portions. A trapezoidal plain concrete lining (12 cm thickness) is designed at the head of the Haraz East Main Canals.

- Further review is necessary such as on the hydraulic profile, the type of canals and the appurtenant structures. Therefore, the design of the canals of this study should be consistent with the canal planning of the MOE.

3) Kari Rud Canal

- The Kari Rud canal is a large scale excavated canal with a capacity of about 50 m^3/s in the lower portion.
- The improvement plan of the Kari Rud canal was carried out by the MOE. In this plan, the present canal is to be utilized as it is basically, and gabionade weirs are designed at the three large turnout sites to control the headwater level, and the rehabilitation and the construction of the two spillways are included.
- The intake unification of the other turnouts (about 70 places) of various scales is under planning at present.
- The scales of these diverted canals range from a large one having the irrigation area of about 2,000 ha to a small one commanding the area of about 5 ha, and they are treated equally in the planning. The effectiveness of the intake unification from the technical and economical viewpoints is to be studied in consideration with the managerial aspects hereafter.
- Some portions of the canal function as a drainage canal, therefore, the facility planning and the operation method are to be designed in consistency with the hydraulic conditions.

4) Diverted Canals from Rivers

- The canals diverting directly from the Haraz river are to be unified because their irrigation areas are planned to be covered by the proposed main canals mentioned above.
- The canals and the turnouts in the Amol urban area are to be utilized as they are in principle, and the additional investment for them is not considered in this study.
- The present canals diverting from the Alesh river are planned to be replaced by the canals from the Haraz river. However, some existing intake facilities are used as supplemental water sources.

5) Secondary Canal

- The secondary canals, which are diverted from the three major rivers, the Kari Rud canal and the proposed new main canals, have many turnouts of various types and their canal lengths are also different. With regard to these facilities, the intake unification and the rerouting of the meandering canals are not considered.
- The main canals as well as the secondary canals are the important irrigation-cum-drainage canals for supplying an irrigation water and discharging a drainage water from the adjacent areas. In the design of these canals, therefore, it is necessary to fulfill both functions of the facilities.

6) Drainage Canal

- In the low land, whose area is about 1/3 of the Project Area, flood damages often occur because of the small difference in water level with the Caspian Sea and the lack of a drainage facility. The MOE is planning the rehabilitation and the construction of the main drains at present.
- Regarding the main drains, the Amol East Main Drain (AEMD) and the Amol West Main Drain (AWMD) are planned to discharge into the Babol and the Alesh rivers respectively. Their routes are parallel to the main irrigation canal which are planned to be constructed on the both banks of the Amol diversion dam.
- There are some drainage canals in the low land, and parts of the seven main drains, the major drainage canals, are proposed to be improved. The drainage water of these canals discharges into the Caspian Sea.

3. 8. 7 On-farm Development

Two project reports can be reviewed on this subject. These are M/P and HWDP-1. The results of the M/P study were incorporated into the HWDP-1. In the M/P, the adopted basic planning and designing criteria are as follows:

1) Drainage and irrigation canals should be separated at the terminal stage.

2) Size of a lot

Width: 30 - 60 m, Length: 100 - 200 m

3) Farm road

Every lot should border on a road, and irrigation canals should run alongside the road.

Interval: 400 m, Total width: 4 m

Effective width: 3 m, Pavement: gravel

4) Drainage canal

Every lot should border on a drainage canal

5) Irrigation canals

Every lot should border on an irrigation canal. A terminal irrigation canal, which supplies water to a lot directly, should be less than 600 m in length.

Then, three types of land consolidation were provided depending on the degree of application of the above mentioned criteria, as follows:

Case-A: The criteria are applied entirely.

Case-B: The irrigation system is simplified in the criteria, i.e., plot-to-plot irrigation system is allowed.

Case-C: The size and shape of lots are not changed. The irrigation and drainage facilities and roads are improved but sometimes it is not possible to apply the criteria. The application ratio of the criteria is 70% for high priority facilities.

Based on the above types, a case study was carried out in the three sample areas, Ejibar Kola in the high land, Barik Mahaleh in the middle land and Suteh in the low land.

After comparison of cost and benefit, the land consolidation of A-type was considered to be advantageous for the middle and the low lands while C-type for the high land. However, as the financial rate of return (FIRR) in case of A-type in the high, middle and low lands was comparatively high at 12.1%, 13.3% and 11.4%, respectively, and the separate irrigation and drainage system is a favorable condition for introducing highly productive agriculture, A-type land consolidation was adopted in the M/P.

Construction cost and FIRR of the above land consolidation types are summarized in percentage using the results of the M/P, as follows:

Sample Area	Case-A		Case-B		Case-C	
	Cost	FIRR	Cost	FIRR	Cost	FIRR
Ejibar Kola	100	12.1	94	12.1	33	12.7
Barik Mahaleh	100	13.3	90	12.7	42	11.3
Suteh	100	11.4	92	11.1	39	10.3

Note: Figures of the cost indicate percentage of Case-B and Case-C to Case-A.

From the above figures, highest FIRR's are estimated in A-type and C-type and those of B-type take a middle position. In addition to this, the reduction of the construction cost of B-type is 6 to 10% of A-type. Therefore, B-type land consolidation is not considered in this study from the viewpoints of investment scale and rate of return.

TABLE 3.8-1 DISCHARGE DATA AND INTERPOLATION BY PREVIOUS STUDIES

River/Station	HWDP-1 Study				M/P Study	
	Data Period	Interpolated Period	Interpolated by	r	Data Period	Interpolated Period
Haraz River						
Karehsang	1329-30~61-62	Meh32-Dey33 Kho59-62	Shirgah (Talar) (A) Razan (M)	- 0.832	1329-30~60-61	1332-33~33-34
Polour	1329-30~61-62	1333-34~35-36 Kho-59-62	Karehsang (A)	0.82	1329-30~60-61	1333-34~35-36 1353-54~55-56 1357-58
Razan	1348-49~61-62	1342-43~47-48 Meh-Bah61	Karehsang (M)	0.8914	1348-49~55-56	—
Baladeh	1355-56~61-62	1352-53~54-55 1357-58	Razan (M)	0.7867	—	—
Sorkh Rud	1344-45~61-62	1350-51 1352-53~53-54*	Karehsang (A)	0.64	1344-45~60-61	—
Babol River						
Gharan Talar	1329-30~61-62	1353-54~55-56	Babol (A)	0.80	1328-29~60-61	—
Babol	1328-29~61-62	1358-59~61-62	Gharan Talar (A)	0.80	1328-29~60-61	—
Miandasht	1350-51~58-59	1347-48~49-50 Kho-Sha51 1352-53 1359-60~60-61	Babol (A)	0.86	1349-50~58-59	—
Kela Rud River						
Diva	1354-55~61-62	Meh-Aba54 Meh-Aba55 1356-57	Shirgah (Talar) (M)	0.44	—	—
Sajjad Rud River						
Band Pey Galough	1353-54~61-62	Meh53-Mor54 Meh-Aba55 1356-57~58-59 Mor-Meh60	Gharan Talar (M)	0.68	—	—

(Note) 1. * : interpolated for other periods than specified.
2. ~ : data not used or not interpolated.
3. (M) : interpolated by monthly basis.
4. (A) : interpolated by annual basis.
5. Data at Karehsang, Polour and Babol have been given on daily basis to M/P study by HWDP-1 study.

TABLE 3. 8 - 2 COMPARISON OF STUDIES ON WATER RESOURCES DEVELOPMENT PLAN

Factors	M/P Study	HWDP-1 Study	F/S Study
Mean Annual Runoff of Haraz River (MCM/yr)			
Polour	(400)	(416)	(416)
Karehsang	1,061	1,085	1,085
Mean Annual Runoff of Tributaries of BabolRiver (MCM/yr)	—	64	—
Possible Groundwater (MCM/yr)			(203) *
Available Amount for Irrigation			
Project Area	137	227	143
New Expantion Area	—	130	—
Sub-total	(137)	(357)	(143)
Abbandan Storage (MCM)	57	98	36
Return-Flow (MCM)	—	—	87
Total	1,255	1,604	1,351
Irrigation Area (ha)			
Project Area	68,120	87,300	78,850
New Expantion Area	—	5,500	—
Total	68,120	92,800	78,850
Water Demands (MCM)			
Irrigation Demand			
Project Area	753-789	N.A.	968
New Expantion Area	—	N.A.	—
Domestic Water Supply	—	73	73
Envoironmental Release	—	46	46
Lar Water Allocation			
Tehran Municipal Water	160	178-419	170
Haraz Irrigation Release	240	0-231	240
Study Cases			
Lar Dam	with	with	with
Mangol Dam	without	with & without	with & without
Abbandans	with & without	with & without	with

(Note) * including demand other than irrigation

TABLE 3.8-3 COMPARISON ON GROUNDWATER BALANCE

Report	HWDP-I	M/P	M/P
Balancing Year	1985 - 86	1982	April - August 1982*2
Balancing Study Area	(III) + IV*1	Project Area	
Balance Study Area (km^2)	956	956	956
Subsurface Inflow	83.4	-	-
Recharge from /through			
Precipitation	48.0	-	-
Surface runoff	14.6		
Overland flow	85.5		
Riverbed	48.0		
Total	279.4	261.6	80.3
Return Flow of			
Agricultural wells	49.5	-	-
Industrial wells	14.8	-	-
Springs	15.5	-	-
Total	79.7	-	-
Total Recharge	359.2	261.6	80.3
Subsurface Outflow	4.5	62.8	18.1
Discharge form/through			
Agricultural wells	198.0	-	-
Industrial wells	22.7	-	-
Total	220.7	126.2	112.2
Spring	61.8	65.7	24.6
Evapotranspiration	32.1	-	-
Drainage from Aquifer	31.6	-	-
Total Discharge	350.7	245.7	154.9
Variation in Storage of Balance	8.5	6.9	(-)74.6

*1 : The value revised from the ratio of balancing areas between M/P (956 km^2) and HWDP-I (968 km^2) report

*2 : Balance in the irrigation period in 1982.

TABLE 3.8-4 MAJOR STRUCTURES OF THE MOE PLANNING

Haraz

Diversion Dam

Length	353.8 m
(Span 24, Width 10 m)	
Crest El.	167.2 m
Flood Q	1,000 cms

HEMC

Length	5,390 m
Max. Q	40 cms
Intake W.S.	165.75 m
Canal Section	178 types
(40 cms - 20 cms)	
Canal Type	Flume, Trapezoidal Concrete
Turnout	13

HWMC

Length	875 m
Max. Q	22.5 cms
Canal Section	1 type
Canal Type	Trapezoidal Concrete
Turnout	3

Kari Rud

Length	about 50.0 km
Max. Q	30 cms
Lining Type	Earth Canal
Turnout	75

Amol

Diversion Dam

Length	70.0 m
(Span 3, Width 15 m)	
Crest El.	44.3 m
Flood Q	1,000 cms

AEMC

Length	25,430 m
Max. Q	20.5 cms
Intake W.S.	49.5 m
Canal Section	16 types
(20.49 cms - 3.37 cms)	
Canal Type	Flume, Trapezoidal Concrete
Turnout	12

AWMC

Length	19,200 m
Max. Q	12.7 cms
Canal Section	12 types
Canal Type	Flume, Trapezoidal Concrete
Turnout	9

AWMD

Length	11.50 km
Max. Q	27.54 m^3/sec (29.50 m^3/sec)
Canal Type	Earth Canal

AEMD

Length	24.50 km
Max. Q	41.13 m^3/sec (59.04 m^3/sec)
Canal Type	Earth Canal

(Note) ( ) : Max. Q for 1/25 year

CHAPTER 4. DEVELOPMENT PLAN

CHAPTER 4. DEVELOPMENT PLAN

4. 1 Limiting Factors in the Development

4. 1. 1 Availability and Use of Land

The Project Area has been reclaimed from forest area and swampy land once extended over the alluvial fan in the Haraz basin during past centuries. Beginning with well-drained parts of the land, the reclamation gradually proceeded and expanded into lowlands with unfavorable conditions as the local population grew, and this past trend is evident in the distribution patterns of villages or of registration of water rights. Reclamation was particularly spurred since the execution of agrarian reform in the sixties, so that presently untapped land remains very scarce in the area.

In terms of pedology, Mollic Fluvaquents with loam - silty clay textures and Fluventic Haplaquolls with silty loam - clay loam textures cover 85% of the Project Area, which have hydromorphic character or always saturated with water, and their major soil formation factor is gleyzation. Soils of this category are poorly drained, liable to cause respiratory inhibition in paddy root system.

Drainage improvement and other measures in lowland have so far not been taken to amend such unfavorable soil characteristics, on account of spontaneous and too rapid progress of development. This negligence has led to the occurrence of red stunt symptoms of rice plants attributable to potash deficiency in soils including a muck that is called "lapar" in a part of the Project Area.

Thus, it seems that the area has already reached the limit from land resources point of view, however, land use still remains at as low as 120% or below 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.

4. 1. 2 Land Holding and Farming

As essential acreages of the area were allotted in accordance with proportional holding (MOSHA system) in the land reform during the sixties, the cases where registration was actually practiced based on cadastral maps was confined to the villages with late royal, feudal manor etc. In addition, any trading by sale or subdivision of parcels released in land reform procedure was prohibited, but such trading was made fairly extensively. Owing to such ambiguous status of land registration, the real land holding is hardly able to be identified.

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

Although such adverse climatic conditions as low temperature spells in early spring, lingering rainfall in early autumn and risk of frost or snowfall during winter may confine the cultivable crops, varieties or cultivation techniques to a fairly serious extent, it is not at all impossible to be engaged in highly productive farming under the given conditions as observed in the practices by some advanced farmers. However, farmers have been overwhelmingly oriented to monoculture dependent on rice crop only, due partly to concentrated and excessive labor input on rice cropping, partly to relatively high income derived from it.

It seems rather anomalous that no particular benefit can be found in livestock sector despite its cattle herd holding nearly 100 thousand heads, but this situation is evidently derived from inferior genetic resources as well as under nutrition as the main causes. Current situation lies far from paying all-out effort to tackle and solve these issues.

4. 1. 3 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 use in other middle or small size streams than the Haraz has been mostly untapped, and also in the future little contribution is expected to serve as a measure to ease or solve water shortage suffered by the Project Area, even in case these are tapped by development projects. Rather, the potential expected in these minor streams should be more bound to the development in the vicinity of the Project Area.

Though a large number of abbandans have been constructed in the middle and lower parts of the Project Area for the purpose of providing supplemental water to meet the shortage, the effective storage capacities are much confined as compared to their surface area occupying 3,500 ha, and their use should be reconsidered from the standpoint of efficient land use.

In the lowland where farmers are not provided with any water right (as to water right, refer to the following paragraph), they are engaged in rice cultivation dependent on lift irrigation, but there is a risk of sea water intrusion if uncontrolled exploitation of groundwater is further pursued, because of a meager difference between sea water level and groundwater level in these areas. Current use of groundwater amounting to 153 MCM on annual basis is considered to have reached the limit for exploitation, judging from the water balance within the area concerned.

4. 1. 4 Irrigation and Drainage Facilities

As mentioned in above para. 4. 1. 1, the Project Area was at first developed in the parts with convenient water access and then the acreage under crop has been gradually expanded. It is commonly understood that in the dawning stage of reclamation small streams formed by flooding of the Haraz river were trained and utilized as canals, that were later year after year

extended and stretched. One can find many cases of water conveyance system in which existing canals are branched to form a herring bone shape and irrigation water finally reaches its terminal command through several kilometers of lateral canals. Under such a difficult situation to secure water farmers are obliged to create plot-to-plot irrigation systems which cover several tens of hectares.

Progress in alignment or improvement of canals lagged behind, and there had been no permanent structures in water intakes along the Haraz river. Lately, however, a construction plan of an intake weir into the 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.

Surface flow in the rivers during irrigation period originates from floods thawed from snow cover, thus containing suspended soil/sand which is observed as sediments deposited on the bottom of the entire canal system. Practices for removing sediments in terminal channels have been offered by beneficiary farmers as their labor service, imposing a considerable burden for them. While ANDWO and BDWO are responsible for the reparation and maintenance of main and secondary canals, lack of maintenance roads is often observed in most parts and difficulties in mechanizing repair operations make proper maintenance difficult.

Issues of drainage have rarely been considered hitherto for the reason of predominant mono-culture of rice crop, and to this 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 plays 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 field.

4. 1. 5 Water Rights and Water Management

Disputes on the water rights in the Project Area were rather an old and sustaining problem as represented in the fixation of water distribution rate between the Haraz and Kari-Rud systems settled in late nineteenth century. In order to avoid such conflict, the case often observed tends to divert water directly from the rivers, thus a lot of canals have been constructed, in a way running side by side or in parallel. Since the late twenties a land registration system came into effect, but in those days land lords held their lands by villages as a unit of land-holding, as a result the registration was substantially made by villages and not by individuals. Not only the names of canals and foundations whose water rights were held by villages were listed in the original copies of registration, but also usufruct rights for surplus water from upstream area.

There has been no particular clause prescribing quantitative water use in the registration of water rights as mentioned above, and the partition of water from each canal has been practiced by dividing the total flow with the certain rate called "abdang", based upon the agreement among beneficiary villages. This traditional system of water division has still been pursued. Accordingly, the unit "abdang" differs from a canal to another, and it is not constant even within a particular area.

Water management in the Project Area constitutes the intake and division of water at the fixed rate, where real quantity of water is never regarded. The mirab takes initiative in operations/practices to install and remove diversion weirs necessary for water intake or division, merely adjusting water distribution among terminal canals concerned.

4. 1. 6 Configuration of Farm Lots and Location by Holding

Because majority of farm plots have been gradually developed by a reclamation process from swamps or deforested land to dried fields, they mostly have irregular boundaries along natural topographic contours or gradients, with the average area of a plot ranging most frequently between 0.1 and 0.3 ha. However, smaller sized plots with less than 0.1 ha are more often observed in the 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.

During the years of agrarian reform, there were often cases where plots under tenancy lease were as a rule released to the same farmer. In many cases several plots in dispersed locations had been leased to a tenant taking consideration of equitable water access, and this pattern is still reflected in the present dispersed holding pattern, except for some villages where land was released based on cadastral maps. Further, it is anticipated that holding pattern by plot has become much more complicated due to the aftermath of land reallocation by hereditary succession or subdivision by trading transfers, but the true situation can hardly be grasped for the whole area on account of lack of complete land registration as mentioned in above para. 4. 1. 2.

4. 1. 7 Road Networks

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.

Access roads to a plot-to-plot irrigation block are mostly located along canals, the width of which barely allows for a small truck with the loading of 2 tons to pass through them. However, progress in improving roads connecting two neighboring villages has quite recently been so much accelerated that villages and national highways are mostly connected with two-lane roads paved with gravel, and a part of them are being asphalt paved.

4. 1. 8 Farmer Organizations and Supporting Systems

Rural 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 to only some 40 thousand Rials or

so indicates a 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 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 the livestock sector in particular, the requirements for veterinarians, extension specialists, technicians for artificial insemination and other staff as well as service facilities have not met.

Financial support for farmers has been provided from the Agricultural Bank through rural cooperatives, with considerable variability in credited amounts from year to year. In addition, fund of the said bank is mostly financed from the national budget and the contribution ratio of farmers' deposits are exceedingly low. As many farmers deposit their margins from the sale of their products to private banks, there seems to be much room for improvement in the way of management of the bank itself.

It is hardly deniable that there is lack of long term and comprehensive activity plans in conformity with current situations in the area in the aspects of both farmers' organizations and supporting institutions. Especially, rural cooperatives are still recognized among people as a subordinate agency belonging to the administrative authority, failing to have due capacity to sufficiently meet the various requirements of farmers.

4.1.9 Environment Protection

With a view to arranging the development works proposed by the project compatible with environmental conservation, the following strategies are proposed for the three conservation areas as well as forest area and water quality etc.

(1) Proper Consideration for Environmentally Protected Areas

Within the Feridon Kenar Protected Area, only a single abbandan (AE88) has been designated as the 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 been so far imposed. Judging from these situations, it is vital to implement works in these abbandans with special consideration to the protection of fish species.

(2) Consideration of Forests

Presently, there remains an extensive forest of around 3,200 ha along the Alesh river running at the western border of the Project Area, and natural ecosystem has still been preserved within it. So, due attention should be paid to avoid constructing flood protection dikes running through these forests in river training works.

(3) Consideration of Wetland of International Importance (located along the coastal shore of the Caspian Sea)

No particular development plan is included in the proposed project for the coastal shore. However, a considerable portion of the coastal area has already been exploited as a resort villa. Besides, due to recent rising up of the sea water level, sand beaches have been increasingly eroded and scoured, sometimes causing drifting of buildings. In this connection, it is technically and economically difficult to conserve the entire coastal shore. Also, problems of sea pollution have arisen among the coastal countries of the Caspian Sea in which conservation of fishery resources has emerged of primary concern. As a major cause of the contamination, leakage of crude oil along the Caspian coast is often pointed out. In the project, due attention should be paid to the water quality conservation of effluent lest pollutant load should be augmented to the Caspian Sea that forms a hydrologically closed system.

(4) Consideration of Environmental Flow of Rivers

It is required to maintain a minimal flow for migratory fish ascending rivers from the Caspian Sea for spawning. No reply has been received so far from the Organization of Environment Protection on how much water flow should be maintained as basic environmental flow. Spawning season ranges

from March to May, and for their protection it is designed to keep the quantity of environmental flow designed by the MRWB. Regarding rivers and streams other than the Haraz river, they are outside the scope of the project because it does not rely on their water sources.

(5) Consideration on Fish Species Within the Project Area

Major fish species found within the Project Area are of demersal within abbandans and do not have to migrate into canals even in their spawning seasons. If some devices are applied so that they can freely move from water channels to abbandans, then some species of pikes may invade into abbandans and devour useful fish species. Therefore, it is not necessary to equip canals with fish ladder. In this connection, it is necessary to use reservoirs so that they never get dried up for their survival.

(6) Attention Towards Deterioration of Water Quality

Surface water quality tends to deteriorate as water flows down stream in canals, and the degree of contamination is remarkably severe in the area of Mahmud Abad and Feridon Kenar where surface drainage water is concentrated, pouring into the Caspian Sea.

Currently, paddy fields within the Project Area are irrigated by plot-to-plot system, making water control in the individual plots difficult. However, when they are consolidated by the project, water can be fully controlled at the farmer's disposal in their own plots. It follows that farmers can economize spreading amounts of fertilizers and chemicals as their optimum doses required for the plot, and they can limit the leakage of those into effluent from their plots. In this report, both current and proposed amounts of application are evaluated and the use of herbicides and other chemicals with less detrimental effects to the ecosystem within the Project Area.

4. 2 Basic Concept of Development

4. 2. 1 Objective of Project & Its Component

The objectives of agricultural development in the Haraz river basin are to upgrade the standard of living of beneficiary farmers and to contribute to the stabilization and development of the national economy by means of an increase of food production under the given conditions at the Project Area solving those constraints mentioned in the above Chapter 4. 1.

In this Feasibility Study, the improvement method of basic facilities for farming which are considered a pre-condition of regional development is examined, and the plans of drainage improvement, improvement of irrigation and drainage facilities and on-farm facilities are provided taking their project benefit into consideration.

4. 2. 2 Improvement of Basic Farmland Facilities

The improvement of basic farmland facilities in the Project Area consist of drainage improvement, improvement of irrigation and drainage facilities and on-farm facilities, and their objectives and goals are as below:

(1) Drainage Improvement

The improvement of soil by means of drying of paddy field and expansion of potential cropping area of second crops are main objectives of the drainage improvement in the Project Area. For such reasons, the improvement level of drainage is set at as below:

- To remove any damage to paddy due to standing water or inundation.
- To avail mid-summer drying up 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 limits such

improvement. The optimum development scale is planned after detailed examination of difficulty of implementation, cost/benefit ratio, and other technical or economical factors.

(2) Improvement of Irrigation and Drainage Facilities

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 much as possible, the most appropriate plan of improvement of secondary and tertiary canals are to provide for making rational water management be applicable in future.

It is understood that a water fee will be levied in the future based on the consumed volume of water in accordance with the agreement between the MOA and MOE in 1991, therefore proper equipment/structures are to be designed for future water management.

(3) On-farm Facilities Improvement

The improvement plan of on-farm facilities is to avail the introduction of mechanized farming of high efficiency and water management at on-farm level in the future. Most existing paddy farms do not have a 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, 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 as each plot of paddy field is in contact with the farm road. Simultaneously, separation of irrigation and drainage canals is to be applied as far as acceptable from economical point of view.

4. 2. 3 Water Resources Development

The effect of improving works of basic farmland facilities will be apparent when a stable water supply is available. As explained in the above

para. 4. 1. 3, 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.

On the other hand, the Lar dam which has been built on the Lar river, one of main tributaries of the Haraz river, aims to transfer wholly available water at the damsite to Tehran metropolitan area except 240 MCM of water right to the downstream.

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. From such point of view, the Mangol dam construction project shall be studied urgently by the MOE as comprehensive water resources plan taking into account drinking and industrial water supply and power generation.

4. 2. 4 Agricultural Development

The afore-mentioned projects are to be provided to achieve increase of 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 for high productivity and high benefitability.

To achieve such target, optimization of cropping intensity and yield/ha of each crop is unavoidable. Taking those non-controllable factors such as climate and other physical conditions, the promotion of paddy-livestock compound farming system is the most recommendable choice for the Project Area even from the viewpoint of the national economy.

As assumption to achieve such target, the level-up of farming practice by individual farmer is not sufficient, but the improvement and strengthening of peripheral conditions around agriculture is unavoidable and the environmental improvement of rural life is also required. From such point of view, those constraint mentioned in the above paras. 4.1.1, 4.1.2 and 4.1.8 are to be removed.

From the above-mentioned points of view, following factors are to be taken into account as main component of agricultural development in the Project Area:

(1) Land Use

The expansion of farmland area is hardly possible in the Project Area, therefore the land productivity is to be increased by means of increase of cropping intensity introducing suitable second crops. In other words, year round use of farmland shall be taken into consideration.

(2) Farming Practice

To optimize the yield/ha of each crop, most suitable growing conditions for each crop shall be provided. For such purpose, appropriate farming practice by crops under the given conditions in the Project Area are to be established and settled.

(3) Improvement of Livestock Farming

It is assumed that the introduction of forage crop/s as second crop is unavoidable as a part of land use plan, therefore the promotion of livestock farming shall be examined. The improvement of livestock is considered as presupposition, and establishment of suitable feeding system for the Project Area which can only produce seasonal forage crops is examined at the first instance.

(4) Profitability of Agriculture

The purpose of farming activities is to increase the value of farmland and labor under proper level of price of products. For this purpose, such effort is required as to obtain a maximum output with a minimum input. Effective use of fertilizer, agri-chemicals, etc. and rational allocation of agri-machinery and labor, etc. are to be examined in this concern.

(5) Farmer's Organization

At the execution of above mentioned improvements, the mutual cooperation of farmers is unavoidable in case of the Project Area where comparatively small scale landowner farmers are sharing a large part of land resource. It is obvious that farmers can obtain more advantages in procurement of agri-input, O & M of agri-machinery and farmland facilities, marketing of products, etc. when they apply joint working system . The reinforcement of farmer's organization is to be examined from such point of view.

(6) Supporting System of Farming Activities

Although the reinforcement of supporting system of farming activities is very important in line with the self helping effort of farmer themselves, the subject and method shall be chosen carefully to avoid any damage to the independence of the farmer. Thereby, such supporting system of farming activities as to focus the direction of future agriculture in the Project Area and, at the same time, to satisfy today's needs of the farmer shall be examined and established.

4. 2. 5 Division of Project Area

the Project Area is divided into following 5 steps of areal divisions in this study report:

1) District/Sub-District	-	covering areas of the east and west main canals diverted from the Haraz and Amol diversion dams.
2) Zone	-	covering area of a secondary canal.
3) Block	-	covering area of a tertiary canal.
4) Sub-block	-	covering area bounded by a tertiary irrigation canal on one side and by a tertiary drainage canal on the other side, consequently.
5) Unit	-	a block is generally divided into several sub-blocks/Units.

The above areal divisions are summarized as table below:

Summary Of Areal Division Of The Project Area

District/Sub-District	Gross Area (ha)	Irrigation Area (ha)	Zone		Block		Sub-Block	
			Number	Average Size (ha)	Number	Average Size (ha)	Number	Average Size (ha)
Haraz West (HW)	15,026	10,680	8	1,335	49	218	116	92
Haraz East (HE-I)	13,485	11,019	7	1,574	39	283	83	133
Haraz East (HE-II)	11,287	8,539	8	1,067	26	328	84	102
Haraz Left (HE-III)	5,480	4,447	5	889	23	193	44	101
Sub-total	30,252	24,005	20	1,200	88	273	211	114
Amol West (AW)								
Amol West-I (AW-I)	9,046	5,486	5	1,097	29	189	70	78
Amol West-II (AW-II)	15,784	11,977	7	1,711	51	235	134	89
Sub-total	24,830	17,463	12	1,455	80	218	204	86
Amol East (AE)								
Amol East-I (AE-I)	8,336	5,924	7	846	21	282	56	106
Amol East-II (AE-II)	9,185	7,379	6	1,230	31	238	59	125
Amol East-III (AE-III)	15,016	10,534	7	1,505	25	421	105	100
Sub-total	32,537	23,837	20	1,192	77	310	220	108
Subject Area	102,645	75,985	60	1,266	294	258	751	101
Urbanization Area								
Amol Urban Area (AUA)	3,849	1,813	1					
Babol Urban Area (BUA)	1,515	1,052	1					
Sub-total	5,364	2,865	2					
Project Area	108,009	78,850	62	1,266	294	258	751	101

(1) District/Sub-District

The Project Area is divided into 5 districts of: (1) Haraz East, (2) Haraz West, (3) Amol East, (4) Amol West and (5) Amol and Babol Urban Area. The agricultural development project will be established at the districts (1) - (4) except the urbanization area.

The area of each of those 4 districts are too large as a unit area for land consolidation project, therefore the Project Area is divided into 9 sub-districts, based on the coverage area of secondary canals and or crossing roads, as shown in the above table.

(2) Zone

The Project Area is divided into 60 Zones, which have 1,266 ha of average areal scale per a Zone.

(3) Block

Each of tertiary canals are covering 100-500 ha, therefore the Project Area is divided into 294 Blocks of 258 ha in average.

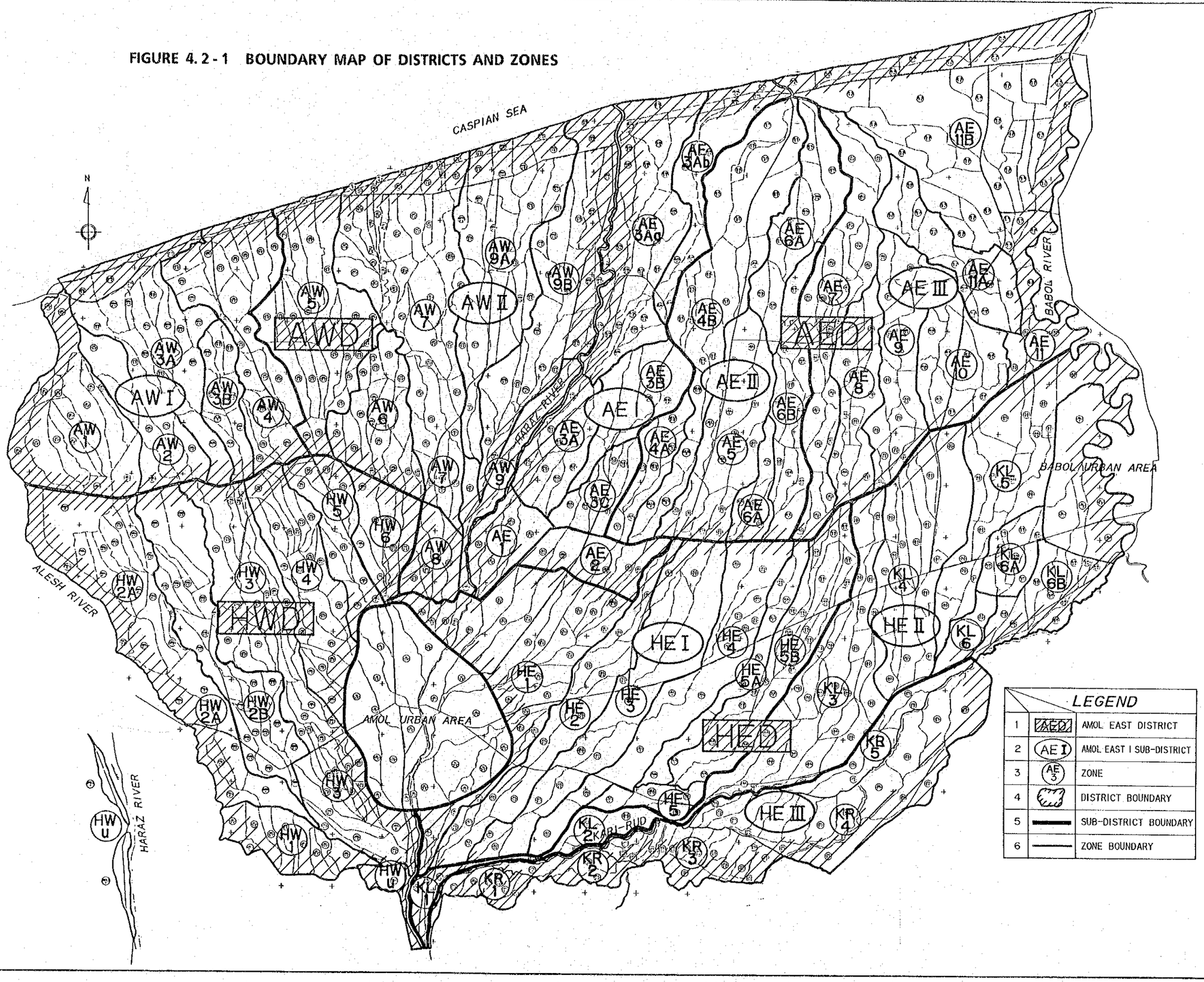
(4) Sub-block

Many of Blocks are divided into 2-4 Sub-blocks in accordance with covering area of tertiary canal system, and each Sub-block is bordered, in principle, with tertiary irrigation canal and tertiary drainage canal. Consequently, the Project Area will have 751 Sub-blocks of 101 ha average area. Whole area of the Project Area is counted with such Sub-blocks which have common code numbers based on the irrigation canal system. The complicated canal system of irrigation cum drainage are clearly classified with such method.

(5) Unit

Unit means the terminal area of joint farming activities such as joint holding of agri-machinery/facilities, preparation of agri-input, water management, etc. The average area of a Unit is about 100 ha, and the land consolidation works will also be executed in such unit area. Except some special cases, most of unit will have same covering area of Sub-block.

FIGURE 4.2-1 BOUNDARY MAP OF DISTRICTS AND ZONES



4. 3 Agricultural Development Plan

4. 3. 1 Land Use

Land use plan is formulated on the following conditions.

1) For the urban areas of Amol and Babol cities, land use plan is based on the Master Plans for Urbanization of the cities concerned. For other urban areas, the present acreage is used.
2) The ullage area resulting from land consolidation is based on the average rate of 5 %. This is applied to all the paddy area, regardless of whether land consolidation would actually be implemented or not.
3) The ullage area that will be occupied by the construction works such as farm roads and canals is included in 2).
4) The existing area under forest, sand dune and rangeland etc. is kept unchanged in the plan.

The following table shows the outline of land use plan by irrigation system / urban areas.

(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

Detail on land use can be found in Appendix C. 1. 4.

4. 3. 2 Farming System and Crop Production

(1) Cropping Plan

The Project is aiming to increase the land productivity by means of introduction of second crops as well as to stabilize rice production, therefore the following cropping plan is applied:

1) Paddy rice - - taking the rationalization of water management, moderation of seasonal concentration of labor demand, increase of rate of self supply of rice, marketability, etc. into account, following cropping plan by varieties is assumed:

Varieties	Representing Seed Name	Maturity	Ratio of Introduction
Local Variety	Tarom	Early matured	37.5%
High Yield Variety	Khazar	Medium matured	37.5%
High Yield Variety	Amol-3	Late matured	25.0%

2) Berseem - - this crop is also called Egyptian clover and a leguminous forage which grows well on wet soil contrarily to alfalfa, a representative leguminous forage, which grows on well drainable soil. The nutrient composition of berseem and alfalfa are compared below:

	DCP	TDN
Green Berseem	2.1%	12.1%
Green Alfalfa	2.6%	11.6%

DCP - digestible crude protein
TDN - total digestible nutrient

The Project Area has considerable rainfall in autumn-winter, therefore the second crops are to have sufficient tolerance to wet conditions of soil. Berseem is considered a suitable crop from such point of view, moreover its nutrient value is also very high comparable to alfalfa. Therefore, this crop is considered a most suitable forage crop to promote livestock farming in the Project Area. In case of over production of berseem, it will also be possible to find a market among the cattle breeders around the Tehran metropolitan area, however, introduction of this crop to 50% of paddy field is suggested in the Project taking the forage requirement by the present population of livestock in the Project Area into account.

3) Vegetables - - vegetables are mainly cropped in the high land which have good drainage condition at present. After the implementation of project, the drainage condition will be improved in almost the whole area. At the same time, the population increase in the metropolitan area will expand the market of fresh vegetables in winter season. Taking such conditions into account, introduction of vegetables in 6,250 ha of paddy field is planned for increasing the income of small land owner farmers of less than 1.0 ha.

4) Broad Bean - - taking the expansion of market as said above into account, introduction of broad bean in 330 ha of paddy field is lanned.

5) Barley - - the harvesting period of existing variety of barley in the Project Area is often disturbing the timely transplanting of paddy, therefore barley is omitted from the cropping plan under the Project. However, barley may be added as second crop if suitable early maturing variety is provided.

6) Other crops - - taking the demand of vegetable oil in the country into account, introduction of colza or similar crops may be considered. However, adaptability of such crops shall be examined in future experimentation, therefore it is not considered in this cropping plan.

(2) Farming System

The farming system planned for the above-stated land use and cropping plans 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.

Based on the above, the recommended cropping pattern is provided as shown in Figure 4.3-1 and the following farming systems are planned emphasizing farming coupled with animal husbandry.

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

(3) Crop Production

Planned yield levels for the major crops with and without the project for the proposed farming management are as follows.

Crop	Yield		
	Present	Without Project	With Project
Paddy: Local - E.M.	4,135	4,135	4,437
Paddy: HYV - M.M.	5,741	5,741	6,378
Paddy: HYV - L.M.	7,375	7,375	7,972
Berseem (green grass)	52,500	52,500	60,000
Barley	2,957	3,000	3,000
Broadbean	2,523	2,500	2,500
Transplanted Vegetables	15 - 25	20 tons	20 tons
Direct-sown Vegetables	12 - 35	25 tons	25 tons

Note : Unit in kg/ha except for vegetables

The basis for projected yield is given in Appendix C. 2. 3. As for the field crops, the impact of the project is considered limited, though some qualitative and quantitative improvement such as proper farming techniques fostered by the project implementation can be expected.

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

Crop	Without Project		With Project		Balance	
	Acreage (ha)	Production (ton)	Acreage (ha)	Production (ton)	Acreage (ha)	Production (ton)
- Paddy 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 (green grass)	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

Current and planned crop acreage are given below.

Summer Crop / Winter Crop	Paddy Berseem	Paddy Barley	Paddy Veg.t	Paddy Veg.d	Paddy Broad Bean	Single Paddy	Total
Acreage Without Project (O.P.)							
Haraz West	1,663	120	474	1,516	90	7,376	11,239
Haraz East	3,787	210	399	1,261	100	19,505	25,262
Amol West	0	0	0	0	0	18,378	18,378
Amol East	0	0	0	0	0	25,090	25,090
Total Project	5,450	330	873	2,777	190	70,349	79,969
Acreage With Project (W.P.)							
Haraz West	4,287	0	600	1,910	90	3,793	10,680
Haraz East	12,009	0	500	1,600	240	9,656	24,005
Amol West	9,427	0	170	550	0	7,316	17,463
Amol East	12,270	0	230	730	0	10,607	23,837
Total Project	37,993	0	1,500	4,790	330	31,372	75,985
Urban (unchanged)	460	25	90	360	15	1,915	2,865
Rural + Urban O.P.	5,910	355	963	3,037	205	72,264	82,834
Rural + Urban W.P.	38,453	25	1,590	5,150	345	30,422	78,850

4. 3. 3 Improvement of Livestock

The total production of forage under the project is roughly estimated as below :

(unit)	Water Content %	Yield t/ha	Crop · Area ha	Gross Product t	Nutrient Content DCP %	Nutrient Content TDN %	Nutrient Product DCP ton	Nutrient Product TDN ton
Paddy :								
Straw	57.6	4.3	75,985	326,735	0.6	17.9	1,960	58,485
Bran	12.0	-	75,985	45,960	14.8	80.5	6,800	36,998
Sub - total							8,760	95,483
Berseem :	82.0	60.0	-	-	2.1	12.1	-	-
50%	(18.0)	(11.7)	37,990	2,279,400 (446,000)			47,867	275,807
65%			49,390	2,963,400 (580,000)			62,231	358,571
75%			56,990	3,419,400 (669,000)			71,807	413,747

Note : Figures in ( ) show dry weight

In relation to berseem, it is natural that the production is dependent on the cropping area. In case 50% of paddy field is cropped with berseem, the production of hay of 8% of water content will be about 446,000t, and it will increase to 669,000t therefore 7.4 - 11.1% of projected increase of fodder crops in the 5-year Plan explained in the above Chapter 2. 3 will be produced in the Project Area. In other words, the Project Area is not only able to contribute at the increase of supply rate of rice, but also has big potentiality to contribute at the increase of fodder crop production.

Among the above nutrient resources, rice bran may be omitted from the nutrient resources for livestocks because it will mainly be consumed as forage of poultry. On condition that berseem is introduced in 50% of paddy field and effective feeding rate of paddy straw and berseem are 60% and 70%, respectively, the number of feedable heads of livestock are estimated below, and Plan A will be most recommended for the Project Area taking into account the prevailing conditions therein.

	Feedable Head of Cattle			Production		
	Calf/Heifer	Adult	Total	Meat	Milk	Wool
A Expansion Milk Cow :						
Local Cattle	20,700	37,000	57,700	933	15,540	-
Improved Cattle	25,400	17,000	42,400	1,476	31,875	-
Pure Race Cattle	12,600	5,500	18,100	654	20,102	-
Total	58,700	59,500	118,200	3,063	67,517	-
Sheep	15,200	21,100	36,300	227	-	31
Goat	1,100	2,000	3,100	15	-	-
Total	16,300	23,100	39,400	242	-	31
B Proportional of Cattle :						
Local Cattle	36,200	64,600	100,800	1,630	27,131	-
Improved Cattle	6,200	4,200	10,400	362	7,875	-
Pure Race Cattle	2,300	1,000	3,300	165	3,655	-
Total	44,700	69,800	114,500	2,157	38,661	-
Sheep	14,700	20,300	35,000	219	-	30
Goat	1,100	1,900	3,000	15	-	-
Total	15,800	22,200	38,000	234	-	30
C Expansion of Meat Animals :						
Local Cattle	50,400	89,600	140,000	2,264	37,632	-
Improved Cattle	3,600	2,400	6,000	209	4,500	-
Pure Race Cattle	1,400	600	2,000	100	2,193	-
Total	55,400	92,600	148,000	2,573	44,325	-
Sheep	34,000	47,300	81,300	511	-	70
Goat	1,100	1,900	3,000	15	-	-
Total	35,100	49,200	84,300	526	-	70

The details of livestock farming plan is explained in Appendix C. 3. 2, however following conditions are to be taken into consideration at the promotion of livestock farming in the Project Area :

1) Improvement of race of cattle - - The above plans are provided aiming to increase number of herds taking the present raising environment and practice into account, therefore proportion of local race and heifer / calf ratio in a herd are rather high. In the future, whole cattle are to be replaced by Hybrid or Pure Race and the ratio of adults is also to be increased to have better productivity. For instance, following breeding plan is also applicable if berseem is introduced in 65% of paddy field and only improved race is raised:

	No. of Head	Slaughter Rate	Production		
			Yield / head	Meat	Milk
Calf	34,420	36 %	120 kg	1,487 t	-
Heifer	51,650	18	144	1,339	-
Adult	57,400	14	270	2,170	107,625 t
Total	143,470			4,996 t	107,625 t

In the above case, if population in AD 2,000 of the Project Area is about 720,000 (assuming that present rate of population increase is kept the period), 19 grams of meat and 410 grams of milk will be supplied per day / capita basis. Although the supply amount of meat is deemed as not sufficient compared to the country-wide average consumption of meat was about 34g/day/capita in 1990, however the mean milk consumption was about 510 g/day/capita in the same year converting the consumption of butter and cheese into milk. Therefore the Project Area can almost achieve self sufficiency taking into account the real consumption of dairy products therein.

2) The improvement of facilities for artificial insemination, pest control, veterinary services, etc.. - - As shown in Table D. 4-1 of Appendix D. 4, there is only 2 veterinary clinics and 21 extension servicemen of livestock in the Project Area other than a veterinary station in Amol city, and neither breeding station to keep good oxen nor quarantine to prevent epidemic diseases is existing therein, and such facilities are to be urgently improved to an acceptable level for promoting livestock farming under the project.

   As minimum requirement, it is recommended to establish a veterinary center for each Sub-district and a crew of 2 veterinarians, 5 assistants, 5 artificial insemination technicians and 10 extension servicemen per each 10,000 heads is to be allocated therein.

   Other than such veterinary center, a breeding station to keep 20 - 30 heads of selected oxen equipping facilities to collect sperm and storage of frozen sperm. As the site of such facilities, the forest area nearby the CAPIC is the most highly recommended considering potential supply of forage from the CAPIC farm.

3) Establishment of Raising Practice - - All cattle are to be fed in sheds which are hygienously acceptable. It is recommended to apply joint feeding system by village unit or smaller group unit employing landless farmers and women as workers for livestock farming.

4) Establishment of Feeding Plan - - To improve the quality of forage applying silage etc., establishment of appropriate feeding plan is urgently requested. In the above raising plan, number and productivity of herd was estimated under such condition as to feed with available forage sources within the Project Area, however the nutrient value and digestible rate will be added if silage system is applied. Furthermore, feeding with proper ratio of the concentration of high DCP content such as bagasse and pulp of sugar cane and sugar beet or cake of oilseeds, the available forage in the Project Area will be used more effectively.

For establishing livestock farming plan, a detailed study to solve the above - mentioned conditions is essential taking the potentiality of effective use of surrounding forest area as range land. It is assumed that the Project Area has good potentiality to export various kinds of meat / dairy products if a suitable feeding system is established.

4. 3. 4 Establishment of Agricultural Mechanization System

Introduction of appropriate mechanization system in compliance with the proposed crop management is considered essential for a sustainable and productive agricultural system. The following criteria for farm management are given taking farm holding size and other conditions into account;

1) except for type C shown in the para. 4. 3. 2 (2), all other farm management will follow the joint-use or hired-use of machinery and farming facilities.
2) the machinery maintenance system will be fortified by unifying the types of machinery.
3) an agricultural machinery registration system will be introduced to secure the maintenance of adequate numbers of working machines as well as to strengthen inventory of spare parts.
4) 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.

The proposed mechanization system is illustrated as Figure 4.3-2 based on the experience in Japan and other countries where farming conditions

are similar to those found in Mazandaran. It should eventually be established according to the trial test results in the Project Area.

It should be noted that land consolidation enables introduction of large-sized machinery that offers a "scale merit" as compared with small-sized one like powertillers. Fortunately, farmers in the Project Area have already experienced how to utilize large scale machinery, and are waiting for better field conditions on which large-sized machines can be efficiently operated.

4. 3. 5 Post Harvest System and Marketing

As crop production is improved after the project, the need for an improved post harvest 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.

1) Introduction of auto-threshing type combines for paddy harvesting should be accompanying device for drying. On the other hand, farm income is eroded by the high rate of post harvest loss in the form of broken rice grain by current rice mills. This leads to the necessity to create a serial processing system covering both paddy drying and milling.
2) It is necessary to store berseem in the form of hay or silage to secure feed all year round. Hence either drying facilities or silos are required. Dryers for this purpose may also be used for drying paddy. However, it should be studied separately.
3) As for collecting and marketing vegetables in winter, it is necessary to develop a marketing facility within the Project Area, thereby rational packaging and forwarding could be realized in closer communication with consumers markets.
4) It is also necessary to establish a fruit collecting and marketing facility, where sorting is made to separate and grade citrus fruits etc., for fresh market fruit from those for processing.
5) In Iran, a wide range of techniques for post harvest treatment and packaging need to be improved, since post harvest loss due to inappropriate handling is not negligible. Therefore, equipment for sorting, packaging and processing should be installed in the marketing facilities.

6) It is also essential to form a cooperative system for collection, treatment and processing of livestock products such as redmeat and milk.

Mobilization of private capitals is desirable to materialize the above mentioned improvement, though it should not result in the exclusion of existing entrepreneurs in these sectors. Instead, it is worthwhile to change their recognition towards facility improvement, and it may be pertinent to launch a model project on a basis of cooperative activities in order to foster qualitative improvement.

4. 3. 6 Fortification of Farmers Organization

The objectives of implementing an irrigation and drainage project or land consolidation lie in a sustainable development in rural agricultural sector, in which voluntary participation of beneficiary farmers is an essential factor to success. To this end, fortification and extension of existing farmers organizations are the preconditions to offer incentives to promote their participation. Strengthening and fostering the activities of the existing organizations, i.d., cooperatives are the fastest way. It should be noted that diversification of activities should be elaborated within the framework of a single organization rather than in the formation of diversified organizations for a specific purpose because such a partitioned, complicated system would become subject to confusion and will disturb rural community structure.

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

1) The function as a land consolidation district to implement the works thereof. As a rule, a block consists of beneficiary farmers of a land consolidation district, but the support for the repayment of funds, guaranteed hedging of farmer's installment, should come from the cooperative level.
2) The function for orderly and efficient use, proper management and maintenance of jointly owned machinery. This part can be entrusted to a group of farmers on a contract basis, thereby users hire the machinery by tariff payment.

3) The function as a group of operating a jointly managed box nursery system associated with mechanized paddy transplanting. Like 2), it can be entrusted and to employ a hiring system.

4) The function to produce paddy seed in relation to the joint nursery system.

5) The function as a joint-purchase for agri-inputs. This role is played by the cooperative at present, but it is desirable to change from hitherto distribution system to a demanded order system, provided that free market with ample input supply is materialized.

6) The function as irrigator's association to secure equitable public service such as terminal water management, collection of water fee and repairing of terminal irrigation facilities. At present, water fee, rated by hectarage, is collected from the individual farmer channelled through the cooperative. However, introduction of a quantitative rating system is expected in the near future, and subsequently registration of water diversion by irrigation unit is necessary.

7) The comprehensive function as a unit to check livestocks from trespassing the berseem fields, buying of berseem seed, joint use of grass dryers or silos, and group husbandry system.

8) The function of joint unit to collect milk and dairy produce coupled with strengthened milching capacity. This should be planned after studying the feasibility of cooperative-run dairy processing unit.

9) The function of joint market for winter vegetables and citrus fruits.

10) The function of smooth and proper management and maintenance of machinery, equipment and facilities. In this context, emphasis must be placed on how to purchase and store spare parts bought from outside the area or abroad.

When attaching these functions to the existing cooperative, some degree of alteration of the existing articles and rearrangements of member villages are needed. However, these institutional changes are worth judging from the long term benefit.

To organize or fortify farmer's organization, the following types of guidance are usually applied in different countries :

1) Forcing type which the governmental organization requests the farmer to participate in the cooperative activities - - The cooperatives in Iran have been started as such type, and not yet cast off from such type after a quarter century activities.

2) Drawing type which the governmental organization guides and supports to organize or fortify the cooperative activities, but observing the independency of farmer - - In many cases, this type is applied as development of forcing type, viz., after establishing the cooperative under forcing type, operation and management are entrusted to members' own initiative.

3) Self - awakening type which the beneficiaries organize the cooperative under their own initiative recognizing necessity of such organization - - This type is often seen at the urban area cooperative in the developed countries, but BONEH in Iran is considered as kind of this type. The prevailing canal maintenance system in the Project Area is also classified as this type.

4) Inducing type which the governmental organization undertakes campaign for the benefit of cooperative - - The diffusion method of land consolidation proposed in the Master Plan is considered to be this type. In case of the Project Area, if some farmer accepts the result of demonstrative activities in the CAPIC and wishes to form the land consolidation district, this type is to be applied for further developing.

In fact, the above types have merits and demerits in different cases, however, it is recommended to cast off from the forcing type to drawing type in case of the Project Area taking the farmers' capability into account, and application of inducing type is recommended for introduction of new functions of activities.

Most important point at the forming or fortifying cooperative activities is the manner how to draw the interest of the farmer and how to make the farmer recognize the necessity of cooperative works such as land consolidation, joint farming, etc.. As an old man in the Project Area said, the farmer is carefully watching what his neighbor is doing despite the fact he is conducting himself indifferently thereupon. Usually, farmers are rather conservative and wish to avoid the challenge of any risk when they encounter any reformation, therefore it is very important to show the merit very clearly and make it recognizable by the farmer. It is the task of the agricultural supporting system explained in the following para. 4. 3. 7 to show the merit of planned

reformation and fortification, however a careful approach is requested to avoid any one - sided drawing or forcing.

The relationship between above mentioned functions and the governmental organizations concerned is shown as Figure 4. 3 - 3. The first approach is to form the irrigator's association as a terminal unit of farmer, and develop it to unit land consolidation district. Many functions are to be added to such land consolidation district and complete it as unit terminal organization of farmer. The completed units are to be developed to Zone - base Federation which covers beneficiary area of a secondary canal, then to form Sub - district - base Federation which covers 3,000 - 5,000 ha. The existing rural cooperatives are recommended to be reformed at this stage to consolidate with the Sub - district Federation of land consolidation district. The different level of federations are to have suitable functions to strengthen the productive activities.

4. 3. 7 Consolidation of the Agricultural Supporting System

The relationship between the farmers or their organizations and the authorities in Iran, inclusive of those in the Project Area, is too close or over-protective to allow any initiative activities by the farmers themselves. However, the role of the authorities should gradually shift from direct management to indirect support concentrating on public service. Appropriate tariff rates for public service must be levied, and in turn the farmer's burden will be offset by the improved level of public service. The following are agricultural support items required for the implementation of the proposed project and subsequently the sustainable development of regional agriculture.

1) Management of water resources to stabilize paddy cultivation. Storage facilities to store discharge during offperiod of irrigation are necessary.
2) Optimization of water distribution which enables timely cultivation.
   Proper maintenance and management of canal networks together with consolidation of water diversion and distribution facilities are necessary.
3) Consolidation of drainage facilities to expand acreage under winter crop and rationalize water management for paddy.

Particularly, repairing of major drainage canals in lowland is essential.

4) Consolidation and improvement of farm road networks connecting the fields to the villages.
In future, asphalt paving should be considered and a system of regular maintenance and management be established.

5) Fortification of technical function for proper implementation of land consolidation. Private consultants will have to undertake the task of planning and design in future. But for the time being, basic requirements such as aerial photographs, establishment of cadastral registration system, formulation of land consolidation criteria and standard design, procedural arrangement, scheduling and logistic strategy of machinery mobilization etc. should be established.

6) Strengthen research and extension activities so as to establish a suitable mechanized farming system.

7) Promote trial test for promising crops and varieties suited to mechanization and breeding.

8) Promote trial test and training activities on paddy cultivation techniques in terms of water management practice.

9) Accelerate trial test on winter crop cultivation and breeding.

10) Establish extensive disease and pest control systems for paddy and orchards.

11) Reinforce research / extension activities on postharvest techniques including sorting and grading, packaging, processing technologies for paddy, citrus, winter vegetables etc.

12) Consolidate facilities related to breeding of animal stock, formulation of standard feeding technique, veterinary service as measures for livestock promotion and extension activities.

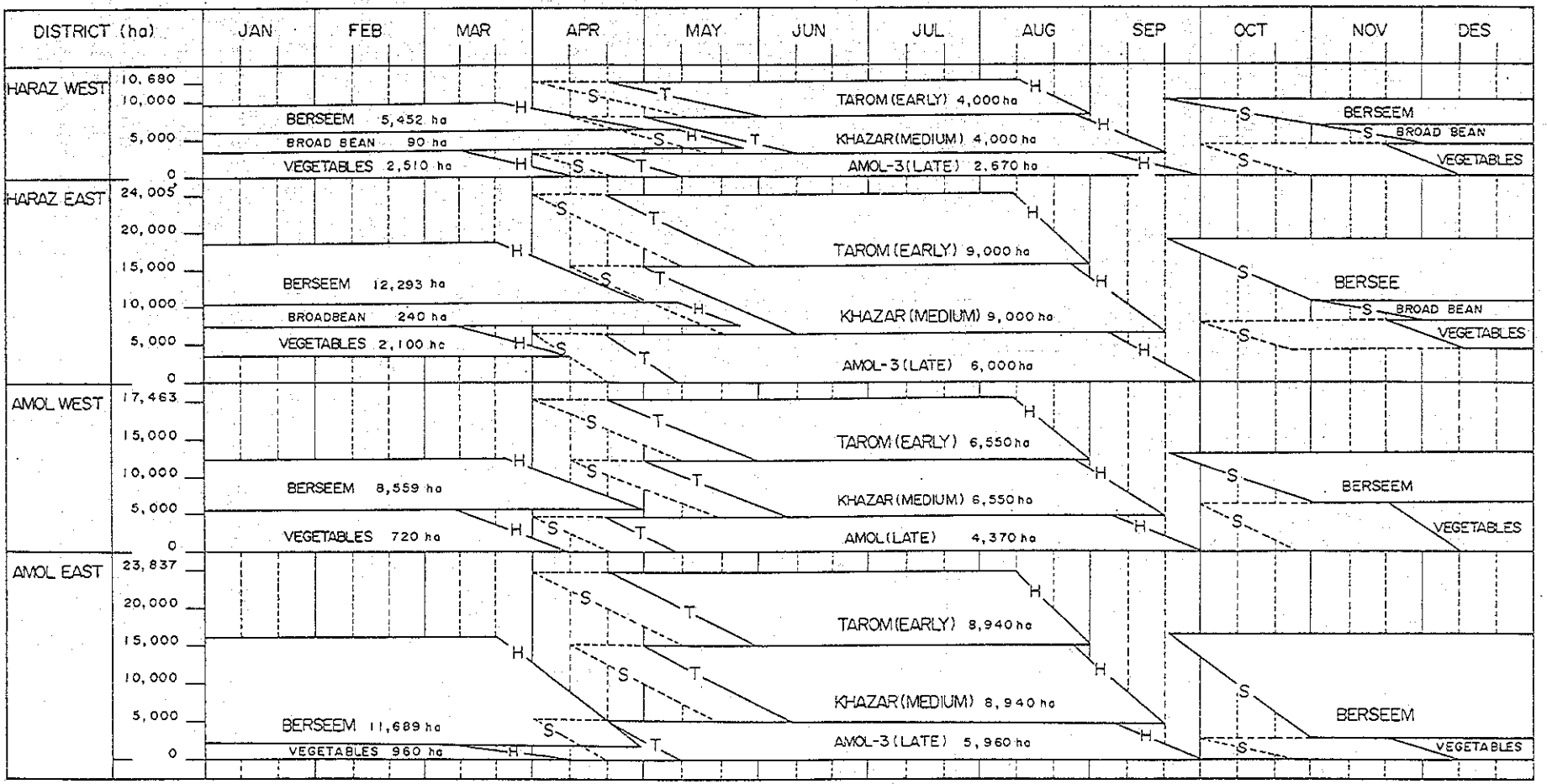
13) Provide comprehensive implementation plans to reinforce agricultural production and technical instruction including training of personnel.

14) Expand and secure provision of funds credited for land consolidation works and introduction of mechanized system.

15) Introduce a comprehensive monitoring system to evaluate the effect of improvement works, so that necessary revision or rectification can be made according to the progress monitored.

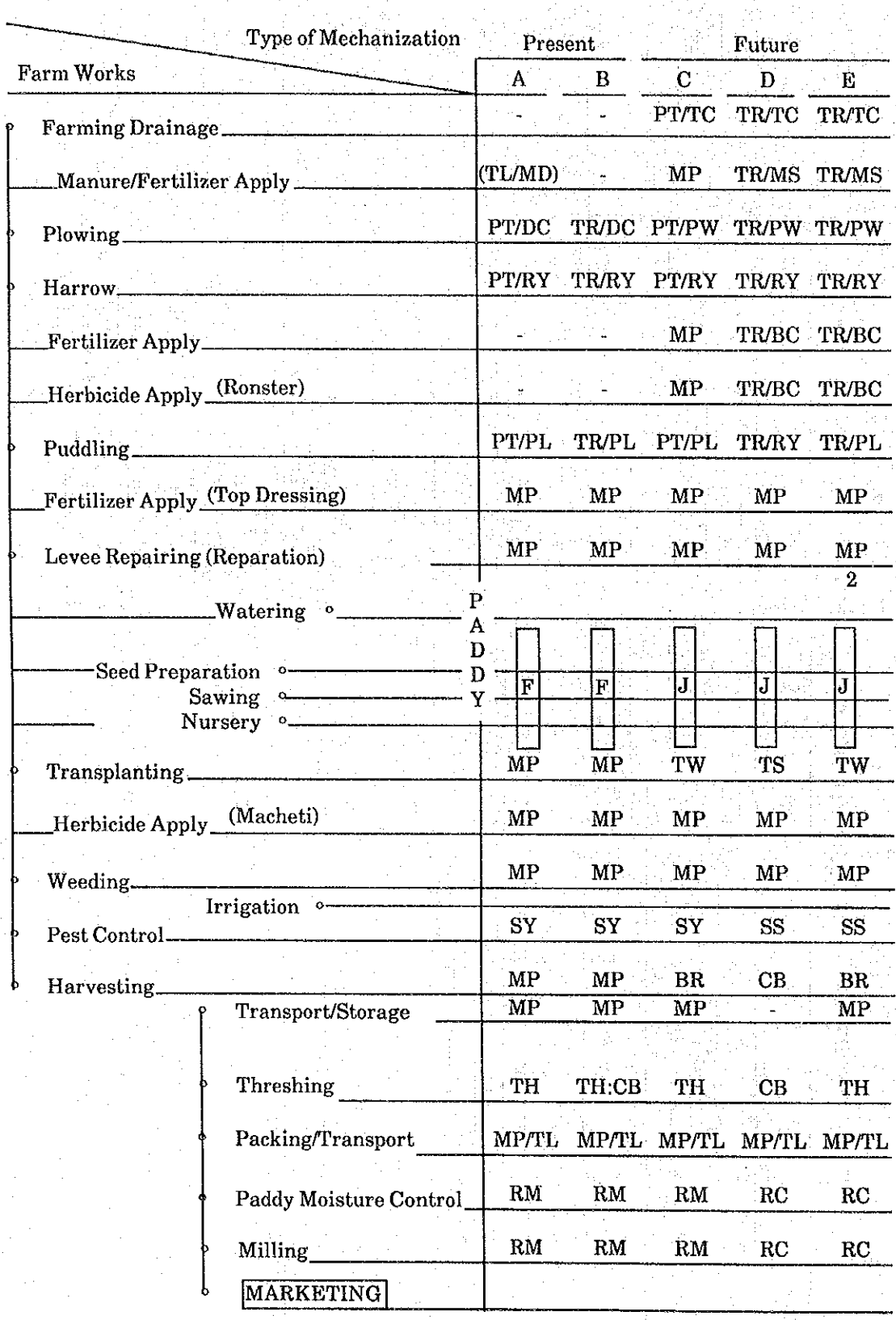
Out of these, MOE will be responsible for items 1) ~ 4) and 12) by MOCJ, 5) ~ 11) and 15), by MOA, 13) by Cooperative Organization of MOA and 14) by Agriculture Bank. However, coordination between these authorities is essential. Use of the CAPIC as a coordinating body should be studied. CAPIC can take the responsibility to perform functions 5) and 15) at the initial stage in coordinating government authorities concerned and district level subordinate offices capable of assessing plans and designs provided by consultants etc. Also, it can participate in the implementation works using its own machinery.

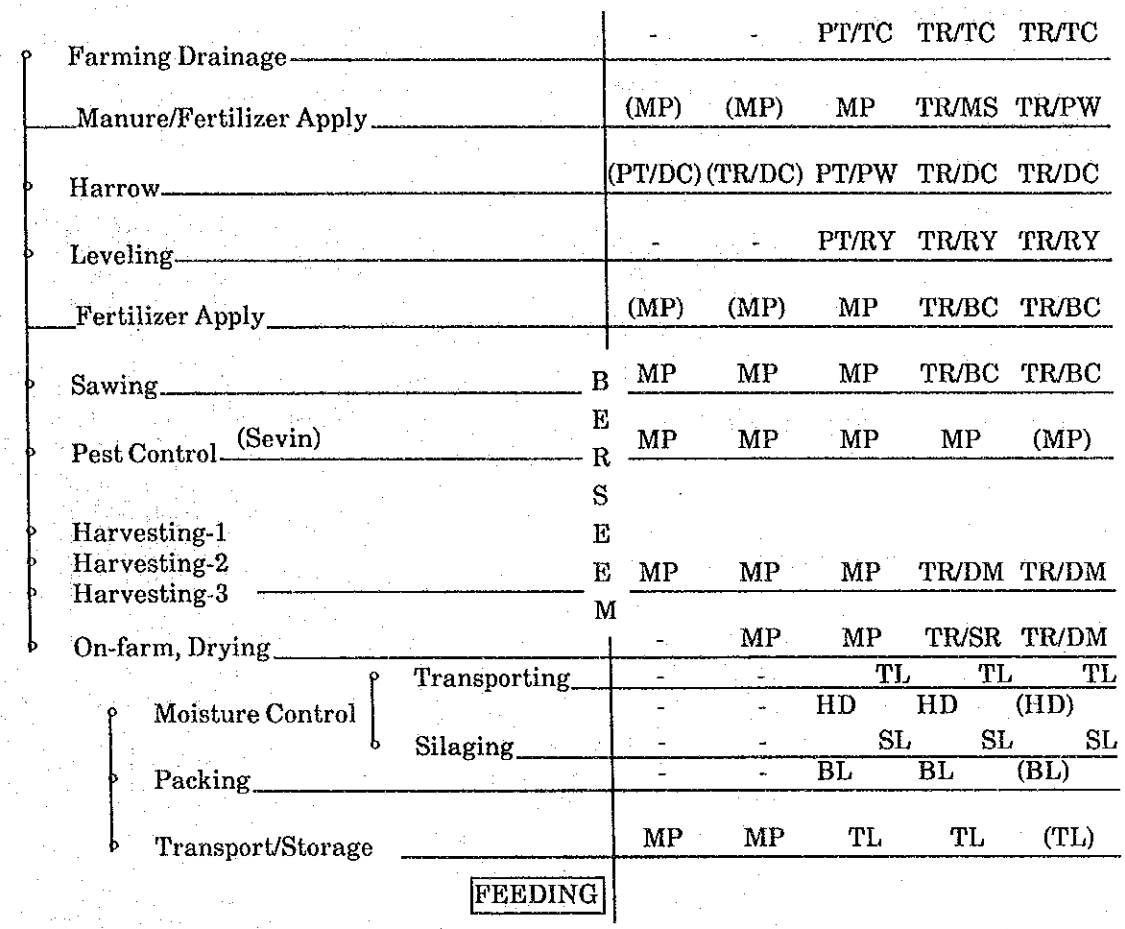
FIGURE 4.3-1 PROPOSED CROPPING PATTERN



S: Seedling, T: Trasplanting, H: Harvesting

FIGURE 4.3-2 FARM MECHANIZATION IN HARAZ PLAIN





PT : Power Tiller (7 - 12 PS)
MP : Man-Power

TC : Tractor-mounted Trecher
DC : Disc Plow
RY : Rotary Plow
PL : Paddy Wheel

TW : Tiller-type Transplanter
F : Farmer-base Nursery

SY : Shoulder-type Sprayer
PS : Powder Sprayer

BR : Binder-type Harvestor
TH : Fixed-type Thresher

TL : Trailer

RM : Rice Mill

DM : Disc Mower
BL : Bailer
HE : Hay Dryer

TR : Tractor (60 - 70PS)

MS : Tractor--mounted Manure Spreader
PW : Horrow Plow
BC : Borad Caster

TS : Tractor-type Transplanter
J : Group-base Joint Nursery

SS : Speed Sprayer

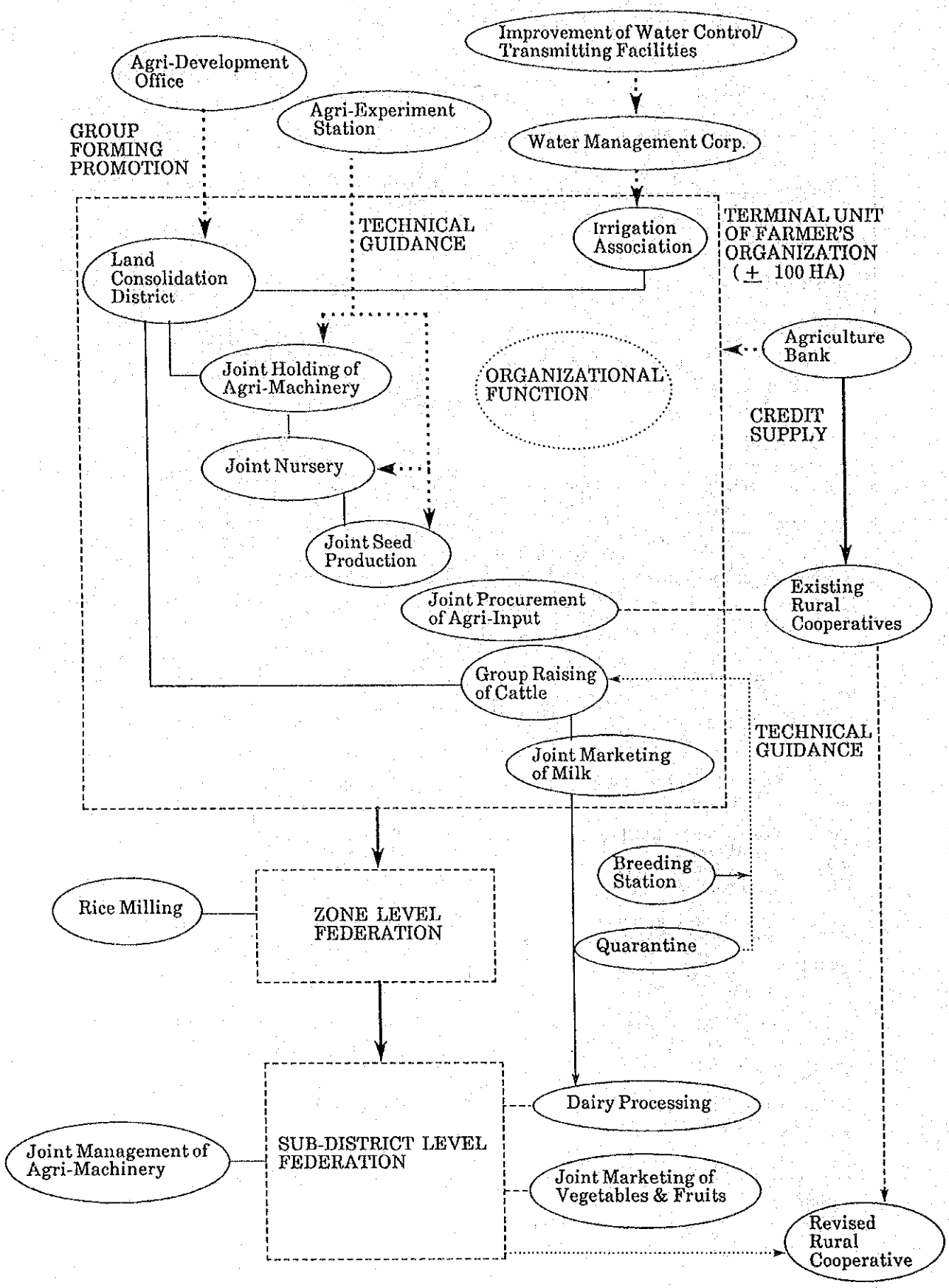
CB : Combine Harvestor

RC : Silo-type Rice Center

SR : Side Rake

SL : Silo

FIGURE 4.3-3 PLAN OF IMPROVEMENT FARMER'S ORGANIZATIONAL FUNCTIONS



4. 4 Irrigation and Drainage Plan

4. 4. 1 Irrigation Area and Water Requirement

(1) Subject Crop on Irrigation

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. Simultaneously, second crops are also excluded from the subject crop, since adequate rainfall can feed their water requirement in the second cropping season.

(2) Irrigation Area

Irrigation area is 78,850 ha of paddy rice depending on the land use plan as described in the para. 4. 3. 1. The irrigation area is divided into two different areas by their water source, namely the surface water irrigation area and the groundwater irrigation area. The former area is 66,504 ha (84%), and the latter is 12,346 ha (16%). The irrigation areas by districts 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%

(3) Water Requirement

The proposed varieties of paddy rice are classified into three varieties, that is the early matured, the medium matured and the late matured varieties. Their cropping area and ratio are as follows;

Varieties	Cropping Ratio (ha)	Cropping Area (ha)
Early matured (Tarom)	37.5	29,569
Medium matured (Khazar)	37.5	29,569
Late matured (Amol - 3)	25.0	19,712
Total	100.0	78,850

Water requirement has been estimated under following conditions;

Crop consumption = Potential Evapotranspiration × Crop Factor
Percolation = 3.0 mm/day
Effective Rainfall = 75% of a monthly rainfall
Irrigation Efficiency = 70% for overall (0.89 × 0.91 × 0.87)
where, : 89% for conveyance (Main & Secondary)
: 91% for conveyance (Tertiary canal)
: 87% for application

Irrigation Efficiency by Canal Level

Main and Secondary Canals = 70% (equal to the overall E.)
Tertiary/4th Canal = 79% (0.87 × 0.91)
Irrigation Ditch = 87% (equal to the application E.)

Puddling Period

Early matured variety : 40 days
Medium matured variety : 40 days
Late matured variety : 20 days
Nursery : 1% of paddy area, and 20 days to transplanting

Design Irrigation Capacity

Main and Secondary Canals : 1.7 lit/s/ha
Tertiary Canal : 2.0 lit/s/ha
4th Canal : 2.6 lit/s/ha
Irrigation Ditch : 5.9 lit/s/ha

Water requirement of each variety in designed drought year is summarized as follows;

Variety	Water Requirement	Net Requirement	Diversion Water Requirement
	(mm)	(mm)	(mm)
Early matured	936.3	846.3	1,209
Medium matured	1,001.3	911.3	1,302
Late matured	1,229.5	1,125.5	1,608

Note: Water Requirement : Evapotranspiration + Percolation
Net Irrigation Requirement : Water Requirement-Effective Rainfall
Diversion Requirement : Net Irrigation Requirement/Overall Efficiency (0.7)

Above diversion requirement can be converted to the amount of water as below;

Early matured	:	1,209 mm * 29,569 ha	= 357 MCM
Medium matured	:	1,302 mm * 29,569 ha	= 385 MCM
Late matured	:	1,608 mm * 19,712 ha	= 317 MCM
Total			1,059 MCM

Using the same manner mentioned above, diversion requirement has been estimated at 1,049 MCM for a normal year. Simultaneously, diversion requirement for nursery is 2.9 MCM for a designed drought year and 2.7 MCM for a normal year. Total diversion requirement is 1,062 MCM for designed drought year and 1,052 MCM for a normal year. The difference is only 1% between the said years.

4. 4. 2 Irrigation Methods by the Areas

(1) Principles on Irrigation

The project aims to change the terminal irrigation system from the existing dominant system "the plot-to-plot irrigation" to the improved irrigation system where irrigation water is supplied directly to each field lot through the irrigation canal and ditch. This is realized by land consolidation.

On the other hand, continuous irrigation is to be applied in the Project Area, because paddy rice is the subject crop for irrigation and flood irrigation is suitable to the paddy field. However, in the puddling period, water is supplied

in a rotational irrigation mode in harmony with the progress of puddling works. The rotational period of puddling differs by the canal level, as below;

Rotational Period of Puddling

Canal Level	Standard Command Area (ha)	Rotational Period
Main Canal	Generally more than 10,000	40
Secondary Canal	More than 500	40
Tertiary Canal	100 to 500	20
4th Canal ※	12 to 100	15
Irrigation Ditch ※	6	4

Note*: Irrigation ditches at on-farm level

Irrigation just after the mid-summer drainage is also achieved in a rotational irrigation mode.

(2) Irrigation Methods

The irrigation network is proposed principally to follow the irrigation-cum-drainage system to realize the effective use of return flow. However, particularities have been given to the irrigation network, taking into consideration the geographical conditions and the necessity from a viewpoint of water management.

1) Irrigation Network in the Low Lying Area (below (-) 20.0 m)

In the low lying area below (-) 20.0 m, the separate irrigation and drainage system is proposed from the viewpoint of difficulty on water management due to a conflict with the drainage water level which is hardly free because of a less available water head to the sea level.

2) Consideration on the Canal Capacity Involving the Groundwater Irrigation area

Although the surface water is dominant for irrigation in the Project Area, groundwater also shares 16% of a whole irrigation area. The groundwater irrigation areas are intermingled and scattered in the surface water irrigation area. The irrigation area by groundwater does not have any water right of surface water, but it is allowed to utilize surface water when

surface water is adequate. Thus, groundwater can be preserved in this manner in a wet irrigation season.

In this study, the acreage of groundwater irrigation area was distinguished from the surface water irrigation area in each sub-block by the number of wells which are located in a said sub-block. Depending upon the above acreage, following considerations have been given to the design capacity of canals which irrigate the area involving the groundwater irrigation area.

- Secondary canal : shall convey a supplemental amount of water to the groundwater irrigation area within 2/3 of a freeboard of canal when surface water is adequate. Without increasing any capacity of canal except AE10, all of the groundwater irrigation areas can be irrigated by surface water when surface water is adequate.
- Tertiary canal : shall have enough capacity to be able to irrigate the whole area regardless of the groundwater irrigation area involved, because the necessary capacity exceeds 2/3 of a freeboard in many cases due to a large range of the ratio of groundwater irrigation area to the whole area.

4. 4. 3 Proposed Irrigation and Drainage Network

Proposed irrigation and drainage network is planned based on the locations of the diversion dams and the main irrigation and drainage canals alignment as proposed as by the HWDP - I Study. The existing canals are utilized as the proposed secondary or tertiary canals as much as possible as they are. The existing canals were clarified on their locations and sections by the topographical map of 1 : 20,000, the profile and sectional survey of about 530 km length, and the TIB survey for the entire Project Area. Thus, the proposed network is almost the same as the network as proposed by the HWDP - I study. (see Figure 4. 4 - 1)

The proposed network is planned principally to follow the irrigation - cum-drainage system to be able to utilize the return flow and to minimize the right of way. In the proposed network, it is planned to divert the drainage area

of about 5,000 ha, that is the most of drainage area of Ezbaran drain, to DAE9 (Shira Rud Drain). This diversion eliminates the drainage rate of Feridon Kenar main drain, and makes the estuary improvement of this drain easier.

(1) Proposed Irrigation Network

As shown in Figure 4. 4 - 1, the Project Area will be divided generally into 5 districts by the Haraz and the Amol diversion dams, the Haraz river and the areas of urbanization. Urbanization areas of Amol and Babol are excluded from the irrigation development area. The districts are further divided into 9 sub-districts from a viewpoint of project implementation as described in the above para. 4. 2. 5.

Relationship of the Haraz East Main Canal and the Kari Rud is as follows;

- The upper reach of Kari Rud will be diverted directly from the Haraz river as same as present, and irrigate 3 secondary canals, KR1, KR2 and KL1, which are located at the higher portions of the Haraz East District. Intake capacity of the upper reach of the Kari Rud is 1.4 cms.
- Irrigation water for the secondary canals of Kari Rud other than above 3 canals will be diverted by the Haraz diversion dam and conveyed through the Haraz East main canal.

Flow diagram of irrigation network is shown in Figure 4. 4 - 2, and the detail of zones and blocks of irrigation is described in the above para. 4. 2. 5.

(2) Proposed Drainage Network

The Project Area will be divided primarily into two drainage areas, viz. the upper and the lower, by the Amol West Main Drain (AWMD) and the Amol East Amol Drain (AEMD) as shown in the flow diagram, Figure 4. 4 - 3. The AWMD (drainage area : 15,453 ha, discharge : 47.59 cms) will be drained to the Alesh river, and the AEMD (drainage area : 22,834 ha, discharge : 66.11 cms) to the Babol river. These two main drains mitigate the drainage rates of the drains pouring into the Caspian Sea.

Modification of drainage areas from the existing drainage network is summarized as below;

Comparison of the Existing and the Proposed Drainage Areas

(Unit : ha)

Drainage District	Existing	Proposed	Difference
Haraz Left Bank District			
- Alesh River Drainage District			
DHW1 - 4, DAW1 - 2	3,587	3,536	Δ51
AEMD Amol West Main Drain	0	15,453	15,453
DAW3 Changar Drain	6,634	3,382	Δ3,252
- Caspian Sea Direct Drainage			
DAW4 Mahmudabad Drain	16,170	4,126	Δ12,044
DAW5 Siahrud Sar Drain	2,353	3,152	1,159
DAW6 Tifangar Drain	6,119	3,974	Δ2,145
DAW7 Bishen Kola Drain	291	381	90
DAW8 Alamdeh Rud Drain	1,792	1,692	Δ100
DAW9 Shiah Kola Drain	761	620	Δ141
DAW10 Bir Rud Drain	3,793	2,949	Δ844
Caspian Sea Direct	0	683	683
- Haraz River Drainage District			
UHW Haraz River Upper	399	399	0
Haraz River Direct	981	2,173	1,192
Sub-total	42,880	42,880	0
Haraz Right Bank District			
- Haraz River Drainage District	1,254	2,926	1,672
- Caspian Sea Direct Drainage District			
DAE9 Shira Rud Drain	1,130	6,675	5,545
DAE10 Feridon Kenar Main Drain	49,070	18,691	Δ30,379
Caspian Sea Direct	0	1,090	1,090
- Babol River Drainage District			
Babol River Direct	8,195	7,433	Δ762
AEMD Amol East Main Drain	0	22,834	22,834
KR Kari Right Bank	5,480	5,480	0
Sub-total	65,129	65,129	0
Total	108,009	108,009	0

Note Δ : indicating the decrease

4. 4. 4 Proposed Utilization Plan of the Abbandans

There exist 206 abbandans in the Project Area, and they play a role of supplemental water source of irrigation. Their surface area and storage volume are about 3,500 ha and 36 MCM in total.

Freshwater fishes centralized by carp species inhabit most abbandans, and some abbandans are utilized as fish ponds. The abbandans are also presently habitats of wild-life, water fowls and migrant fowls. Furthermore, beautiful vistas are created by abbandans in harmony with extensive paddy fields. Although these abbandans had been artificially constructed by farmers throughout the long history of rice cultivation, the abbandans provide for not only the farmers but also wild-life with an important environment.

On the other hand, available water resources are limited, and some water shortage of about 133 MCM is expected even in a normal year, as clarified in the para. 4. 4. 5 below. It is , therefore, necessary to develop the storage function of abbandans, preserving the above environment. There is no particular restriction on development of the abbandans except, AE88, which is designated as an important wetland by the Ramsar Convention, however, it is important to preserve the environment for fishes.

Consequently, paying attention to environment, abbandans are to be developed in the following manner. Development will be given to 200 abbandans excluding the said one abbandan and five abbandans located in the urban area.

- excavating abbandan bottom by 1.0 m depth, to develop a new storage function of about 14 MCM.
- to provide a depressed emergency pond for fish, that is around 10% of abbandan surface, deepened by another 1.0 m from abbandan bottom for preserving their living needs.
- to link abbandans with irrigation and drainage canals to enable the utilization of return flow easier.

4. 4. 5 Availability of Water Resources

(1) River Water

River water of the Haraz river and release water from the Lar dam are as follows;

(Unit : MCM)

	Annual	Irrigation Period	
	(Normal Year)	Normal Year	Drought Year
Release from Lar Dam	240	240	240
Runoff of Residual Basin	670	402	225
Total	910	642	465

It is impossible to utilize above water fully for irrigation, because runoff water of the Haraz river is not regulated in full scale.

(2) Storage Water in Abbandans

Storage water is expected to increase by 14 MCM, to 50 MCM from 36 MCM by improvement on 200 abbandans. Storage water is fed with runoff of the Haraz river and local runoff during non-irrigation period.

(3) Groundwater

Available groundwater is estimated at 143 MCM for irrigation, that is 135 MCM by shallow and deep wells and 8 MCM by springs. There exist 5,837 wells and 48 springs in the Project Area.

(4) Return Flow

As indicated in the Appendix B. 1. 1, the proposed return flow ratio is estimated at about 12% of the intake water at the diversion dam, increasing 4% of present one because 50% of horizontal percolation (1 mm/day) will be drained to the drainage canals as excess water.

From the analysis of return flow, its available amount is estimated at 87 MCM.

(5) Water Balance

Annual water balance is summarized as below for normal year and designed 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 seen in above table, water shortage occurs not only in drought year but in normal year. Water shortage is 317 MCM for drought year, and 133 MCM for normal year. From the view-point of this water shortage, it is important for irrigation to develop water resources of the residual basin.

New storage dams are proposed by the MOE, in the basins of Haraz and Babol rivers, but all proposals are still under preliminary study stage. For eliminating the above mentioned water shortage, necessary storage capacity has been studied at the possible damsites, that are the Mangol damsite in the Haraz river and the Pasha Kola damsite in the Babol river. Mangol damsite is located just at the upstream of the Karehsang gauging station, and the locations of these damsites are shown in the Figure 4. 4 - 4.

Studied Damsite	Catchment Area (Km^2)
Mangol damsite (1)	4,061
Mangol damsite (2)	3,773
Pasha Kola dam site	220

The main role of the Pasha Kola dam is to supply irrigation water to the right bank area of the Babol river, therefore, this water resources is not considered as irrigation water to the Project Area for the time being.

Case studies are as follows;

Case-1 : Normal water allocation between Irrigation and Tehran domestic water supply (248 MCM : 177 MCM), and irrigation area in this case : 53,878 ha

Case-2 : Modified water allocation between Irrigation and Tehran domestic water supply (186 MCM : 239 MCM), and irrigation area in this case : 53,878 ha

Case-A : Mangol damsite (1)

Case-B : Mangol damsite (2)*

In case increasing a diversion to the Tehran water works to 230 MCM from 177 MCM (increased by 30%), the release amount of irrigation water will decrease to 186 MCM from 248 MCM (decreased to 75%).

Note: Since geological formation of the site (1) of Mangol dam is limestone, another site (2) has been selected at about 12 km upstream of the site (1) as an alternative site.

Using runoff data for 27 years from 1956 to 1982, necessary storage capacity of the Mangol dam has been studied. Necessary storage capacity to sustain a drought year (1/10-year) is as follows;

(Unit : MCM)

Case	Necessary Effective Storage Capacity	Losses	Sediment Volume	Necessary Gross Storage Capacity
Case - 1 - A	280	14	180	474
Case - 1 - B	305	15	170	490
Case - 2 - A	323	16	180	519
Case - 2 - B	362	18	170	550

This study proposes the Case - 1 - B, that is the case of 490 MCM dam size of the Mangol.

4. 4. 6 Concepts of Drainage Improvement

In the Project Area, rice cultivation has been achieved in a great extensive scale, and century long experience has realized high productivity with the well organized techniques on cultivation and water management. However, as clarified in Chapter 3, there still exist several problems with cultivation from the viewpoint of drainage aspects. The goals and the necessary improvements on drainage are summarized as below:

(1) Goals and the Necessary Improvements on Drainage

By the improvement of the drainage conditions in the Project Area, the following three goals might be realized;

- to increase agricultural and labor productivities, through improvements of environment for paddy growth and cultivation.
- to increase cropping intensity for effective utilization of land resources and man-power resources.
- to preserve and protect the Project Area from external hazards such as the rising of the sea level and floods from adjacent rivers.

From the above cited goals, the following improvements and measures might be necessary for drainage.

- to remove inundation and water logging or stagnation from farmlands during a period of paddy growth for increasing rice yield.
- to make farmlands able to conduct mid-summer drainage for increasing rice yield.
- to make farmlands well-drained for mechanization.
- to remove inundation/water logging and to control groundwater table from autumn to winter for introduction of second crops and for effective land-use.
- to remove or mitigate drainage obstructions cause by the rising up of the sea level for preservation of the low-lying area.
- to train the adjacent rivers for preservation of the Project Area from floods.

Other than the above improvements or measures, the following matters are also to be taken into consideration;

- The existing irrigation and drainage system has realized high irrigation efficiency by utilization of return flow and by the abbandans to store return flow through the irrigation-cum-drainage system.
- Groundwater of the shallow aquifer is recharged mainly by the percolation of rainfalls from autumn to winter.

- In the low-lying area, where the excess runoff flows down from the hinterland, difficulty is increased on drainage by the rising up of sea level.
- From the environmental aspect, it is necessary to preserve forestry and abbandans, and water quality conservation is also important.

(2) Basic Plans on Drainage Improvement

For the above concepts, following basic plans are prepared.

1) Drainage Network for the Effective Use of Water Resources

The proposed drainage work follows principally the irrigation-cum-drainage system, that enables farmers to use the return flow easier, for sustaining the high irrigation efficiency by the effective use of water resources. Although it is not proposed to connect the abbandan directly with the drainage canal from a viewpoint of safety, a diversion facility, which diverts return flow from the drainage canal to the abbandan, is proposed.

2) Preservation of Groundwater and the Sub-surface Drainage

It is necessary to consider the groundwater recharging rate of shallow aquifer, that is estimated at 2.0 mm/day, into the sub-surface drainage rate. It will be effective not only for preserving the groundwater but for decreasing the sub-surface drainage rate.

3) Mitigation of Drainage Rate in the Low-lying Area and Drainage Network

By the improvement of drainage system in the upper hinterland, drainage discharge will be increased to the low-lying area. Furthermore, due to the rising up of sea level of the Caspian Sea, it will be necessary to provide excavated large sectional drainage canals in the said low-lying area.

To avoid the above, it is proposed to provide two main drainage canals, which intercept the drainage discharge of the upper region of the Project Area and release the discharge to the Babol and the Alesh rivers. For the Haraz left bank area, providing the Amol West Main Drain (AWMD), the upper region of 15,400 ha will be drained to the Alesh river. Also, for the Haraz right bank

area, the upper region of 22,800 ha will be drained to the Babol river by the Amol East Main Drain (AEMD). Furthermore, it is proposed to divert the Ezbaran Drain to the Shira Rud Drain for reducing the drainage rate of the Feridon Kenar Main Drain (see Figure 4. 4-1).

On the other hand, it is difficult to conduct proper drainage by the irrigation-cum-drainage system in the low-lying area due to less available water head, and therefore, the separate irrigation and drainage system is proposed for the area below (-) 20.0 m.

4) Considerations to the Environment

For preserving the environment, following considerations are given to the drainage plan:

- to preserve abbandans inhabited by fishes and wild-life.
- to minimize the inundation in the forest along the Alesh river, where river training is necessary.
- to preserve water quality in the Project Area by introduction of a separate irrigation and drainage system at the on-farm level. This system minimizes the wash-out of fertilizers and chemicals from the farm lot.

5) Removal of Inundation/water Logging During the Paddy Growth

Removal of inundation/water logging is necessary especially in the middle and the low lands. Water logging is caused by various obstructions, such as plot-to-plot drainage, insufficient capacity of drainage canals, interceptions by roads and irrigation canals. It is, therefore, difficult to remove water logging only by the efforts of individual farm plots. Inundation occurs in the low-lying area below (-) 24.0 m behind Feridon Kenar. Inundation is caused mainly by less water head to the Caspian Sea and other reasons, such as river mouth closure of the Feridon Kenar Drain, insufficient capacity of drainage canals of the Feridon Kenar and its tributaries, drainage discharge from the upper region, poor drainage abilities due to the gentler land slope and the insufficient density of terminal drainage ditches.

As mentioned above, the case of inundation and water logging is different, consequently different measures are to be established for inundation and for water logging.

(a) Drainage Plan for Water Logging

As clarified above, it is necessary to provide and improve drainage canals to remove excess water smoothly from farm plots. The land has a sufficient slope of 1/200 to 1/700 for providing drainage canals. The following drainage plan is proposed for removing the water logging:

- to provide irrigation and drainage ditches by land consolidation to connect with each farm plot, and eliminate the plot-to-plot irrigation and drainage. This provision enables each farm plot to control water to a proper depth.
- to facilitate the secondary and tertiary drainage canals by means of the enlargement of sections, removal of interceptions, and to drain excess water from the land consolidation area.
- Drainage rate of rice growing period is to be two-day rain (1/10-year) drained by two-days. However, drainage rate of second cropping season is larger than that of the rice growing season, therefore, drainage facilities will be improved by the second cropping drainage rate.

(b) Drainage Plan for Inundation

For eliminating inundation, the following measures have to be provided as well as the measures for water logging;

- to intercept the drainage discharge from the upper region by the AWMD and the AEMD, and to mitigate drainage rate in the low-lying area.
- to remove drift sand deposit, which caused the river mouth closing of the Feridon Kenar Main Drain, by the groins and the training jetties. Other drains than the said drain will not be necessary to facilitate such measure, because they have sufficient water head to the Caspian Sea.
- Inundation will not be eliminated entirely, but it will not be harmful for rice growing as below;

Inundation Condition During Rice Growing

Inundation Level	:	(-) 24.20 m
Inundated Area	:	340 ha (paddy field)
Max. Water Depth	:	30 cm
Duration	:	2days

- From the above results, it is not necessary to provide any pumps to remove excess water in the rice growing season.

6) Mid-summer Drainage for Rice

The mid-summer drainage is effective for accelerating the tillering of rice and for increasing yield. The drainage ditches, which are provided by the land consolidation, enable the farm plots to conduct the mid-summer drainage easily.

7) Well-drained Paddy Field

It is essential for mechanization to reform the fields well-drained. Reformation is the role of drainage ditches, and also a role of tile drainage where the land is impermeable or an impermeable layer lies at a shallow depth. Since the rice is harvested from August to late September and the rain generally starts from September, it is recommended to introduce early matured variety into the low-lying area where inundation will occur. However, for the fields of about 500 ha below (-) 24.0 m, it is difficult to reform the field well-drained due to less water head only 1.0 to the sea level.

8) Removal of Inundation and Control of Groundwater from Autumn to Winter

It is essential for introduction of second crops to remove inundation and to control groundwater table. Since drainage rate of this period is the highest, all drainage facilities are designed with this drainage rate. From a viewpoint of growing condition of berseem , groundwater has to be maintained below 20 cm from field surface. For this purpose, tile drains will be buried into 24,100 ha land, equivalent to 32% of the entire paddy field. Due to the high sea level, the land of 1,300 ha which is located below (-) 22.50 m will be excluded from the groundwater controlled area. Inundation will occur on the land of about 500 ha below (-) 24.0 m, and this area is limited in the said excluded land from groundwater control.

Inundation Condition During Second Crop Growing

Inundation Level	:	(-) 24.00 m
Inundated Area	:	511 ha (paddy field)
Max. Water Depth	:	50 cm
Duration	:	2days

9) Measures for Rising up to the Caspian Sea Water Level

The Caspian Sea rose to (-) 26.10 m as of June 1992. On the other hand, the design sea level has been set at (-) 25.00 m. The rising up of the sea level causes several hazards to the coastal area, such as erosion of the shore, river mouth closing of drains, and deterioration of drainage canal capacity. In case the sea level remains at (-) 25.00 m, the coastal sand dunes will not be eroded entirely and farm land will remain from erosion. However, there are many villas on the sand dunes, and it is necessary to protect the shore line from erosion. For this purpose, it is required to provide shore protection works and groins for the entire shore line for controlling erosion and the movement of drift sand. These works have to be considered to involve all concerned sectors not only agriculture. In this project, items 5), (b) and (8) will be considered for preserving the Feridon Kenar Main Drain.

10) River Training

The floods, which intrude into the Project Area, are caused by overbank flow at lower reaches of the Babol river, by the flood disbursed in the forest from the Alesh river, and by overbank flow from the Kari Rud. For the Babol river, river training is necessary to enlarge the river section for 2.0 km long of the lower reach, where river section is small to pass the design flood. Regarding the Alesh river, it is necessary to provide a protection dike at the upper reach of the Alesh river along the forest and to excavate the river channel of 10 km long below the junction with the AWMD. It is able to mitigate the peak flood discharge by enclosing the flood in the forest by the protection dike. For the Kari Rud, it is proposed to provide a floodway to divert excess flood of 80 cms over the Kari Rud capacity. The excess flood is diverted to the Kharan Rud river through the floodway.

4. 4. 7 Drainage Improvement Level

(1) Design Year

Design years for the drainage improvement are set as follows;

- 1/10 - year for agricultural drainage.
- 1/25 - year for maximal structure capacity.

The drainage discharge of 1/25 - year has to be drained within a freeboard which is necessary for 1/10 - year design discharge.

(2) Drainage Criteria

1) Surface 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 rather small compared to that of the winter crop season, consequently the drainage plan is prepared based on the rainfall of the winter crop season.

2) Sub-surface Drainage Criteria

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 is to within 5 days. Consequently, the drainage rate of sub-surface drainage is decided to drain 5-day consecutive rainfall within 5 days.

(3) Drainage Rate

1) Surface Drainage Rate

Surface drainage rate is estimated using the Cypress-Creek Formula that was developed by SCS, USDA. (Reference Dr - 1. 2) The adaptability of

this formula has been examined in this study, from the viewpoint of the experience in Iran and the applicability by actual data. Design rainfalls for estimation of drainage rate are summarized as below;

Design Rainfall

Period	2 - day Rainfall (mm)	
	1/10 - year	1/25 - year
Annual	166	204 (*1 - 2)
Second Crop Season (Sep- Mar)	148 (*1 - 1)	178
Rice Growing Season (Apr - Aug)	73	80
Rice Harvesting Season (Aug - Sep)	107 (*2)	128

Note: (*1 - 1) Design rainfall for the canal capacity
(*1 - 2) Design rainfall for the maximal capacity
(*2) Design rainfall for the bypass capacity of checks.

Based on above rainfalls, surface drainage rates are estimated by the following equations; (see the details in Appendix B. 3. 6)

Drainage rate for the canal capacity;

$$1/10 \text{ - year}: \quad Q_{10} = 0.01542\, M^{5/6}$$
$$1/25 \text{ - year}: \quad Q_{25} = 0.01917\, M^{5/6}$$

Drainage rate of the bypass capacity of the check gate;

$$1/10 \text{ - year}: \quad Q_{10} = 0.01084\, M^{5/6}$$

where, Q : Drainage rate (m^3/sec)
M : Drainage area (ha)
Above equations are shown in Figure 4. 4 - 5.

Discharge below the junction is computed by the 20 - 40 rule based on the drainage areas and discharges of upstream channels which join at the junction. (reference Dr - 1)

Summary of 20 - 40 rule

Channels - 1 : drainage area (M1), discharge (Q1)
Channels - 2 : drainage area (M2), discharge (Q2)