MBT and Jhelum Fault are known as active faults, the maximum values of seismic intensity are located at a little western side of Jhelum Fault and on the MBT line or at a little Northern side of MBT.

Federal Capital Territory of Islamabad lies about 30 km west of Jhelum Fault and about 20 km south-east of MBT. The maximum seismic intensities in ICT have being recorded from eight to nine of Richter Scale.

3.2.5. Soil and Land Classification

1) Soil

a) Characteristics of the Soils

The characteristics of the soils in the Project Area are developed by the rolling uplands with soils derived from calcareous wind deposits and the gently sloping land with soils derived from alluvial or mountain outwash deposits. Most of the former is distributed at the mountainous area in the northeastern part of the upstream of Rawal Dam. The latter is distributed at the area gently inclining from north to south in the downstream of Rawal Dam. The diagnostic soil profile is as follows;

- The surface soils consist mainly of grains by sizes ranging from fine texture to medium texture and are reddish brown or yellowish brown in color.
- Most of the subsoils consist of of medium size grains and are reddish to yellowish brown in color in developing about 1.0 m deep. There are gravels found in mixture in some parts. In some deep parts of the alluvial zone, there are sandy layers found.
- The soils, although being slightly compacted and prone to form plow sole, are in weak alkali with pH value of around 7.0. The survey has revealed that the EC value is 0.3 ms (25°C) and few adverse factors for vegetable cropping can be found with sufficient chlorine but little nitrogen and sulfate as plant nutrients.

b) Classification of Soils

The soils in the Project Area are classified into five soil series and most of them are the wind medium-textured soils, and followed by alluvial medium-textured soil, residual soil, alluvium fine-textured soil and gullied medium-textured soil as shown below, and the distribution of the soils is illustrated in Figure 3-5.

Classification of Soils

Soils		Area ha	Area %
Alluvial Medium-Textured Soil	①	750	10
Alluvial Fine-Textured Soil	②	200	3
Wind Medium-Textured Soil	④	5,800	80
Residual Soil	⑤	450	6
Gullied Medium-Textured Soil	⑦	100	1
Total		7,300	100.0

Alluvial Medium-Textured Soils ①

These soils are distributed in the downstream of the Kurang River and at the confluence of the rivers of the Kurang and the Gumreh Kas, and are constituted by the good drainage medium textured soils (L-Sil) which were derived from comparatively late deposits. As the groundwater in the areas with these soils is exploitable, vegetables cultivation by irrigation is encouraged at present. The subsoils are found deep, and brown or yellow-brown in color with good physical and chemical properties. No limiting factors for crop production are found because of the favorable soil conditions for suitable agricultural production.

Alluvial Fine-Textured Soils ②

The alluvial fine-textured soils which are distributed in the flat area in the eastern part of Rawal Dam are characterized as deep subsoils in yellowish brown in color. The upper subsoil in soil profile is non-calcareous due to base eluviation. The pH value is 5.5 with low acidity. The caliche soils are rarely found in the deeper part of the subsoils. This kind of soil is suitable to the rainfed upland farming because of low erosivity. But the physical characters are considered as limiting factors for the rainfed upland farming due to the formation of plow sole and difficulty in harrowing practices.

Soil fertility is generally low in the Area, but deep plowing to replace surface soils with subsoils is effective to extend the root zone of plants.

Wind Medium-Textured Soils ④

This kind of soil is widely distributed in the flat and gently sloping areas and classified into two types depending upon land slope of the flat land with medium-textured soils and the gentle slope land with medium-textured soils. The subsoils are found deep in dull reddish brown or dull yellowish brown. Small gravels are rarely found in the deeper part of the subsoil.

The land with these soils will need an adequate erosion control due to its high erosivity. Therefore, the farmers should take necessary countermeasures against soil erosion by means of land leveling and terracing works of field and subdividing the fields into small plots. In general, since plow sole is formed in this type of soils, deep plowing is essential to plant vegetables. Soil fertility different in the total supplied amounts of organic matters is generally low. However, the soils in the flat area in the south of the Rawal Dam have high potentiality for farming with appropriate soil physical characteristics.

Residual Soils ⑤

The residual soils in the Project Area have various types with sandy to clayey soils derived from weathered sedimentary rock. This type of soil is distributed in mountainous area under complicated conditions such as topography and effective depth of the soils. The main limiting factors to crop production are shallow effective depth of the soils and the contents of gravel and exposed rock, and risk of the soil erosion which deems to be high. But it could be considered fruitful that a part of this type of soils could be utilized for vegetable cultivation by improved farming methods.

Gullied Medium-Textured Soil ⑦

A large part of the gullied land is presently wasted as uncultivated areas due to predominant soil erosion, but these types of lands could be utilized for continuous cultivation of pasture by levelling the land.

2) Land Classification

Land classification was made based on the criteria in consideration of the soil characteristics, climate conditions, etc.

including wind, topography, extent of water management and farming practices. In the Project, land is evaluated by four classes, I, II, III and IV. The relation between land classification and soil classification is presented as follows;

Land Classification

Soil Classification	Land Class			
	I	II	III	IV
Alluvial Medium-Textured Soils ①	○	–	–	–
Alluvial Fine-Textured Soils ②	○	–	–	–
Wind Medium-Textured Soils ④	○	○	○	–
Residual Soils ⑤	–	○	○	–
Gullied Medium-Textured Soils ⑦	–	–	○	○

Class I : This is flat, or has a gentle slope with high suitability for agricultural production. This land class is located in the neighbor of water sources, villages and roads. Furthermore, water management, farming practices and marketing to urban area will be easily conducted.

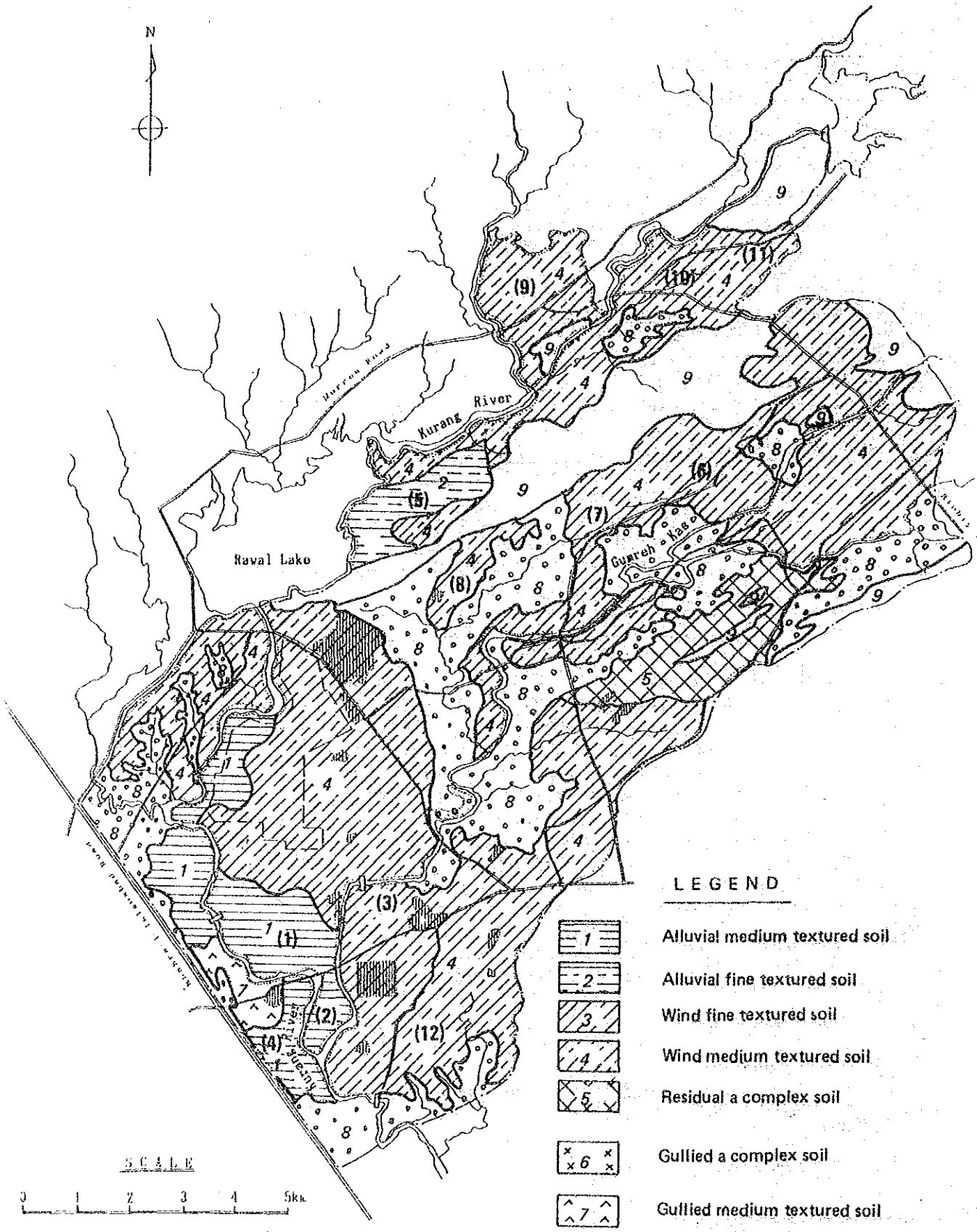
Class II : Suitability for agriculture production is comparatively high, although the sloping land with sand and gravel soils. This class area is located in the neighbor of water sources, and distributed in the hilly land constituted by gravel lands, facing south slope prevented from weak wind.

Class III: This land with a gentle slope has comparative high suitability for agricultural production, and is located far from the water sources. Water management and farming practices would be difficult.

Class IV : This class of land corresponds to wasted land due to soil erosion, but some parts of land could be utilized for cultivation of pasture with the provision of terracing works.

Present land classification in the commanded area is shown in Figure 3-6.

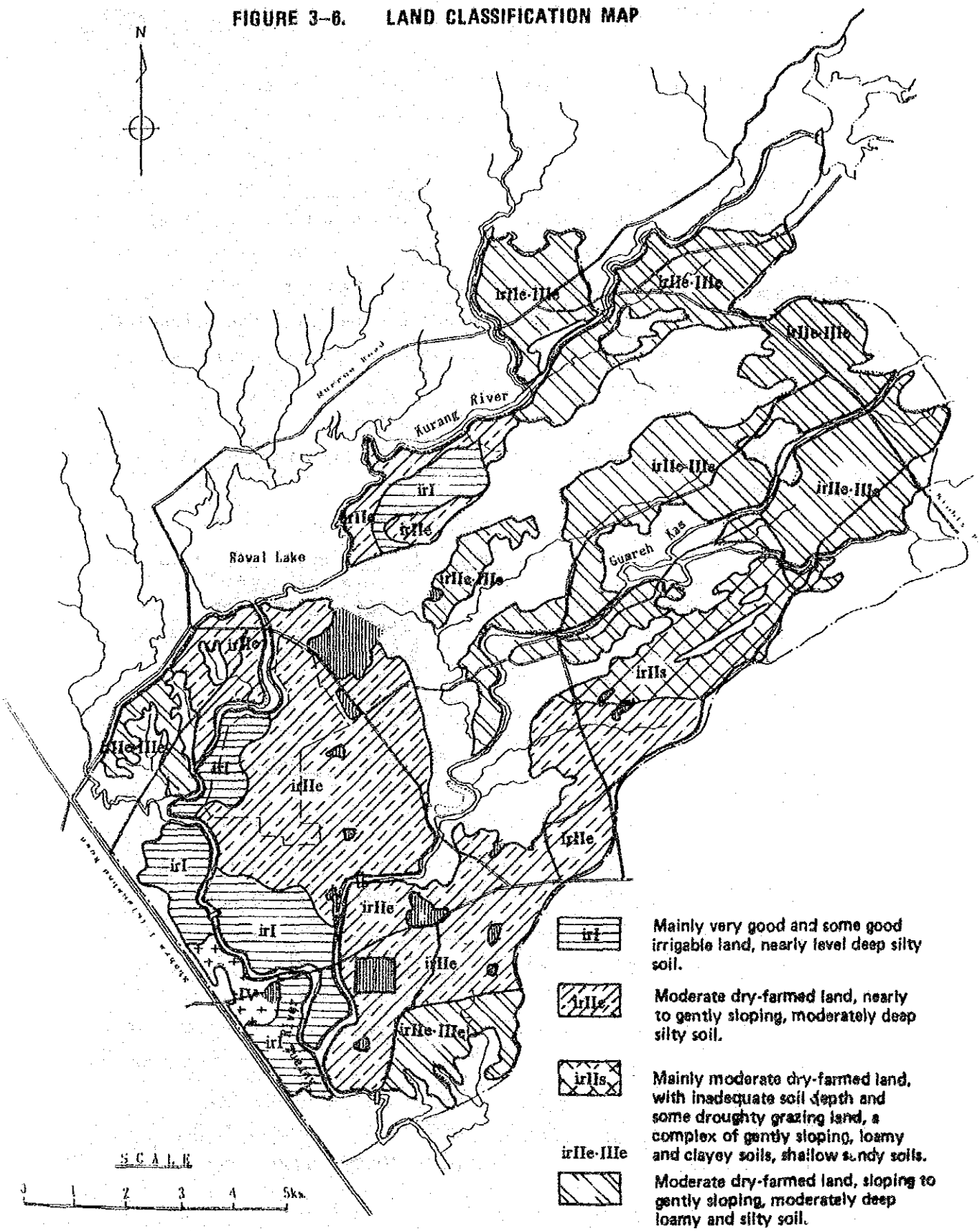
FIGURE 3-5. SOIL MAP IN THE PROJECT AREA



Source ; 1. " Soil Map , 1:50,000 " , 1974
Soil Survey of Pakistan ,
Ministry of Food and Agriculture

2. " Master Plan Study for Intgrated Rural
Development Project " , 1986 , J I C A

FIGURE 3–6. LAND CLASSIFICATION MAP



3.3. Present Agriculture

3.3.1. Land Use

1) Present Land Use

Present land use in the Project Area was studied on the basis of topographic map with scale of about 1:21,100 (three inches to one mile). As a result, the area of 7,300 ha (18,038 acres) was selected as a potential cultivable commanded area from the viewpoint of topography to enable to supply irrigation water by gravity system from the proposed K-2 Dam.

The following table indicates the present land use in the Project Area.

Present Land Use in the Project Area

Land Category	Acreage (ha)	Percentage (%)
Cultivable Area	7,300	56.6
Wasted Land	3,400	26.4
Forest	1,600	12.4
Roads, Rivers and Others	600	4.6
Total	12,900	100.0

The potential cultivable commanded area of 7,300 ha (18,038 acres) is presently utilized for cultivation of upland crops although there are small orchard and pasture under the rainfed condition, and its land use and cropping intensity are estimated as shown below;

Cultivated Area (ha)	Cropped Area (ha)			Cropping Intensity (%)
	Rabi	Kharif	Total	
7,300	4,000	3,700	7,700	106

Data Source: "Village Profile Survey 1986", LGRD, ICTA.

2) Land Holding

The number of private landowners by land holding sizes in ICT rural area is tabulated below;

Number of Private Landowners by Land Holding Sizes

(ICT Rural Area, 1984)

Size of Land Holding (ha)	Number of Landowners (Person)	(%)	Land Holding (ha)	(%)	Average Land Holding/Land Owner (ha)
Less than 0.4	37,323	(65.0)	7,780	(13.8)	0.2
0.4 - 2.0	15,674	(27.3)	20,380	(36.3)	1.3
2.0 - 4.8	2,933	(5.1)	10,100	(18.0)	3.4
4.8 - 10.0	1,053	(1.8)	7,900	(14.1)	7.5
10.0 - 20.0	344	(0.6)	4,360	(7.8)	12.7
More than 20.0	135	(0.2)	5,600	(10.0)	41.5
Total	57,462	(100.0)	56,120	(100.0)	1.0

Note : The above data covers the entire ICT rural area excluding the protection forest lands and the common lands.

Source: Master Plan Study Report for Integrated Rural Development Project, JICA, 1986

The above table shows that the number of small landholders is very large; and that about 65 percent of all the landowners are small landholders of less than 0.4 ha (1.0 acre). Their averaged land holding is also very small as 0.2 ha (0.5 acre). On the contrary, large landholders are more than 20.0 ha (49 acres) and occupy 10 percent of the total land owned by private landowners.

Land is usually obtained through ordinary inheritance, lease, share rental, or purchasing. Among them, the lease and share rental are predominant ways as it is difficult for most farmers to afford cash to purchase land.

The Master Plan Study Report mentions that the number of farm households in the ITC rural area is 14,190, of which 12,116 are

cultivators and 2,074 are landless animal breeders. The difference between 57,462 landowners and 12,116 cultivators could be explained by the fact that all the landowners are not the farm landowners and the average farm size of a cultivator is larger than the size of average land holding. The latter is closely related to the prevailing land holding type in the area.

The number of farm households in the ITC rural area by their land holding types is tabulated below;

Cultivated Land by Tenure Types in ITC Rural Area

Tenure Type	Percent (%)
Cultivated land by owner farmers	75
Cultivated land by owner and tenant farmers	15
Cultivated land by tenant farmers	10
Total	100

Source: Master Plan Study Report for Integrated Rural Development Project, JICA, 1986

According to the Report of the Agricultural Economic Research Unit, NARC, the percent of owner farmers in three Barani Districts of Rawalpindi, Attock and Jhelum increased from 1960 to 1980 are as follows;

Owner Farmers in Three Barani Districts

District	1960 (%)	1980 (%)
Rawalpindi	64	81
Attock	41	58
Jhelum	53	68

Source: Barani Farming Systems of the Punjab. Agricultural Economic Research Unit, NARC, 1985

In Pakistan Ayub's and Bhutto's Land Reforms were affected in 1959 and 1972, respectively, resulting in an increase in owner

farmers for the last two decades as high as 75 percent of cultivated lands by owner farmers in the ICT rural area.

The tenancy system in Punjab is divided into two categories; the tenant-at-will system (Muzaraeen) and occupancy/hereditary system (Maurusi Muzaraeen). In Barani areas, the former system prevails, and the latter is rare. The Master Plan Study Report describes that the tenant-at-will tenancy system is predominant in the ICT rural area. Both the systems are share cropping. The share cropping in the hereditary system is that one-fourth of the harvested grain goes to the landowner, and the remaining three-fourths to the tenant while in the tenant-at-will system a half of the grain goes to the land owner, and the reminder to the tenant, and usually no operation costs are shared with the landowner, but borne by the tenant. In the former, the rights of tenancy are reserved by tenant farmers while in the latter the decision-making powers are with the landowner. Uncertainty of tenant rights, which makes tenant farmers hesitate to introduce improved technologies in their farming, is one of the major constraints of this type of tenancy system.

3.3.2. Water Use

1) Rawal Dam

The Rawal Dam plays an important role as water resources in the Study Area. The Rawal Dam was planned and constructed by WAPDA in May 1962, in order to meet the requirements of the both domestic water supply for Rawalpindi and Cantonment, and irrigation purposes.

According to Completion Report of the Rawal Dam, the discharge capacity of the right canal for domestic water supply was 2.04 cu.m/sec (72 cusec) and that of left canal for irrigation water supply was 1.13 cu.m/sec (40 cusec) for the area of 1,368 ha (3,380 acres).

However, a recent increase in domestic water demand from Rawalpindi, which has been supplied by the right canal, reduces discharges from the left canal. As a result, the irrigation water is presently reduced to 0.23 cu.m/sec (8.0 cusec) in supply to the farms of NARC, nurseries of CDA, and private farms. According to the data available on water supply from the Rawal Dam prepared by SDO, an annual average released discharge is estimated at 35.4 MCM (29×10^3 acre ft), equivalent to 25 years average from 1962 to 1986 (see Table B-35).

The salient features of the Rawal Dam are given in Table 3-1.

2) Shallow Wells

In the proposed cultivable commanded area of 6,600 ha (16,300 acres), there exist about 447 shallow wells, which are used for domestic and irrigation purposes. The domestic water is carried by women and girls with buckets or cans of about 20 litters in capacity carrying on the head.

The irrigation areas with water supplied from tubewells and wells are about 200 ha (496 acres) in the Project Area, according to the data available by the Village Profile Survey conducted by LGRD in September 1986. These irrigated areas are concentrated to UC Sohan and Tarlai in the Downstream Area. About a half of these wells suffer from the water shortage in the dry months.

3) Village Ponds

About 15 village ponds exist in the cultivable commanded area adjacent to the villages and are used for drinking water of livestock, bathing, laundry and recreation in swimming. These Ponds are very small in depth with 1.0 m to 1.5 m and about 10 cu.m of storage capacity, so that in the dry season no water exists generally.

TABLE 3-1. OUTLINE OF RAWAL DAM

Description	Dimension	
1. General		
Name of River	Kurang River	
Catchment Area	275.1 sq.km	(106 sq.mile)
Annual Mean Rainfall	1,411 mm	(46.1 inch)
Annual Mean Runoff	103.0 MCM	(86,420 acre ft)
Construction Year	1959 - 1962	
2. Reservoir		
Reservoir Area		
Gross Storage Capacity	58.6 MCM	(47,500 acre ft)
Live Storage	53.0 MCM	(43,000 acre ft)
Dead Storage	5.6 MCM	(4,500 acre ft)
Maximum Water Level	EL.537.1 m	(RL 1,761 ft)
Retention Water Level	EL.534.4 m	(RL 1,752 ft)
Minimum Level	EL.520.9 m	(RL 1,708 ft)
Effective Water Depth	16.2 m	(53 ft)
3. Dam		
Dam Type	Gravity Dam	
Dam Height	40.7 m	(133.5 ft)
Dam Length	213.3 m	(700 ft)
Dam Crest Width	4.3 m	(14 ft)
Dam Crest Elevation	EL.537.5 m	(RL 1,763.5 ft)
Slope of Dam	Upstream	1 : 0.04
	Downstream	1 : 0.675
4. Spillway		
Type	Ogee Type Weir	
Max. Probable Flood	3,400 cu.m/sec	(120,000 cusec)
Design Flood Capacity for Spillway	2,320 cu.m/sec	(82,000 cusec)
Gate (W x H)	8 Radial, 9.1 m x 3.1 m	(30 x 10.2 ft)
Overflow Depth	5.8 m	(19 feet)
Overflow Length	73.2 m	(240 feet)
5. Intake Facilities		
Type	Conduit	
Maximum Intake Capacity		
Right Bank Canal	2.04 cu.m/sec	(72 cusec)
Left Bank Canal	1.13 cu.m/sec	(40 cusec)

4) Kurang River and Gumreh Kas River

The farmers living near the Kurang River and Gumreh Kas River use the river water for drinking for livestock, bathing, laundry water and car washing, but some farmers use pumps to lift the river water, although small in scale. The pump irrigation areas are 43 ha (107 acres) and concentrated to UC Sohan and Urban Area.

3.3.3. Population, Agricultural Household and Farm Labor Force

1) Farm Household and Population

The total number of farm households related to the Project is estimated at about 5,200 in 43 villages in 1987.

According to the Master Plan Study Report, most of the landless farmers are livestock breeders. The figures quoted above includes 14.6 percent of landless farmers. The number of the farm households by villages shown in the Village Profile Survey Report is more than two times of that estimated from the data of population by villages. It suggests that a considerable number of landless farmers or lahdless rural workers live in the Project Area.

2) Farm Labor Force

The 1980 Agricultural Census Report shows that average farm labor force available per farm household is 3.4 persons. The full-time labor of them is 2.2 and temporary labor of 1.2. These figures depend on the data covering the entire Rawalpindi District, and the size of farm labor force in the Project Area seems to be similar to them in general trend. The following table shows that the larger is the size of land holding, the more is the farm labor required.

Farm Labor by Size of Land Holding

Land Holding	Family Member	Family Laborers	Full-time Laborers	Temporary Laborers
Below 1 acre	5.7	2.7	1.3	1.4
1 - 2.5 acres	6.1	3.0	1.7	1.3
2.5 - 5.0 acres	6.5	3.3	2.1	1.2
5.0 - 7.5 acres	6.7	3.6	2.5	1.1
7.5 - 12.5 acres	7.0	3.8	2.8	1.0
12.5 - 25 acres	7.1	4.0	3.0	1.0
25-50 acres	7.5	4.5	3.3	1.2
50 - 150 acres	8.0	4.7	3.7	1.0
More than 150 acres	9.1	3.7	3.0	0.7
Average	6.5	3.4	2.2	1.2

Note : Family laborers means those of more than 10 years old engaging themselves in farming.
Source: Data of Rawalpindi District, 1980 Agricultural Census

3) Farm Labor Balance

In general, there is a shortage of farm labor in both harvesting and sowing seasons. It is mainly because of shortage in key persons of family labor due to labor discharge to urban areas in the country and foreign countries and also short duration of suitable harvesting time due to characteristic features of the crops grown at present.

According to the results of field survey, labor shortage is pronounced in harvesting of wheat. Most of the farm labor available in the peak is the people who are working out in urban areas and return temporarily to cover the labor shortage at the peak.

Many male farmers have permanent or temporary off-farm jobs to cover poor productivity and low income in farming. The females are important farm laborers, accordingly.

The composition of aged population in both ICT urban and rural areas was studied. The population rates of the males from 20 to 49 years of age and the females from 20 to 39 in the rural area are less than those in the urban area. This suggests that the farm labor has a structure composed with comparatively aged males and females.

Under the circumstances, the Tarlai Markaz officer has an idea to introduce medium or small size wheat harvesters which can be operated in small field plots.

The UC Sohan is in the suburbs of ICT, producing vegetables in a large scale. One of the most important jobs of full-time vegetables growers is to secure the necessary number of hired laborers in time.

4) Farm Size

According to the Pakistan Census of Agriculture, 1980, the average farm size in three Barani Districts of Rawalpindi, Attock, and Jhelum is 2.5 ha, 4.9 ha, and 4.6 ha, respectively. In comparison with them, the average farm size per cultivator concerned with the Project is a little small as 1.7 ha (4.2 acres).

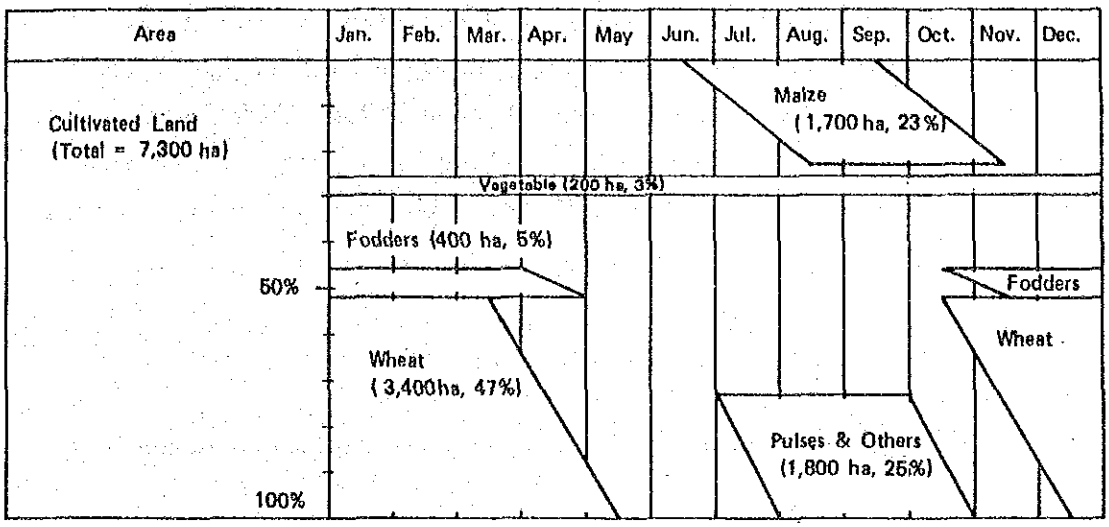
The farmers holding the land less than 2.0 ha account for about 80 percent of the total farm households, which is an indicator of the potential poverty of the farmers in the Area.

3.3.4. Agricultural Production

1) Crops and Cropping Pattern

The present main crops in the Project Area are wheat with the cropping ratio of 89 percent and fodder with the remaining 11 percent in Rabi season, while maize, pulses and others in Kharif season. Annually planted acreage and cropping system in the Project Area seem steady, although their cropping areas vary depending upon rainfall in the year.

Present Cropping Pattern



The above figure shows the present cropping pattern prevailing in or around the Project Area. The fallow land is found in the Kharif season rather than in the Rabi season. In the Downstream Area of the Rawal Dam, farmers grow vegetables using irrigation water lifted from Persian wells, and some farmers are testing to plant fruit trees in the mountainous area because there is no strong wind throughout the year.

2) Cropping Method

The present crop yields are generally very low due to the application of an extensive method of rainfed upland farming without rotational cultivation. The cropping method applied at present is described below;

a) Crop Varieties

The recommended varieties of wheat and maize have been encouraged to be grown. The diffusion rate of these varieties is not high yet, because the seeds are expensive. Therefore, most of the farmers use their own seed of low quality.

b) Plowing

In general, two-time plowings and one-time harrowing are practised immediately before sowing, and several harrowings by tractor after rainfall in harrowing season. Some farmers use draft cattle. Plowing depth is usually shallow at around ten centimeter and this fact causes easy formation of plow sole and poor drainage in the field.

c) Seeding

The following seeding practices are generally conducted at present;

Wheat	:	broadcasting by hand and line sowing by draft cattle or tractors.
Vegetable and others	:	broadcasting by hand

d) Fertilizering and Culture Management

Fertilizer is hardly applied to crops except wheat and vegetables, and anmonium phosphate is applied by about 125 kg/ha in wheat cropping, while garbages, farm yard manure and fowl droppings to vegetable cropping so as to maintain soil fertility. However, such fertilizer application is made to the limited areas adjacent to the villages and farm management practices are very extensive. Weeding works are not made, and spraying is limited to vegetables and fruit crops.

e) Harvesting and Transportation

Harvesting works of the crops are practised by hand, and threshing of wheat is mostly conducted by thresher powered by tractor engine or draft cattle. Hauling and transportation of inputs and products are made by draft cattle because of poor farm road networks in the area.

With the present farming practices, the following problems are pointed out for crop cultivation;

- Recommended seeds are very scarce at present. Especially, vegetable seeds are of low quality except the imported ones.
- The depth of root zone of crops is relatively shallow due to shallow plowing depth, causing drainage damage to the crops due to ill drainage during the wet season.
- Since the seeds are presently broadcasted on the field with low ridge, distribution of crop plants is biased and causes the light-interception to the crops. Furthermore, due to low ridge with irregular field surface, uniform water distribution is difficult and then causes uneven growing of plants.
- A little amount of fertilizer for wheat and vegetable is applied at present.
- Seedling technique remains at low level.
- Continuous cropping is practised in the field, and crop damages are found.
- Cultivation practices are very extensive.

3) Crop Production

The present crop yield remains low as shown in the following table. Wheat is the main crop in the area and its production has been increasing with the expansion of cropping acreage, diffusion of improved varieties, and chemical fertilizers application. However, the average yield of wheat was 1.7 ton/ha, according to the data of Rawalpindi Station in Punjab Province for the period of 1980/81 to 1984/85. This is much lower than the target of 5.0 ton/ha which is estimated with the experimental results of NARC.

Present Crop Production in Project Area

Crops	Cropped Area (ha)	Average Average Yield (ton/ha)	Production (ton)
1. Rabi Crop			
- Wheat	3,400	1.7	5,610
- Fodders	400	70.0	28,000
- Vegetable (Cabbage)	200	13.0	2,600
Sub-total	4,000		
2. Kharif Crop			
- Maize	1,700	2.0	3,400
- Pulses	1,800	0.8	1,440
- Vegetable (Cucumber)	200	15.0	3,000
Sub-total	3,700		
Total	7,700		

Basic Data: (1) ... Farm Economic Survey in the Project Area, 1986, Study Team
(2) ... "Village Profile Survey", 1986, LGRD, ICTA

Under the situation, it could be considered that the cropping increase in this area has a high potentiality of production through introduction of improved varieties, application of fertilizer, supply of irrigation water, and improvements of farming practices and management.

4) Supply and Demand Balance of Crops

The study was made on present demand and supply in the ICT. The following table indicates the demand and supply of the crops. As it is seen in the study, wheat production is insufficient to meet the demand of the rural inhabitants. Maize, pulses and vegetables seem to be the main marketable crops in surplus.

Supply and Demand Balance of Crops, 1985

Items	Urban Area	Rural Area	Total
- Population (persons)	218,000	152,000	370,000
- Demand Volume (tons)			
Wheat (120.6 kg/capita)	26,290	18,331	44,621
Maize (8.1 kg/capita)	1,766	1,231	2,997
Pulses (5.0 kg/capita)	1,090	760	1,850
Vegetable (Urban 33.6 kg, Rural 27.6 kg)	7,325	4,195	11,520
- Supply Volume (tons)			
Wheat 10,820 ha x 1.02 ton/ha		11,036	
Maize 4,670 ha x 0.70 ton/ha		3,269	
Pulses 4,440 ha x 0.42 ton/ha		1,865	
Vegetable 400 ha x 16.0 ton/ha		6,400	
- Balance in Rural Area (tons)			
Wheat		(-) 7,295	
Maize		(+) 2,038	
Pulses		(+) 1,105	
Vegetable		(+) 2,205	

Source: 1. Crop acreage and yield per hectare are based on the Master Plan Study Report, 1986.
2. Per capita consumption of wheat, maize and pulses is based on FAO Report.
3. Per capita consumption of vegetable is based on the Housing Census of Pakistan, 1980.

3.3.5. Animal Husbandry

1) Raising Conditions

The Project Area can be divided into Upstream and Downstream Areas in terms of the present conditions of livestock breeding. The Upstream Area has more farm villages and households, and large cultivated land area than the Downstream Area. Accordingly, the former raises more livestocks per farm household than the latter, except for poultry, and the largest breeder of which is the UC Tarlai located in the latter.

Number of Livestock in the Project Area

(unit: head, bird)

	Number of Farmer	Cattle	Buffaloes	Goats	Sheep	Poultry
Upstream Area	2,635	1,930	1,810	2,790	2,400	42,900
Downstream Area	1,960	800	750	690	600	175,300
Total	4,595	2,730	2,560	3,480	3,000	218,200

Basic Data: "Village Profile Survey", 1986, LGRD, ICTA

The major animals bred in the Area are milk cows, milk water baffaloes, bulls and goats. Most bulls are slaughtered after fattening for one year or so. As for goats, the limited number of farmers raise many of them.

Reportedly, about 90 percent of the farmers have been raising some animals, mainly for milk production. The Village Profile Survey, 1986, however, revealed that the number of the animals bred per farm household is small due probably to the fact that the landless farmers are counted into the number of the farm households in the Survey. And further study will be necessary on this point.

The poultry farmers in the Project Area are classified into two categories, extensive one for self-consumption and intensive one for commercial farming for farm income increase . The commercial farming in the Project Area has been promoted by the CDA under the Poultry and Vegetable Scheme. 3,000 to 10,000 fowls are accommodated in a henhouse of 500 to 1,000 sq.m. The commercial farming in the Project Area has played an important role as a supplier of chicken to the urban areas.

2) Livestock Breeding Types

Presently, the livestock breeding in the Project Area is coming to a turning point from self-consumption to business for increasing

farm income, although the majority of livestock breeding farmers remain in extensive one by self-sufficient feeds in poor quality and females and aged males.

The animals are fed mainly with by-products of wheat, maize, sorghum, etc. as well as rapeseed and other green fodder crops. Most draft animals, goats, and sheep are raised in the grazing areas utilizing the fallow land, waste and sloping land. Condensed feeds like soybean cakes are limitedly used.

In general, one hectare of grazing land is necessary for feeding one cattle. The grazing land per adult cattle in the Project Area is computed at 0.2 ha. Apparently, the cattle population is over the appropriate raising number in the Project Area.

The majority of poultry raised in the Area is yard fowls for home-consumption of the farmers. And the commercial poultry breeders purchase feeds to give them after mixing medicine/vitamin to prevent the fowls from diseases and use plastics in the henhouses to keep them in health.

3) Livestock Products

In the Project Area milk is produced by many small farmers, and collected and transported by milkmen. Assuming the daily milk production of 2.0 to 2.5 lit. per milk cow, 1.0 lit. per draft milk cow, and 4.6 lit. per water buffalo, the total milk product in the Project Area is estimated at 7,000 lit. (for 30,000 to 40,000 persons).

The growth rate of the milk demand in the entire Pakistan was maintained as high as five percent for these five years from 1982 to 1987. The growth rate in the urban areas is considered to be higher than the above-mentioned. However, since the Project Area is a

Barani area where irrigation depends on rainfall, it is very difficult for livestock farmers to secure fodder in the Rabi season when the fodder cropping area and the grazing land are quite limited as compared with the Kharif season.

3.3.6. Fisheries

The water resources available for fisheries in the ICT is 1,770 ha in water surface area as follows:

Water Surface for Fisheries in ICT

Water Resources	Number	Water Area (ha)	Development Body
Rawal Dam	1	730	CDA
Simly Dam	1	970	CDA
Village Ponds	13	10	Private firm: 8 ha
Rivers	-	60	ICTA: 2 ha
Total		1,770	

Source: Master Plan Study Report, JICA, 1986

Rawal and Simly Dams are under the jurisdiction of CDA, and the water surface controlled by the Fishery Department, ICTA is only 70 ha.

The Fishery Department as extension wing has conducted the following works in 1986/87.

- Fish culture ..... Private fish farm 5
- Collecting/stocking of fish seed .....
  - Government/community fish ponds/dams : 250,000
  - Stream/Nallahs : 530,000
  - Private fish farms including mini-dams: 51,000
- Conservation
- Maintenance of fish ponds in Awan-i-Saddar
- Arrangement for fish sales in the three weekly bazzars of Islamabad ..... 180 stores

- Supply of brooders for research
- Fish production ..... Rawal Dam: 71 tons
  Others : 87 tons

The inland fishery development in ICT is in the initial stage. The fish hatchery established in 1984 beside Rawal Dam belongs to the Fish Hatchery and Research Centre of Punjab Government.

The potential requirement for fish fries in ICT is estimated at five million per year. The annual production capacity of the Fish Hatchery and Research Centre of Punjab Government is only two million fish fries to the annual demand of 3.2 million required for the inland water surface in Rawalpindi District.

According to the small dam fisheries survey conducted by Punjab Economic Research Institute, 1983, the fish productivity of the leased reservoirs is higher than that of the reservoirs managed by the Fishery Department.

Private sector ..... 75.2 kg/pond acre (185.8 kg/pond ha)
Public sector ..... 52.3 kg/pond acre (62.4 kg/pond ha)

3.3.7. Agricultural Supporting Services

1) Agricultural Research

Agricultural researches in Pakistan are conducted by a large number of both the federal, the provincial institutions and other autonomous organizations in addition to three agricultural universities - Faisalbad Univ. (Punjab Province), Tandojan Univ. (Sind), Peshawar (NWFP).

At the federal level, the researches are conducted by the Agricultural Research Division in the Ministry of Food, Agriculture

and Cooperatives, while at the provincial level, the research institutions which are administratively controlled by different provincial departments.

The principal organization responsible for undertaking and coordinating research activities at the federal level is the Pakistan Agricultural Research Council (PARC), which is an autonomous body under the Agricultural Research Division in the Ministry of Food, Agriculture and Cooperatives (see Figures 3-7). The PARC operates three main institutes at the national level; i.e., the National Agricultural Research Centre (NARC), Islamabad, the Cereal Diseases Research Institution (CDRI), Islamabad, the Arid Zone Research Institute (AZRI), Quetta.

The NARC is located at the Union Council Sohan, Islamabad, and has two main wings; i.e., research and technical support.

The agricultural research activities for the last ten years in Pakistan have been made to increase the productivity in all the agricultural sectors. Specially, the main emphasis has been put on the improvement of the major food grains and cash crops including wheat, rice, maize, sugarcane and cotton. Only a comparatively little attention has been paid to oil seeds and food legume crops.

The Government has followed the agricultural research policy to attach a very high priority to the development of an integrated agricultural research systems.

2) Agricultural Extension Services

a) Background

Before 1980 ICT was included in Rawalpindi District of Punjab Province. Since July 1st, 1980 ICT has been became an independent district under the Federal Government. Consequently, the

agricultural extension services in ICT has been rendered under the responsibility of the Federal Government.

Agricultural extension services in ICT are presently performed by NARC mentioned above.

The Technical Transfer Unit (TTU) of NARC, which is directly engaged in the agricultural extension services consists of the following Wings.

- Agricultural Extension
- Livestock & Dairy Development
- Soil Conservation
- Fisheries

b) Approach

Agricultural extension services aim at the total development in agricultural sector in the area. A comprehensive area development approach is supported by the research activities at every level. The main emphasis is given to the following items;

- Education and training of farmers;
- Regular updating of knowledge of extension staff; and,
- Continuous feeding of researchers with field problems in making research more objective and realistic.

The approach mentioned above aims at developing an adequate linkage between the research activities and the extension services though it is reported that there is no effective mechanism to link the two, either at the provincial level or the federal level.

c) Objectives

The main objectives of the agricultural extension services in the ICT are as follows;

- To develop an agricultural extension model suitable for the area.

- To narrow down the gap between potential and actual productions of field crops and to introduce high value crops to farmers. Actual ways are as follows;

  ° To enhance fruits and vegetables production for home consumption and sales to the market;

  ° To streamline the supply of farm inputs (seeds, fertilizer, pesticides, credit and farm machinery) and marketing of farm surplus;

  ° To encourage aforestation including block and linear planting, farm forestry and community planting;

  ° To conserve soils and moisture, harness the water runoff and to develop groundwater resources for irrigation purpose;

  ° To increase fodder and forage production and to improve grazing lands;

  ° To encourage the optimum production of meat, milk and egg by developing proper measures in livestock, poultry and fish production;

d) Problems/Constraints in Extension Services

The extension service in Pakistan is confronted with a number of problems as follows.

- Functions of the extension services as the transfer of technology is quite iimited because emphasis is mainly put on the performance of administrative and regulatory functions;

- Linkage between research and extension organizations is weak. The institutional arrangements for the flow of improved technology from research to extension are very poor;

- The extension workers do not have adequate in-service training facilities to refresh and update their knowledge on the latest technological development;

- The operational area and field of the on-extension worker who is in the forefront of services is usually too large;

- The functioning of various levels of extension staff is not clear;
- Research work is mostly slow and not problem-oriented. Therefore, the recommendations originating from the research institutes are not always suited to the local conditions; and,
- The linkage between agricultural extension and the agencies dealing with farm inputs leaves much to be desired. This affects the adaption of improved technology at farmers' level badly.

e) Progress

The major progresses in different wings of agricultural extension services are as follows;

Agricultural Extension Wing

An Extra Assistant Director in charge of Agriculture is posted under the Director of TTU, NARC, and controls the extension officers such as Agricultural Officers and Field Assistants. Besides, the Assistant Director in charge of Extension resides at Markaz Offices of Tarlai, Sihala and Bharakau, respectively. The terminal extension services are conducted through these three Markaz offices. At present Bharakao and Sihala are served by one Assistant Director. Five Field Assistants are posted at 11 Union Councils despite that each union council should be served by one Field Assistant.

According to the monthly progress reports of the agricultural extension services in ICT for 1986/87, TTU, the progress of agricultural extension wing was as follows;

° Training and meeting:

Markaz level	9 courses, 1,808 farmers trained
Union Council level	150 meetings, 5,714 farmers participated

° Distribution of literature:

Leaflets, pamphlets, posters	2,745 farmers
Literature supplied to libraries established at Markaz and UC level .	725 Nos

° Fairs/Field Days:

Agricultural fairs organized	1 No.
Field days/Special days	7 Nos.

° Show/Competitions:

Vegetable and fruits show	1 No.
Film show	6 Nos.

° Demonstrations/Exhibitions:

Demonstration plots	42 Nos.
Demonstration of farm machinery/ implements	12 Nos.
Research plots	6 Nos.

° Plants Protection:

Spray of crop vegetables and fruit plants	303 ha
Rodent control	3,562 ha
White and black ants control	272 ha

° Supply of Inputs:

Crop seeds	2,591 Quint
Vegetable seeds	1,254 Packet
Fertilizers	4,210 Bags
Pesticides	513.56 kgs and 200 lit.

Soil Conservation Wing

The main components of the works are the soil conservation and agricultural machinery operation. The progress of sub-components for 1986/87 are as follows;

° Soil Conservation Works:

Improved cultural and agronomical practices	78 ha
Range improvement/afforestation	25 ha

Gully plugging to stabilize land ..... 61 ha
Harnessing of wild streams ..... 0.5 km
Improvements of ponds ..... 2 Nos.

° Agricultural Machinery Operation:

Bulldozer work ..... 2,219 hrs, Rs 22,776
Tractor work ..... 578.80 hrs, Rs 8,118

Source: Monthly Progress Report, June 1987, TTU, NARC

According to the information of the Assistant Agricultural Engineer, the annually conserved land areas is approximately equivalent to the annually eroded land areas. Though the Department owns six bulldozers and 22 tractors, these machines are insufficient in capacity to meet the farmers' demand. Specially, more bulldozers are required for land levelling which is necessary for successful on-farm water management. The Department has proposed to introduce 30 bulldozers in the Master Plan Study.

Livestock and Dairy Development Wing

The Livestock and Dairy Development Department, ICTA, has three veterinary hospitals at Rawat, Tarlai and Bharakao, and four veterinary centers at Sihala, Charah, Pind Begwal and Golra Sharif.

The extension services of livestock wing made progress in 1986/87 as follows;

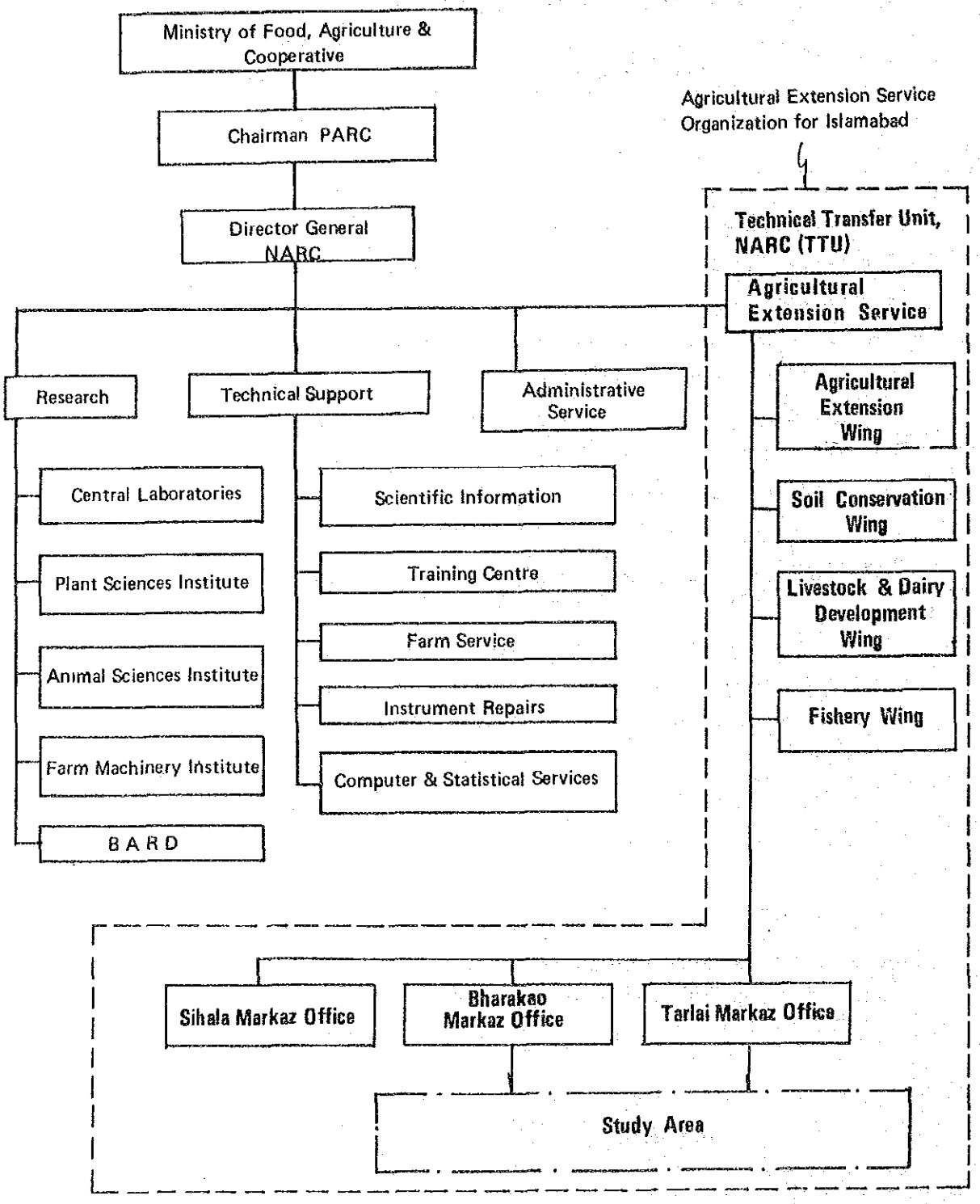
° Veterinary Activities:

Non-contiguous ..... 19,876 head
Castration ..... 445 head

° Breeding Activities:

Artificial insemination ..... 1,007 head
Tests for pregnancy ..... 469 head
Cattle show arrangements ..... 1 time

FIGURE 3-7. NARC AND AGRICULTURAL EXTENSION SERVICE FOR ISLAMABAD AT PRESENT



° Disease Control Measures:

Deworming/spraying/dipping	Cattle	:	537 head,
	Baffaloes	:	783 head,
	Sheep	:	417 head,
	Goats	:	1,822 head,
	Poultry	:	16,961 hens
Vaccination/inoculation			84,028

According to the information of Assistant Director, Livestock and Dairy Development Department, present constraints are as follows;

- Quantity of medicines has been reduced due to the unsteady budget;
- Buildings of the veterinary hospital have been deteriorated; and,
- Central office has only one vehicle (station wagon). No more car is available in the field level including the hospital and centre.

The present development schemes are as follows;

- Establishment of Artificial Insemination Centres: Golra Sharif, Bharakao, Tarlai, Charah, Sihala, and Rawat
- Establishment of a Veterinary Diagnostic Laboratory: Tarlai

These schemes have been already approved by the Pc-1, but not yet implemented due to the limitation in budget.

3) Farmers' Organizations

a) Agricultural Cooperative Society

An institutional regulation in the Cooperative Society Department, ICTA, is different from that in Punjab Province. In ICTA the Deputy Commissioner is the registrar, while the Circle Registrar is in duty in the other provinces.

The functions of the Cooperative Society Department are the promotion of cooperative movement, education, registration, management, and guidance.

In Pakistan the majority of the farmers and livestock owners are small in farming size. Hence, the cooperatives are expected to play an important role. However, because of the unique historical experience in development of the cooperative movement, their role has been rather limited. According to the Sixth Five-Year Plan (1983 to 1988), the Federal Bank for Cooperatives, which is responsible for promotion of the cooperative movement in the country, has evolved a strategy for remedying the constraints. The programme is under various stages of implementation in the Province. The high priority is given to the establishment of the primary cooperative societies at villages/Union Council levels.

According to the information obtained at the Cooperative Society Department, ICTA, the number of agricultural cooperatives registered in the rural area of ICT, has increased from 80 in the Master Plan Study stage to 98 at present. The number of societies in the Project Area amounts to 22 according to the Village Profile Survey, 1986.

The outline of 98 agricultural cooperative societies is reported as follows;

- Number of membership 3,854
- Share capital ..... Rs 244,800
- Working capital ..... Rs 5,563,336
- Loan advanced/individual ..... Rs 4.796 million
- Receipts from loans paid/ individual ..... Rs 4.000 million
- Percent of recovery of loan 99.30%

Source: Circle Registrar, Cooperative Societies Department, Islamabad

The cooperative movement in Tarlai Markaz area is more active than that in Bharakao Markaz area.

The commercial agricultural cooperatives organized by vegetables growers or poultry breeders are observed in Tarlai Markaz area.

b) Irrigators' Cooperative Organization

There are six Irrigators' Cooperative Societies registered to the Cooperative Society Department, ICTA, through the five of which were reported in the Master Plan Study Report. These Societies have been organized by the beneficiaries irrigated by small ponds. These societies play a role for the initial body of the water users association. Each society is described in Annex G. The outline of the society is as follows;

- Year of registration ..... Five in 1984, and one in 1986
- Number of membership ..... Min. 13, max. 40, average 26
- Irrigated acreage ..... Min. 48 ha, max. 216 ha, average 69 ha
- Irrigation fee ..... Not charged
- Operation and maintenance .. The Soil Conservation Department is responsible for maintenance of mini-dams

4) Credit

Credit is one of the essential inputs requirement to reach the target production after implementation of the Project. Specially, the credit availability will effectively assist small farmers, most of whom have not used any loans from the institutions, depending generally upon non-institutional credits. They prefer loans from friends, relatives and shop-keepers to the institutional credit.

According to the 1981 Agricultural Census Reports, the numbers of the farm households in debt in Rawalpindi District are;

All farmers	:	9 %
Cultivating farmers	:	10 %
Livestock farmers	:	8 %
Owner farmers	:	8 %
Owner tenants	:	19 %
Tenants	:	15 %

The amounts of outstanding debt from institutional and non-institutional sources are as follows;

		Cultivators	Owner Farmers	Owner Farmers + Tenant Farmers	Tenants
Average value	(Rs)	5,689	6,530	4,316	3,485
Institutional	(%)	28.5	34.0	14.8	3.2
Non-institutional	(%)	71.5	66.0	85.2	96.8

The agri-crediting institutions serving for the local farmers are the Agricultural Development Bank of Pakistan, the commercial banks, and the Federal Bank for Cooperatives.

There are four commercial banks at Kot Hathir (UC Bharakao), Rihara (UC Phulgran), Chak Shazad (UC Sohan) and Tarlai Kalan (UC Tarlai). Reportedly commercial loans do not find their way easily to small farmers despite that the seasonal loans are free from interest. According to the field survey, Tarlai Kalan Branch Office of Allied Bank (Commercial Bank), extended loans to about 100 farmers holding less than 5 ha (12.5 acres) of land in total in 1987. The upper limit of credit was Rs.12,000 per farm household per year without interest and pledge.

The agricultural cooperatives in ICT are loaned through Rawalpindi Zonal Office under Punjab Provincial Cooperative Bank. According to the Cooperative Societies Department, ICTA, the crop loan to the cooperative societies, which is provided by Punjab Provincial Cooperative Bank, has been remarkably increased in

amount. The recent loans for Rabi season crops increased to 2.07 times from 1983/84 to 1986/87, and Kharif season crops 2.69 times as shown in the following table;

Loan Advanced by Punjab Provincial Cooperative Bank to ICT

Seasons of Crops	Loan Advanced (Rs, Lac)
Rabi 1983-84	27.19
Kharif 1984	23.70
Rabi 1984-85	39.51
Kharif 1985	29.65
Rabi 1985-86	39.53
Kharif 1986	49.73
Rabi 1986-87	56.16
Kharif 1987	63.83

Source: Circle Register, Cooperative Societies Department, Islamabad

The Agricultural Development Bank of Pakistan (ADBP) has two credit disbursement areas of general credit and mobile credit. In the former, the acreage of land to be pledged for purchasing of one tractor is almost 10 ha (25 acres) of land, and in the latter, only 2.5 ha (6 acres) are sufficient to get a loan for one tractor.

The networks of the field offices of ADBP are organized by 27 Regional Offices and 213 Branch Offices. Islamabad is included in the territory of the Head Office and Murree Branch Office. The Bank has introduced a system of the Functional Mobile Credit Officers (MCOs). One MCO is assigned to 25 villages, and responsible for all the loans in the area. MCOs are specialists in a particular field such as dairy, poultry, irrigation, fruits and vegetables. The ADBP Training Farm of 40 acres is established in UC Sohan in the Project Area in order to train 853 MCOs (year 1984).

The ADBP has continuously concentrated in strength upon loans to small farmers to increase their productivity. Farmers holding less than 10 ha (25 acres) received Rs 3,235 million in 1986. This occupies 69 percent of the general credit disbursed to the farmers.

The Annual Report of ADBP, 1986, mentions that the general credit disbursed to the farmers is Rs 4,722.717 million and 129,346 farmers served. The credit amount per farmer/borrower is averaged at Rs 36,512.

There are three types of loan offered by the ADBP. Their terms and conditions are as follows;

Credit Condition of ADBP

Term	Duration (Years)	Interest (%)	Note
Long	5 to 8	11 Compounded	Tractors, tube-wells and farm machinery
Medium	1 to 5	11 Compounded	Livestock, poultry low cost implements of soil conservation and land reclamation
Short	0.5	10	Seasonal loans for all inputs and cash needs to raise any crops

Source: Barani, Farming System of the Punjab Constraints and Opportunities for Increasing Productivity, NARC, 1985.

3.3.8. Marketing

A proper marketing system is prerequisites to increase agricultural production and meet consumers' requirements. The elements of the marketing system are pricing, procurement, transport, storage, processing, grading of products, quality control, merchandising, etc.

Development of an efficient marketing system is one of the key factors to attain the projected production as early as possible after completion of the Project works.

1) Marketing and Processing

a) Marketing Channel

The existing agricultural marketing system in the ICT rural area seems inadequate at several points of shortage in marketable surplus due to low productivity or low self-sufficiency in farm economy, poor marketing roads, difficulty in cooperative marketing, and insufficient marketing facilities both in public and private base. Marketing of agricultural products is usually carried cut by middlemen or their agents in villages to result in multiple marketing channels.

Typical marketing channels for the major agricultural products in the ICT rural area, according to the Master Plan Study, are as shown below;

- Crops:
  Producer - Village shop keeper - Rawalpindi markets

- Livestock products (Milk):
  Producer - Consumer in urban areas
  Producer - Retail shops in urban areas - Consumer

- Livestock products (Meat):
  Producer - Middlemen - Slaughter house - Market
  Producer - Animal open market - Slaughter house - Market

- Vegetables:
  Producer - Open market and wholesale market

According to the supply and demand study of the agricultural products in the ICT rural area, wheat is mostly consumed as staple food by farmers. Therefore, the marketable volume is limited. On the other hand, the maize and pulses have a considerable amount of marketable surplus, and these crops are important commercial goods.

Vegetables produced in UC Sohan and UC Tarlai in the Project Area are forwarded to the open market, ICT, and the wholesale market for vegetables and fruits established in Sector I-11, ICT. To study the route of vegetable retailers, a marketing survey was conducted by Study Team in August 1987.

Several retailers of vegetables in the main residential markets of ICT informed of the origin of vegetables supply as follows;

Origin of Vegetables to be Supplied to Retailers

(in Main Vegetable Markets of ICT)

Vegetables	Store A	Store B	Store C	Store D
Tomato	Swat, NWFP	Peshawar	Retailers directly go to the wholesale market located at Sector I-11, ICT	
Eggplant	Lahore	Lahore		
Cucumber	Rawalpindi	Sialkot		
Radish	n.a.	Gaio Wala		
Spinach	Rawalpindi	n.a.		
Potato	Sialkot	Gaio Wala		
Onion	Quetta	Gaio Wala		
Melon	Afganistan	Gaio Wala		

Note: Stores A and B are located in production areas.
Stores C and D are located in consumption areas.

Though these retailers did not clearly reply to the questions on the losses of perishable vegetables, Store B told that at the wholesale market he bought an optimum volume of fresh vegetables to meet the consumption of the regular customers.

According to the field survey, some vegetables retailers in Pind Pegawal village about 30 km apart from the wholesale market facilities in Sector I-11 of ICT reported that they used to go to the market to buy fresh vegetables around six o'clock in the early morning. He reported that the loss of perishable vegetables did not appear on the first day, but 30 to 40 percent loss on the second day.

b) Marketing Facilities

In order to streamline the marketing of agricultural products, a marketing committee is established for each market area. The marketing in the Capital Development Authority Area is governed by the Marketing Committee, Rawalpindi, and Municipal Office as prescribed by the Agricultural Product Market Ordinance of Punjab Province. This committee functions to ensure fair trading practices, such as standard weights and measures, to promote general development and amenities in the market place. And the committees are empowered to levy standard fees. The markets are obliged to adhere the strict auctioning procedures.

The marketing facilities in ICT are as follows;

Urban Area:

Retail market	.....	Open market on Friday, Sunday and Tuesday
Cold Store	.....	Five stores in Sector I-11, ICT
Retail Store	.....	Main shopping market in urban area

Rural Area:

Public slaughter house	....	Sihala for large animals, two places for small animals
Public markets	.....	Not provided
Retail store	.....	Shop in the central villages

Three open markets in Islamabad are organized by CDA. The similar bazaars to these open markets are held in many cities and towns throughout the country. In these markets, many producers and goods are welcome to be on the market without any interference of middlemen. Five cold stores located in the Sector I-11, ICT, are private facilities. And they were established in the period from 1981 to 1986, and stores perishable fruits and vegetables. The storage capacities are 20,000 crates (60 x 30 x 30 cm) by two storages and 50,000 crates by three. The outline of storages is shown in Annex C.

According to the storage survey, the presently stored products and goods are limited to fruits like apples, oranges, banana, pears, peaches, vegetables and flowers, and one store handled fruits by 90 percent, vegetables by five percent, and flowers by five percent, respectively. The storage temperature has been kept at three degrees by Centigrade. At present, apples are stored for a long period from October to August in the following year so as to control the market price for profitable business.

c) Processing

The main agricultural processing facilities in the rural area are small-scale flour mills and oil extraction factory. There are 15 flour mills in the Project Area. One milk plant located in UC Tarlai was surveyed by the Study Team. This plant is going to be closed although fresh milk and long life milk were processed till 1986.

2) Farm Input Materials

The supply system of farm input materials in the Project Area is controlled by Punjab Agricultural Development and Supplies Corporation (PADSC), and Punjab Seed Corporation (PSC). The PADSC distributes such agricultural input materials to farmers as seeds, agri-chemicals, farm machinery, tools and fertilizer. The PSC distributes to farmers the certified seeds of wheat, cotton, potato, and paddy.

In 1984/85, the PADSC sold fertilizer of 829.1 thousand nutrient tons, of which nitrogen is 607.6 thousand nutrient tons, phosphate 204.6 and potash 16.9, respectively. Only 15 thousand nutrient tons of the total volume sold in Punjab Province was distributed to Rawalpindi District. Both the districts of Rawalpindi and Islamabad were supplied with only seven thousand nutrient tons according to the Punjab Development Statistics, 1985.

The statistics of the PADSC reveals that the distribution of indigenous improved seeds by crops are as follows;

Distribution of Improved Seeds by Crops

- Punjab Province -

(unit: tons)

Year	Wheat	Maize	Gram
1974 to 75	11,309	336	187
1978 to 79	22,171	373	224
1979 to 80	37,547	672	224
1983 to 84	41,083	1,306	896

Source:
1. For 1974 to 75 and 1978 to 79 - Director, Seed, Punjab Agricultural Development & Suppliers Corporation, Lahore
2. For 1979 to 80 and 1983 to 84 - i) Director, Marketing, Punjab Seed Corporation, Lahore, and ii) Director, Seed, Punjab Agricultural Development & Supplies Corporation, Lahore
3. Punjab Development Statistics, 1985

Distribution points of the PADSC are located in UC Tarlai, Bharakao, Sihala, and Rawat. The Project Area has two depots. Though the PSC has no distribution points in ICT,certificated seeds are supplied through distribution points of the PADSC.

In order to increase the capacity to supply the materials through the above four main depots, the District offices of PADSC have established a seasonal mobile sales point by using their own facilities and contractors.

The agricultural cooperative society plays an important role in distributing fertilizer to member farmers. The society staff collect the required quantity of fertilizer from each member farmers and report to the Cooperative Society Department, ITC. After that, the department proposes a loan to buy fertilizer to the Provincial Cooperative Bank. With the loan approved, the member farmers with the authored slip can have fertilizer at depot of the PADSC. In

fiscal 1986, the NARC reported the supply volume of inputs as crop seeds by 259.1 tons, vegetable seeds by 1,254 packet, fertilizer by 4,210 bags, and pesticides by 513 kg and 197 liters.

According to the Agricultural Census Report, 1980, the consumption of fertilizers and insecticides in Rawalpindi District is different by farming sizes and by kinds of fertilizers as shown below;

Use of Fertilizers and Insecticides in Rawalpindi District

(unit: Percent of farmers used)

Item	Fertilizers and Manure	Fertilizers Only	Manure Only	Insecticides
Rawalpindi District	27	17	38	1
Below 1.0 ha	7	7	53	2
1 to 2.5	21	15	45	1
2.5 to 5.0	27	22	34	1
5.0 to 7.5	33	21	32	1
7.5 to 12.5	38	21	30	0
12.5 to 25.0	44	13	33	0
25.0 to 50.0	48	11	29	0
50.0 to 150.0	43	22	20	0
Over 150.0	41	31	13	-

Source: Agricultural Census, 1980, Govt. of Pakistan

The quantities of various fertilizer used in Rawalpindi District were reported in the Agricultural Census Report as follows;

Proportion of Quantities of Various Fertilizers
Used for Crops (Rawalpindi District)

(unit: tons)

Crops	Urea	DAP	Ammonium Nitrate	Ammonium Sulphate	Super Phosphate	Others	Total
Wheat	4,507	2,923	969	306	225	186	9,116
Paddy	14	26	-	2	-	-	42
Sugarcane	30	10	-	-	-	-	40
Cotton	75	3	1	1	-	4	84
Maize	1,528	463	311	202	113	10	2,627
Tobacco	0	-	-	0	1	-	1
Potato	1	9	-	0	-	-	10
Onion	4	-	-	-	-	-	4
Orchard	22	19	21	6	2	1	71

Note : Above maize is for grain.

Source: Agricultural Census, 1980, Govt. of Pakistan

3) Prices of Products and Inputs

In Pakistan, a price support mechanism has been introduced only several years before to accomplish self-sufficiency of farm products through securing of their supply. The Government controls the procurement, and support the prices of wheat, paddy, cotton, sunflower, safflower, and soybean though the price determination for most commodities is not interfered by the Government.

The following table shows the wholesale prices for last five years;

Wholesale Prices

(unit: Rs/40 kg)

Crop	Market	1981	1982	1983	1984	1985	Note
Wheat	Rawalpindi	66.23	75.75	77.63	84.11	101.06	Max. Pak
Rice	- do -	257.17	270.42	274.58	275.00	296.19	Basmati
Rice	- do -	111.35	103.08	111.53	118.78	123.04	Irri.
Maize	Lahore	81.06	100.67	90.47	95.34	96.85	
Gram	Rawalpindi	240.11	264.98	210.18	182.20	199.93	Black
Mash	- do -	254.25	209.56	233.09	291.72	293.74	Whole
Mung	- do -	235.95	255.29	264.12	282.18	265.10	Whole
Potato	Lahore	97.88	59.22	66.90	89.65	73.80	Red
Onion	- do -	93.88	65.99	120.12	93.29	55.92	

Source: Agricultural Statistics of Pakistan, 1985

The prices of fertilizer have been fixed by the Government in accordance with the import price and policies related to subsidies and taxation. The present prices of fertilizer are shown in the following table;

Prices of Various Types of Fertilizer in Punjab

- 11 June, 1983 to Present -

Fertilizer		Size of Bag (kg)		Price/Bag (Rs)
Nitrogen Fertilizer	- Ammonium Sulphate	50		59
	- Ammonium Nitrate	40		60
	- Urea (large bag)	50		128
Phosphate Fertilizer	- Super Phosphate	50	Powder	37
	- -do-	50	Granulate	40
	- Triple Super Phosphate	50		95
Potash Fertilizer	- Sulphate of Potash	50		40
Compound Fertilizer	- Nitrophosphate	50		110
	- Di-Ammonium Phosphate	50		133

Source: "Punjab Development Statistics, 1985" Punjab Agricultural Development & Supplies Corporation, Lahore

The installation of diesel tubewells and the hiring rates of bulldozers and tractors are subsidized. The rates fixed per tubewell is Rs. 20,000 in Barani. The subsidy for tractors or bulldozers varies year by year.

3.3.9. Farm Economy

The results of the farm survey and other agricultural survey reveal that the average cultivated area of a farm and cropping intensity at present are estimated by 1.7 ha (4.2 acres) and 106 percent, respectively.

Annual Farm Income at Present

Items	Average Farm Size
1. Cultivated Area (ha)	1.7
2. Total Cropping Area (ha)	
- Rabi Season	0.9
- Kharif Season	0.9
Sub-Total	1.8
3. Gross Income (Rs.)	7,710
4. Production Cost (Rs.)	4,180
5. Net Agricultural Income (Rs.)	3,530
6. Farm Household Income (Rs.)1/	5,440

Note: 1/ ... include the production cost of family labor.

As for the living expenses, at least Rs.6,000 to Rs.8,400 per farm is annually required on average based on the minimum annual living expenditure per capita of Rs.1,200 to Rs.1,400. Therefore, the minimum living expenditure of the farmers in the Project Area is not covered by the income from crop cultivation. It is relevant to the situation that the farmers had other income sources within the farm like milk sales.

Annual Income Level in the Project Area

Items	Project Area	Total of Pakistan	Rural Area of Pakistan	Rural Area of Punjab
1. Average Income of All Industries (Rs./household)	no data	21,300	18,500	18,300
2. Percentage of self Cultivator (Total Farm=100)	75	81.6	82.0	81.9
3. Average Household Income of Self Cultivator (Rs./household)	5,440	20,900	20,700	23,600

Source: "Household Income and Expenditure Survey, 1984 - 85" Statistics Division, Govt. of Pakistan.

CHAPTER IV. THE PROJECT

CHAPTER IV. THE PROJECT

4.1. Objectives and Components of the Project

4.1.1. Objectives of the Project

The Islamabad Capital Territory Area and such three Districts in Rawalpindi Division, Punjab Province as Rawalpindi, Jhelum and Attock occupy most of parts of Potwal Plateau. The Punjab Barani Tract different from the alluvial land shows the topography with heavy gully erosion from the alluvial land in extreme undulation without cultivation. Such waste land has resulted from heavy soil erosion which has been caused by intensive rainfall in the Kharif season.

Under the conditions, the soil conservation has become quite a necessary for the agricultural development. In other respects, there are many deep valleys and streams in the Tract where the farmers cultivate the land at comparatively high elevation in rather heavy undulation. Such features of the farmland have hindered the irrigated agriculture in the Tract.

The crops grown in the Tract can be roughly classified into two, Rabi crops and Kharif crops; the former is such winter crops as wheat, barley, chick peas, lens beans, rape colza, mustard, etc., while the latter is such summer crops as maize, sorghum, millet, pulses, groundnuts, etc. The yield of each crop is low, a half of that grown with irrigation due to uncertainty of rainfall, particularly a little rainfall in the seeding season. Such unfavourable conditions have caused difficulty to apply fertilizer and to shift to more profitable cash crops. Besides, limited green fodder crops grown between the Rabi and the Kharif croppings have been a bottleneck for encouraging animal husbandry. In general, 10 to 30 percent of the farmlands in the Tract have always been kept in fallow for soil fertility conservation. The fallow land occupies a large portion of the total acreage of suburban areas.

Farm management has turned into subsistence farming resulting from reduction in scale and diversification into minor crops. Under the circumstances, many farmers have given up agriculture, and young men have migrated to the urban area. Consequently, there have remained only women, children and un-skilled aged farmers in the villages to lower the agricultural production. The per capita income in the Area is less than Rs.1,000 per annum, which is desperately lower than the Pakistani national average of Rs.3,600 as of 1984 - 1985.

The Government of Pakistan, therefore, has taken up the Kurang River water resources development project that is envisaged with the effective utilization of the developed water resources so as to raise the agricultural production, to increase the employment opportunity and to level up the living standards of the local people.

4.1.2. Components of the Project

The project components are provided on the following development concepts.

a) Water Resources Development

The present crop cultivation in the Project Area has been mostly relying upon instable rainfall to result in low productivity in crop husbandry. The existing water resources available in the Project Area are limited to those in the Rawal Dam supplying irrigation water to the area of about 240 ha (593 acres) and, the water lifted by pumps provided with the wells.

The water resources development by an adequate storage reservoir and/or headworks is essential for the project, accordingly.

b) Irrigation System Development

There is no irrigation canal system available in the Project Area. A new irrigation canal system to deliver water to be stored in the K-2 reservoir should be provided in taking into account the irrigation requirements and method. The distribution and management methods of irrigation water should be also established.

c) Development of Marketing Road Networks

Roughness of the existing road networks is a bottleneck for smooth transportation of the agricultural inputs and outputs, which will be largely increased in their amount by development of the irrigation and drainage systems.

In particular, the development of the road networks is indispensable for successful marketing in view of securing the year-round supply of fresh vegetables and enabling the farmers to earn the stable and increasing net income. The proposed road networks will be provided in extending the inspection road to be provided along the proposed irrigation canals or in connecting new roads with those inspection roads.

d) Introduction of Irrigated Agriculture

The irrigated agriculture plan should be established in considering the following subjects;

i) Formulation of suitable land use plan and cropping pattern to realize maximum utilization of water and land resources, and

ii) Formulation of farming cultivation practices to increase the agricultural productivity and farmer's income.

e) Improvement of Agricultural Supporting Services

It is essential to strengthen the following agricultural supporting services for the achievement of the successful irrigated agriculture development in the Project Area and promotion of the agricultural activities;

i) Organization of Water Users' Association by villages to carry out operation and maintenance of irrigation facilities and adequate water distribution and management,

ii) Establishment of research and extension systems for irrigated agriculture.

4.2. Optimum Scale of the Project

4.2.1. Present Available Water Resources and Water Use

1) Present Available Water Resources

The main water resources available for the development of the Upper Kurang River Irrigation Project are the runoff discharges of the Kurang River, although runoff discharges of its small tributaries such as the Gumreh Kas and Sohan Nala River are considered as supplemental water resources for the Project.

The runoff analysis of the Kurang River at the Rawal Dam having the catchment area of 275.1 sq.km (106 sq.mi) was thoroughly made as described in Paragraph 3.2.3, covering 35 years from 1952 to 1986, and the result is given in Table B-44. The following shows the annual average and droughty runoff discharges of the Kurang River.

Average Annual Runoff Discharge:		103.0 MCM(*10)	(84 x 10^3 acre ft)
Droughty Annual Runoff Discharge			
1/5 Probability	:	78.7 MCM	(64 x 10^3 acre ft)
1/10 Probability	:	69.7 MCM	(56 x 10^3 acre ft)

2) Water Use of Kurang River Discharge

The present water use of the Rawal Dam is mostly for domestic water supply under CDA and PHED. Furthermore, these Government agencies have a plan to expand their production capacity as shown in the following table.

Present and future demand for the both purposes of urban domestic water and irrigation water supplied from the Rawal Dam are summarized as follows;

Note: *10... According to the estimated runoff discharge at the Rawal damsite by SDO dealing with Rawal Dam Operation, average runoff discharge at the site is estimated at 100.9 MCM/annum (82 x 10^3 acre foot), which is of 24 years average from 1963 to 1986.

As it is seen in the following table, the water used presently from the Rawal Dam is about 42.0 MCM/annum (34 x 10^3 acre ft) and 56.2 MCM (46 x 10^3 acre ft) in Stage I(*11) and 66.5 MCM (54 x 10^3 acre ft) in Stage II(*12), respectively, while an average runoff discharge is 103.0 MCM/annum (84 x 10^3 acre ft).

Monthly Water Demand

(unit: MCM)

Month	Domestic Water Demand			Irrigation Water Demand
	Present	Stage I	Stage II	
Jan.	2.46	3.40	4.09	0.46
Feb.	2.61	3.61	4.34	0.41
Mar.	2.76	3.83	4.60	0.46
Apr.	3.07	4.25	5.11	0.44
May	3.53	4.89	5.88	0.46
Jun.	3.84	5.31	6.39	0.44
Jul.	3.22	4.46	5.37	0.36
Aug.	3.07	4.25	5.11	0.36
Sep.	3.22	4.46	5.37	0.44
Oct.	3.22	4.46	5.37	0.46
Nov.	3.07	4.25	5.11	0.44
Dec.	2.76	3.83	4.60	0.46
Total	36.83	51.00	61.34	5.19

Note: Detailed estimation is referred to Table F-2 and Table F-3.

4.2.2. Water Balance Study of Rawal Reservoir

The water balance study of the Rawal reservoir was made for the following two cases on the daily basis in order to find out available water resources to be developed and reservoir behavior in both the present and future conditions mentioned above.

Case I : Rawal Dam reservoir operation using SDO estimated runoff discharges for 24 years, 1963 - 1986.

Case II: Rawal Dam reservoir operation using estimated runoff discharges by Tank Model Method for 35 years, 1952 - 1986.

Note: *11 ... Coincide with the PHED water supply expansion of 28.0 MGD
*12 ... Coincide with the PHED water supply expansion of 34.0 MGD

The Rawal Dam reservoir operation study on the aforesaid two cases is detailed in Annex F. Chapter I, "Rawal Reservoir Operation Study under Present Conditions (without K-2 Dam)". Table 4-1 summarizes the results, and the followings were ascertained;

- Runoff discharges at the Rawal damsite estimated by the both procedures are not so much different from 100.9 MCM/annum (82×10^3 acre ft) by the SDO data and 103.0 MCM/annum (84×10^3 acre ft) by the Tank Model data.

- Released discharges from the Rawal Dam was estimated at about 50 MCM/annum (41×10^3 acre ft) with similar amounts between the both figures. However, in terms of water shortage, water shortage in cases of Stage-I and Stage-II water supply expansion plans will be observed in the SDO data.

Based on the aforesaid facts, the application of the Tank Model method is considered more practicable and reasonable for estimating the runoff discharges of the Kurang River so that an optimum project plan can be formulated with the Kurang River water resources developed by construction of the K-2 Dam in the upstream of the Rawal Dam.

The reasons are given as follows;

- Runoff discharge at the proposed K-2 Dam could not be estimated by using the specific discharge based on the Rawal damsite data calculated by SDO, because the rainfall magnitude in the catchment area of K-2 Dam is bigger than that of Rawal Dam catchment area (see Table B-39 and B-40).

- SDO runoff discharge data are available for 24 years from 1963 to 1986. However, according to the areal rainfall in the Kurang River basin, the amounts of annual rainfall are quite different before and after 1975 (see Figure B-9). Therefore, it would be recommendable that study on optimum scale of project facilities such as capacity of K-2 Dam and size of cultivable commanded area should be carried out using reliable and more long term runoff data.

With these considerations of the above, the formulation of the Upper Kurang River Irrigation Project, which will be described subsequently, will be based on the runoff discharges for 35 years, 1952 - 1986, in the estimation by the Tank Model Method.

4.2.3. Water Resources Development Plan by Proposed K-1 and K-2 Reservoirs

According to the Master Plan Study for Integrated Rural Development Project which was conducted by JICA from 1985 to 1986, two reservoirs, K-1 and K-2, were proposed in the upstream of the Kurang River to develop the water resources of the Project. The K-2 Dam was planned to function as a main reservoir while the K-1 Dam was proposed closely to the K-2 as a regulating reservoir with sufficient head to convey irrigation water by gravity.

The Study, however, revealed that the low water level in the K-2 Dam should be kept relative high in elevation by 637.0 m (2,089 ft) above the mean sea level in taking into account the designed sediment volume from the catchment area. This fact enables the irrigation water to be conveyed by gravity system directly from the K-2 Dam to commanded area except a part of the area. Therefore, it was revealed that there would be no possibility to apply the combination plan with two reservoirs of K-1 and K-2 in this approach.

Under these considerations of the Study, the subsequent descriptions on the optimum reservoir size for the project will focus on the K-2 reservoir only.

1) Alternative Plans

As discussed in the previous paragraph, a relatively large amount of spilled discharges from the Rawal Dam, which could be considered as development potential, is observed ordinarily. In

expecting more effective utilization of these spilled discharges, the following alternative plans are prepared in the use of Rawal Dam and the K-2 Dam as illustrated in Figure 4-1.

Plan I : Plan without combination use of Rawal Dam
Plan II : Plan with combination use of Rawal Dam

In the Plan I, the runoff discharges of the Kurang River at the proposed K-2 damsite will be stored in the reservoir, when the discharges spill over the Rawal Dam. Namely, no influence to Rawal reservoir operation conducting as it will be caused by the provision of K-2 Dam in the upstream of the Kurang River. And, the stored water in the K-2 Dam will be conveyed to the commanded areas in the downstream of the K-2 Dam with sole irrigation canal networks connecting with the K-2 Dam intake structure.

In the Plan II, contrarily, the Rawal Dam and the proposed K-2 Dam will be operated in combination in taking into account the most effective utilization of the runoff discharges of the Kurang River. The irrigation canal networks will be provided in the same way as the Plan I.

Figure 4-1 summarizes merits and demerits of the both plans of I and II.

In addition to the aforesaid main water resources available by K-2 Dam, potential supplemental water is expected by diverting through head works of Kc-1 and Kc-2 proposed along the Kurang River and Gc-2 along the Gumreh Kas River. And the supplemental water will ensure to expand irrigated areas as large as possible in drought years by making better use of their own runoff discharges of the related catchment areas.

Base Flow Discharge at Proposed Head Work Sites

Station	Name of River	Catchment Area (sq.km)	Base Flow Discharge (cu.m/sec)
Kc-1	Kurang River	24.9	0.62
Kc-2	Kurang River	18.0	0.22
Gc-2	Gumreh Kas	125.0	0.13
Total			0.97

2) Water Balance Study

a) Proposition for Water Balance Study

Available Water Resources at K-2 Damsite

The runoff discharges of the Kurang River at the proposed K-2 damsite commanding the catchment area of 137.0 sq.km (53 sq.mi), were analysed by applying the same procedures described in the paragraph on Rawal Dam.

The following gives the annual average runoff discharges and the droughty runoff discharges of the Kurang River, and the details are shown in Table B-43.

Average Annual Runoff Discharge: 62.1 MCM (50×10^3 acre ft)

Droughty Annual Runoff Discharge

1/5 probability : 47.4 MCM (38×10^3 acre ft)

1/10 probability : 41.1 MCM (33×10^3 acre ft)

Irrigation Water Demand

The irrigation water demand for the project was estimated on the basis of the proposed cropping pattern which was prepared with the careful study from the viewpoints of water use for crops, and proposed land use to meet the demand and supply forecast of crops in and around the Project Area.

The diversion water requirements in taking into account the effective rainfall and water losses, were estimated with the cropping intensity of 142 percent for irrigation crop and 168 percent for total crop cultivation, and shown below.

Annual Irrigation Water Requirement

Items		Probability 1/2	1/5	1/10
Crop Water Requirement	(mm)	529.3	529.3	529.3
Effective Rainfall	(mm)	308.5	255.1	206.5
Diversion Water Requirement	(mm)	368.0	457.0	538.0
- do -	(MCM/1,000 ha)	3.68	4.57	5.38

Note: Detail estimation of irrigation water requirement is shown in Paragraph 4.7.2.

Monthly diversion water requirement in case of above probability is shown below;

Monthly Irrigation Requirement

(unit: MCM/1,000 ha)

Month	1/2	1/5	1/10	Month	1/2	1/5	1/10
Jan.	0.55	0.11	0.69	Jul.	0.19	0.11	0.20
Feb.	0.36	0.53	0.81	Aug.	0.04	0.13	0.12
Mar.	0.44	0.95	0.81	Sep.	0.03	0.09	0.05
Apr.	0.31	0.28	0.67	Oct.	0.09	0.35	0.26
May	0.55	0.54	0.50	Nov.	0.31	0.50	0.50
Jun.	0.38	0.46	0.50	Dec.	0.43	0.52	0.27
Total					3.68	4.57	5.38

Proposed K-2 Dam

The proposed K-2 damsite is located on Dohala, about 15 km (9 mi) upstream of the Rawal Dam. According to the topographic survey of the reservoir area, stage - storage volume - water surface area (H-V, H-A) curve was prepared as shown in Figure 4-5.

In the study to determine the optimum size of the K-2 Dam, following three sizes of reservoir capacity are planned as alternatives.

Alternative Size of K-2 Dam

Alternatives	Full Water Level (m)	Gross Storage Capacity (MCM)	Live Storage Capacity (MCM)
Case A	EL 647.0	29.4	18.5
Case B	EL 645.0	24.7	13.8
Case C	EL 643.0	20.5	9.6

Note: Case A is the plan with the maximum storage capacity from topographic viewpoints. In this plan, saddle dam will be needed at the village of Sakrila.

b) Water Balance Study

The water balance study for the both Plan I and II was made for each alternative with variations in the K-2 Dam size, and the demands of urban domestic water and irrigation water for 35 years.

Table 4-3 to Table 4-8 summarize the results of the operation study.

4.2.4. Optimum Scale of the Project

The followings are found out by the reservoir operation study;

- No water shortage for domestic water supply by Rawal Dam will appear in the case of stage I and Stage II Plans for domestic water supply.
- Plan II with the combination reservoir operation plan for the Rawal Dam and K-2 Dam is more recommendable for the both aspects of domestic and irrigation water supply purposes from viewpoint of effective utilization of the Kurang River water resources.

- The target commanded area of 6,600 ha (16,300 acres) could be irrigated by the K-2 Dam only with dam size of Case A under the return period of about 10 years (three times of water shortage during 35 years) in case of present and Stage I conditions of domestic water supply in Plan II.

- Three times of water shortage will occur during the Kharif cropping, especially April to July, and no water shortage is observed during the Rabi cropping for the periods of 35 years. As the result, an average cropping intensity under the irrigation conditions for 35 years is estimated at 141 percent, 100 percent for Rabi cropping and 41 percent for Kharif cropping, while that in normal year is 142 percent, 100 percent for rabi cropping and 42 percent for Kharif cropping.

- Under these considerations, the provision of head works mentioned previously will not be needed in terms of not only available water resources to be developed by the K-2 Dam but also topographic conditions especially elevation of land to meet the gravity irrigation system.

- In case of Stage II Plan for domestic water supply, eight times of water shortage during 35 years even in case of dam size of Case A are observed, which corresponds to about four year return period with relatively low probability. This fact is deemed to be inadequate irrigation plan from viewpoint of project formulation.

- Regarding the study on alternation of K-2 reservoir size, the same water balance studies mentioned above in Case B and Case C were made in the Plan II, and their results are summarized as follows:

Item	Case A	Case B	Case C
° Gross Storage Capacity (MCM)	29.4	24.7	20.5
° Commanded Area (ha)[1/]	6,600	6,100	4,500
° Released Water for Irrigation (MCM)	25.1	22.9	17.0
° Dam Cost (million Rupees)[2/]	400	370	280
° Water Cost (Rupees/cu.m)[3/]	1.54	1.56	1.59

1/: Irrigation area with return period of 10-years in case of Stage I condition for domestic water supply.
2/: Dam cost does not include land acquisition and compensation costs.
3/: Water cost is estimated by the following equation;

$$\text{Water Cost} = \frac{C \times (1 + 0.4 \times i \times P) \times (A + i) + O/M}{D}$$

Where;

C = Construction cost
i = Interest, 7%
P = Construction period, 4 years
A = Amortization rate, 1/80 = 0.012
O/M = Operation and maintenance cost, C x 0.5%
D = Water demand (released water for irrigation)

- As the results, Case A with the maximum storage capacity from topographic viewpoint at K-2 damsite could be recommended as the most suitable size for the project in terms of water cost.

From the results of the water balance study, it can be concluded that the optimum size of the Upper Kurang River Irrigation Project is described as follows;

Domestic Water Supply Components:

- Future expansion Plan	:	Stage I with annual water demand of 51.0 MCM.
- Dam operation	:	Combined reservoir operation with K-2 reservoir.

Irrigation Water Supply Components:

- Target commended area	:	6,600 ha
- K-2 Dam size	:	29.4 MCM (Case A)
- Irrigation networks	:	Gravity irrigation system connected with K-2 Dam

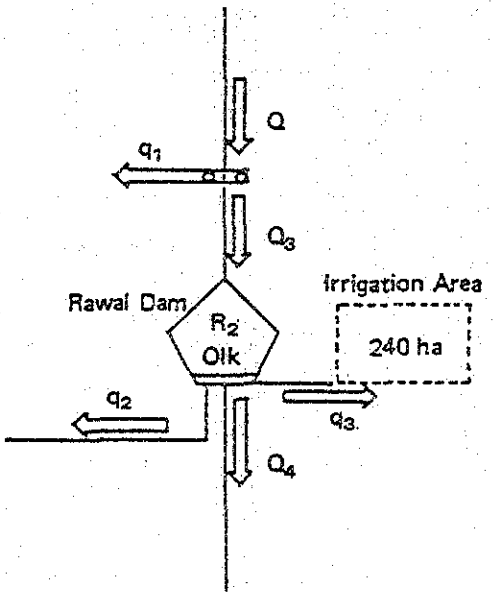


TABLE 4–1. RESULT OF RAWAL DAM RESERVOIR OPERATION STUDY UNDER PRESENT CONDITIONS

(unit: MCM)

Case I: Reservoir Operation by SDO Data

Item		Present	Stage–I	Stage–II
Q : Runoff (275.1 sq.km)		100.9	100.9	100.9
q_1 : H. W Release (Domestic)		7.5	8.3	9.7
Q_3 : Inflow		93.4	92.6	91.2
Olk : Reservoir Loss		9.2	9.2	8.7
q_3 : Left Canal (Irrigation)	]	35.4	46.6	51.1
q_2 : Right Canal (Domestic)				
Q_4 : Spillage		48.8	36.8	31.4
Q_5 : Shortage Water		0	1.3	5.8

Case II: Reservoir Operation by Tank Model Method

Item	Present	Stage–I	Stage–II
Q : Runoff (275.1 sq.km)	103.0	103.0	103.0
q_1 : H. W Release (Domestic)	7.5	8.4	10.2
Q_3 : Inflow	95.5	94.6	92.8
Olk : Reservoir Loss	9.2	9.1	8.9
R_2 : Rainfall in Reservoir	7.3	7.3	7.3
q_3 : Left Canal (Irrigation)	5.2	5.2	5.2
q_2 : Right Canal (Domestic)	32.6	42.5	50.9
Q_4 : Spillage	55.9	45.1	35.1
Q_5 : Shortage Water	0	0	0

TABLE 4–2. RESULT OF RAWAL DAM WATER BALANCE STUDY (CASE II) (1952 – 1986)

Year	Inflow (MCM)	Present			Future Stage I			Future Stage II		
		Released Discharge (MCM)	Spilled Discharge (MCM)	Water Shortage (MCM)	Released Discharge (MCM)	Spilled Discharge (MCM)	Water Shortage (MCM)	Released Discharge (MCM)	Spilled Discharge (MCM)	Water Shortage (MCM)
1952	70.19[1/]	45.29[2/]	31.80	0	56.19[2/]	24.48	0	66.53[2/]	17.90	0
1953	75.43	45.29	24.66	0	56.19	13.54	0	66.53	3.17	0
1954	99.91	45.29	50.87	0	56.19	39.41	0	66.53	28.76	0
1955	110.12	45.29	58.60	0	56.19	47.96	0	66.53	38.37	0
1956	118.19	45.29	68.05	0	56.19	56.96	0	66.53	46.58	0
1957	98.01	45.29	48.97	0	56.19	36.20	0	66.53	24.06	0
1958	99.20	45.29	50.35	0	56.19	39.36	0	66.53	29.24	0
1959	129.44	45.29	85.29	0	56.19	75.52	0	66.53	66.37	0
1960	62.61	45.29	20.03	0	56.19	11.00	0	66.53	3.09	0
1961	108.46	45.29	54.86	0	56.19	43.48	0	66.53	32.44	0
1962	68.10	45.29	19.08	0	56.19	7.62	0	66.53	0.00	0
1963	107.20	45.29	62.15	0	56.19	52.45	0	66.53	40.56	0
1964	111.27	45.29	69.25	0	56.19	58.42	0	66.53	48.40	0
1965	88.84	45.29	45.89	0	56.19	35.96	0	66.53	26.66	0
1966	85.66	45.29	31.88	0	56.19	19.38	0	66.53	8.58	0
1967	105.45	45.29	54.00	0	56.19	41.19	0	66.53	28.52	0
1968	106.06	45.29	59.59	0	56.19	50.46	0	66.53	43.68	0
1969	57.92	45.29	12.99	0	56.19	1.86	0	66.53	0.00	0
1970	126.69	45.29	79.52	0	56.19	69.00	0	66.53	49.66	0
1971	93.62	45.29	52.03	0	56.19	42.46	0	66.53	33.22	0
1972	59.94	45.29	11.49	0	56.19	6.29	0	66.53	1.58	0
1973	100.79	45.29	50.20	0	56.19	33.43	0	66.53	18.09	0
1974	56.20	45.29	8.87	0	56.19	0.00	0	66.53	0.00	0
1975	98.63	45.29	51.18	0	56.19	38.76	0	66.53	19.10	0
1976	190.87	45.29	144.27	0	56.19	132.91	0	66.53	122.09	0
1977	137.26	45.29	87.78	0	56.19	75.95	0	66.53	64.86	0
1978	150.09	45.29	106.20	0	56.19	95.35	0	66.53	85.83	0
1979	99.99	45.29	55.39	0	56.19	46.32	0	66.53	37.58	0
1980	90.21	45.29	43.08	0	56.19	31.61	0	66.53	20.54	0
1981	126.70	45.29	84.64	0	56.19	74.07	0	66.53	64.16	0
1982	130.39	45.29	79.77	0	56.19	67.52	0	66.53	57.92	0
1983	122.15	45.29	83.64	0	56.19	73.55	0	66.53	62.74	0
1984	103.42	45.29	56.79	0	56.19	46.49	0	66.53	36.32	0
1985	93.44	45.29	40.52	0	56.19	26.86	0	66.53	15.23	0
1986	122.28	45.29	74.22	0	56.19	63.62	0	66.53	52.66	0
Average	102.99	45.29	55.94	0	56.19	45.13	0	66.53	35.08	0

1/: Runoff discharge of Kurang River at Rawal Dam having the catchment area of 275.1 sq.km.

2/: Total urban domestic water demand is included in the released discharge.

TABLE 4-3. RESULT OF WATER BALANCE STUDY IN PLAN I (CASE 3)

Item	Rawal Dam			K-2 Dam				
					Irrigation Area			
	Inflow Discharge 1/ (MCM)	Spilled Discharge 1/ (MCM)	Water Shortage 2/ (Times)	Inflow Discharge (MCM)	Covered by Dam (ha)	Covered by Head Works (ha)	Spilled Discharge (MCM)	Water Shortage (Times)
Dam Size: Case A								
Present	80	46	0	62	4,900	800	26	4
Future								
Stage I	80	36	0	62	3,800	800	22	4
Stage II	80	28	0	62	3,200	800	17	4
Dam Size: Case B								
Present	84	50	0	62	3,800	800	30	4
Future								
Stage I	83	39	0	62	2,900	800	25	4
Stage II	84	31	0	62	2,300	800	21	3
Dam Size: Case C								
Present	88	54	0	62	2,800	800	34	4
Future								
Stage I	87	43	0	62	1,900	800	29	4
Stage II	87	34	0	62	1,500	800	24	2

Note: 1/: Annual average discharge for 35 years (1952 - 1986)
2/: Occurrence time of water shortage during 35 years
3/: Irrigation area covered by three head works depending upon baseflow of the Kurang River and Gumreh Kas.

TABLE 4–4. RESULT OF WATER BALANCE STUDY IN PLAN I (1952 – 1986)

Year	Present Conditions								Future (Stage I) Conditions							
	Rawal Dam				K-2 Dam 1/				Rawal Dam				K-2 Dam 1/			
	Inflow Discharge (MCM)	Released Discharge (MCM)	Spilled Discharge (MCM)	Water Shortage (MCM)	Inflow Discharge (MCM)	Released Discharge for Irrigation (MCM)	Spilled Discharge (MCM)	Water Shortage (MCM)	Inflow Discharge (MCM)	Released Discharge (MCM)	Spilled Discharge (MCM)	Water Shortage (MCM)	Inflow Discharge (MCM)	Released Discharge for Irrigation (MCM)	Spilled Discharge (MCM)	Water Shortage (MCM)
1952	45.24 2/	32.63 2/	19.64	0	42.75	27.54	21.83	0	42.09 2/	42.49 2/	10.94	0	42.75 2/	27.54 2/	21.83	0
1953	35.86	32.63	0.00	0	43.87	32.77	8.14	0	32.91	42.49	0.00	0	43.87	32.77	8.14	0
1954	66.17	32.63	27.47	0	66.66	27.19	37.11	0	62.54	42.49	0.18	0	66.66	27.19	37.11	0
1955	76.71	32.63	39.20	0	79.97	27.01	50.30	8.45	74.01	42.49	26.94	0	79.97	27.01	50.30	8.45
1956	82.09	32.63	45.93	0	81.68	29.94	49.78	0	78.31	42.49	32.26	0	81.68	29.94	49.78	0
1957	75.70	32.63	35.97	0	67.57	15.56	49.46	0	71.76	42.49	19.51	0	67.57	15.56	49.46	0
1958	62.01	32.63	25.65	0	66.53	32.07	33.31	0.54	58.93	42.49	12.39	0	66.53	32.07	33.31	0.54
1959	106.70	32.63	75.40	0	79.13	18.43	60.58	0	102.66	42.49	62.99	0	79.13	18.43	60.58	0
1960	33.40	32.63	3.78	0	41.64	29.98	16.53	0	30.26	42.49	1.38	0	41.64	29.98	16.53	0
1961	75.76	32.63	34.54	0	69.18	21.81	40.69	0	71.94	42.49	12.16	0	69.18	21.81	40.69	0
1962	40.29	32.63	4.71	0	36.66	22.83	12.89	0	37.03	42.49	0.00	0	36.66	22.83	12.89	0
1963	77.16	32.63	44.36	0	52.73	25.87	26.67	0	73.79	42.49	23.47	0	52.73	25.87	26.67	0
1964	82.01	32.63	53.72	0	63.73	30.16	38.65	0	78.31	42.49	40.17	0	63.73	30.16	38.65	0
1965	61.29	32.48	30.22	0	59.66	19.60	36.31	0	57.51	42.49	17.37	0	59.66	19.60	36.31	0
1966	56.55	32.63	15.19	0	52.16	24.29	27.24	0	53.20	42.49	0.45	0	52.16	24.29	27.24	0
1967	73.93	32.63	34.53	0	65.57	23.68	38.27	0	70.29	42.49	18.51	0	65.57	23.68	38.27	0
1968	78.52	32.63	44.40	0	53.45	23.09	29.92	0	74.65	42.49	35.60	0	53.45	23.09	29.92	0
1969	27.27	32.63	0.00	0	34.16	27.69	7.66	0	23.81	42.49	0.00	0	34.16	27.69	7.66	0
1970	92.64	32.63	53.93	0	68.55	28.54	38.65	0	89.14	42.49	25.65	0	68.55	28.54	38.65	0
1971	60.57	32.63	30.98	0	48.83	31.83	19.98	0	56.76	42.49	18.68	0	48.83	31.83	19.98	0
1972	30.27	32.63	4.92	0	39.64	19.58	14.16	0	26.91	42.49	0.00	0	39.64	19.58	14.16	0
1973	72.22	32.63	25.17	0	63.67	26.77	39.31	0	68.30	42.49	3.02	0	63.67	26.77	39.31	0
1974	22.53	32.63	0.00	0	32.72	28.73	2.99	0	19.79	42.49	0.00	0	32.72	28.73	2.99	0
1975	66.67	32.63	19.83	0	61.87	29.48	34.01	0	62.65	42.49	0.00	0	61.87	29.48	24.70	0
1976	164.18	32.63	130.22	0	112.89	22.38	90.41	0	160.02	42.49	109.63	0	112.89	22.38	90.41	0
1977	100.32	32.63	64.05	0	87.01	27.08	54.27	0	96.34	42.49	49.03	0	87.01	27.08	54.27	0
1978	122.81	32.63	90.45	0	89.34	24.31	66.20	0	119.30	42.49	77.87	0	89.34	24.31	66.20	0
1979	71.90	32.63	40.91	0	57.99	22.00	34.11	0	67.76	42.49	28.96	0	57.99	22.00	34.11	0
1980	69.17	32.63	34.57	0	60.14	18.71	43.30	0	65.17	42.49	19.51	0	60.14	18.71	43.30	0
1981	107.29	32.63	76.46	0	63.65	19.97	48.45	0	103.05	42.49	62.87	0	63.65	19.97	48.45	0
1982	103.19	32.63	66.03	0	66.26	16.59	43.27	0	98.91	42.49	51.82	0	66.26	16.59	43.27	0
1983	101.94	32.63	75.20	0	58.11	22.06	42.09	0	97.71	42.49	60.31	0	58.11	22.06	42.09	0
1984	66.71	32.63	34.39	0	60.47	30.72	27.98	0	62.84	42.49	21.67	0	60.47	30.72	27.98	0
1985	58.82	32.63	17.43	0	55.79	25.86	25.08	2.67	55.75	42.49	0.83	0	55.79	25.86	25.08	2.67
1986	93.30	32.63	57.77	0	89.80	23.69	65.03	0	89.17	42.49	44.06	0	89.80	23.69	65.03	0
Average	73.17	32.63	38.77	0	62.11	25.08	36.42	0.33	69.53	42.49	25.38	0	62.11	25.08	36.15	0.33

Note: Irrigation Area is based on the following figures:

Items	K-2 Dam(ha)	Head Works(ha)	Total(ha)
Present Conditions	4,900	800	5,700
Stage I Conditions	3,800	800	4,600

1/: Dam Size: Case A

2/: Urban domestic water diverted by head works located on the upstream of Rawal Dam is subtracted.

TABLE 4-5. RESULT OF WATER BALANCE STUDY IN PLAN II (CASE 1)

Item	Rawal Dam			K-2 Dam				
					Irrigation Area			
	Inflow Discharge 1/ (MCM)	Spilled Discharge 1/ (MCM)	Water Shortage 2/ (Times)	Inflow Discharge (MCM)	Covered by Dam (ha)	Covered by Head Works (ha)	Spilled Discharge (MCM)	Water Shortage (Times)
Dam Size: Case A								
Present	68	33	0	62	6,600	-	31	4
Future								
Stage I	68	24	0	62	5,600	800	35	3
Stage II	77	25	0	62	3,400	800	45	0
Dam Size: Case B								
Present	75	40	0	62	5,100	800	38	4
Future								
Stage I	71	27	0	62	5,100	800	38	4
Stage II	79	27	0	62	3,000	800	47	0
Dam Size: Case C								
Present	81	47	0	62	3,700	800	44	4
Future								
Stage I	78	33	0	62	3,700	800	44	4
Stage II	81	29	0	62	2,600	800	49	0

Note: 1/: Annual average discharge for 35 years (1952 - 1986)
2/: Occurrence time of water shortage during 35 years
3/: Irrigation area covered by three head works depending upon baseflow of the Kurang River and Gumreh Kas.

TABLE 4-6. RESULT OF WATER BALANCE STUDY IN PLAN II (CASE 2)

Item	Rawal Dam			K-2 Dam				
					Irrigation Area			
	Inflow Discharge[1/] (MCM)	Spilled Discharge[1/] (MCM)	Water Shortage[2/] (Times)	Inflow Discharge (MCM)	Covered by Dam (ha)	Covered by Head Works (ha)	Spilled Discharge (MCM)	Water Shortage (Times)
Dam Size: Case A								
Present	70	36	0	62	6,600	-	34	4
Future								
Stage I	68	24	0	62	6,200	400	35	3
Stage II	77	25	0	62	3,700	800	45	0
Dam Size: Case B								
Present	75	40	0	62	5,600	800	38	4
Future								
Stage I	71	27	0	62	5,600	800	38	4
Stage II	79	27	0	62	3,200	800	47	0
Dam Size: Case C								
Present	81	47	0	62	4,100	800	44	4
Future								
Stage I	77	33	0	62	4,100	800	44	4
Stage II	81	29	0	62	2,800	800	49	0

Note: 1/: Annual average discharge for 35 years (1952 - 1986)
2/: Occurrence time of water shortage during 35 years
3/: Irrigation area covered by three head works depending upon baseflow of the Kurang River and Gumreh Kas.

TABLE 4-7. RESULT OF WATER BALANCE STUDY IN PLAN II (CASE 3)

Item	Rawal Dam			K-2 Dam				
					Irrigation Area			
	Inflow Discharge 1/ (MCM)	Spilled Discharge 1/ (MCM)	Water Shortage 2/ (Times)	Inflow Discharge (MCM)	Covered by Dam (ha)	Covered by Head Works (ha)	Spilled Discharge (MCM)	Water Shortage (Times)
Dam Size: Case A								
Present	73	39	0	62	6,600	-	36	3
Future								
Stage I	70	25	0	62	6,600	-	36	3
Stage II	78	25	0	62	4,000	800	46	0
Dam Size: Case B								
Present	76	41	0	62	6,100	500	39	4
Future								
Stage I	72	28	0	62	6,100	500	39	4
Stage II	80	27	0	62	3,500	800	48	0
Dam Size: Case C								
Present	81	47	0	62	4,500	800	45	4
Future								
Stage I	78	34	0	62	4,500	800	45	4
Stage II	82	29	0	62	3,000	800	50	1

Note: 1/: Annual average discharge for 35 years (1952 - 1986)
2/: Occurrence time of water shortage during 35 years
3/: Irrigation area covered by three head works depending upon baseflow of the Kurang River and Gumreh Kas.

TABLE 4–8. RESULT OF WATER BALANCE STUDY IN PLAN II (1952 – 1986)

Year	Present Conditions								Future (Stage I) Conditions							
	Rawal Dam				K-2 Dam 1/				Rawal Dam				K-2 Dam 1/			
	Inflow Discharge (MCM)	Released Discharge (MCM)	Spilled Discharge (MCM)	Water Shortage (MCM)	Inflow Discharge (MCM)	Released Discharge for Irrigation (MCM)	Spilled Discharge (MCM)	Water Shortage (MCM)	Inflow Discharge (MCM)	Released Discharge (MCM)	Spilled Discharge (MCM)	Water Shortage (MCM)	Inflow Discharge (MCM)	Released Discharge for Irrigation (MCM)	Spilled Discharge (MCM)	Water Shortage (MCM)
1952	52.51 2/	32.63 2/	23.97	0	26.17	20.45	12.69	0	51.60 2/	42.49 2/	17.53	0	20.76 2/	15.86 2/	10.41	0
1953	49.72	32.63	11.50	0	24.55	19.63	3.00	4.70	52.50	42.49	4.07	0	14.91	16.61	0.00	2.25
1954	73.09	32.63	37.15	0	48.09	20.19	25.47	0	69.95	42.49	25.37	0	38.88	15.66	17.37	0
1955	86.68	32.63	47.37	0	53.00	19.05	33.69	7.28	83.42	42.49	34.29	0	48.23	17.98	29.40	2.44
1956	90.54	32.63	55.52	0	62.28	22.23	38.83	0	91.82	42.49	44.30	0	50.91	17.24	33.07	0
1957	76.87	32.63	41.65	0	49.56	11.55	32.63	0	75.55	42.49	28.49	0	39.08	8.96	25.14	0
1958	69.52	32.63	33.26	0	47.73	24.21	22.25	0	71.12	42.49	24.66	0	40.12	18.77	20.09	0
1959	112.31	32.63	79.86	0	65.23	13.68	52.30	0	110.90	42.49	70.07	0	61.14	10.61	51.11	0
1960	40.06	32.63	8.82	0	22.59	22.26	4.25	0	42.45	42.49	5.57	0	13.69	17.26	1.81	0
1961	82.12	32.63	42.61	0	50.73	16.19	28.59	0	80.84	42.49	29.89	0	41.75	12.56	22.64	0
1962	49.17	32.63	13.38	0	14.73	16.95	0.00	0	52.57	42.49	5.25	0	7.23	13.14	0.00	0
1963	80.43	32.63	47.51	0	37.83	19.20	15.25	0	77.70	42.49	36.54	0	31.57	14.89	10.34	0
1964	90.92	32.63	59.77	0	49.78	22.39	33.63	0	88.90	42.49	49.65	0	45.25	17.36	31.29	0
1965	67.04	32.63	36.01	0	45.44	14.55	27.84	0	66.51	42.49	26.87	0	35.15	11.28	21.32	0
1966	61.37	32.63	21.70	0	33.43	18.04	13.35	0	61.65	42.49	9.69	0	21.58	13.99	6.03	0
1967	79.23	32.63	41.86	0	46.84	17.58	24.83	0	79.41	42.49	29.96	0	39.32	13.63	21.81	0
1968	84.27	32.63	50.29	0	40.39	17.14	22.82	0	86.46	42.49	42.95	0	31.64	13.29	20.58	0
1969	36.78	32.63	3.45	0	17.05	20.56	0.12	0	42.00	42.49	0.36	0	7.56	15.94	0.00	0
1970	98.78	32.63	63.99	0	54.18	21.19	30.48	0	91.57	42.49	47.34	0	46.98	16.43	20.29	2
1971	68.21	32.63	38.27	0	33.61	23.63	12.40	0	68.67	42.49	30.56	0	26.86	18.33	10.40	0
1972	47.26	32.63	7.55	0	13.21	14.53	4.74	0	45.16	42.49	2.71	0	7.99	11.27	1.69	0
1973	68.19	32.63	34.51	0	45.37	19.87	16.99	0	69.65	42.49	18.58	0	31.02	15.41	8.40	0
1974	39.87	32.63	4.46	0	12.12	21.33	0.00	0	45.08	42.49	0.80	0	2.88	16.54	0.00	0
1975	70.04	32.63	35.71	0	39.95	16.09	15.56	5.79	72.04	42.49	27.09	0	28.70	5.44	10.59	11.53
1976	169.66	32.63	136.09	0	98.00	16.62	80.99	0	169.03	42.49	125.08	0	87.93	12.89	74.62	0
1977	108.55	32.63	72.35	0	67.61	20.10	43.10	0	109.50	42.49	62.34	0	57.94	15.59	38.69	0
1978	127.79	32.63	96.65	0	75.86	18.05	57.78	0	127.83	42.49	86.75	0	67.93	14.00	54.15	0
1979	79.60	32.63	46.34	0	44.89	16.34	28.71	0	78.99	42.49	58.03	0	38.34	12.67	25.86	0
1980	72.95	32.63	38.80	0	43.49	13.89	30.44	0	71.00	42.49	26.51	0	31.82	10.77	21.14	0
1981	110.48	32.63	80.88	0	52.64	14.83	40.62	0	109.08	42.49	70.01	0	49.08	11.50	39.98	0
1982	108.20	32.63	72.25	0	51.34	12.31	33.35	0	109.52	42.49	60.62	0	40.06	9.55	27.70	0
1983	106.68	32.63	79.41	0	47.18	16.38	35.90	0	103.54	42.49	68.44	0	42.62	12.70	32.51	0
1984	76.50	32.63	42.05	0	45.53	22.80	22.82	0	77.22	32.49	33.90	0	42.27	17.69	24.59	0
1985	67.80	32.63	29.30	0	40.69	16.05	19.23	5.12	64.80	42.49	12.86	0	29.31	15.62	8.66	0.80
1986	99.49	32.63	63.85	0	70.39	17.59	51.81	0	99.12	42.49	54.01	0	59.90	13.64	45.26	0
Average	80.08	32.63	45.60	0	44.90	18.21	26.19	0.65	79.92	42.49	35.63	0	36.58	14.14	21.91	0.49

Note: Irrigation Area is based on the following figures:

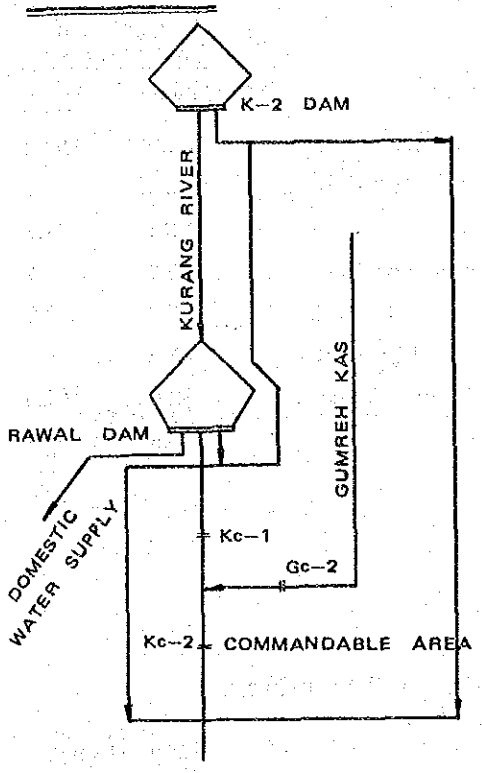
Items	K-2 Dam(ha)	Head Works(ha)	Total(ha)
Present Conditions	6,600	0	6,600
Stage I Conditions	6,600	0	6,600

1/: Dam Size: Case A

2/: Urban domestic water diverted by head works located on the upstream of Rawal Dam is subtracted.

FIGURE 4-1. MERITS AND DEMERITS OF PLAN I AND II

PLAN I



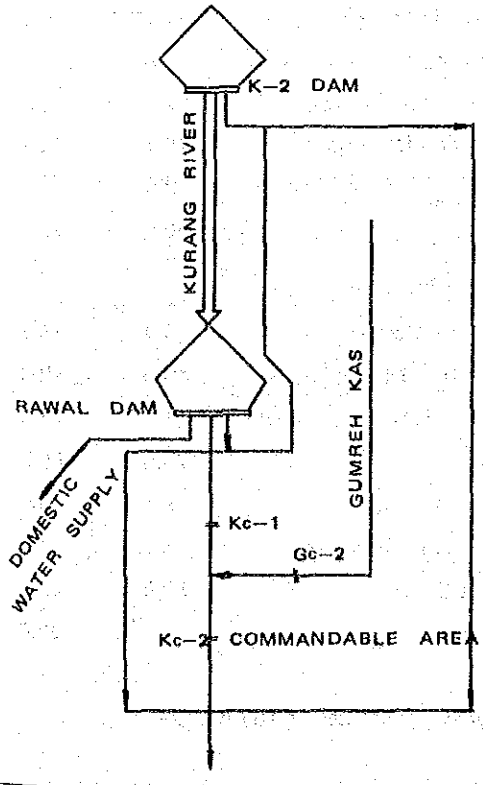
Merit

- No change of present Rawal reservoir behavior

Demerit

- No effective utilization of water resources with spilled discharge from Rawal Dam
- Restriction for expansion of water supply capacity for irrigation and domestic water supply
- No expectation of functional reservoir operation because of independent reservoir operation

PLAN II



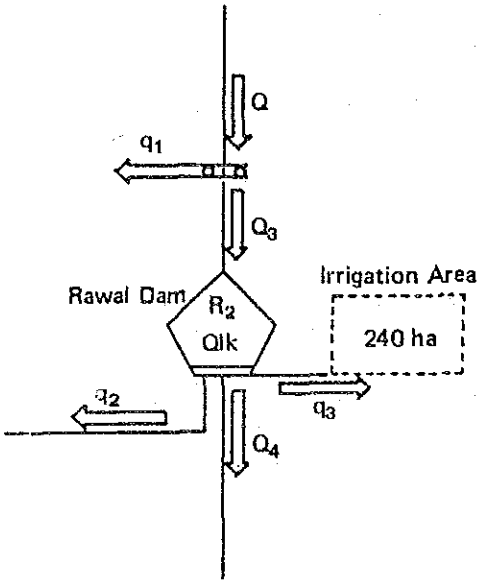
Merit

- More effective utilization of water resources in the Kurang River basin
- Expansion of water supply capacity for irrigation and domestic water supplies
- Functional reservoir operation with the combination of two reservoirs

Demerit

- A little lowering of Rawal reservoir water level in the dry month

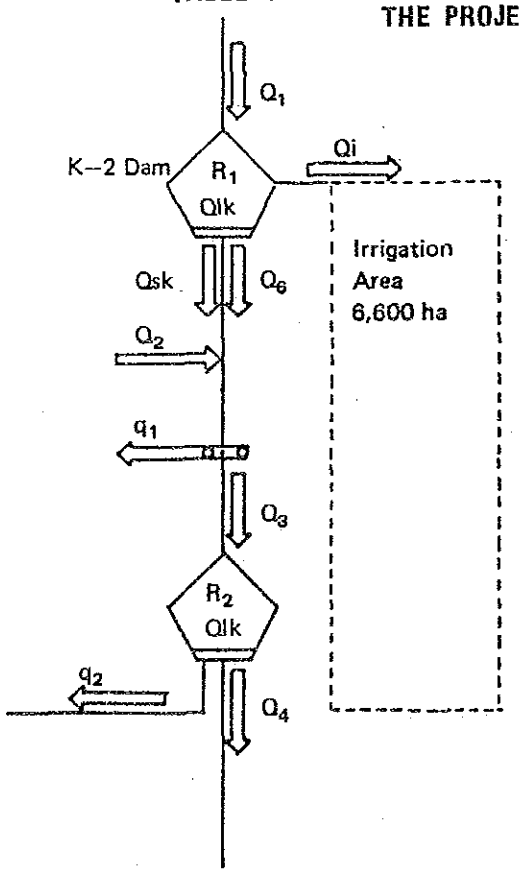
TABLE 4-9. RESULT OF WATER BALANCE STUDY UNDER PRESENT CONDITIONS (WITHOUT K-2 DAM)



(unit: MCM)

			Rawal Dam Water Demand	
			Present	Stage I
Q	:	Runoff (275.1 sq.km)	103.0	103.0
q_1	:	H.W Release (Domestic)	7.5	8.4
Q_3	:	Inflow	95.6	94.6
Qlk	:	Reservoir Loss	9.2	9.1
R_2	:	Rainfall in Reservoir	7.3	7.3
q_3	:	Left Canal (Irrigation)	5.2	5.2
q_2	:	Right Canal (Domestic)	32.6	42.5
Q_4	:	Spillage	55.9	45.1

TABLE 4-10. RESULT OF WATER BALANCE STUDY UNDER THE PROJECT (WITH K-2 DAM)



			Rawal Dam Water Demand	
			Present	Stage I
K-2 Dam Operation				
Q_1	:	Inflow (137.0 sq.km)	62.1 1/	62.1
Qlk:	:	Reservoir Loss	3.0	2.9
R_1	:	Rainfall in Reservoir	2.4	2.4
Qi	:	Irrigation Demand	25.1	25.1
Q_6	:	Release for Rawal Dam	0.0	0.3
Qsk	:	Spillage	36.4	36.2
Rawal Dam Operation				
Q_6 + Qsk:		Total Release	36.4	36.5
Q_2	:	Runoff (138.1 sq.km)	40.9 1/	40.9
q_1	:	H. W Release (Domestic)	4.1	7.9
Q_3	:	Inflow	73.4	69.5
Qlk	:	Reservoir Loss	9.1	8.9
R_2	:	Rainfall in Reservoir	7.3	7.3
q_2	:	Right Canal	32.6	42.5
Q_4	:	Spillage	38.8	25.4

1/: Total runoff at Rawal Dam is estimated at 103.0 MCM

4.3. Selection of Cultivable Commanded Area

There exist the cultivable commanded areas to be developed along the both sides of the Kurang River and Gumreh Kas River, and most of these areas are presently used for rainfed cultivation of crops and some parts of the areas are left as waste land due to undulation in topography, lack of farming fund and farm labour, etc.

According to the detailed field survey with the topographical map at the scale of about 1/21,100, some areas are selected out of the cultivable commanded areas from the viewpoints to meet the Project requirements in elevation for gravity irrigation by the proposed K-2 Dam, topography, soil features, present conditions of soil conservation, etc.

The total area related to the project is estimated at 12,900 ha (16,300 acres) by using the planimeter on the said map to be shown below. Out of the area, 6,600 ha are selected as a cultivable commanded area for the project, and the area is divided into two areas from the topographic conditions, including 3,790 ha (9,365 acres) of the Upstream and 2,810 ha (6,944 acres) of the Downstream.

Cultivable Commanded Area in the Project

(unit: ha)

Items	Upstream Area	Downstream Area	Total
Cultivable Commanded Area	3,790	2,810	6,600
Wasted Land	2,440	940	3,380
Mountain/Hilly Area	1,340	210	1,550
River, Road, Villages	730	640	1,370
Total	8,300	4,600	12,900

4.4. Land Use Plan

4.4.1. Basic Requirements in Plan Formulation

The Project Area, being a Barani area located in the suburbs of ICT and Rawalpindi, suffers presently from harsh climate for agricultural production as well as unfavorable conditions like no irrigation water and such social constraints as outflow of labor and lower income than that in the urban areas.

On the other hand, the neighboring urban areas have a great demand for fresh farm products including livestock products, and the Project Area is an important supplier of vegetables, fruits and milk to the urban consumers.

Under the circumstances, a land use plan has been formulated to meet the following basic conditions in the Project Area;

- To expand the service areas of irrigation to the maximum possible extent by gravity method so as to make the most of limited water resources for the largest farm population presently suffering from unstable and low farm income;
- To divide the service areas into several priority areas of specified crop depending on the soil conditions, land slopes, present land use and other cultivation conditions in each divided area; and
- To utilize the waste land excluded from the service areas as grazing lands for the promotion of livestock breeding and
soil erosion control.

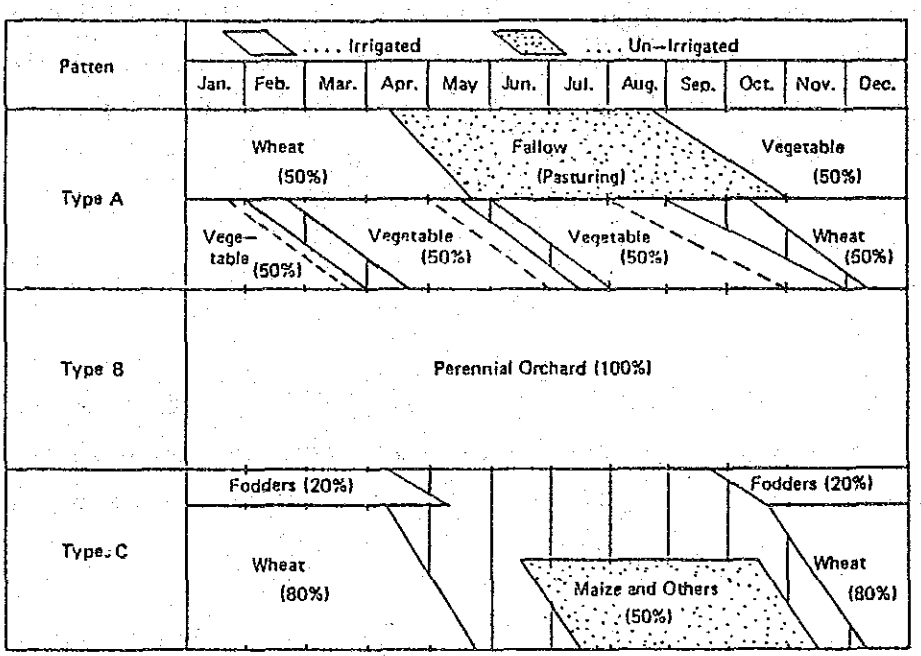
4.4.2. Land Use Plan

Wheat in the Rabi season and maize and beans in the Kharif season are the major crops in the Project Area at present. Taking into account the present types of farm management, farmers' expectation on future farm management and labour resources available

as well as a large demand for vegetables, fruits and milk in ICT urban area and Rawalpindi, the following three types of farm management are proposed for the Project;

Type A : Vegetables and grains
Type B : Fruits and livestock
Type C : Grains and livestock

Proposed Cropping Pattern by Type of Farming



From the viewpoint of farm management, the Project Area is roughly divided into the Upstream and Downstream Area. The former is the sloping land where mountainous area and waste land are scattered, while the latter is the gentle sloping land with limited mountainous area. The interview survey with sample farmers on irrigated agriculture has revealed that the farmers in these two areas have different opinions on new crops to be introduced; farmers in the mountainous upstream portion intend to introduce Type C as above, while those in the flat downstream area like Type A.

Farmers' Intention on New Crops to be Introduced

	Area	Topography	New Cropping System (%) Type A	Type B	Type C
Upstream Area	50%	Sloping	15 - 35	5 - 15	50 - 80
Downstream Area	50%	Gentle Sloping	50 - 70	1 - 5	25 - 49

Source: Farm Survey, JICA Survey Team, 1987

In consideration of the geological, topographic and meteorological conditions in the Project Area, the practicability of the above-mentioned types of farm management in the cultivable commanded area of 6,600 ha could be described as follows;

Type A	:	3,300 ha	(50%)
Type B	:	700 ha	(10%)
Type C	:	2,600 ha	(40%)
Total		6,600 ha	(100%)

Although it is difficult to fix areas to one of the three types of farm management, the Project Area was divided into priority areas according to the farm management types (see Figure 4-2 and Figure 4-3).

However, it is recommended to promote Type A which can expect a higher income than Type B in the vicinity of every beneficial village in order to create the equal income distribution among the villages and among farmers. Therefore, the use of the distant farmland from the villages shall be arranged according to the adaptability of each of the three types.

FIGURE 4-2. PRIORITY AREA FOR AGRICULTURAL PRODUCTION

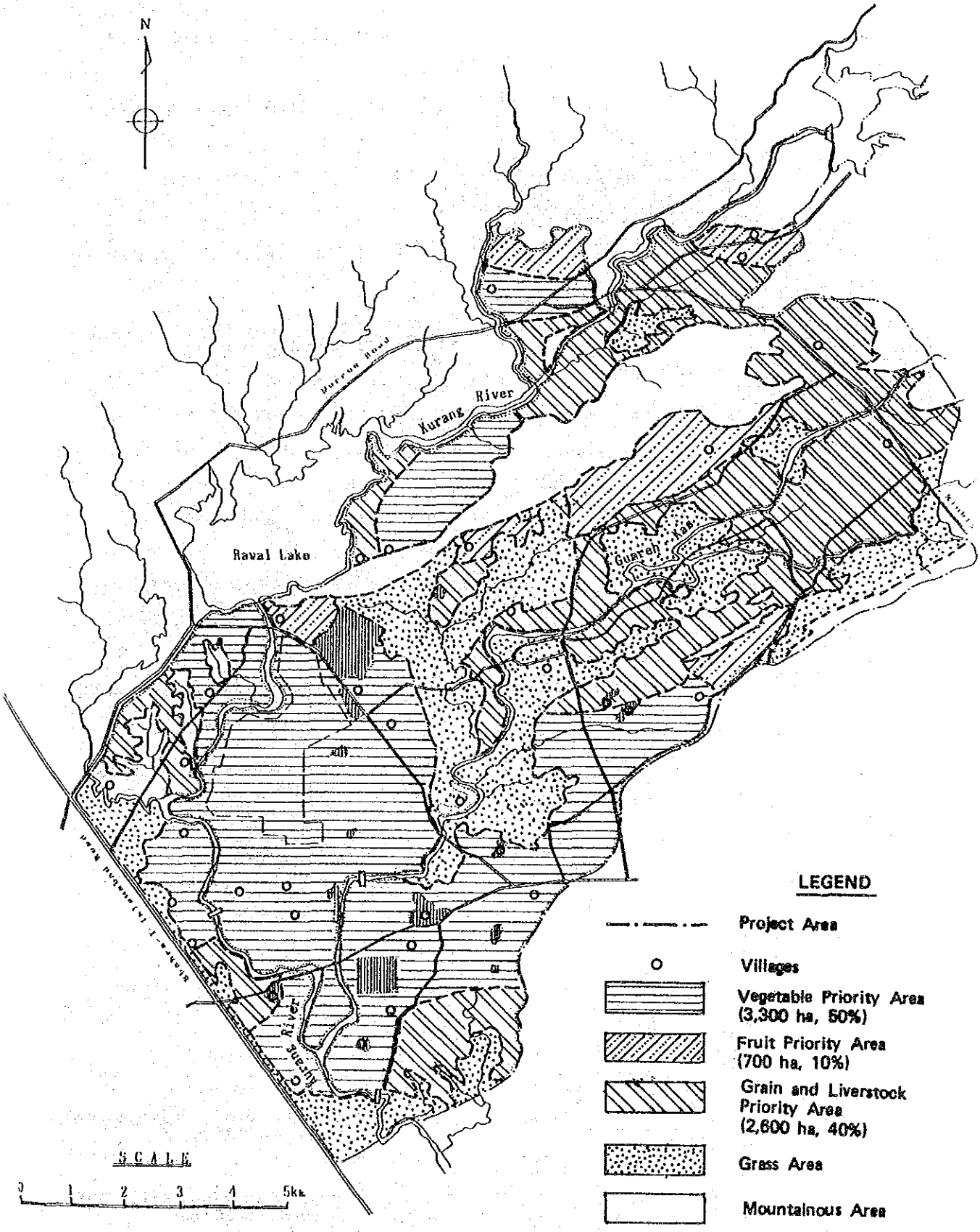
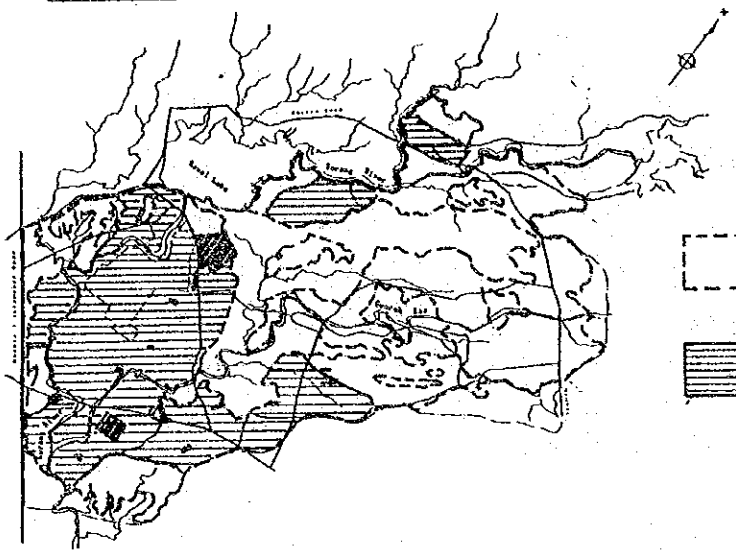


FIGURE 4-3. AGRICULTURAL PROMOTION AREA

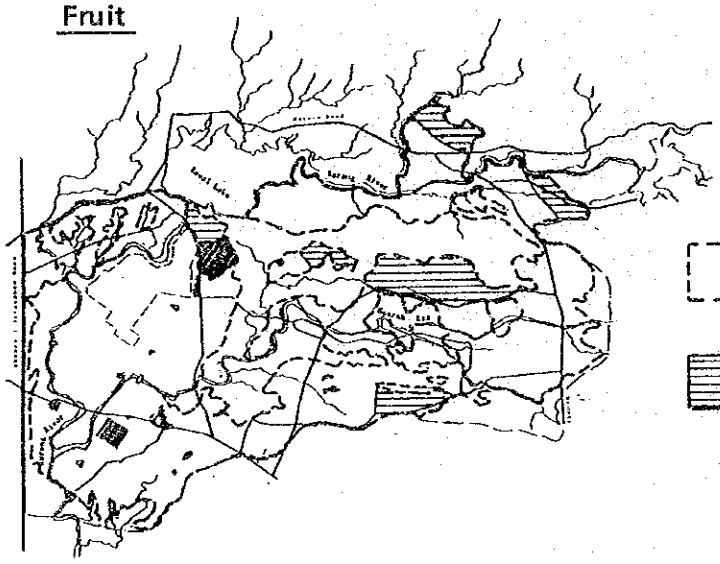
Vegetable



Promotion Area of Vegetable Production (6,600 ha)

Priority Area of Vegetable Production (3,300 ha)

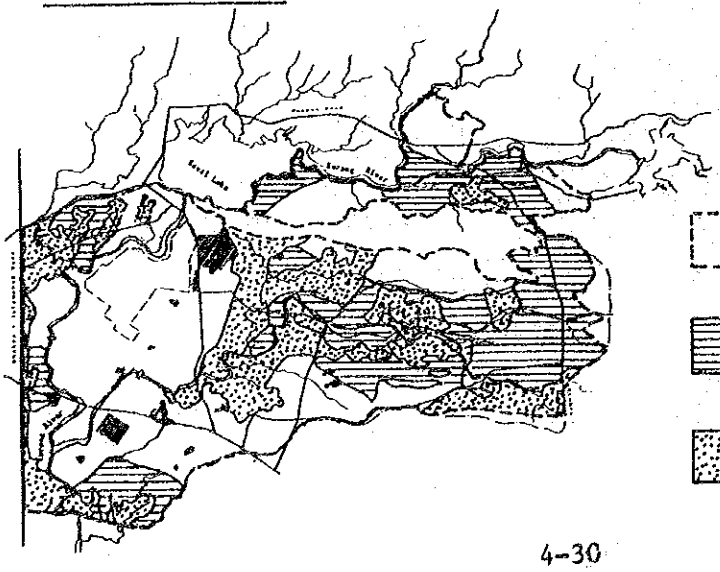
Fruit



Promotion Area of Fruit Production (6,600 ha)

Priority Area of Fruit Production (700 ha)

Grain and Livestock



Promotion Area of Grain and Livestock Production (10,600 ha)

Priority Area of Grain and Livestock Production (2,600 ha)

Grass Area for Livestock (3,900 ha)

4.5. Water Resources Plan

4.5.1. Available Surplus Water at Rawal Dam

As discussed in the previous paragraph of 4.2 "Optimum Scale of the Project", the water resources for irrigation development are the runoff discharges of the Kurang River and of its related small tributaries.

According to the result of runoff analysis for 35 years from 1952 to 1986, annual average runoff discharges at the Rawal Dam in the Kurang River are estimated at 103.0 MCM (84 x 10^3 acre ft) with a catchment area of 275.1 sq.km (106 sq.mile), and out of those annual runoff discharges, about 55.9 MCM (45 x 10^3 acre ft) of discharges equivalent to about 54 percent of the annual runoff are presently spilled from the Rawal Dam uselessly. The spilled discharges are considered as the potential water resources to be developed by storage dam.

The following table indicates the potential water resources estimated at the Rawal damsite.

Catchment area	:	275.1 sq.km	(106 sq.mi)
Average Annual Runoff	:	103.0 MCM	(84 acre ft)
Probable Annual Runoff			
1/5 probability	:	78.7 MCM	(64 x 10^3 acre ft)
1/10 probability	:	69.7 MCM	(57 x 10^3 acre ft)
Average Spilled Discharge	:	55.9 MCM	(45 x 10^3 acre ft)

4.5.2. Available Water at Proposed K-2 Damsite

The annual average runoff discharge at the proposed K-2 damsite having the catchment area of 137.1 sq.km (53 sq.mi) is 62.1 MCM/annum (50 x 10^3 acre ft/annum) as shown below, and equivalent to 60 percent of the runoff discharge at the Rawal damsite.

Catchment Area	:	137.0 sq.km	(53 sq.mi)
Average Annual Runoff	:	62.1 MCM	(50 acre ft)
Probable Annual Runoff			
1/5 probability	:	47.4 MCM	(38 acre ft)
1/10 probability	:	41.1 MCM	(33 acre ft)

4.6. Reservoir Operation Plan

4.6.1. Major Dimension of Reservoir Operation

1) Rawal Dam

The Rawal Dam constructed by WAPDA in 1962 has an important function to supply the municipal water and the irrigation water, as mentioned previously, with the gross storage capacity of 58.6 MCM (48 x 10^3 acre ft) by retention water level of 534.4 m (1,753 ft) above the mean sea level. However, due to heavy sedimentation every year after construction of dam, the reservoir capacity was decreased to 48.7 MCM (39 x 10^3 acre ft) in total in 1972 at the retention water level: in other words, 9.9 MCM (8 x 10^3 acre ft) in capacity had been decreased for those 10 years an shown in Figure 4-4.

In order to clarify development potential of water resources, the reservoir behaviour in storage capacity and water level, the Rawal reservoir water balance study was made on the daily basis for 35 years from 1952 to 1986, in the following conditions;

- Reservoir Dimension (see Figure 4-4)

  Live Storage : 47.0 MCM (38x10^3 acre ft)
  Retention Water Level: 534.4 m (1,753 ft)
  Minimum Water Level : 520.9 m (1,709 ft)

- Water Demand

  Present Condition : 36.7 MCM/annum (30x10^3 acre ft)
  Stage I Condition : 51.0 MCM/annum (41x10^3 acre ft)
  Stage II Condition : 61.1 MCM/annum (50x10^3 acre ft)

- Water Losses from Reservoir: Evaporation from water surface plus seepage

2) K-2 Dam

The K-2 Dam is proposed to be constructed at Dohala, about 15 km (9 mile) upstream of the Rawal Dam, in order to secure more effective utilization of the Kurang River water resources. The water balance study for the K-2 reservoir was made in the following various conditions to find the optimum K-2 Dam size and the project scale covering the cultivable commanded area under K-2 Dam and ensuring adequate expansion capacity of urban domestic water supply by Rawal Dam.

- Dam Operation Plan
  - ° Plan I : Without combination use of Rawal Dam
  - ° Plan II : With combination use of Rawal Dam
- Irrigation Water Demand
  - ° Case 1 : Cropping Intensity : 166%
  - ° Case 2 : " : 154%
  - ° Case 3 : " : 142%
- Dam Capacity 1/

	Gross Capacity (MCM)	Live Capacity (MCM)
° Case A	29.4	18.5
° Case B	24.7	13.8
° Case C	20.5	9.6

1/: Stage - Storage Capacity - Water Surface Area (H-V, H-A) curve is presented in Figure 4-5.

- Irrigation System : Refer to Figure 4-9.
- Water Losses from Reservoir: Evaporation from water surface plus seepage

4.6.2. Reservoir Operation Procedures

1) Alternative Plan of Reservoir Operation Plan

For the study of the water resource available to irrigate the proposed commanded area of 6,600 ha (16,300 acres), the reservoir

operation should be made considering both reservoirs of K-2 and Rawal to supply urban water to Rawalpindi, and as a result, the following plans are formulated in due consideration of prevailing water use in the Kurang River.

Plan I: Plan without Combination Use of Rawal Dam

The runoff discharge of the Kurang River at the proposed K-2 damsite will be stored in the reservoir, when the spilled discharges at the Rawal Dam are observed, and the stored water will be released to irrigate the farm land of 6,600 ha (16,300 acres). Consequently there will be no adverse influence to the Rawal reservoir operation by the construction of K-2 Dam in the upstream of the Kurang River.

However, the water resources at the K-2 damsite will not be available except in the wet season, in which the Rawal Dam will release the surplus water through spillway, and this plan is deemed inadequate from the viewpoint of the maximum utilization of the Kurang River water resources.

Plan II: Plan with Combination Use of Rawal Dam

The reservoir operation in combination with the Rawal Dam and the K-2 Dam will be made in taking into account the most effective utilization of the runoff discharges of the Kurang River for irrigation of the area of 6,600 ha (16,300 acres). In this plan, the runoff discharge of the Kurang River at K-2 damsite will be stored in the K-2 reservoir as much as possible, and the water demand for the Rawal Dam will be supplied in meeting the amount of the runoff discharges available from the Rawal Dam catchment area of the downstream of the K-2 Dam. If the

amount of the said runoff discharges is not sufficient for the demand, the stored water in the K-2 Dam will be released supplementally to the Rawal Dam.

Under these considerations, this plan is conceived as the most adequate one in view of the maximum utilization of the Kurang River water resources available.

2) Calculation Methods and Procedures of Reservoir Operation Study

The subsequent deals with the calculation methods and procedures of the reservoir operation study mentioned above. Figure F-9 indicates the flow diagram of the reservoir operation study.

a) Plan I

Rawal Dam

Inflow; $Q_3 = Q_2 + Q_6 - q_1$

where;

Q_3 : Rawal Dam inflow
Q_2 : Inflow from K-2 downstream catchment area
Q_6 : K-2 Dam released discharge to Kurang River
q_1 : Diverted water for domestic water at Rawal Dam upstream

Outflow; $Qor = Q_4 + q_2$

where;

Qor: Outflow from Rawal Dam
Q_4 : Spilled discharge from Rawal Dam
q_2 : Released water for domestic water at Rawal Dam

Water Balance; Q_4 or $Qsr = Qvr + Q_3 - (Qor + Qlr)$

where;

Qsr: Water shortage at Rawal Dam
Qvr: Effective storage capacity of Rawal Dam
Qlr: Water losses at Rawal Dam
= Qsp + Qep
Qsp: Reservoir seepage (2% of storage capacity)
Qep: Evaporation from water surface
(Surface area x Pan-evaporation Rate x 0.7)

K-2 Dam

Inflow; $Q_5 = Q_1$, when $Q_4 = Qvr + Q_3 - (Qor + Q1r)$ 0

where;
Q_5 : Inflow from K-2 catchment area

Outflow; $Qok = Qi + Q_6 + Qsk$

where;
Qok: Outflow from K-2 Dam
Qi : Irrigation water demand for 6,600 ha
Qsk: Spilled discharge from K-2 Dam

Water Balance; Q_7 or $Qsk = Qvk + Q_5 - (Qok + Q1k)$

where;
Q_7 : Water shortage at K-2 Dam
Qvk: Effective storage capacity of K-2 Dam
Q1k: Water losses at K-2 Dam

b) Plan II

Rawal Dam

Inflow; $Q_3 = Q_2 + Q_6 - q_1$

Outflow; $Qor = Qsr + q_2$

Water Balance; Q_4 or $Qsr = Qvr + Q_3 - (Qor + Q1r)$
Q_4 : Water shortage at Rawal Dam
Qsr: Spilled discharge at Rawal Dam

K-2 Dam

Inflow; $Q_5 = Q_1$

Outflow; $Qok = Qi + Q_6 + Qsk$
Q_6 has higher priority to be released than the Qi.

Water Balance; Q_7 or $Qsk = Qvk + Q_5 - (Qsr + Qok + Q1k)$

4.6.3. Result of Reservoir Operation

1) Rawal Dam

The results of the Study are shown in Table 4-4 and Table 4-8, and the outline of the Study on Plan II is as follows;

Result of Rawal Reservoir Operation Study
(With K-2 Dam)

Item		Present	Future	
			Stage I	Stage II
Annual Average Inflow	(MCM)	103.0 (73.2)1/	103.0 (69.5)	103.0 (77.7)
Annual Release	(MCM)	37.8 (32.6)2/	47.7 (42.5)	56.1 (50.9)
Spilled Discharge	(MCM)1/	38.8	25.4	25.3
Water Shortage	(Times)	0	0	0

1/: Figures in parenthesis show an inflow discharge subtracting diverted urban domestic water at upstream of Rawal Dam.
2/: Figures in parenthesis show an actual release discharge from Rawal Dam excluding irrigation water.

As it is seen in the above table, the Rawal Dam can meet the requirement for increasing water demand in case of Stage I and Stage II Plans with an annual demand of 42.5 MCM (34 x 10^3 acre ft) and 50.9 MCM (41 x 10^3 acre ft) with the supplement of released water from the K-2 Dam; however, in case of Stage II, the K-2 Dam will not function properly for irrigation purpose because the Rawal Dam will require a large amount of water for the K-2 Dam for the domestic water supply.

2) K-2 Dam

The result of K-2 Dam operation study is tabulated in Table 4-4 and Table 4-8. And the following optimum size of the K-2 Dam and the project scale are proposed. Also, Figure 4-6 and Figure 4-7 show the results of the Rawal Dam and the K-2 Dam reservoir operation studies for the proposed Project Plan mentioned above.

- Dam Operation Plan : Plan II (with combination of Rawal Dam)
- K-2 Dam Size : Case A (Gross storage capacity of 29.4 MCM)
- Irrigation Plan
  - ° Target Commanded Area : 6,600 ha (Probability: 1/10)
  - ° Proposed Cropping Intensity: 142%
  - ° Average Cropping Intensity : 141%

- Domestic Water Supply Plan : Expansion plan of Stage I
- Irrigation Canal Networks : Gravity irrigation system connected with K-2 Dam

4.6.4. Reservoir Operation Rule

The reservoir operation rules of the Rawal Dam and K-2 Dam are proposed as shown below;

1) Rawal Dam

- The inflow discharge to the Rawal Dam is the runoff discharge of the Kurang River having the catchment area of 138.1 sq.km (53.mi) located in the downstream of the proposed K-2 Dam. The urban domestic water to be diverted by headworks of Kurang River such as Shahdara and Nurpur at the upstream of the Rawal Dam will be subtracted from the inflow discharge.

  The outflow discharge of the Rawal Dam is used as the urban domestic water by 42.5 MCM (34×10^3 acre ft) per annum in corresponding to the future expansion plan of Stage I for Rawalpindi, which is presently supplied by the Rawal Dam Right Canal. Irrigation water of 5.2 MCM (4×10^3 acre ft) per annum for NARC farm, CDA nursery and private farm will be supplied by the proposed irrigation networks to be connected with K-2 Dam.

- The Rawal Dam will be utilized within a range of water level from retention water level of EL.534.4 m (1,753 ft) to low water level of EL.520.9 m (1,709 ft). However, when the outflow discharge from the Rawal Dam is larger than the inflow discharge in amount and the water level of the Rawal Dam is forecasted to be lowered than the low water level of EL.520.9 m, Rawal Dam Operation Office will request to release supplemental water from the K-2 Dam.

2) K-2 Dam

- The inflow discharge to the K-2 Dam is the runoff discharge from its own catchment area of 137.0 sq.km (53 sq.mi).

- The outflow discharge from the K-2 Dam is principally used as irrigation water for the area of 6,600 ha (16,300 acres) under the project. But as mentioned previously, water shortage in the Rawal Dam will be released through river outlet works of K-2 Dam. Released discharge to the Rawal Dam has higher priority than that of irrigation use.

- The reservoir operation of K-2 Dam will be practised within a range from water level of retention water of EL.647.0 m (2,122 ft) to that of the low water of EL.637.0 m (2,089 ft). According to the long term reservoir operation study for 35 years, the subsequents are revealed.

- The K-2 reservoir water level at the end of September, in which Rabi season cropping will be started in the proposed cropping pattern, is observed at the full water level in the rainy season, and the target cultivable commanded area of 6,600 ha (16,300 acres) will be irrigated by the stored water in the K-2 Dam, accordingly.

- On the other hand, since the start of cultivation of the Kharif season cropping will coincide with the period of the relatively low reservoir water level of K-2 Dam in March, the irrigation area of the Kharif season crops will be decided based on the reservoir water level at the end of January, about one month in advance.

- When the K-2 reservoir water level is higher than EL.645.0 m (2,116 ft), the target commanded area of 2,772 ha (42 percent of 6,600 ha) can be irrigated for the Kharif season. But when the water level is lower than EL.645.0 m, the cropping area will be controlled by the following criteria for the Kharif season;

Water Level of K-2 Reservoir	Kharif Season Cropping Area
more than EL.645.0 m	2,772 ha (42%)[1/]
EL.645.0 m - EL.644.0 m	1,000 ha (15%)
less than 644.0 m	0

Note: 1/: targeted cropping intensity of 142%

FIGURE 4-4. STAGE-STORAGE CAPACITY CURVE OF RAWAL DAM

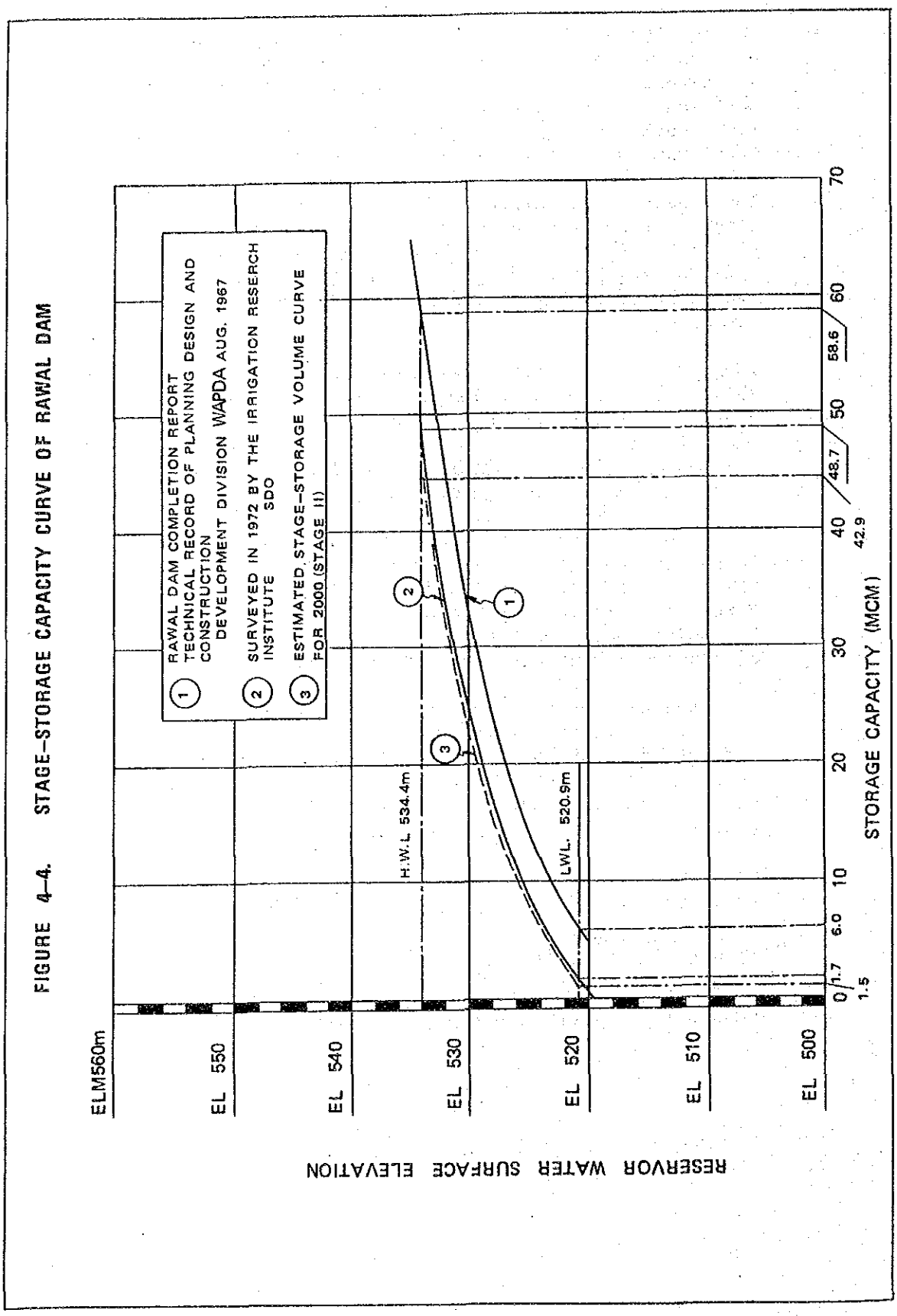


FIGURE 4–5. STAGE–STORAGE VOLUME AND AREA CURVE OF K–2 DAM

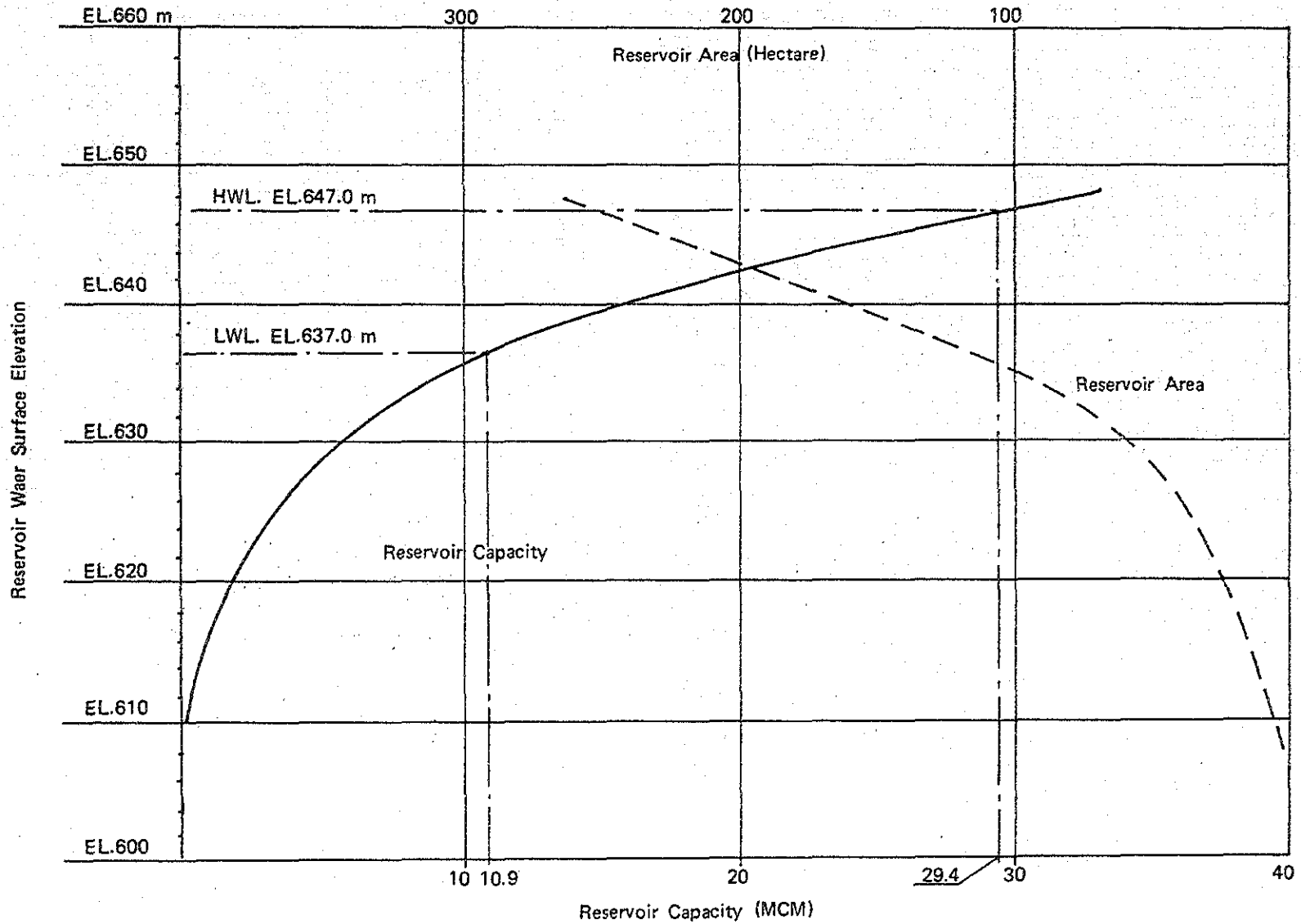


FIGURE 4-6. RESULT OF RAWAL DAM OPERATION STUDY UNDER THE PROJECT (DOMESTIC WATER DEMAND STAGE 1, WITH K-2 DAM)

(Stage I , Plan II, K-2 Dam Size : Case A, Irrigation Area : 6,600 ha, Irrigation Demand : Case 3)

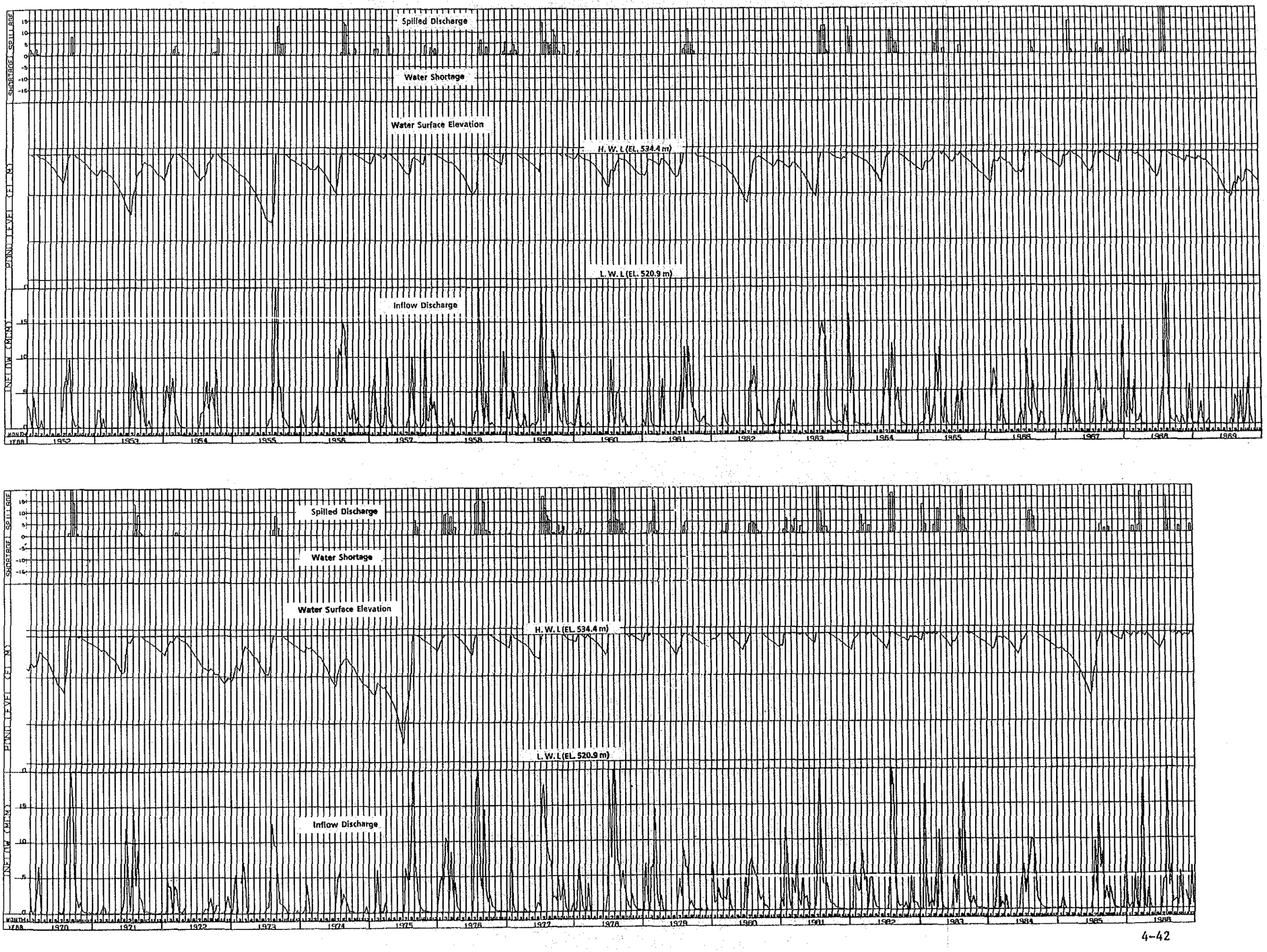


FIGURE 4-7. RESULT OF K-2 DAM OPERATION STUDY UNDER THE PROJECT (DOMESTIC WATER DEMAND : STAGE 1)

(Stage I, Plan II, K-2 Dam Size : Case A, Irrigation Area : 6,600 ha, Irrigation Demand : Case 3)