dam project is urgently requested by the Ministry of Energy as multi-purpose water resources development taking into account irrigation, drinking/industrial and power generation.

37 : Agricultural Development

The afore-mentioned projects are to be provided to achieve better agricultural productivity in the Project Area. Therefore the agricultural development plan will be pictured on the improved basic farmland facilities. Consequently, agricultural development in the Project Area is to aim at high productivity and better profitability.

To achieve such targets, optimization of cropping intensity and yield/ha of each crop are indispensable. Taking account of those non-controllable factors such as climate and other physical conditions, the promotion of a compound farming system with rice and livestock is a really recommendable choice for the Project Area even from viewpoint of the national economy.

38 : Zoning

The Project Area is divided into 5 categories taking land use, natural features, administrative boundary and irrigation / drainage conditions into consideration.

- District or Sub-District: (4 or 9) — Command area of main canals or bounded area by roads, etc.
- Zone (62) : Command area with more than 500 ha of Secondary Canal
- Block (294) : Command area with more than 100 ha of Tertiary Canal
- Sub-block (748) : Further divided block by drainage system
- Unit : Command area with about 100 ha and terminal unit of land consolidation

(Figures in parenthesis indicate number of zoning)

C. 3 : Agricultural Development Plan

39 : Proposed Land Use

Proposed land use can be summarized as below.

unit: ha

	Paddyland	Upland	Orchard	Total Farmland	Non-farmland	Total
Command Area from Haraz Diversion						
West Bank	10,680	123	413	11,216	3,816	15,026
East Bank	24,005	24	219	24,248	6,004	30,252
Command Area from Amol Diversion						
West Bank	17,463	67	373	17,903	6,927	24,830
East Bank	23,837	24	259	24,120	8,417	32,537
Urban Area	2,865	27	135	3,027	2,333	5,364
Total Area	78,850	265	1,399	80,514	27,495	108,009

40 : Agriculture and its Production

The farming system planned for the above-stated land use plan is formulated on the following basis.

1) Winter crop will be introduced in the paddy field with improved drainage.
2) A joint use of machinery and farm facility is proposed to ensure efficient and economic use of these inputs.
3) Proper water management and farm drainage practice, midsummer drainage, timely cropping pattern etc. will be adopted to improve yield of paddy and other crops.

Farming System	Average Holding Size/Farm	Cropping Intensity	Crop Rotation System
A1	1.0 ha	175 %	paddy - veg.t - paddy - berseem
A2	1.0	167	paddy - veg.t - paddy - veg.d
B1	2.5	158	paddy - berseem - paddy - veg.d
B2	2.5	150	paddy - veg.t - paddy - berseem
C1	5.0	150	paddy - berseem - paddy
C2	5.0	133	paddy - berseem - paddy

Note : veg.t; transplanted vegetables, veg.d; direct-sown vegetables

Expected crop production based on the proposed land use and planned yield levels can be estimated as follows:

Crop	Without Project		Without Project		Balance	
	Acreage	Production	Acreage	Production	Average	Production
	(ha)	(ton)	(ha)	(ton)	(ha)	(ton)
- Padd. H.Y.V. Late	12,509	92,254	18,997	151,444	6,488	59,190
H.Y.V. Medium	32,275	185,291	28,494	181,735	-3,781	-3,556
L.V. Early	35,185	145,490	28,494	126,428	-6,691	-19,062
- Berseem	5,450	286,125	37,993	2,279,580	32,543	1,993,455
- Vegetables	3,650	82,125	6,250	141,525	59,400	53,150
- Broadbean	190	475	330	825	140	350
- Barley	330	990	0	0	-330	-990

41 : Promotion of Livestock

For promoting livestock farming, production of berseem and rice straw to be produced from winter fodder cropping in 38,000 ha and paddy field of 76,000 ha provides about 2,280,000 tons (green berseem weight) and 330,000 tons, respectively. Annual livestock productions from the above mentioned forages are estimated at about 68,000 tons of milk, 3,000 tons of meat and 31 tons of wool.

In order to realize the targets, the following countermeasures shall be undertaken as follows:

- Improvement of cattle races
- Improvement of facilities for artificial insemination, pest control, veterinary service
- Establishment of feeding and rearing practices
- Establishment of feeding plan

42 : Farm Mechanization

Introduction of appropriate mechanization system in compliance with the proposed cropping pattern is considered essential for a sustainable and productive agricultural system, and following criteria for mechanization are recommended taking the farm holding size etc. into account;

- Farm mechanization will follow in principle, the joint-use or hired-use of machinery and farming facilities.
- the machinery maintenance system will be fortified by unifying the types of machinery to be employed.
- an agricultural machinery registration system will be introduced to secure the maintenance of adequate numbers of working machinery as well as to strengthen inventory of spare parts.
- in the long run, improvement and exploitation of attachments and specialized machinery rightly matched to the local conditions will be challenged to improve field working efficiency.

43 : Post Harvest Facilities

As crop production is improved after the project, the need for an improved postharvest system as well as efficient marketing facilities will arise. The following should be considered, though these sectors should be specifically dealt with by other projects.

- Introduction of auto-threshing type combines for paddy harvesting should be accompanied with device for paddy drying. Presently, farm income is eroded by the high rate of postharvest loss in the form of broken rice grain by currently working rice mills. This leads to the necessity to create a serial processing system covering both paddy drying and milling.
- It is necessary to store berseem in the form of hay or silage to secure feed all year round. Hence either drying facility or silos are required. Dryers for this purpose may also be used for drying paddy. However, it should be studied separately.
- As for collecting and marketing vegetables in winter, it is necessary to develop marketing facilities within the Project Area, thereby rational packaging and forwarding could be realized in closer communication with consumer's markets.
- It is also essential to form a cooperative system for collection, treatment and processing of livestock products such as redmeat and milk.

44 : Farmers Organization

The following are the functions and activities of farmers organizations needed for planned production.

- The function as a land consolidation district to implement the works
- The function for orderly and efficient use, proper management and maintenance of jointly owned machinery.
- The function as a group operating a jointly managed box nursery systems associated with mechanized paddy transplanting.
- The function to produce paddy seed in relation to the joint nursery system.
- The function as a joint-purchase for farm inputs.
- The function as water users' association to secure equitable public service such as terminal water management, collection of water fee and repairing of terminal irrigation facilities.
- The comprehensive function as a unit to check livestock from trespassing the berseem fields, buying of berseem seed, joint use of grass dryers or silos, and group raising system.
- The function of joint unit to collect milk coupled with strengthened milching capacity.
- The function of joint market for winter vegetables and citrus fruits.

C. 4 : Irrigation and Drainage Plan

45 : Irrigable Area

Irrigation plan has been prepared for only paddy rice as a subject crop for irrigation. The summer crops other than paddy rice, which are citrus and upland crops, are excluded from the subject crop, because their cropping area is negligibly small as compared to the area of paddy rice.

The irrigation areas by district wise are summarized as below;

District	Irrigation Area (ha)	Irrigation Area by Water Source	
		Surface Water	Groundwater
1.Haraz West	10,680	9,755	925
2.Haraz East	24,005	21,409	2,596
3.Amol West	17,463	14,010	3,453
4.Amol East	23,837	19,051	4,786
5.Urbanization Area	2,865	2,279	586
Total	78,850	66,504	12,346
	100%	84%	16%

46 : Irrigation Water Requirement

The variety of paddy rice to be introduced is classified into three types, i.e., early, medium and late matured and their cropping acreage and water requirement are tabulated as follows;

Varieties	Cropping Density	Acreage	Annual Demand
	(%)	(ha)	(MCM)
Early matured	37.5	29,569	357
Medium matured	37.5	29,569	485
Late matured	25.0	19,712	316
Sub-total	100.0	78,850	1,059
Nursery Water	1.0	790	3
Total		79,640	1,062

47 : Water Resources

Annual water balance is summarized as shown below for normal year and design drought year.

(Unit :MCM)

Item	Normal Year	Drought Year
1) Water Demand	1,055	1,062
2) Available Water Resources		
- Surface Water	642	465
- Abbandans	50	50
- Groundwater	143	143
- Return Flow	87	87
Total	922	745
3) Water Shortage	133	317

As shown in the above table, water shortage occurs not only in drought years but in normal years. Water shortage is 317 MCM for drought year, and 133 MCM for normal year. From a view-point of this water shortage, it is important for irrigation to develop water resources of the residual basin.

Construction plan of proposed Mangol dam, which is located at the point of 15 km upstream of Karehsang gauging station, was prepared preliminarily.

Approximate dimensions of the proposed dam are as follows:

- Catchment area : 3,773 sq.km
- Live storage volume : 305 MCM
- Sediment volume : 170 MCM

- Water losses : 15 MCM
- Total storage volume : 490 MCM
- Height of dam : 220 m
- Length of dam : 1,000 m

48 : Drainage Plan

Following improvements and measures might be consequently necessary on drainage.

- to remove inundation and water logging or stagnation from farm lands during a period of paddy growth, for increasing the rice yield.
- to enable farmers to practice mid-summer drainage, for increasing the rice yield.
- to make farm lands better-drained for mechanization.
- to remove inundation/water logging and to control groundwater table from autumn to winter, for introduction of secondary crops and for effective land-use.
- to remove or mitigate drainage obstructions caused by the up-coming of the sea level, for the protection of the low-lying area.
- to train the adjacent rivers, for preservation of the Project Area from floods.

49 : Drainage Network

The drainage network of the Project Area is divided into six categories based on the location of the Haraz river and proposed main drainage canal systems.

Drainage District	Drainage Area (ha)
- Haraz Left District	
Alesh river drainage area	22,371
Direct drainage to Caspian Sea	17,937
Haraz river drainage area	2,572
Sub-total	42,880
- Haraz Right District	
Haraz river drainage area	2,926
Direct drainage to Caspian Sea	26,456
Babol river drainage area	35,747
Sub-total	65,129
Total	108,009

50 : Drainage Criteria

Surface drainage plan is established to drain the excess water within 2 days, which is caused by 2-day consecutive rainfall in the winter crop season. Berseem is selected as a subject crop for drainage planning. Rainfall intensity of the rice growing season is somewhat smaller than that of the winter crop season, consequently the drainage plan is prepared based on the rainfall of the winter crop season.

Berseem is also selected as a subject crop for sub-surface drainage, and groundwater table has to be kept below 20 cm from the field surface during a growing period of berseem. From a viewpoint of temperature during the growing period, tolerability for high groundwater table is limited within 5 days. Consequently, the drainage rate of sub-surface drainage has been decided to drain 5-day consecutive rainfall within 5 days.

51 : River Training

Proposed Amol West Main Drain and Amol East Main Drain, which are aligned eastward and westward direction in the center of the Project Area, will be connected to the Alesh and Babol rivers to mitigate flood damages in the low lying area. Therefore, the section of downstream of both rivers after junction of the said main drains will be improved to enlarge the required drainage capacity.

Since the Kari Rud canal has basically a function of irrigation, after adding the flood discharge from the Garma Rud it will have to be improved also as a floodway, diverting to the Babol river.

The length to be improved and design discharges for the said rivers are tabulated as below.

River	Design Discharge	Design Length
	(m^3/s)	(km)
Alesh	374	10.0
Babol	664	2.0
Kari Rud	130	4.6
Floodway	80	1.5

C. 5 : Land Consolidation Plan

52 : Conditions of On-farm Facility

On-farm system development (land consolidation) has the following basic concepts:

- Land consolidation scheme forms part of the long-term regional development plan in rural areas,
- Land consolidation serves to increase agricultural (land and labor) productivity through comprehensive consolidation of agricultural lands. In line with these concepts, the project should satisfy envisaged agricultural requirements and allow establishment of effective and rationalized farming,
- Land consolidation is to contribute to preserving a favorable rural production and living environment through comprehensive consolidation of agricultural lands.

To attain further improvement and stabilization of farm economy under such circumstances, it is necessary to increase cropping intensity and labor productivity. Therefore, the following on-farm improvement is to be carried out:

- Improvement of on-farm irrigation system; to stabilize the yield by means of timely irrigation,
- Improvement of on-farm irrigation system; to increase the yield by means of application of intermittent irrigation method, to increase cropping intensity (introducing second crops) through draining the inundated water due to autumn-winter rain, and to increase operation efficiency of agricultural machinery through improving the bearing capacity of soil,
- Improvement of farm road network; to avail access of agricultural machinery,
- Readjustment of field lot; to increase operation efficiency of agricultural machinery,
- Land repotting to increase the efficiency of farming works by means of collection of fragmented parcels.

53 : Design Criteria

These criteria are prepared considering the project area conditions and the above mentioned basic concepts. The salient features of these criteria are as follows:

1) Basic Layout

(a) Layout of farmland systems is determined to keep the shapes and sizes of field-lots in mind so as to minimize the ditch and the road densities. The most economical way to form field-lots is to lay the long side parallel to contour lines.

(b) Layout of the terminal ditches is decided considering the proposed canal systems. Irrigation/drainage ditches border the short side of field-lots to control irrigation/drainage operation independently for each field-lot or field-block. Lateral irrigation/drainage ditches border the short side of field-blocks and farm-blocks.

(c) Layout of farm roads is determined in conformity with the present road networks, and is incorporated in the layout of farmland systems. Farm roads are planned along the lateral irrigation/drainage ditches and the irrigation ditches.

2) Shapes and Areas of Field-lot

On balance, the standard shapes and areas of field-lots are recommended, as follows:

Short side length : 30 - 60 m,
Long side length : 100 m
Field-lots area : 30 - 60 a.

54 : Application of the Criteria

The sharing of land leveling cost to the total land consolidation cost accounts for about 60 to 70%. From the viewpoint of sample designing and CAPIC experiences, application manners of standard design will be the following five types taking mainly land gradient of the project area into consideration.

Type	Land Gradient	Acreage (ha)
- A type with land leveling	1/50 ~ 1/100	9,060
	1/100 ~ 1/200	13,818
	1/200 ~ 1/800	41,578
Sub-total		64,456
- B type without land leveling	More than 1/50	2,870
	Less than 1/800	8,659
Sub-total		11,529
Total		75,985

D. FACILITY PLAN

D. 1: Project Implementation Agencies

55 : Implementation Agencies

It is important that the implementation has proceed under a comprehensive and integrated plan.

The implementation of this project needs close cooperation among the project implementation agencies, viz. the MOE, the MOA, and the associations of beneficiary farmers. Major facilities and their responsible implementation agencies are as follows;

Facilities	Implementation Agency
Water Resources Facilities	
Amol Diversion Dam	MOE
Amol East & West Main Canals	MOE
Amol East & West Main Drains	MOE
Feridon Kenar Main Drain	MOE
Secondary and Tertiary Irrigation Canal	MOE
Secondary and Tertiary Drainage Canal	MOE
Terminal On-farm Facilities	MOA (L. C. D.)
Abbandan Improvement	MOA (L. C. D.)
River and River-mouth Improvement	MOE

(Note) L.C.D.: Land Consolidation District

D. 2: Facility Plan

56 : Condition of Canal Facility

Basic conditions to be considered of canal facility are summarized as follows;

- The land for the improved canals is considered within the present right of way as much as possible.
- At present, almost all existing canals are earth canals. In this study, earth canals are also adopted for the greater part of the proposed canals.
- Drops are designed to slow down the flow velocities along steep longitudinal slope portions.
- Gentle longitudinal slopes of canals are to be improved to an appropriate grade in order to solve the sedimentation and inundation problems in and around the canals.

- Suitable appurtenant structures (turnouts, measuring devices, checks, junctions and road crossings, etc.) are proposed in order to keep the functions and the facilities of canals stable.
- Operation and maintenance roads are designed in principle.

57 : Level of Canal Improvement

In order to determine the improvement level of irrigation and drainage system of the proposed secondary and tertiary canals, expected benefits and estimated costs incurred to the project implementation are tentatively compared. In this study, four (4) alternatives on the facilities improvement level are considered as follows:

Case-1 : Earth trapezoidal canal entirely.

Case-2 : Concrete canal for around 1/3 length in Case-1,

Case-3 : Provision of checks, drops and turnouts only,

Case-4 : Same as Case-2, however saved construction equipment costs for land consolidation works.

Based on this study, Case-4 is considered as the optimum investment level of the project. In line with this, the improvement level of on-farm facilities (the amount of investment) is considered within the range of Case-4.

58 : Canal Construction and Improvement

The length of canal to be constructed and or improved can be summarized as follows:

(Unit: km)

Canal Class	New Construction	Improvement	Total
Main irrigation canal	50	10	60
Main drainage canal	42	9	51
River training	1	17	18
Secondary irrigation canal	72	136	208
Second irrigation / drainage canal	8	128	136
Second. drainage canal	114	136	250
Tertiary irrigation canal	180	516	696
Tertiary drainage canal	243	234	477
Total	710	1,186	1,996

D. 3 : On-farm Facility

59 : Density of On-farm Facility

These densities are computed on the basis of the proposed net paddy field areas.

District	Farm Road	Ditch (Irri.)	Ditch (Drai.)	Proposed Paddy Field
	(m/ha)	(m/ha)	(m/ha)	(ha)
1. Haraz West	91.4	133.4	87.9	10,680
2. Haraz East	85.5	130.8	83.2	24,005
3. Amol West	80.5	124.6	82.7	17,463
4. Amol East	84.5	125.7	86.3	23,837
5. Project Area	84.9	128.2	84.7	75,985

Note) Proposed paddy field: The land reduction ratio of 5% is applied on the entire Project Area.

E. IMPLEMENTATION AND OPERATION/MAINTENANCE OF THE PROJECT

E. 1: Implementation of the Project

60 : Methodology of Project Execution

In order to keep smooth and efficient implementation of the project, the following manners shall be adopted taking financial availability, scale of civil works, capability of the contractor and mobilization of governmental officials etc. into consideration.

Facility	Agency	Method	Period
- Water source	MOE	Contract	Year round
- Canal/facility	MOE	Contract	Year round
- On-farm level	MOA/LCD	Semi-Contract	Winter season

61 : Implementation Schedule

- Topo-survey / Mapping: 1994 to 1997
- Construction work for Haraz D.D. area: Commencement in 1996
- Construction work for Amol D.D area : Commencement in 1996 for diversion dam, and commencement of other works in 1998 and completion in 2006
- Preparatory works, such as establishment of farmers' organization, preparation of laws and regulations, financial plan: between 1994 and 1998

62 : Organization of Project Implementation

The project will be implemented under the mutual cooperation of the MOA and the MOE, and that part of the MOE's responsibility will be managed by the Mazandaran Regional Water Board. In case of the MOE, a Project Office will usually be established under the Water Board to superintend the activities of the consultant who will be employed for design works and supervisory services of construction works at the implementation of such kind of projects. It is assumed that a similar system will be applied in case of this Project.

The improvement works of on-farm facilities for which the MOA will be the responsible agency for executing or promoting them are rather different from those past activities of the MOA, viz., the Project Area has comparatively high income levels in the country and, consequently, a large portion of required project cost are to be borne by the beneficiary farmer. Also, it is doubtful if the Soil and Water Engineering Service Corporation, SWESC, and/or ARTSC have sufficient experience in such category of project implementation. Therefore, CAPIC shall be the executing agency after reorganization of existing capacity.

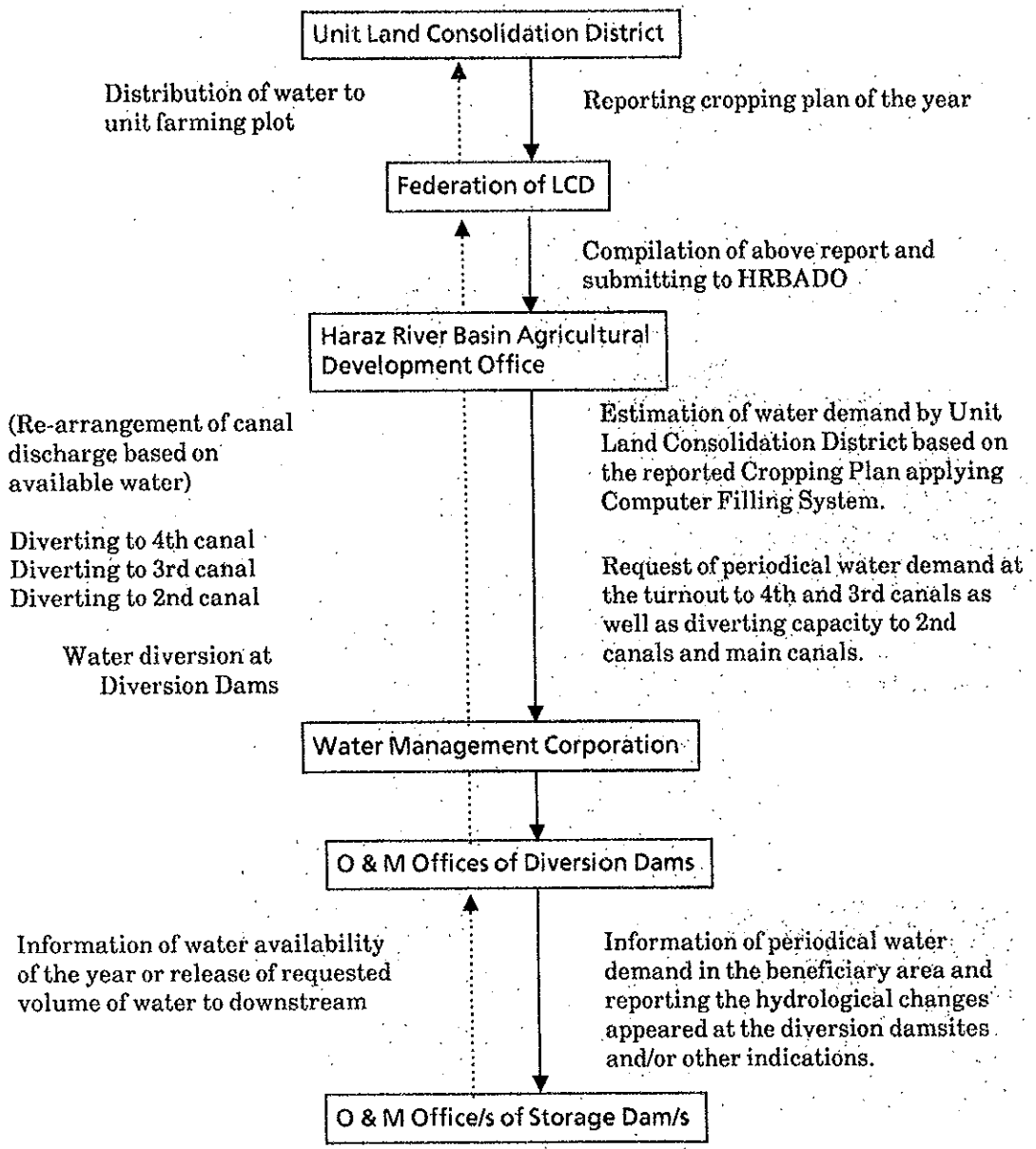
63 : Operation and Maintenance

The facilities constructed by the project can be managed as following demarcation.

- Management and maintenance of storage dam and diversion dam: Ministry of Energy
- Management and maintenance of main, secondary and tertiary canals: Water Management Corporation to be newly established
- Management and maintenance of on-farm facilities Land Consolidation District

64 : Manner of Water Management

Considering the responsibility of the MOA for guidance and coordination to the farmer's organization, following water management system is recommended:


Unit Land Consolidation District
Distribution of water to unit farming plot
Reporting cropping plan of the year
Federation of LCD
Compilation of above report and submitting to HRBADO
Haraz River Basin Agricultural Development Office
(Re-arrangement of canal discharge based on available water)
Diverting to 4th canal
Diverting to 3rd canal
Diverting to 2nd canal
Water diversion at Diversion Dams
Estimation of water demand by Unit Land Consolidation District based on the reported Cropping Plan applying Computer Filling System.
Request of periodical water demand at the turnout to 4th and 3rd canals as well as diverting capacity to 2nd canals and main canals.
Water Management Corporation
O & M Offices of Diversion Dams
Information of water availability of the year or release of requested volume of water to downstream
Information of periodical water demand in the beneficiary area and reporting the hydrological changes appeared at the diversion damsites and/or other indications.
O & M Office/s of Storage Dam/s

F. COST AND BENEFIT

F. 1: Cost

65 : Project Cost

The project costs comprising foreign and local currency components are tabulated as follows:

(Unit: M. Rial)

District	Cost			
	Foreign C.	Local C.	Total	Cost per ha
Haraz West	45,900 (110,631)	30,667 (112,343)	76,567 (222,974)	7.16
Haraz East	94,720 (232,891)	63,528 (263,633)	158,248 (496,524)	6.59
Amol West	54,695 (139,846)	35,327 (166,370)	90,022 (306,216)	5.15
Amol East	85,861 (220,020)	58,687 (287,549)	144,548 (507,569)	6.06
Total	281,176 (703,388)	188,209 (829,895)	469,385 (1,533,283)	6.17

Note: Figures in parenthesis indicate the project cost including price escalation.

66 : Annual Disbursement Schedule

Annual disbursement schedule without price escalation is tabulated as follows:

Year	Cost		
	Foreign C.	Local C.	Total
1994	4,930	5,515	10,445
1995	2,133	7,032	9,165
1996	11,164	10,571	21,735
1997	20,456	16,326	36,782
1998	27,622	21,532	49,154
1999	41,863	23,508	65,371
2000	34,026	22,755	56,781
2001	33,861	21,966	55,827
2002	32,450	19,469	51,919
2003	30,362	17,396	47,758
2004	23,811	12,948	36,759
2005	12,534	6,528	19,062
2006	6,011	2,728	8,739
Total	281,176	188,209	469,385

F. 2: Project Benefit

67 : Project Benefit

The with-project crop value estimated from major crop production amounts to 212,872 million Rial/year at the stable phase of the project, consisting of 78% derived from rice and the remaining 22% from winter crops. The net benefit in this stage comes to 55,118 million Rial/year, of which around 60% is brought about by berseem and roughly 20% each stems from rice and vegetables, respectively. Average benefit per hectare in the whole project is expected at 725 thousand Rial/year, realizing 2.802 million Rial/ha/year at the stable phase.

Crop	Component	Irrigation	Drainage	Land Consolidation	Total
Rice	Benefit	1.9 (16.3)	-1.0 (22.1)	13.8 (3.9)	14.7 (42.3)
	Cost	3.8 (3.0)	3.0 (3.0)	-7.9 (-0.5)	5.0 (5.5)
Berseem	Benefit	0 (0)	38.1 (8.5)	38.8 (51.0)	77.8 (59.5)
	Cost	0 (0)	-16.8 (-1.0)	-1.4 (-13.0)	-18.2 (-14.0)
Vegetables	Benefit	0 (0)	5.3 (4.2)	5.5 (4.1)	10.8 (8.3)
	Cost	0 (0)	7.0 (2.3)	2.7 (0.5)	8.7 (1.8)
Others	Benefit	0 (0)	0.2 (0.1)	0 (0)	0.2 (0.1)
	Cost	0 (0)	0 (0)	0 (0)	0 (0)
Total	Benefit	1.9 (16.3)	42.6 (34.9)	59.0 (59.0)	103.5 (110.2)
	Cost	3.8 (3.0)	-0.8 (-0.2)	-6.2 (-13.0)	-3.5 (-10.2)
	Net Benefit	5.7 (19.3)	41.8 (34.7)	52.5 (45.0)	100.0 (100.0)

Note : Figure by financial prices, and without-dam basis (the bracketed figures give those on with-dam basis. The rate of labor-saving component in the production cost falls in 36.7% (16.7%). Negative values of the production cost indicate augmented cost by the project.

68 : Indirect Benefit

Indirect benefits are consisted of secondary and inevitable or those associated ot hte direct components. The major indirect benefits expected from the project are tabulated as follows:

Direct Benefits	Secondary Benefits	Associated Benefits
Increase of Crop Production	Expansion of :	
	Livestock Farming	Increase of Employment
	Agri-product Processing	-ditto-
	Marketing & Transporting	-ditto-
	Machinery-related Service	-ditto-
Increase of Winter Cropping	Increase of Livestock Productivity	Expansion of Regional Economy Supply of Organic Material in Soil
	Moderation of Seasonal Fluctuation of labor Demand	Creation of Time for Refreshment throughout Year
Labor Saving	Increase of Off-farm Income	Activation of Region Economy
(Facilities Improvement)		(Conservation of Water Quality & Environment) (Traffic & Living Convenience)

G. PROJECT EVALUATION

G. 1 : Economic Evaluation

69 : Internal Rate of Return

Economy and financial internal rate of return for with and without Mangol Dam case by sub-district-wise are evaluated as follows;

Sub-District	Without Mangol Dam		With Mangol Dam	
	EIRR(%)	FIRR(%)	EIRR (%)	FIRR(%)
Overall	13.5	10.1	9.3	6.5
Haraz West - 1	7.3	7.0	6.9	5.7
Haraz East - 1	9.8	8.6	9.3	6.6
Haraz East - 2	9.4	8.5	9.2	6.3
Haraz East - 3	12.9	9.9	10.8	6.9
Amol West - 1	15.6	10.6	9.0	5.9
Amol West - 2	20.0	13.7	14.9	9.2
Amol East - 1	17.4	11.8	10.8	6.9
Amol East - 2	17.8	12.2	9.9	6.6
Amol East - 3	13.2	10.4	4.5	4.0

The economic internal rate of return show considerable fluctuation by sub-districts due to difference of cropping intensity, cost sharing ratio of irrigation and/or drainage facilities as well as difference in the cost of land consolidation works which depend on the topographical conditions. However, the implementation of the project will economically be justified in total if the construction of Mangol dam is not considered accepting some water shortage.

70 : Sensitivity Analysis

The major influencing factors considered in economic feasibility of the project are, change in construction period, in particular the rate of progress of land consolidation, fluctuation in construction cost and benefits attributable to technical ability and inflation, and fluctuation of different foreign exchange rates used for cost-benefit estimation.

The analysis indicates that though unexpected paddy failure (stagnant yield growth) and delay in land consolidation works affect to a fairly large degree cost-benefit factors, it does not go beyond the breakeven point where the benefits cannot offset the total project cost.

71 : Financial Situation of the Representative Farm Household

Most of the farm households in the Project Area hold small scale farmland averaging 1.4 ha in Babol and 1.7 ha in Amol and are taken as typical ones for the respective area. For each of these types the current balance and expected farm and non-farm incomes with project are shown below.

Project Economy of Farm Household

Farm Size	1 ha	1 ha	2.5 ha	2.5 ha	5 ha	5 ha
Annual Crop Acreage						
Before Project	1.43 ha	1.30 ha	3.10 ha	2.93 ha	5.50 ha	5.35 ha
Increase by Project	0.32 ha	0.33 ha	0.85 ha	0.83 ha	2.00 ha	1.30 ha
Household Income (million Rial/family)						
Before Project	3.0	2.9	5.8	5.7	11.1	11.0
Increase by Project	1.1	0.9	2.2	2.3	4.4	3.4
Surplus After Project	1.4	1.1	3.9	3.9	7.0	6.0
Land Consolidation Charge	0.4	0.4	0.9	0.9	1.8	1.8
Ultimate Surplus	1.0	0.7	3.0	3.0	5.2	4.2
% of Farmers Burden	26%	33%	23%	23%	26%	30%

72 : Farmer's Capability of Repayment

Sharing capacity of beneficiary farmer for the cost after completion of the project are land leveling cost for land consolidation, O & M cost and farming input materials. As mentioned above in the item 71, most of the farmers in the Project Area can afford to pay those annual costs within their ultimate surplus annual incomes.

G. 3: Conclusion and Recommendation

73 : Conclusion

The implementation of the project herewith proposed is duly evaluated feasible according to cost-benefit analysis and project evaluation. It will be timely served to pursue long-term national goals if it is implemented as early as possible because of the following:

(1) The Project Area is so to speak a granary of Iran but the production is being leveled off due to various constraints such as standstill in productivity improvement through mechanization attributable to poor drainage and dilapidation of irrigation facilities as well as typical monocultural cropping. Now the study submitted herewith has identified what the constraints are and how they are overcome or improved, with a conclusion that water and land resources should be more efficiently utilized to

maximize total output therefrom, by introducing winter cropping and more reasonable combination of rice varieties in terms of water, land and machinery use, accompanying with compound farming with other sectors like livestock. The study also reveals that the way of developing the area is technically justified without any particular difficulty except construction of Mangol dam. This direction is fully in compliance with what are included in the Five Year Plan to expand rice and fodder production to reduce imports and rely more on self-sustenance.

(2) Time seems to have ripened enough now for its implementation because CAPIC has been functioning and there have emerged a number of advanced cadres of farmers who are keen in improving their way of farming towards less hired labor cost or machinery cost while they diversify their agricultural activities as well as enhance land and water use to maximize agricultural production and value-addedness. They can take leadership and initiative to organize the whole beneficiary population to enjoy the benefits expected from the proposed project.

(3) The project will significantly contribute to create labor opportunities within the Project Area, thus improving labor absorbing capacity both through the process of construction works and after its completion in the field of agriculture and related sectors. During the period of world-wide economic recession, additional domestic labor opportunities are more valuable to those who will graduate from school and enter into active labor force or those who repatriate from foreign labor markets. It is also needless to say that exodus of younger generation from the area can be prevented on one hand, while growing difficulty in agricultural practice engaged mainly by aged farm labor can be eased by further mechanization, on the other.

(4) Last but not least important is the environmental aspect of project implementation. The proposed project can be implemented without bringing about any serious detrimental or deleterious impact on the natural as well as living environment. In refraining from any artificial works on what have been designated as the protected area for international significance, those who implement the project are observant of any environmental care officially promoted. Even some positive contribution could be expected on environmental conservation from its implementation, because improved water control can reduce load of water pollutant/contaminants in effluent from rice fields and land consolidation works provide farmers with more convenient road/waterway networks in rural areas. Well consolidated farmland is so to speak a value added to national wealth as compared with natural ground because of higher productivity and ease of controlling water, machinery, transport etc..

74 : Recommendations

(1) Major irrigation water sources in the Project Area constitute surface flow of the Haraz river, shallow wells scattered over the area and return flow within the area. A reservoir is required to supplement quantities in short, i.e., 300 MCM for the drought year recurring once in ten years and around 100 MCM for normal and ordinary years that arise from the difference between the irrigation pattern for rice crop and that of runoff discharge of the Haraz, as well as from a change induced by the introduction of more winter crops. An enormous amount of construction cost will be unavoidable for Mangol Dam planned in the Haraz basin, judging from its geologic and topographic conditions in the proposed site, also from the cost of relocating the national high way running along the basin. There, the plan should be considerately reviewed from the viewpoint of feasibility of allocating the cost among municipal and industrial water supply to the urban area in and around Tehran, hydro-power generation and irrigation for the Project Area, along with the detailed survey for the feasibility of those implementation. In this case, relevant measures should be taken to supplement water to meet the water shortage in ordinary years, and also it is imperative to make effort to realize the expected measures through a coherent coordination between the beneficiary farmers and administrative authorities concerned, such as reinforcement of flexible water management for Lar Dam, including limited discharge from the Dam during wet year/season and appropriate discharge during dry year/season, efficient use of abbandans within the Project Area (with more frequent turns as well as expansion in their storage capacities by dredging), improvement in water management techniques inclusive of timely utilization of groundwater resources during dry periods and their reuse.

(2) One major development component of the project is land consolidation, and this coupled with drainage improvement will serve to promote mechanized farming and enhanced land use through winter cropping, thereby raising the level of farm incomes. The project proposed for the first time implementation of a large scale land consolidation in rice producing area in Iran. In this project, a part of the project cost is as a rule to be met by farmers themselves. It also includes various other issues, e.g., procedural establishment of land reallocation (parcel exchange among farmers) decision on the period of works in adverse climatic conditions, ways of designing, project management, organizing beneficiary farmers, canalization of fund resources for farmers, to which sufficient studies and orderly solutions should be sought and provided for prior to the implementation by the initiative of the relevant administrative agencies.

(4) The main course of land consolidation comprises land leveling of rice fields. Since such works tend to be operated during rainy winter season, procurement of construction machinery specifically designed for the operation in swamps is essential. Unfortunately, experiences of such works, funding capacities of local contractors or ability in mobilizing construction machinery have not been sufficiently available in Iran. With a view to smoothly implementing the project along with assisting the development of local contractors, it is proposed that the government agencies purchase the construction machinery to lease it to these undertakers of construction works.

(5) The Government of Islamic Republic of Iran plans to execute an efficient, proper management of irrigation/drainage facilities. As to the operation and maintenance of the project facilities after their completion, MOE is responsible for the direct management of those of major water sources, i.e., the storage dam and diversion dams, while the Water Management Corporation is to cover from main canals to tertiary ones, but the terminal facilities commanding less than 100 ha of the beneficiary are managed by the farmers organizations (land consolidation district). In regard to the Corporation, it is newly established in compliance with the mutual agreement among MOA, MOE and Plan and Budget Organization, by positively disintegrating the sectors related to irrigation, that consist of a part of duties undertaken by existing Amol and Babol Water Management Offices. It is also indispensable to actively study and realize the enforcement of laws and regulations for the establishment of the said Corporation, in parallel with the project implementation.

(6) It is also vital to formulate a farmers guidance program by the authorities concerned in cooperation with experiment stations and extension service agencies concerned to steadily pursue the cropping, production and livestock plans as proposed by the project. At the same time along with this program, relevant administrative guidance is desirable to establish farm mechanization program and arrangement for joint use of machinery, coordinated strategies between marketing systems and cooperative activities etc.

(7) The detailed design to be provided prior to the implementation of the project should pay due regard to :

- the provision of topographical maps with the scale 1/10,000 from aerial photographs to keep better conformity among facilities mutually connected, in drawing the detailed design for irrigation and drainage canals, access/maintenance roads, block plan for land consolidation etc..

- the provision of other sets of topographical maps with the scale 1/2,000 for the purpose of more accurate planning and providing detailed designs of land consolidation. Simultaneous cadastral survey conducted for clearly identifying the current status of land-holding.
- the efficient mobilization/application of results from the benchmark survey conducted during the study period of the project for the process of land surveys covering canals etc.
- although the detailed designs for basic facilities can be provided by the conventional methods employed by MOE, those for land consolidation will have to be covered for a large tract of land within a short period through the consultation with a number of farmers concerned. To meet this demand, it is actually needed to rapidly train the staff in MOA, implying the necessity of hiring fully experienced consultant(s) therefore.

CHAPTER 1. INTRODUCTION

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1. 1 Authorization and Report

This report has been prepared in accordance with the Scope of Works for the Feasibility Study on the Irrigation and Drainage Development Project in the Haraz River Basin agreed upon between the Ministry of Agriculture of Government of Islamic Republic of Iran and the JICA dated on September 6, 1990.

The report, comprised of the Main Report, Appendixes, Data Book and Drawings, was compiled based on field surveys, analysis and review of collected data, information, and printed reports, careful studies conducted in Iran and Japan, including a series of discussion meetings between the government officials and the Study Team.

The main subjects of the report are : 1) to establish a basic agricultural development plan for the Haraz River Basin based on the results of field surveys and analyses, and 2) to arrange and design the improvement plan for water resources, irrigation/drainage, and on-farm facilities, implementation program, and project evaluation.

1. 2 Objectives of the Study

The Government of Iran has planned to increase rice production from 1.7 million tons in 1988 to 2.0 million tons in 1994, with an annual growth rate of 3.8 %. At the same time, the Government has also planned to improve the irrigation and drainage system of about 500 thousand ha within the on-going Five-Year Plan. (1988 - 1993)

In order to realize the above-mentioned targets, the Ministry of Energy (MOE) and Ministry of Agriculture (MOA) have implemented comprehensive agricultural development programs which include improvement of irrigation and drainage systems along with on-farm facilities. In compliance with the said policies, the objective of the study is to evaluate the feasibility of the

irrigation and drainage development project in Haraz River Basin aimed at increasing rice production and to challenge the introduction of a large scale winter cropping after drainage improvement.

1.3 Scope of Work

The study area covers an area of about 108 thousand ha in Haraz River Basin, which is located in the northeast of the Capital City of Tehran.

The scope of work undertaken by the Study is divided into two phases. The basic development plan was formulated in Phase I and detailed feasibility study was conducted in Phase II.

The following are the outlines of the respective phases.

(1) Formulation of Basic Development Plan (Phase I)

- To collect and review the relevant maps, data, information and printed reports related to the project, especially the HWDP-I Report (Report on Haraz River Water Resources Development Project-I) by the MOE.
- To conduct field surveys/investigations and inventory surveys on topography, geology, groundwater, land use, soil, irrigation/drainage system and agriculture.
- To study the current farming practice, irrigation and drainage management.
- To assess the availability of water resources including surface runoff, groundwater, spring, abbandan (farm ponds) and return flow.
- To clarify the major constraints and problems encountered in the formulation of development.
- To provide a basic development plan covering land use, cropping pattern, crop production, livestock feed production, improvement and management of irrigation/drainage systems and land consolidation.
- To prepare the Interim Report focusing on the formulation of basin development plans.

(2) Feasibility Study (Phase 2)

- To collect supplemental data and information, and to conduct additional survey for detailed feasibility study.
- To discuss the improvement plan for the main irrigation and drainage system proposed by the MOE, from the stand point of tertiary canal, on-farm facilities improvement and land consolidation plan.
- To prepare the schematic maps for irrigation and drainage networks by zone and block.
- To formulate a comprehensive agricultural development plan taking into account land and labor productivity.
- To exhibit a model-layout plan and preliminary design for the irrigation/drainage canal, and on-farm facilities and land consolidation.
- To justify the project based on cost-benefit analysis and to propose an implementation program in accordance with the result of the said analysis.
- To write the feasibility report and to make recommendations.

(3) Technical Transfer

During the course of the study, technical transfer was made from the Study Team to the counterpart personnel. Transfer activities were focused on weekly free discussions on the entire scope of the study so that the planning process would be understood well by all the members.

1.4 Schedule of the Study

The study was conducted in two phases as mentioned above, i.e., Phase I study and Phase II study. The respective periods of study in each phase are as follows.

(1) Phase I

Preparatory study in Japan	Nov. 29, 1990	Dec. 5, 1990
Field study 1st period	Dec. 6, 1990	Mar. 18, 1991
Field study 2nd period	May 21, 1991	Jul. 19, 1991

Home study 1st period	Aug. 2, 1991	Oct. 15, 1991

(2) Phase II

Field study 1st period	Nov. 1, 1991	Mar. 16, 1992
Field study 2nd period	Jun. 1, 1992	Oct. 31, 1992
Home study 2nd period	Nov. 1, 1992	Feb. 28, 1993
Reporting / explanatory visit	Apr. 10, 1993	Apr. 21, 1993

CHAPTER 2. NATIONAL ECONOMIC DEVELOPMENT PLAN AND ITS BACKGROUND

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2.1 Background

The Islamic Republic of Iran is geographically located at 25°03' - 39°47'N and 44°05' - 63°18'E, and it is located at the Temperate Zones from the viewpoint of the latitude. However, its physical standings varies considerably due to its complexity in topography which has more than 5,000 m of elevation difference.

The total land of Iran is 1,645,000 sq.km. The South is facing the Persian Gulf and the Sea of Oman in 1,880 km of shore line, and about one fourth of the North or 630 km in 2,370 km of border faces to the Caspian Sea. The eastern and western parts of the North neighbor the Torkman Republic and Azarbaijan Republic, respectively. The East neighbors Afghanistan (850 km) and Pakistan (830 km) and the west borders with Turkey (470 km) and Iraq (1,280 km). The land is roughly divided into 3 main features: of mountainous area of over 1,500 m height, arid desert area and pasture/forestry area.

The topographic particularities of Iran are mainly caused from the Alborz mountains which range at the north and the Zagros mountains which are curving from the south-east to the north-west of the country. The triangle region which is formed with those 2 adjoining mountains at the north-west is called the Iranian Plateau, which has higher than 300 m of elevation. Many lateral mountains are running out from the inner wall of the Zagros, and they make the topography of the triangle region more complex. However, a large portion of the eastern half of the triangle region is arid desert having small undulating topography.

The northern slope of the Alborz is rather gentle at its east and westerly ends, but it is rather steep at the central part where is facing to the Caspian Sea. Except the deltaic plain of the Sefidrud, the Haraz and other rivers, the coastal area of the Caspian Sea mostly forms a narrow belt shape plain of few km width. Only 41% of this region has less than 300 m of elevation,

and more than 31% is located at over 1,500 m elevation. The water surface of the Caspian Sea is about (-)26 m from sea level, but it fluctuates considerably as explained in para. 3. 1. 5.

About 98% of the coastal area of the Persian Gulf and the Sea of Oman have an elevation of less than 300 m, but a large portion of this region is shared by the Khozestan plain which is located at the easterly region of the Mesopotamia Plain.

About 61% of the Iranian Plateau, which includes the southern slope of the Alborz and Zagros mountains, is located at an elevation of 300 ~ 1,500 m, and half of it is desert areas of the Lut and Kavir. Another 39% is highland of more than 1,500 m. Many small basins are scattered in the highlands.

Those above mentioned topographical particularities also represent the meteorological particularities, viz., the country is roughly divided into 3 meteorological regions of the Caspian Sea coast, the Iranian Plateau and the Persian Gulf / Sea of Oman coast. Many micro climatic zones are formed in accordance with the topographic elements.

In general, the Caspian Sea coast has the Mediterranean climate, and its dry and rainy seasons are comparatively distinguished, however its easterly region belongs to the semi-arid zone having less than 650 mm of annual precipitation. The precipitation increases in the westerly regions, and reaches 2,000 mm at the west end of the region. The mean maximum temperature is about 20°C and the mean minimum temperature is 2 - 5°C.

The wall of the Alborz and the Zagros mountains isolates the Iranian Plateau from other regions, and the vapor transport from the Mediterranean Sea or the Indian Ocean is prevented by those walls, therefore this region has the driest climate in the country. The mean maximum temperature is greatly influenced by the elevation. The mean minimum temperature also varies greatly between 3 and 17°C . The annual precipitation is about 500 mm at the north-west area which is influenced by the Mediterranean Sea, but that of eastern region around the desert is less than 100 mm.

The mean maximum temperature often exceeds 30°C at the southern coastal region, and the mean minimum temperature is also as high as more than 17°C. Most parts of the plain area has an annual precipitation of 150 ~ 250 mm, but the eastern area facing the Sea of Oman has less 100 mm. There, the relative humidity is rather high compared with the plateau region. This region is generally classified as high temperature-humid zone.

The country has become Islamic Republic since 1979, but it has own culture based on their own languages, peoples and their own history.

The total population of Iran was 49.45 millions by the National Census in 1986, 54.3% of which were urban inhabitants. The rural inhabitants were 45.2% and 0.5% were unsettled such as nomad, etc. Male : female ratio was 51.1: 48.9, and the age group population was still a pyramid shape having 45.4% of young population less than 14 years old. The growth rate of population was 2.7% at 1966 ~ 76, but it rose to 3.9% at 1976 ~ 86.

2. 2 National Economy

The annual report of the Central Bank of Iran reported that the gross national product in 1987/88 (1366 of Iranian Calendar) was about 18,681.2 billion rials, therefore the GNP per capita was 4,294 U.S. dollars converted by the mean official exchange rate of 71.46 rials/dollar that year. Many arguments are repeated on the exchange rate, and some experts are insisting that the real exchange value is one tenth of the said official rate. The confusion about the exchange rate is turning the reality of Iranian economy incomprehensible.

The sectorial composition of GDP in the above year was 26% in Agriculture, 14% in Mining & Manufacturing, 5% in Petrolium & Gas and 55% in Services, and the formation factors were 59.8% of Personal Consumption, 16.2% of Public Expense, 30.7% of Investment/Stock Holding and (-)6.6% of Foreign Trade.

The total export value in 1985/86 was 16.88 billion US dollars, 89% of which was crude oil and other petro-products shared 8%. The non-oil export shared less than 3% of the total. On the other hand, the country imported

11.989 billion US dollars in the same year; 32.5% of Vehicles/Machinery, 28.0% of Raw Material for Industries/Steel, 12.8% of Foodstuff/Alive Animals and 26.7% of other items.

The country-wide development in modern time Iran started in the 1930s, and many social infrastructures such as road networks, railroads, tele-communication, etc. were provided. At the same time, many industries such as textile, food processing, cement, etc. were also introduced at that time showing a clear attempt toward industrialization, however the out-break of the Second World War cut the effort of development in the country.

Post-war economic development started from 1947 as 7-year National Development Plan which was provided under the guidance of the experts of IBRD and/or UN as medium-term development plan. The rate of target achievement of this plan was estimated at less than 50% because of political and economical unstability due to the nationalization of petroleum industries and others. The Second 7-Year Plan was followed thereafter spending large portion of oil revenue. The main target of the second plan was improvement of social infrastructure, and the improvement of agriculture related facilities shared next position. The development plan was changed to a 5-year Plan since the third plan, and up to the fifth plan was executed before the revolution. Although the first and the second plans were provided under the guidance of foreign experts, the third plan and thereafter were planned/operated by Iranian experts themselves. Especially, the fifth plan was planned in those years of rising oil prices and the national income increased very sharply, therefore very ambitious and impetuous development which caused serious shortage of man-power and material was planned. Such shortages accelerated price inflation and social instability in those times.

Although the development plans from before the revolution suffered from incompleteness and many other problems, it is also true that those development plans provided much social infrastructure such as roads, railroads, ports/harbors, airports, tele-communication, etc., and improved or established many productive facilities such as irrigation facilities, different kinds of light industries, heavy industries like steel plants and petro-chemical plants as well as educational and cultural facilities, which fostered modernization of national economy.

The political instability in the post-revolution period caused rather serious stagnation of the national economy, but the government provided a new 5-year plan in 1983. This plan was not accepted by the parliament and not announced formally. The new 5-year plan was provided in 1989, and this plan was approved by the Islamic parliament in January 1990. The approved plan entered into force from March 21, 1989 with optimum investment of 34,632.3 billion rials, equivalent to 480.87 billion US dollars with the official exchange rate in 1989. The target investment during this 5-year Plan was estimated at 27,620 billion rials. The required foreign currency expenditure was estimated at 119 billion rials, but foreign currency income in the period was estimated at 103.6 billion dollars expecting 27.4 billion dollars in foreign investments or loans.

The main target of the recent 5-year Plan is establishment of social justice, accordingly the development of the poverty region has a higher priority of investment. This means that improvement of social infrastructure in rural areas, irrigation and other agricultural facilities, transportation / communication facilities, educational facilities, etc. have high priority. The planned index of increase was 8% per annum by the GDP, and per capita increase rate of production was set as 4.8%.

2.3 Agriculture Sector

The annual reports of the Central Bank of Iran said that the share of agriculture sector in GNP in 5 years of 1973/4-77/78 and 1983/4-87/88 were 9.1% at the former and 20.8% at the latter 5 years in average. The percentages were 9.2% and 14.9%, respectively even with the constant price of 1973/74. Although the increase of share of agriculture sector in GNP was caused due to stagnation of other sectors, the effect of governmental policy is also not negligible.

According to the Agricultural Census in 1988, total area of agricultural land in Iran was 16.9 million ha, 32% or 5.4 million ha of which was fallow. In annual cropping land, 5.6 million ha was irrigated, but the other 5.9 million ha was cropped as dry farming.

On the other hand, the number of farming families was 2.8 million households or 68% of total households in the country. The mean size of land ownership per farming household was estimated as 6 ha from the above figures: 1.9 ha of fallow, 3.68 ha of annual crops and 0.42 ha of perennial crops in average.

The 1990 and 91 editions of Production and Trade Yearbooks of FAO reported the production and export / import of main crops and foodstuff of Iran as shown in the table below:

Crop or Commodity	Cropped Area	Yield	Production	Import	Export	Consump-tion	Self Supply
Unit	(1,000 ha)	(kg/ha)	(1,000t)	(1,000t)	(1,000t)	(1,000t)	(%)
Wheat	9,765	1,421	13,876	4,420	-	18,296	75.8
Rice	605	3,755	2,273	938 *	-	3,211	70.8
Barley	2,651	1,268	3,360	390	-	3,750	89.6
Maize	3F	2,600	7F	830	-	837	0.8
Potato	150	16,500	2,475	-	-	2,475	100.0
Soya Bean	58	1,810	105	2,847 *	-	2,952	3.6
Sunflower	19	1,195	23	117 *	-	140	16.4
Sugarbeet	150	24,540	3,681	-	-	-	
Sugarcane	25F	68,800	1,720	-	-	-	
Sugar			625	604	-	1,229	50.9
	**(1,000hd)	(kg/hd)	(1,000t)	(1,000t)	(1,000t)	(1,000t)	(%)
Beef	2,019	114	230	125	-	355	64.8
Mutton	14,400	16	231	15F	-	246	93.9
Goat-meat	7,100	14	100	-	-	100	100.0
Poultry			270	-	-	270	100.0
Butter			183	25	-	208	88.0
Cheese			66	82	-	148	44.6

Notes: * White rice or crude oil was converted into farm crops.
Paddy/rice = 0.65, soya bean / crude oil = 0.17, sunflower seed/crude oil = 0.24
** Number of slaughter. hd = heads
F: Value estimated by FAO

As shown in the above table, Iran is not producing even the staple foods such as wheat and rice, and a large portion of vegetable oil, mainly soya bean or sunflower oil, are dependent on import. Moreover, the self sufficiency rate of sugar, beef, cheese, etc. are also very low at present.

To improve such a situation, it is possible to guess from the recent 5-year Plan that the plan is aiming to achieve the following goals:

- To expand the irrigated farmland to 6.3 ~ 6.7 million ha, therefore;

- To increase usable water resources from 89 billion to 92.36 billion cu.m. Simultaneously the reservoir capacity of storage dams is to be increased from 22.1 billion to 22.4 billion cu.m, and;
- To improve irrigation networks for 750,000 ha and to execute land leveling works for 50,000 ha within the period of 5-year Plan.

Consequently;

- To increase production of wheat at a rate of 5% per annum or to increase total production of wheat from 7 million to 11.05 million tons. This goal was achieved in 1990, but the production of wheat in Iran is rather unstable due to application of dry farming for large portions of wheat farms. Expansion of irrigated farmland is very important to stabilize the production of wheat.
- 3.8% of annual rate of production increase was expected for paddy, and total production is to be increased from 1.7 million to 2.06 million tons. This target was also achieved in 1990, however the imported quantity of rice is still keept at a high rate.
- The annual rate of production increase for forage crop was set at 10.6% to increase total production from 9.06 to 15 million tons of dry material. This target will be achieved through an increase of production of alfalfa and other forage crops, but large portion of the demand for maize is still dependent on importation.
- The increase rate of red meat; mutton and beef were expected at 3.4% per annum or to increase the total production from 525,000 to 620,000 tons. Simultaneously, the increase rate of production of white meat, different kinds of poultry meat, was expected at 11.6% per annum.

Taking such afore-mentioned prevailing statistics condition in the agriculture and food supply of the country into account, the possible contribution of the Project Area is to be examined.

CHAPTER 3. THE PROJECT AREA

CHAPTER 3. THE PROJECT AREA

3.1 Natural Features

3.1.1 Location

The Project Area is located in the eastern part of the coastal area of the Caspian Sea. As shown in the location map, the Project Area of about 108,000 ha gross lies in an alluvia plain bounded by the Caspian Sea to the north, by the Kari Rud Canal and its lateral canals to the south, by the Babol river to the east, by the Alesh river to the west, and extends from 35° 24' N to 36° 43' N, and 52° 12' E to 52° 40' E and is about 40 km east to west and 25 km north to south.

The Alborz mountains, one of the two major mountain ranges in Iran, runs in the east west direction and divides the Caspian Coastal Area from the Central Plateau. The Haraz river, originating in the Alborz and flowing down the middle of Project Area, is the major water resource. The Project Area is connected to Tehran via a national highway which crosses the Alborz and runs along the upper stream of the Haraz river. The distance is about 200 km from Tehran to Amol, the urban center of the Project Area.

3.1.2 Physiography and Geology

The Haraz plain covers an extensive area with alluvial deposits along the southern coast of the Caspian Sea. The southern end of the plain is abruptly bounded by the Alborz Height, which forms the watershed of the Haraz river. The watershed extends over an area about 4,000 km^2 and is characterized by the aligned peaks of 4,000 m or higher.

The alluvia plain has two distinctly different physiographic features marked by a transient point of terrain gradient which divides the plain at about 15 km from the Caspian coast. The altitude of the southern part of the plain, or the upstream side ranges from 20m (PGD) to 190m (PGD), forming a steep terrain with a mean gradient of 10/1,000. The downstream side is characterized by gentler terrain slope of 1.5/1,000 to 3.0/1,000. Other

physiographical and geological features are also differentiated by this point. Therefore, proper physiographic classification is applied in conformity with this differentiation: The upstream side is classified as the alluvial fan, and the downstream side is subdivided into alluvial lowland and hinterland. Also, coastal dunes, which form a flat belt of several hundred meters wide, cause inundation and swamp in the southern side of the belt. The swampy hinterland of Feridon Kenar, with elevation as low as (-)24.5 m, is the largest and lowest of the swampy hinterlands.

These physiological components appear in different landscapes between the eastern and western part of the Haraz plain. In general, the eastern side, where Babol city is located, is a wider alluvial lowland. In the western side where the Haraz river flows, the alluvial fan developed far into the plain and approaches the coastal line, thus confining the alluvial lowland to a narrow strip along the coastal area.

The sequence of geological formations in the Haraz river basin ranges widely from Palaeozoic members to recent fluvial deposits. However, by confining the argument to the Haraz plain, the geological sequence is reduced to a simpler one with surface formations consisting of only Quarternary layers and a part of Neotertiary formations. They are summarized from well drilling data as follows.

- Lower Layer (Sediments of Asheronian epoch): The facies predominantly consist of blue, gray and green marl, laminated with fine grained sand, gravelly layer and intercalation of volcanic ash occasionally.
- Middle Layer (Ancient Caspian Sediments): The layer lies on the Asheronian sediment. 450m thick, comprising alternate layers of gray, green and blue marls, fine sandstone with slight cement material and thin gravel layers are interblended.
- Upper Layer (Novo Caspian Sediments): The thickness of this layer is observable as 30m to 160m. The facies consist of loss in the alluvial terrace in addition to marine sediment near the sea coast.
- Upper Deposit (Alluvial Fan Deposits): The facies comprise mostly weathered conglomeratic soil with coarser deposits and intercalation of silt layer, piling on/beside the recent marine sediment. The thickness, however, is not known since the lowest boundary is obscure.

These Quarternary layers, covering over the basement consisting of Miocene and Pliocene, are found in the major part and the coastal area of the Haraz plain, and form the main aquifer of the Project Area. In the upper part of the basement a unique, gravelly layer is recognized that could be traced up to the foot hills in between the Haraz plain and the mountain area. Moreover, continuous fluvial terraces are found to develop along the river basin over the area from these foothills to the mountain range.

3.1.3 Climate

Semi-mediterranean temperate climate, prevailing in the Caspian coastal area in where the Project Area extends, is characterized by a hot and humid summer and a mild winter with abundant rainfall.

Compared with the central plateau which is a typical arid zone, the project area receives much rainfall, reaching 788mm of annual mean precipitation. Most of the precipitation occurs in autumn-winter and in spring, but less in summer which is the rice growing season. Precipitation is derived from aqueous vapor evaporated from the Caspian sea and carried mainly by the Siberian or north wind during winter. Most of the precipitation occurs as rainfall but seldom in the form of snow in the Project Area. However, most of it falls as snowfall in the Alborz range, the catchment area of the Haraz basin.

The mean annual atmospheric temperature is 16.3°C, with the maximum monthly mean of 25.7°C in August, the minimum of 7.2°C in February. Humidity is high throughout the year with an average of 83%. April to August are the drier months.

3.1.4 Rivers

The Alesh, the Haraz and the Babol rivers, are the major rivers in the Project Area, as shown in Fig. 3.1-1.

The following streams or canal are also important in the Project Area:

- Kari Rud Canal (flowing along southern boundary)
- Garma Rud River (a tributary of the Kari Rud Canal)
- Kharan Rud River (a tributary of the Babol River)
- Kela Rud River (a tributary of the Kharan Rud River)

The following table gives the major features of these rivers.

River Regime

River	Gauging Station	Drainage Area (km^2)	Annual Runoff (MCM)			Extreme Daily Discharge (m^3/s)	
			Max.	Mean	Min.	Max.	Min.
Haraz	Karehsang	4,061	1,817	1,085	572	311	8
Babol	Babol	1,643	785	479	196	700	0
Alesh	(Nur-Amol Bridge)	163	-	-	-	-	0
Garma Rud	(Kari Rud Junction)	116	-	-	-	-	0
Sadjjad Rud	Bandpei	260	82.5	67.4	42.6	42	0
Kela Rud	Diva	136	80.5	60.5	26.5	46	0

(1) Haraz River

1) River Regime

The Haraz river is the main water resource in the Project Area. The Haraz river, originating in the Alborz mountains and collecting discharges from the tributaries such as the Lar and the Nur rivers, flows northward into the Caspian Sea. And with basin of 4,061 km^2 at Karehsang, is the largest river in Mazandaran Province.

The Haraz river is fed mainly by snow melt in the Alborz mountains, and its discharge reaches its peak in May to June and the minimum in December to January. Mean annual runoff was 1,085 MCM before the construction of the Lar dam, and is 910 MCM after due to water allocated to Tehran.

2) Water Resources Development

In the Haraz river basin, the Lar dam was constructed in 1980 in the Lar river, the uppermost tributary of the Haraz river. The Lar dam was constructed to supply irrigation water (240 MCM during summer season) to the Haraz plain and to divert drinking water (170 MCM annually) to Tehran. However, due to leakage in the foundation, the dam has never been fully operated since it was not possible to raise water level to the design full level. The dam had been operated almost exclusively to release irrigation water to the Haraz plain until 1991. When water shortage became very severe in Tehran, diversion for domestic water was started in the summer of 1991. However, the Haraz plain faced severe water shortage for irrigation in that summer, because it was not possible to release sufficient water from the Lar dam due to less snow cover.

Other than the Lar dam, the Mangol dam has been proposed at Karehsang in the Haraz river, aiming to exploit water resources of the residual basin below the Lar dam.

Proposed as a water diversion facility, the Haraz diversion dam is under construction. The diversion dam aims to divert irrigation water to the upstream region of the Project Area. Also, the Amol diversion dam (the second diversion dam) is proposed at the middle reach of the Haraz plain to irrigate the lower region.

(2) Babol River

1) River Regime

The Babol river flows down the middle reach of the Alborz mountains, and is shorter and steeper than the Haraz river. However, after entering the plain, the river flows with very gentle slope along the eastern boundary of the Project Area and meanders at several locations after Babol City and finally into the Caspian Sea at Babolsar.

Since the Babol river is fed mainly by rainfall from the basin with no high peaks, the discharge is unsteady compared to that of the Haraz river. However, the peak discharge is larger than that of the Haraz river, although

the basin is much smaller (1,643 km2) than that of the Haraz river. Floods in the Babol river generally occur in September to October, due to heavy rainfall.

The Babol river is utilized for irrigation mainly in the upper reach of the plain. Therefore, its discharge sometimes drops to zero at Babol Gauging Station.

2) Water Resources Development

Although there has been as no particular water resources development in the basin, several possible dam sites are under investigation. The Pasha Kola dam is being investigated as the most possible dam site.

Proposed Dams in the Babol River

Proposed Storage Dam in the Babol River	Catchment Area (km^2)	Annual Discharge	
		(cms)	(MCM)
Pasha Kola Dam	220*	4.36	138
Marzi Darreh Dam	360	7.14	225
Raeis Kola Dam	526	7.14 **	225 **

Data Source: HWDP-1, A-2
Note: * Estimated on 1 : 50,000 map.
** Discharge is uncertain, but estimated very less below the Marzi Darreh damsite

The Babol river is planned to drain water from the newly proposed Amol East Main Drain (AEMD). In this connection, it is necessary to review flood passage capacity of the Babol river taking into consideration flood mitigation effect of the Pasha Kola dam. The effect is, however, to be less because the dam is planned as an exclusive storage dam and its catchment area is only 13% of the Babol river basin (1,643 km^2).

(3) Alesh River

1) River Regime

The Alesh river flows northward, down the piedmont hills of the Alborz mountains and along the western project boundary, and into the Caspian Sea at Keshtsar.

River channel of the Alesh river is clearly defined until the Nur-Amol road bridge. After the bridge, it becomes smaller and more shallow, and spreads into several smaller channels in the forest. Since these smaller channels do not have enough capacity to drain the flood, flood water overbanked and spread into the forest.

The Alesh river has a small basin of only about 163 km^2 at the said bridge. Since it is fed mainly by rainfall the discharge is unsteady. Therefore, the Alesh river is difficult for both flood protection and water utilization. At present, irrigation is conducted only in very limited areas.

2) Water Resources Development

A dam in the Alesh river is under investigation by MRWB. If it was constructed, it would contribute greatly to water resources development and flood control. However, no detail is available at present.

(4) Kari Rud Canal and the Garma Rud River

1) River Regime

The Kari Rud canal is presently the main irrigation canal irrigating the western half of the Haraz Right Bank Area. It was artificially improved from a natural diversion stream in the ancient days.

The Garma Rud river joins to the Kari Rud canal on its right bank at Nezam Abad village. The Garma Rud river flows northward from the piedmont hills. This river is also fed mainly by rainfall, and therefore, its discharge is unsteady. The Garma Rud causes floods and carries heavy sediments occasionally to the Kari Rud canal. Due to flood intrusion, the stream section of the Kari Rud canal is larger for about 100m at the junction with about 300 m^3/s discharge capacity.

The Kari Rud canal decreases its stream section to about 50 m^3/s and gradient after the junction. The Old Amol-Babol road runs on the left bank along the Kari Rud canal, and many villages are established beside the canal. Although some of the flood is released to the Project Area through the

secondary irrigation canals, floods occasionally overbank and cause damage to the villages and the farmlands.

At the termination point of the canal, the Kari Rud canal is diverted into two secondary irrigation canals, namely the Khan Rud canal and the Seid Rud canal. The Kari Rud canal has three emergency spillways, of which one is at the end of the Kari Rud spilled to the Kharan Rud river, the second is at the head of the Seid Rud to the Kharan Rud, and the third is at the middle reach of the Khan Rud to the Babol river.

2) Water Resources Development of the Garma Rud River

The Garma Rud has a problem in its water quality due to several mineral springs in the basin. Therefore, water of the Garma Rud is utilized for irrigation in a limited scale after mixing with water in Kari Rud.

As a future development of this river, the Garma Rud dam has been considered in the basin by the study of HWDP-1. If this dam was constructed it would not only mitigate the flood in the Kari Rud canal but also reduce to a considerable extent flood intrusion to the Project Area, besides development of water resources. Details on this dam is not available.

3.1.5 Caspian Sea

(1) General

The Caspian Sea is the largest inland lake in the world. It has a surface area of 371,000 km^2. The length from north to south is 1,280 km and the width from east to west 160 to 440 km. The Maximum depth reaches 905 m. The total length of coastal line is approximately 7,000 km, of which 630 km belongs to Iran.

Water of the Caspian Sea is slightly salty and salt concentration is about 13,000 ppm.

The sea level of the Caspian Sea fluctuates in long and short term cycles. Short term fluctuation is caused by the annual cycle of river inflow and evaporation. The amplitude of annual fluctuation is about 30 cm. The long term fluctuation appears to have larger amplitude and cycle. Due to the recent rising of sea level, damages to the houses, farmlands and the coastal structures have been reported. These damages are becoming acute social problems. International seminars were held between Iran and the littoral countries to cooperate in study seeking the cause and solution. The Gilan University was nominated as the centre of Iranian side for cooperation among these countries.

Also, the Ministry of Interior has decided to proceed with the emergency protection works for shore protection, land and farms, and the coastal structures such as ports and fisheries facilities, with the cooperation of concerned ministries such as MOE, MOA and MORT.

(2) Long-term Fluctuation of the Sea Level of the Caspian Sea

As seen in Fig.3.1-2, the sea level remained relatively stable at (-)27.6 m PGD around 1984. However, the sea level has fluctuated considerably since 1926. After reaching the highest record of (-)25.3 m PGD in 1929, it continued to recede until reaching the lowest level of (-)28.5 m PGD in 1977. During that 48-year period (1929 to 1977), it receded by 3.2 m.

After making record a low in 1977, the sea level began to rise, and according to a recent study, it has risen by 2.40 m since 1977, reaching (-)26.10 m PGD in 1991. The annual rising rate during this period is to 20 cm. However, the average rate during the recent 6 years is about 15 cm, somewhat decelerated.

(3) Design Maximum Sea Level

Drainage from Feridon Kenar Drain and the low-lying hinterland of Feridon Kenar are currently affected by the rising of the sea level and estuary blockade. The estuary is chocked by the increased height of bars caused by a deposit of drift sand. Given the present trend of rising sea level, not only the estuary blockade but also the elevated sea level itself will affect drainage condition. As seen in Fig. 3.1-2, the sea level was high and relatively stable from 1840s to 1910s. Referring to this trend the design maximum sea level was

estimated at (-)25.0 m PGD. For design purpose it is set at (-)24.65 m PGD, allocating 0.35 m for surcharge taking into account the influence of rolling waves and swelling by the drop in atmospheric pressure.

(4) Anomalous Highest Sea Level

According to the result of a sediment study with isotope analysis of C14 to assess past sea levels in geological epoch (reference Hy-1), it was estimated that the sea level was elevated to as high as (-)22 m PGD. Should this happen again, around 5,000 ha in the lowland of the Project Area would be inundated, causing serious impact not only to agriculture but also to social systems and environment.

3.1.6 Environmental Assessment

It is important to identify and assess the natural status of the environment when pursuing a sustainable development. The present environmental conservation restrictions found in and around the Project Area are as following.

Environmental Conservation Areas Related to the Project Area

Environmental Conservation Areas Within the Project Area
(1) Feridon Kenar Conservation Area
(2) Amol Conservation Area
(3) Southern Caspian Coastal Line Conservation Area
Garma Rud Basin Conservation Area
(4) Baliran Conservation Area
Haraz River Basin Conservation Area
(5) Sang Chal Conservation Area
(6) Namarestagh Conservation Area
(7) Baladeh Conservation Area

Among the three areas directly related to the Project Area, only Feridon Kenar Conservation Area is of concern in the study. In this area a pond (Abbandan: AE88) has already been reserved as of international

importance, and likewise no development has been proposed in the study. For other ponds, no particular restriction on development has so far been imposed.

It has been proposed by the Organization of Environment Protection that discharge of basic maintenance flow and installment of fish ladders are the desired pursuits for any diversion dams which are to be installed in the Haraz river. The drops and checks which are proposed for the canals, need not be equipped with fish ladders since the fish species inhabiting the ponds are demersal and do not migrate. When the fish ladder is equipped, it helps carnivorous fish to invade into the ponds. The Organization also hopes to keep up proper use of ponds for the conservation of aquatic life.