fields. Although different modes of irrigation such as surface irrigation using water from the Gudrung river and Ghorahi drain, pond irrigation, etc. have been used, the areas under these irrigation systems are very limited since the systems themselves are primitive and inefficient. A major part of the project area has to rely on uncertain rainfall for cultivation, resulting in very low unit yields for each crop.

Major constraints on agriculture development for irrigation are as follows:

(1) Agricultural Constraints

1) Inefficiency of the existing irrigation systems and variation in precipitation from year to year have been affecting the cropping area as well as crop yield.
2) Due to an insufficient supply of farm inputs such as improved seed, fertilizers, pesticides, etc. and improper extension services, the present crop yields are as low as 1.7 ton/ha, 1.2 ton/ha, 1.4 ton/ha, and 0.6 ton/ha for paddy, wheat, maize, and pulses, respectively.
3) Modern irrigation farming and cultivation techniques have not yet been introduced because of improper extension services.
4) No additional land can be reclaimed for cultivation, hence, there is no possibility of increasing production by expanding average landholdings of 1.1 ha (including 1.0 ha for paddy fields), even to the district average of 1.5 ha.

(2) Irrigation Constraints

1) Since the project area receives 86 % of the annual rainfall (2,100 mm) in four months of the rainy season, the source rivers, the Gudrung and Kondre, carry a very high flood discharge. On the other hand, due to the relatively small catchment area, they carry a rather low discharge in the normal seasons of the year. For these two reasons, the development of proper irrigation facilities is beyond the capacity of the farmers.
2) The bed levels of the Belwagurdwa and Kondre rivers are very low compared to the elevation of the adjacent command area, hence, diversion of water from these rivers using traditional methods is hardly possible.
3) Year-round irrigation using pond water is not possible because of the high concentration of rainfall in the rainy season. Such an uneven distribution of rainfall over a year causes the spilling of water during the rainy season, whereas the ponds run out of water during the dry season.
4) Use of drainage water by temporary diversion is also not reliable for year-round irrigation because of the uneven distribution of rainfall.

4.3.3 Basic Development Concept

The objective of the project is to eradicate poverty and to correct the imbalance of the rural and urban economy, which is also the policy adopted by HMG/N, by increasing farmers income through the stable increase of agricultural production. It has been proposed that to meet the above objective an effective utilization of the river discharge of the Gudrung and Kondre

rivers and the storage of rainwater in several ponds must be started. The basic development concepts set to meet the above objective are as follows:

(1) Increase of unit yields and production of summer paddy by constructing new irrigation facilities and introducing modern irrigation farming techniques;
(2) Increase of agricultural production by extending the cropping area in winter and spring seasons through year-round irrigation;
(3) Enlargement of the irrigation area by effective use of available water in the Gudrung and Kondre rivers, ponds, etc.;
(4) Provision of a simple irrigation system for easy O&M and water management and for equitable distribution of irrigation water so as to maintain the balance in production within the project area;
(5) Provision of a drainage system to insure ideal growing conditions for paddy, wheat, and other crops by improving maldrained paddy fields;
(6) Establishment of proper water management and O&M by involving the beneficiary farmers right from the planning stage by organizing them in a WUA;
(7) Improvement of village roads to facilitate easy and smooth transportation of agriculture inputs and farm products. This will also improve the socio-economic condition of the project area; and
(8) Reorganization of the existing WUAs and Cooperatives for the improvement of agricultural support services such as input supply, extension services, and credit facilities by coordinating them with the agencies concerned.

4.4 Technically Feasible Irrigation Development Plan

4.4.1 Conceivable Development Plans

In order to irrigate a part or the whole of the irrigable area estimated in Section 4.2.3, eight development plans are conceivable. The specific features of each plan are summarized below:

Alt.-1, Gudrung River Development Plan - A

Under this plan, the arable land will be irrigated by a canal system branched from the Gudrung River at the Ranikudwa site. However, due to the relatively small discharge of the source river in June and early July, i.e., the land preparation term and lastly in October, i.e., the maturing term, irrigation of the rainy season paddy is limited to 340 ha, a part of the command area (about 630 ha), of the existing Ranikudwa Farmers' Irrigation System, lying to the north of the East-West Highway. However, irrigation of wheat, mustard, and vegetables in the dry season will be slightly increased to 480 ha owing to the small water requirement of such crops despite the small discharge of the river.

Alt.-2, Gudrung River Development Plan - B

In this alternative, five irrigation ponds consisting of a new one and four existing ones have been provided to Alt.-1. Out of 2,000 ha of irrigable area estimated by the water balance computation of the available water and water requirement, 200 ha of arable lands can't be irrigated because of their higher ground elevation. Thus the irrigation of the rainy season

paddy will be limited to 1,800 ha, of which about 850 ha lie to the north of the East-West Highway and the remaining 950 ha are located on the other side. The irrigation area in the dry season will be 1,000 ha by the effective use of the five ponds provided they are at their optimum size.

Alt.-3, Kondre River Development Plan - A

The original plan of this alternative, irrigating 900 ha of arable land was formulated by a Nepalese consulting firm in 1988. But, in this alternative only 210 ha of arable land, which is in the southern most part of the existing Ranikudwa command area, can be irrigated by a canal system that branches from the Kondre river at the confluence of its tributary, the Rajkudwa river, because the source river has a limited discharge in the beginning of the rainy season, i.e., the end of May to early July. In addition, out of the 5 km long headrace canal, about 3 km of the last stretch will run through arable land, of which gravity irrigation is impossible because of the low water level of the canal. The irrigation area in the dry season will be slightly increased to 280 ha because of the small water requirement of upland crops. This alternative can't provide the irrigation system with an irrigation pond owing to the low water level at the proposed intake site.

Alt.-4, Kondre River Development Plan - B

295 ha of arable land, extending south of the East-West Highway will be irrigated by a canal system branching from the Kondre river at a point, about 3 km upstream from the Highway. The irrigation area in the dry season will be 385 ha. This alternative is not provided with an irrigation pond because of the low water level at the proposed intake site.

Alt.-5, Gudrung and Kondre Plans Combined

In this alternative, Alt.-2 and Alt.-4 have been combined into one irrigation system. By doing so, 2,095 ha of paddy fields could be irrigated during the rainy season, whereas the irrigation area for the dry season could be 1,385 ha. However, the water management of the combined system will be very complicated.

Alt.-6, Pond Irrigation Plan in the Northern Part

Only 60 ha of arable land can be irrigated for two seasons using the effective storage of the four existing and an equal number of new ponds to be constructed in the natural forest located in the northern part of the study area. The reason behind considering this alternative with such a small area is that the system is isolated from that of the Gudrung and Kondre development plans mentioned above and could be implemented independently.

Alt.-7, All Available Resources Combined

In this alternative, Alt.-5 and Alt.-6 are combined into a single system. The irrigation area would be 2,155 ha and 1,445 ha in the rainy season and dry season, respectively, but the water management of the multiple resources is hardly possible.

Alt.-8, Combination of Three Independent Systems

In this alternative, Alt.-2, Alt.- 4, and Alt.- 6 will be combined, but each system will function independently. This is a considerable plan to increase the irrigable area by a large

amount using the available water without unnecessary complexity in water management. The total irrigation area for the rainy and dry seasons will be 2,155 ha and 1,445 ha, respectively.

Alternative-3, which was considered during the rainy season study is not viable because :

(i) The available discharge for irrigation is very low throughout the year due to the limited size of the catchment area;

(ii) The first 2 km out of the 5 km long headrace canal will have to be constructed on a difficult terrain, requiring a closed conduit after excavating to a depth of 10 m and the remaining part will have to be a 6 to 8 m deep open cut channel in the arable land, which creates the problem of acquiring land.

Therefore, to overcome the problems in Alt.-3, Alt.-4 has been formulated during the dry season study. It is also worth mentioning that there is no suitable location for the headworks site between Alt.-3 and Alt.-4.

4.4.2 Technically Feasible Irrigation Development Plan

The above-mentioned eight irrigation options were examined in terms of (i) irrigable area, (ii) available discharge, (iii) intake water level, (iv) loss of farmland due to headrace canal construction, (v) ease or difficulty of water management, and (vi) estimated construction cost (Table 4.3 shows the analysis of the various alternatives.).

Alt.-1, Alt.-3, and Alt.-4, which are not provided with irrigation ponds have little possibility of realization, since the respective irrigable areas are very small compared to the size or capacity of the required headworks and headrace canal. Alt.-6 is not attractive because of its small irrigable area. Furthermore, Alt.-5, Alt.-7, and Alt.-8 are also less attractive because each of them is based on two medium sized headworks and two lengthy headrace canals despite the fact that the respective irrigable areas (2,095 ha , 2,155 ha, and 2,155 ha) are not mush more in comparison with that of Alt.-2. Therefore, Alt.-2, which will irrigate 1,800 ha of paddy fields in the rainy season and 1,000 ha of upland crop fields in the dry season with the optimum use of the available discharge of the Gudrung river by a headworks and five irrigation ponds, is the sole irrigation development plan to be taken up for purposes of agricultural development and socio-economic improvement in the study area from technical and socio-economic view points.

The technicals reason why Alt.-2 is to be the sole irrigation development plan are as follows:

1) It is essential for enlarging the irrigable area that the excess flow of the Gudrung river is stored in five irrigation ponds, including a new one and four existing ones, since the irrigable area which can be directly covered by the river flow is only 340 ha at the cropping intensity of 155 %, consisting of 100 % paddy in the rainy season, 50 % winter crop, and 5 % spring vegetables. The bigger pond capacity enables a larger irrigable area;

2) Therefore, the total capacity of the five ponds was set at 3.08 million m^3 from the following comparative study on the relationship between total effective storage and total irrigable area of the five ponds at a cropping intensity of 155 %.

Size of Pond	Effective Storage (10^6 m^3)	Irrigable Area (ha)
Max.	3.080	2,000
Medium	2,473	1,810
Small	1,390	1,390
Existing	391	630

3) Although the above study shows that the max. irrigable area at the cropping intensity of 155 % is 2,000 ha, the planned irrigation area was confined to 1,800 ha because of a topographical constraint, i.e., 200 ha of the arable lands are higher than the water level of the planned canals;

4) In connection with the planned irrigation area, the water balance of the five ponds was re-studied to enlarge the irrigable area of winter crops and spring vegetables where the total effective storage of the five ponds was 3.08 million m^3 and the irrigation area of the rainy season paddy was 1,800 ha. The cropping intensity was set at 168 %, consisting 100 % paddy, 63 % winter crops, and 5 % spring vegetables from the following water balance of the five ponds;

Cropping Intensity (%)	Critical Storage ($10^3 m^3$)
155	542
165	209
168	13
170	0 (- 42)

CHAPTER V THE PROJECT

5.1 Objective and Scope of the Project

The project aims at stably increasing agricultural production, creating employment opportunities, rising farmers' income and thereby uplifting living standards in the project area through construction of irrigation and drainage facilities and agricultural support facilities, in line with the irrigation development target and policies set by HMG/N. The objective area covers about 4,280 ha of arable lands (excluding 280 ha in the isolated northwest area), most of which are paddy fields, consisting of the command area (630 ha) of the Ranikudwa Farmers' Irrigation Scheme, the arable lands extending south of the Ranikudwa command area, and the surrounding natural forests.

Out of the 2,000 ha of irrigable area computed in Section 4.2.3, the irrigation area of the project is set at 1,800 ha of arable lands owing to the topographical limitation. The irrigation area comprises about 630 ha of the Ranikudwa command area and about 1,170 ha of arable lands extending south of the Ranikudwa area. It is divided into two parts by the East-West Highway; the northern part is about 850 ha including the 630 ha of the Ranikudwa area, and the southern part is about 950 ha.

In consideration of the present situation in the objective area, the scope of the project is set as follows:

i) Construction of the Gudrung headworks including a tyrolean type diversion weir and construction of a headrace canal;
ii) Improvement and enlargement of four existing irrigation ponds and construction of an irrigation pond;
iii) Construction of primary and secondary feeder canals and related structures, which will supply water from the headrace canal to the five irrigation ponds mentioned above;
iv) Reconstruction of main, secondary and tertiary irrigation canals and related structures in the existing Ranikudwa command area (630 ha);
v) Construction of main, secondary and tertiary irrigation canals and related structures in the newly planned area (1,170 ha);
vi) Construction of primary, secondary and tertiary drains and related structures in the project area;
vii) Improvement of existing major village and farm roads in and around the project area for facilitating O&M of the completed irrigation and drainage facilities, transport of farm inputs and outputs, etc.;
viii) Construction of agricultural support facilities consisting of a farmers' association center and five VDC farmers' cooperative offices;
ix) Consulting services including additional survey and investigation, detailed design and construction supervision;
x) Operation, management and administration of the project; and
xi) Agricultural extension services and training of farmers.

5.2 Agricultural Development Plan

5.2.1 Basic Concept for the Agricultural Development

The agricultural development plan aims at stably increasing paddy production in the rainy season and upland crops production in the dry season by supplying irrigation water to the existing farmlands. In order to achieve the planned agricultural development, it is essential not only to provide irrigation and drainage systems but also to improve the production techniques and to reinforce the related support services. The production techniques to be improved include introduction of high yield varieties, fertilization, pest and disease control, water management, etc. The support services to be reinforced involve farmers' organization, extension services, input supply and agricultural credit, etc. The proposed agricultural development plan has been based on technical and economic studies on the future landuse, cropping pattern and farming technique.

5.2.2 Farm Household and Agricultural Labour Force

The project area covers the northern half of the existing farmlands in the study area. Administratively, the area includes five Village Development Committees (VDCs): Mahendrakot, Dubiya, Jayanagar, Buddi and Rajpur, and 29 wards in total. The population in the project area is about 16,000, and the total number of farm households is 2,180, consisting of 47 of large size, 128 of medium size, 472 of small size, and 1,533 of marginal size. Besides, there are 85 landless farm households. The project area covers the existing 1,840 ha of paddy fields, and the average size of paddy field per farm household is 0.84 ha. This average is smaller than that of 0.97 ha in the study area. Agricultural labour force in the project area is estimated at about 7,700 including landless farmers.

5.2.3 Future Landuse

As almost all of the project area consists of paddy fields, there should be no major change in the types of crops to be planted in the area. Paddy will remain a staple crop. With the completion of the project, all the paddy fields in the project area will be fully irrigated and more intensively used. The project will therefore provide the farmers with a good opportunity to expand their production activities.

The two different scenarios of landuse under the with- and without- project conditions are compared as follows:

(Unit: ha)

Description	Without Project	With Project
Gross project area	2,000	2,000
Irrigation/drainage canals, farm roads and field borders	160	200
Paddy fields	1,840	1,800
Net irrigation area	850	1,800

5.2.4 Proposed Cropping Pattern

To determine the future cropping pattern for the project, the following basic principles have been adopted:

a) Higher benefit for farmers;
b) Optimum utilization of irrigation water;
c) Practical farming for family labour; and
d) Crops and cropping pattern acceptable to farmers.

Rice is the most prevailing crop in the project area and acceptable to farmers. Farmers have long experience in rice cultivation and will therefore easily master the irrigated rice cultivation to realize higher production and thereby large irrigation benefit under the project. Wheat, oilseeds and vegetables (potato, tomato, pulses, okra, red pepper, cauliflower, etc.) are also important for home consumption at present. In the future project condition, such crops remain unchanged because of climatic condition, soil conditions, available water, social conditions, etc. in the project area.

Therefore, the following cropping pattern has been proposed:

1)	Rainy Season	Paddy (1,800 ha)	1/30 Jun. - 1/31 Oct.
2)	Dry Season (Winter)	Wheat (680 ha)	1/10 Nov. - 1/10 Mar.
		Mustard (225 ha)	11/20 Nov. - 11/20 Feb.
		Vegetables (225 ha)	11/20 Nov. - 21/28 Feb.
3)	Dry Season (Spring)	Vegetables (100 ha)	1/10 Mar. - 1/10 Jun.

The proposed cropping pattern is illustrated in Fig. 5.1.

Since the discharge of the Gudrung river sharply decreases in the dry season due to small rainfall, the cropping areas of winter and spring crops in the dry season are considerably limited, and thereby the cropping intensity based on the proposed cropping pattern has been set as follows:

Cropping Intensity	Summer Crops	Winter Crops	Spring Crops
168 %	100 %	63 %	5 %

For determination of the above cropping intensity, comparative studies were made in terms of profitability, labour requirement and water requirement as mentioned in Annex D. The results of the studies are shown in Table 5.1.

5.2.5 Proposed Farming Practices

Introduction and extension of appropriate irrigation farming practices are essential to realize full exploitation of the agricultural potential in the project area. The proposed farming practices for the proposed cropping pattern are summarized as follows:

(1) Paddy

Land preparation should be initiated with occurrence of first rains. Land should be cultivated to the desirable depth by ploughing the land 3 to 4 times using improved

primary and secondary tillage implements such as mould board plows, tine cultivators, harrows, and puddlers drawn by draft animals. A basal dose of fertilizers, i.e., a half amount of nitrogen and full amount of phosphate and potash should be applied to the field at the time of puddling. A second dose of nitrogen should be applied as top dressing after transplanting. The proposed per ha quantity of fertilizers is 120 kg, consisting of 60 kg of N, 30 kg of P and 30 kg of K.

Transplanting, which is a common practice in the Terai plain, should be carried out after puddling. Seedlings should be uprooted from the nursery without injuring or breaking leaves and roots. Seedlings about 25 days old in the case of early maturing varieties and about 35 days old in the case of late maturing varieties should be transplanted at a rate of 2 - 3 seedlings per hill, a density of 20 - 25 hills per m^2, and at spaces of 15 cm x 20 cm.

Weeding should be performed two to three times according to weed growth. A water depth of about 5 - 6 cm should be maintained up to the dough stage of the crop. Timely control of insect-pests and diseases should also be ensured by using pesticides recommended by the extension agents or technicians concerned.

Harvesting should be carried out when the ears are nearly ripened and the straw is still slightly green. Paddy is to be be harvested by manual labour, using sickle , dried in the field for 3 to 4 days, stacked in the threshing yard for a week or so and then threshed using either a bullock or a mechanical thresher.

(2) Wheat

The old wheat varieties such as RR21 and UP262 should be replaced by new high yielding varieties such as Nepal 297, H.D.1982 and B.L.1022 recommended by the Buddi Agricultural Service Center for the project area.

Land should be prepared by ploughing 3 - 4 times as same as land preparation for paddy fields. A basal dose of fertilizers should be given to the field at the time of land preparation at a rate of a half amount of nitrogen and full amount of phosphate and potash. A fertilizer dose of 150 kg/ha (N: 80 kg, P: 40 kg, K: 30 kg) is recommended. Three to four times of irrigation at the critical growth stages such as crown root initiation, maximum tillering, heading, and dough stage are recommended to increase the unit yield to the target.

Harvesting, threshing and drying are almost same as for paddy.

(3) Oilseeds (mustard)

Mustard should be sown in the middle of November, since timely sowing is a prerequisite for higher yields. Mustard may suffer seriously from a special parasite known as orobanche and other pests and diseases if improved varieties are not used and sowing is not carried out in optimum time. Mustard well responds to a fertilizer dose of 60: 40: 20 kg of N: P: K/ha under the irrigated condition. As mustard is a cross-pollinated crop, certain isolations in time and space should be maintained to harvest genuine seeds for the next season.

Land is prepared by ploughing 3 - 4 times to a desired depth by using improved primary and secondary tillage implements available in the area. Sowing should be done on continuous solid rows at intervals of 30 - 40 cm, and followed by thinning at the 3 to 4-leaf stage. The matured plants should be harvested when the siliqua turn yellow before the pods start shattering, dried for some days in a threshing yard and threshed by sticks or bullocks.

(4) Vegetables

Potato, radish, leaf mustard, cauliflower, cabbage, onion and garlic are proposed for winter vegetables, while tomato, okra and water melon are recommended as spring vegetables. Potato has been commercially grown in the northern part of the project area. Okra (lady's finger) is one of the most profitable crops in the spring season. Vegetables respond to a fertilizer dose of 60: 50: 40 kg of N: P: K/ha under the irrigated condition. Irrigation should be applied at an interval of 10 - 15 days in case that there is no rainfall. Weeding should be done by hoeing at least 3 times during the growing period.

5.2.6 Anticipated Crop Yield and Crop Production

After construction of the project facilities, the crop yields would gradually increase from the present level to the target level and stabilize in the fifth year after the completion of the project facilities. The anticipated crop yields are set at 4.5 tons/ha of dried paddy, 3.0 tons/ha of wheat, and 1.2 tons/ha of oilseeds under the "with project" condition. These unit yields were estimated from the present unit yield of crops under full irrigation condition in the Terai plain and they are rather conservative in comparison with those in the data for the past 10 years (1983 to 1992) obtained from the District Agricultural Development Office (DADO).

The target unit yields of the proposed crops under the "with project" and the "without project" conditions are compared as follows:

(Unit : ton/ha)

Crops		Without Project	With Project	Increment
Paddy	: partially irrigated	2.20	4.50	2.30
	non-irrigated	1.42	4.50	3.08
Wheat	: partially irrigated	1.70	3.00	1.30
	non-irrigated	0.98	3.00	2.02
Oilseeds	: partially irrigated	0.71	1.20	0.49
	non-irrigated	0.46	1.20	0.74
Vegetables	: partially irrigated	3.85	12.0	8.15

To achieve the target yields, optimum application of farm inputs is required as well as efficient water management. The target unit yields will be attained in the fifth year after the completion of the project facilities, particularly the irrigation and drainage facilities.

Total agricultural production in the project area under the with and without project conditions is estimated by multiplying the target unit yield and cultivation area of the proposed crops as follows:

Crops		Without Project P.I.	N.I.	Total	With Project F.I.	Increment
Paddy	: P.A (ha)	840	850	1,690	1,800	110
	Prod. (tons)	1,840	1,210	3,050	8,100	5,050
Wheat	: P.A (ha)	310	110	420	680	260
	Prod. (tons)	520	110	630	2,040	1,410
Maize	: P.A (ha)	25		25		-25
	Prod. (tons)	40		40		-40
Oilseeds	: P.A (ha)	80	30	110	225	115
	Prod. (tons)	60	10	70	270	200
Pluses	: P.A (ha)	80	190	270		-270
	Prod. (tons)	50	110	160		-160
Vegetables	: P.A (ha)	50		50	325	275
	: Prod. (tons)	190		190	3,900	3,710

Note : P.I. : Partial Irrigation, N.I. : Non-irrigation, F.I.: Full irrigation
P.A : Planted Area, Prod. : Production, (Ref. : Table D.9)

Annual incremental production of paddy, wheat, mustard and vegetables at the full development stage is expected to be 5,050 tons, 1,410 tons, 200 tons and 3,710 tons, respectively as tabulated above.

5.2.7 Marketing and Price

The Kapilvastu District is one of the food grain surplus areas in the Terai plain. The surplus grains in the district has been traded to such populated areas as Bhairahawa, Butwal, Krishnagar, and Kathmandu and the hill and mountain areas as well. In the project area, a part of the surplus food grains has been supplied to the northern hill area via Pattharkot.

The surplus of agricultural products in the project area is estimated to be 4,300 tons of paddy and 1,300 tons of wheat at the full development stage as shown below:

Product	Per Capita Consumption	Total Consumption	Seed & waste	Total Production	Marketable Product
	kg/person/year	ton	ton	ton	ton
Paddy	187	2,990	810	8,100	4,300
Wheat	33	530	200	2,040	1,310

Note 1: Total consumption is calculated by per capita consumption x population (16,000)
2: Per capita consumption = present amount x 1.1

These marketable products are expected to be supplied to the above mentioned populated areas and the hill areas, where food is in shortage, through existing market channels.

The economic prices of internationally tradable commodities: paddy, wheat, fertilizer, etc. were estimated referring to a 1992 price forecast of IBRD based on the 1993 constant price level. The per kg economic farm-gate prices of crops were NRs. 9.7 for paddy, NRs. 14.1 for wheat, 10.4 for maize, NRs. 14.9 for oilseeds (mustard) and NRs. 5.0 for vegetables.

The farm-gate prices of agricultural products and inputs used for the financial analysis are current prices of 1992/93 based on the market price survey and farm economy survey carried out in and around the project area.

5.2.8 Crop Budget

The economic crop budgets were estimated based on the farm inputs and labour requirements, prices of inputs and products, and unit yield of each crop under the without and with-project conditions. The production cost under the without-project condition was assumed to be equal to that under the present condition. Under the with-project condition, the production cost will increase due to the increase of fertilizer, agro-chemicals and labour requirements. The estimated economic crop budgets are as tabulated below.

(unit: NRs. per ha)

		Without Project			With Project			
Crops	Cond -ition	Gross Income	Production Cost	Net Profit	Gross Income	Production Cost	Net Profit	Incremental Net Profit
Paddy	N.I.	13,720	6,130	7,590	-	-	-	25,210
	P.I.	21,250	6,490	14,760	-	-	-	18,040
	F.I.	-	-	-	43,470	10,670	32,800	-
Wheat	N.I.	13,830	6,280	7,550	-	-	-	23,360
	P.I.	23,990	6,540	17,450	-	-	-	13,460
	F.I.	-	-	-	42,330	11,420	30,910	-
Maize	P.I.	17,910	4,610	13,300	-	-	-	-
Oilseed	N.I.	6,860	3,550	3,310	-	-	-	6,800
	P.I.	10,590	3,820	6,770	-	-	-	3,340
	F.I.	-	-	-	17,890	7,780	10,110	-
Pulses	N.I.	7,090	3,930	3,160	-	-	-	-
	P.I.	8,350	4,300	4,050	-	-	-	-
Vegetables	P.I.	17,250	9,960	7,290	-	-	-	31,250
	F.I.	-	-	-	53,760	15,220	38,540	-

Note: N.I.: Non-irrigated, P.I.: Partially Irrigated, F.I.: Fully Irrigated

5.2.9 Improvement Plan for Agricultural Support Services

After construction of the project facilities, it is essential to increase the agricultural productivity as well as production to the proposed target level by improving the input situation, rendering proper extension services, providing necessary credit facilities, strengthening farmers' organizations including cooperatives, and providing proper marketing facilities.

However, the present situation of the above-mentioned services and facilities is not very encouraging and needs a lot of improvements and interventions. Only one agricultural service center, located at Buddi, exists in the project area, but its service for the extension works is minimal as it has to cover quite a large area compared to its staff. Regarding the supply of farm inputs, two cooperatives, located at Gorusinge and Kaudalihya in Dhankauli VDC, are functioning in the project area. However, the farmers could seldom buy the inputs in time and in necessary quantity, because of shortage of fund and storage facilities. There is no branch office of ADB/N within the project area to provide farmers with credit facilities for agricultural development. Only a minor part of farm households have access to a branch office of the bank located at Taulihawa, the district headquarters.

In the light of the insufficient agricultural support services as mentioned above, the following improvements were suggested through a series of discussions with farmers, village chiefs and representatives of district agencies during the field survey period for the feasibility study on this project.

(1) Strengthening of the extension services in the northern part of the project area by establishing a special demonstration cum seed multiplication farm, of which operation and management will be carried out by the farmers' association under the technical guidance and supervision of agricultural extension technicians of the Buddi Agricultural Service Center.

(2) Establishment of a farmers' association center, consisting of a farmers' cooperative office, a water users' association office and a sub-branch office of ADB/N, in the center of the project area (along the East - West Highway).

(3) Extension of the cooperative activities and construction of godowns (100 MT capacity each) for the buffer stock of farm inputs and products in each VDC.

(4) Construction of rice mill(s) for easy access to the farmers of Dhankauli, Mahuwa, Rajpur and Hariharpur VDCs where transportation is difficult.

Among the above suggestions, (2) and (3) have been incorporated into the project works, while (1) is expected to be provided by the Department of Agriculture Development (DOAD) and the Buddi Agricultural Service Center, and (4) is expected to be implemented by the farmers' cooperatives to be strengthened.

The proposed organization structure for the improvement to the existing agricultural support services is shown in Fig. 5.12.

5.2.10 Improvement of Farmers' Organization

Two cooperatives, located at Gorusinge and Kaudalihya in Dhankauli VDC, are functioning in the project area, but their services are not effective. Their services, in input supply, providing market facilities, etc. are minimal. Besides, the cooperatives are also facing the problem of lack of facilities compared to the area to be covered.

For strengthening the existing cooperative in Gorusinge, sub-unit farmers' cooperatives are proposed to be organized in each of the five VDCs within the project area. These sub-unit cooperatives will operate with their own management under supervision of the cooperative. The members of such farmers' cooperatives shall also be the members of water users' associations for better coordination of agricultural development activities.

5.3 Irrigation and Drainage Development Plan

5.3.1 Basic Planning Concept

The basic concept in formulating the optimum irrigation and drainage development plan which aims at stably increasing agricultural production, rising farmers' income and uplifting living standards in the objective area is as follows:

(1) Among 8 Alternatives described in Section 4.4, Alternative 2 is the sole irrigation development plan which seems technically and economically appropriate. The alternative aims at increasing irrigation area through effective use of the Gudrung river discharge by constructing headworks and five irrigation ponds including the four existing ones;

(2) Available water for Alternative 2 is to be computed at daily basis as the total of daily river discharge, daily discharge of springs and daily discharge of irrigation ponds for fifteen years from 1978 to 1992. The daily river discharge is to be computed from the daily rainfall by using a four-series tank model developed for a large-size computer;

(3) Water requirements for the proposed cropping pattern: paddy in rainy season, wheat, mustard and vegetables (3: 1: 1 in cropping ratio) in winter (dry season) and vegetables in spring (dry season) are to be computed on a 10-day basis from the consumptive use of water of each crop, based on the evapo-transpiration calculated by the modified Penman formula, deep percolation loss and effective rainfall;

(4) The irrigable area is to be set at 80 % dependable value among the annual irrigable areas computed on a 10-day basis from the water balance between the available water computed on a daily basis and the diversion water requirement based on the proposed cropping pattern. Then the irrigation area is to be decided by maximizing the capacity of the five irrigation ponds, since the source river has a large discharge in the rainy season but relatively small runoff in both the dry season and the transition periods between the two seasons;

(5) The canal system in the project area is to be divided into a supply system feeding the five irrigation ponds and five distribution systems including four of pond irrigation system to enable independent water management by (1) feeding the ponds with excess discharge of the Gudrung river, and (2) distributing irrigation water from the ponds to the fields;

(6) Except for 209 ha in the northernmost part of the project area, which is irrigated directly by the primary feeder canal and branched secondary irrigation canals, all the other areas are to be irrigated by the five irrigation ponds and their distribution systems. The capacity of the main, secondary and tertiary irrigation canals and related structures in the distribution system is to be planned at peak water requirement to facilitate a rotative irrigation in the whole project area, but that of primary feeder canal up to a new pond

and related structures is to be set at twice the peak water requirement to smoothly feed the five irrigation ponds, particularly the first one;

(7) The primary and secondary feeder canals of the supply system are to be continuously operated to effectively feed the irrigation ponds with excess discharge of the river during a limited period of time. However, a rotation distribution system is to be applied to equitably distribute water to all the fields in the project area (except the 209 ha in the northernmost part to be irrigated directly by the supply system) by intermittent operation of the main and secondary irrigation canals;

(8) The primary and secondary feeder canals are to be so planned as to keep low velocity in case of earth canals and to be provided with sediment traps to protect the ponds from sediments brought by erosion and scouring;

(9) Headworks consisting of a tyrolean type weir and intake structure, a headrace canal and structures related to the feeder and distribution canals and irrigation ponds are to be planned as permanent structures, taking into consideration the difficulty in repair and restoration and the cost sharing by beneficiary farmers;

(10) In the command area of the Ranikudwa Farmers' Irrigation System the existing canal routes are to be utilized as long as possible to mitigate the farmers' burden in land acquisition for construction of feeder and distribution canals and related structures;

(11) Existing four ponds are to be enlarged by heightening and extending their levees and constructing inlet, outlet and spillway structures; a new pond is to be created by constructing dikes and levees around the pond area, inlet, outlet and spillway structures, taking their economic viability into account;

(12) The drainage network consisting of primary, secondary and tertiary drains and related structures is to be planned based on the unit drainage requirement computed in line with the design manual compiled by the Planning and Design Strengthening Project (PDSP), in which the drainage requirement is based on 3-consecutive day rainfall with a 10-year recurrence period; and

(13) The service roads along the feeder canals and main and secondary canals would not be provided because of the sufficient number of existing village and farm roads in the project area and in order to mitigate the farmers' burden in land acquisition. This was requested by farmers in a series of explanation meetings on the Rajkudwa Irrigation Project between the study team and the farmers. Thus, instead of constructing new service roads, the existing major village and farm roads in close vicinity of the canals are to be improved for facilitating O&M of the canals and related structures and transport of agricultural inputs and products, as well as for improving the socio-economic conditions in the project area.

5.3.2 Water Resources and Availability

Water resources of the project are part of the discharge of the Gudrung river diverted at the headworks site in Ranikudwa, about 400 m north of Pattharkot village, and a series of springs in the vicinity of Birpur village. In addition, to assure supplementary irrigation to both the rainy season paddy and the dry season crops, the excess discharge of the Gudrung river will be stored in the four existing ponds which will be enlarged and a new pond to be constructed in the state-owned natural forest outside the arable lands.

However, in order to ensure the implementation of such a pond development plan as mentioned above, it is indispensable to obtain the final permission of the ministries and agencies concerned for cutting trees and acquiring lands, though a general consent on such issues was made at the district level during the field investigation for the feasibility study.

The 10-day gross and available discharges of the Gudrung river and the available discharge of springs in 1983, the base year in computing the daily river discharges at 80 % dependability against the water requirement calculated on a 10-day basis for 15 years, were estimated as follows:

(Unit: 1,000 m^3)

Month	Gross Discharge of Gudrung	Available Discharge of Gudrung	Available Discharge of Springs	Total
Jan. 1	168	168	21	189
2	166	166	21	187
3	380	318	23	341
Feb 1	162	162	21	183
2	160	160	21	181
3	148	142	19	161
Mar. 1	153	153	7	160
2	149	149	7	156
3	158	158	8	166
Apr. 1	138	138	7	145
2	234	174	7	181
3	131	131	7	138
May 1	145	129	7	136
2	506	346	7	353
3	276	191	8	199
Jun. 1	136	119	41	160
2	252	189	41	230
3	238	176	41	217
Jul. 1	1,204	936	41	977
2	722	422	41	463
3	3,142	847	46	893
Aug. 1	8,011	2,415	41	2,456
2	1,819	1,113	41	1,154
3	1,642	729	46	775
Sep. 1	6,492	2,381	41	2,422
2	6,018	2,005	41	2,046
3	2,074	1,365	41	1,406
Oct. 1	2,544	1,015	41	1,056
2	1,718	1,157	41	1,198
3	239	239	46	285
Nov. 1	179	179	21	200
2	176	176	21	197
3	173	173	21	194
Dec. 1	170	170	21	191
2	168	168	21	189
3	932	694	23	717

The available discharge of the Gudrung river was estimated based on the meteo-hydrological analysis on hourly rainfalls recorded by an automatic rain-gauge installed at Basantapur and hourly discharges of the river measured by the study team. The details of the available discharge are given in Section A.4 in the Annex Report.

5.3.3 Irrigation Area

The Gudrung irrigation system, supplemented by natural springs in Birpur area and five irrigation ponds including a new one, would irrigate 1,800 ha of paddy fields in the rainy season and 1,130 ha of upland crop fields in the dry season, provided that the cropping ratio of wheat, vegetables and mustard in the dry season be 3 : 1: 1. The irrigation area of 1,800 ha is divided into two different types of irrigation system, i.e., 209 ha is directly irrigated by both the upper reaches of the primary feeder canal branching off from a headrace canal and the natural springs in Birpur area, and the remaining 1,591 ha is irrigated by the five irrigation ponds.

5.3.4 Irrigation Water Requirement and Water Balance

The irrigation water requirement was computed on a 10-day basis for 15 years from 1978 to 1992, from evapo-transpiration calculated by the modified Penman formula on a 10-day basis, consumptive use of water of crops based on the evapo-transpiration, deep percolation (in case of paddy only), and effective rainfall. The evapo-transpiration was based on such meteorological data as temperature, relative humidity, wind velocity and sunshine duration of 11 years (1976-86) at the Bhairahawa agricultural station, located about 50 km east-south-east of the center of the project area. Then, the unit peak water requirement was set at 1.2 l/sec/ha with a 80 % probable value (peak water requirement for paddy in August 1978) among the annual peak water requirements for paddy for 15 years.

The base year in computation of irrigation water requirement on a 10-day basis was set at 1983, showing a 80 % dependable value among the cumulative water requirement of a paddy growing season calculated on a 10-day basis for each of the 15 years. The irrigable area has come to 2,000 ha as a minimum value of the daily irrigable areas computed from both daily available water, including daily discharge of the five irrigation ponds and daily water requirement of paddy growing in the base year. However, the irrigation area of the project was set at 1,800 ha of arable lands, since 200 ha of arable lands can't be irrigated because of higher ground elevation. The daily water balance between irrigation water requirement and available water for the proposed cropping pattern (1,800ha of paddy, 680 ha of wheat, 225 ha of mustard, 225 ha of winter vegetables and 100 ha of spring vegetables) in the base year (1983), which is detailed in Section F.4 in the Annex Repot, is summarized below:

(Unit: 1,000 m^3)

Month		Irrigation Water Requirement	Available Water	Water Balance	Month		Irrigation Water Requirement	Available Water	Water Balance
Jan.	1	492	189	-303	Jul.	1	698	977	279
	2	497	187	-310		2	1,489	463	-1,026
	3	108	341	233		3	0	893	893
Feb.	1	460	183	-277	Aug.	1	0	2,456	2,456
	2	152	181	29		2	924	1,154	230
	3	0	161	161		3	0	775	775
Mar.	1	15	160	145	Sept.	1	0	2,422	2,422
	2	29	156	127		2	0	2,046	2,046
	3	49	166	117		3	324	1,406	1,082
Apr.	1	84	145	61	Oct.	1	0	1,056	1,056
	2	49	181	132		2	0	1,198	1,198
	3	98	138	40		3	0	285	285
May	1	106	136	30	Nov.	1	116	200	84
	2	27	353	326		2	294	197	-97
	3	43	199	156		3	396	194	-202
Jun.	1	16	160	144	Dec.	1	339	191	-148
	2	772	230	-542		2	398	189	-209
	3	1,557	217	-1,340		3	0	717	717

In addition, the daily water balance of the five irrigation ponds is graphed in Fig. 5.2.

The gross irrigation water requirements were computed by applying irrigation efficiencies to net water requirements. The applied irrigation efficiencies are 0.60 and 0.50 in paddy fields and upland crop fields, respectively.

5.3.5 Irrigation System and Method

The canal system in the project area is divided into a supply system feeding the five irrigation ponds with excess discharge of the Gudrung river and five irrigation systems comprising a canal system branching off from the primary feeder canal and four pond systems originating from the respective ponds and irrigating the respective command areas, to facilitate water management in independent operation of the supply system and the irrigation systems.

The supply system consists of headworks, a headrace canal, and primary and secondary feeder canals to the five irrigation ponds. The respective irrigation systems comprise main, secondary, tertiary and quaternary irrigation canals, in principle. Except 209 ha of paddy fields which are irrigated directly by the secondary canals, branching from the upper reaches of the primary feeder canal, 1,591 ha of paddy fields are commanded by the five irrigation ponds, each of which has a canal network. The command area under each tertiary unit is 30 ha, in principle.

The size of 30 ha of each tertiary unit was determined based on the past experience so as to minimize application loss of irrigation water in paddy fields and to assure effective functioning of the water users' group organized for each unit.

The irrigation area is divided into five irrigation blocks by a canal system and four pond systems as follows:

Irrigation Block	Irrigation Area(ha)
1. Primary feeder canal upstream (including springs)	209
2. Tikker pond	695
3. Badahara pond	79
4. Gorusinge pond	400
5. Dewari/Buddi pond	417
Total	1,800

The irrigation diagram of each system is shown in Fig. 5.5.

Except an upstream section of the primary feeder canal up to Tikker pond, irrigation canals commanded by five irrigation ponds at all levels will always carry the design discharge for a particular season. In case of scarcity of water, the alternate secondary canals will either be allowed to carry the design discharge or shut down completely by applying a rotation system. However, the water level in the main canal will have to be maintained to the design level by means of cross regulators. No proportional distribution of reduced discharge throughout a system is applied to avoid difficulty in equitable distribution. This system of irrigation has been proposed in order not to allow farmers to adjust the gates according to their wish and to reduce the gate operation difficulty. In this way, all a gate operator needs to do is to maintain the water level to the design level in the main canal and open or close the secondary canal gates completely in turn. The rotation mode to be applied is in the range from 1 : 1 to 1 : 3 for paddy, and 1: 5 to 1 : 10 for such winter crops as wheat, vegetable and mustard, and also for spring crops.

5.3.6 Irrigation Facilities

The intake structure of the headworks, headrace canal and upstream section of the primary feeder canal (up to Tikker pond) were designed with the design discharge of 4.4 m^3/sec, which is twice the peak water requirement of 2.2 m^3/sec for paddy growing, to effectively feed the Tikker pond with the excess discharge of the Gudrung river during several hours of flood. On the other hand, the primary and secondary feeder canals downstream of the Tikker pond, main, secondary and tertiary canals and related structures were designed with an unit design discharge of 1.2 l/sec/ha, to smoothly feed the other four irrigation ponds with the Gudrung discharge and also to facilitate a rotative irrigation in all of the pond command areas, taking into account the peak water requirement in paddy and wheat growing, i.e., 1.2 l/sec/ha and 0.6 l/sec/ha, respectively.

The Gudrung headworks will consist of a tyrolean type 40 m long and 1.5 m high diversion weir to avoid damage by large rolling boulders during high floods, with a cutoff wall resting on the bed rock to reduce the seepage loss. The geotechnical investigation conducted during the feasibility study confirmed the existence of bed rock 5 m to 6.5 m below the existing river bed. The silt excluder, which will be inside the weir body, will be an integral part of the headworks. It will also have an intake structure, spillway and flushing gate at the left end of the weir. Large particles like boulder and gravel will be sieved out by a screen fitted on the weir. The preliminary design of the headworks is shown in Fig. 5.3.

The 450 m long Gudrung headrace canal will consist of a closed concrete conduit in the first 420 m and a sand excluder including spillway and wasteway in the last 30 m. This provision has been proposed in order to protect the headrace canal from both the falling stones and debris from the steep transverse slope on the left bank and the partial surface erosion of the slope, and also to protect the primary feeder canal from sediment load, erosion and scouring by floods.

The number and length of canals for the proposed irrigation system were estimated as follows:

Canal Type	Nos.	Length (km)
1. Feeder Canals		
Primary	1	15.5
Secondary	3	5.3
Sub-total	4	20.8
2. Irrigation Canals		
Main	3	4.5
Secondary	25	26.8
Tertiary	64	57.0
Sub-total	89	88.3
Total	93	109.1

As far as possible, the existing canal routes will be utilized for the proposed canal network to reduce construction cost and also to avoid loss of farmland due to construction. As a result, the majority of primary and secondary feeder and irrigation canals in the northern part from the East-West Highway will follow the existing canal routes. However, only a minor part of them will be aligned along the existing routes in the southern area. Most of the tertiary canals will be constructed in new alignments.

In general, all canals will have an unlined trapezoidal section. However, rectangular concrete flumes are proposed for a section of about 650 m of the primary feeder canal in Pattharkot village which is a built-up area. Rectangle flumes are also proposed for 3.9 km out of about the 9.3 km long primary feeder canal section from Pattharkot village to a bifurcation structure for the east and west primary feeder canals located near Murmi village, where the natural longitudinal slope is 1: 200 on an average, to avoid problems in land acquisition for wider right-of-way of the canal and to protect the canal and related structures from erosion and scouring. The East-West Highway will have to be crossed by primary feeder and main and secondary canals at three locations, one of which will be a box type syphon and the other two will be box type culverts.

The following table shows the numbers of structures related to the feeder and irrigation canals for the whole Gudrung irrigation system estimated from the preliminary layout and canal designs based on the topo-map at a scale of 1: 5,000 and topo-survey of canal routes conducted by the study team:

Type of Structure	(Unit)	Feeder Canals	Main Canals	Secondary Canals	Tertiary Canals	Total
1) Concrete flume	(km)	6.1	0	0	0	6.1
2) Cross regulator	(no)	16	6	0	0	22
3) Proportional bifurcation	(no)	1	0	5	0	6
4) Inlet of pond	(no)	4	0	0	0	4
5) Outlet of pond	(no)	1	3	0	0	4
6) On-off gated turnout	(no)	14	10	0	0	24
7) Ungated APM turnout	(no)	0	0	0	64	64
8) Drop structure	(no)	22	2	10	161	195
9) Syphon	(no)	1	0	3	0	4
10) Aqueduct	(no)	6	2	8	30	46
11) Culvert for canal	(no)	20	4	17	35	76
12) Side spillway	(no)	5	0	0	0	5
13) Gated spillway	(no)	1	0	0	0	1
14) Sediment trap	(no)	4	0	0	0	4
15) Terminal structure	(no)	0	0	25	0	25
16) Foot bridge	(no)	55	19	64	0	138
17) Cross drain	(no)	19	1	9	18	47
18) Washing steps	(no)	50	0	0	0	50
19) Drainage out-fall	(no)	15	0	6	0	21
20) Protection works for curved part	(no)	35	6	54	0	95
21) Offtake for 4th canal	(no)	0	0	0	470	470
22) Spring intake	(no)	1	0	0	0	1
23) Stilling basin	(no)	8	0	0	0	8
Total		278	53	201	778	1,310

These structures will be made of concrete and wet masonry. Of the above-listed structures, only those in items 2), 4), 5), 6), 13) and 14) are gated structures. Adjustable Proportional Module (APM) turnouts are proposed for the tertiaries, but the APMs once being adjusted for a particular design water level in a secondary canal will never be allowed to be adjusted later by the farmers. APM turnouts will be made of precast concrete blocks.

The preliminary layout of the irrigation canal network and the irrigation diagram are shown in Figs. 5.4 and 5.5, and the preliminary design of the primary feeder canal, some of the secondary irrigation canals and some of the major related structures is shown in the Annex Report.

5.3.7 Irrigation Ponds

In order to store the surplus discharge of the Gudrung river and rainwater during the rainy season and to use the storage water effectively for both the rainy season paddy and the dry season crops, the four existing ponds will be improved and enlarged, and a new pond will be constructed in the state-owned forest outside the irrigation area. The effective storage capacities of the four existing ponds at present and their proposed capacities after improvement and enlargement are as follows :

Name of Pond	Effective Storage (m^3)	
	Existing	Proposed
North of East-West Highway		
1. Badahara	84,000	120,000
2. Gorusinge	54,000	135,000
South of East-West Highway		
3. Buddi	180,000	490,000
4 Dewari	73,000	270,000
Total	391,000	1,065,000

The above-mentioned ponds will be fed by a primary and two secondary feeder canals. The new irrigation pond, which will be fed by the primary and secondary feeder canals will have the following maximum capacity:

Name of Pond	Effective Storage (m^3)
1. Tikker	2,065,000

The overall seepage loss of the Tikker pond with a water surface area of 51.5 ha was estimated to be 1.5 mm a day (8.9 l/sec) by the additional geotechnical and soil mechanical surveys to the proposed five irrigation ponds conducted by JICA, including the field survey carried out by dispatching an expert of the study team to the site during the one month from September 17 to October 16, 1993 and the consecutive office works, including a seepage analysis for the Tikker pond, in Japan. In addition, the seepage losses of the other four existing ponds after enlargement were judged to be less than that of the Tikker pond, since these ponds are located in a flatter area of the Terai plain where has high groundwater levels and will have shallower water depth, after enlargement, compared to the Tikker pond. Therefore, no seepage protection works is necessary for the Tikker pond as well as the other four existing ponds to be enlarged, besides the drainability of the farmlands located downstream of each pond will not be worse because of a few seepage from each pond. However, in the water balance computation of the five ponds, by which the irrigation area was decided to be 1,800 ha, the overall seepage loss of the five ponds was set at 3.0 mm a day on an average, taking the indefinite factors in the seepage analysis into account. The results of the geotechnical and soil mechanical surveys and the seepage loss of the proposed Tikker pond are compiled as Attachment - II in the Annex Report.

For both improvement and enlargement of the existing four ponds and construction of a new pond the following land acquisition will have to be settled mainly between DOF and DOI:

Name of Pond	Proposed Pond Area (ha)	Existing Pond Area (ha)	Required Land Aquisition (ha)
Existing Pond			
1.Badahara	18.2	7.4	10.8
2.Gorusinge	7.7	1.7	6.0
3.Buddi	28.6	19.2	9.4
4.Dewari	52.6	12.2	40.4
New Pond			
5.Tikker	55.5	0	55.5
Total	162.6	40.5	122.1

Note: The above figures include the dikes or levees of the ponds.

It is already confirmed by the Nepalese couterpart engineers that there exists no inhabitant to be removed as well as no house and farmland to be inundated in the proposed pond areas, and the extension area of the Gorusingen pond was set to be outside the present army camp located east of the existing pond.

Improvement and enlargement of the existing ponds will be carried out by heightening the existing dikes or levees and enlarging the storage area, limiting it within the forest area only. All the irrigation ponds will be equipped with inlet, outlet and spillway structures. No excavation of pond bed is proposed because of the high cost involved. The new pond will be constructed by providing an earth dike in the narrowest part of the natural depression, with spillway and outlet structures for irrigation, embanking necessary levees around the storage area, and constructing an inlet structure for receiving water from the feeder canal. The preliminary designs for improvement and construction of the irrigation ponds are shown in Figs. 5.6 and 5.7.

5.3.8 Drainage Water Requirement

In line with the Design Manual of the PDSP being used by DOI, the unit drainage requirements were set as follows:

(Unit: l/sec/ha)

	Drain	Structure
1) Drainage in the command area	6.0	9.0
2) Drainage from the outside area	9.0	13.5

The unit drainage requirements were calculated based on the following conditions:

1. Drainage in the Command Area (in case of drains)
   1) To drain 3-day rainfall with a 10-year recurrence period over 3 days.
   2) Presumption
      (1) 3-day rainfall with a 10-year recurrence period is 407 mm, according to the rainfall data at Pattharkot.
      (2) The initial water depth in the fields is 40 mm.
      (3) The allowable water depth in the fields is 300 mm.
      (4) The allowable period of inundation of more than 200 mm is 3 days.

2. Drainage in the Command Area (in case of structures)
   1) 1.5 times the drainage requirement for drains.

3. Drainage from the Outside Area (in case of drains)
   1) 1.5 times the drainage requirement for drains in the command area, in consideration of the economic viability.

4. Drainage from the Outside Area (in case of structures)
   1) 1.5 times the drainage requirement for drains from the outside area.

5.3.9 Drainage System and Facilities

The drainage network, consisting of primary, secondary and tertiary drains with related structures, was planned to meet the drainage requirement of the proposed irrigation canal network and the runoff from outside of the project area. The drainage canals and the related structures in the irrigation area were designed with the unit discharge of 6.0 l/sec/ha and 9.0

l/sec/ha, respectively to smoothly drain off 3-day rainfall with a 10-year recurrence period over 3 days from the paddy fields.

The existing Ghorahi drain was designed to be the primary drain for the system after being rehabilitated. Major parts of secondary drains will be aligned along the existing irrigation canals and natural drains, while tertiary drains including some parts of secondary drains will follow new alignments in farmlands.

The preliminary layout and drainage diagram of the proposed drainage network are shown in Figs. 5.8 and 5.9.

The number and length of the proposed drains of different types are as follows:

	Nos.	Length (km)
1. Primary drain	1	18.6
2. Secondary drain	20	24.2
3. Tertiary drain	48	26.4
Total	69	69.2

The structures required for the drainage network are as follows :

Type of Structure	Primary Drain	Secondary Drain	Tertiary Drain
1) Cart bridge	4	2	0
2) Foot bridge	11	13	0
3) Culvert	0	15	57
Total	15	30	57

These structures will mainly be made of concrete and wet masonry.

5.3.10 Farm Roads

No service road was proposed to be constructed along the canals to avoid loss of farmland due to road construction. An other reason for not providing such roads is that most of the major canals are aligned close and parallel to either the East-West Highway or the Gorusinge - Pattharkot road and other existing village or farm roads. Instead of constructing the service roads, the existing major village and farm roads will be improved by widening and gravelling for increasing accessibility to different places, improving transportation facilities to supply agricultural inputs and outputs, and improving the socio-economic conditions. The routes of the village and farm roads to be improved are shown in Fig. 5.10.

The improvement works will be carried out to keep the width of village and farm roads at 3.5 m and their height at 50 cm, including surface gravel metalling over 2.5 m in width and 15 cm in thickness.

The length of village and farm roads to be improved will be 49.5 km in total, and the number of the required structures was estimated as follows :

Type of Structure	Numbers
1) Box type culvert	1
2) Pipe type culvert	111
Total	112

These structures will mostly be constructed with concrete and wet masonry.

5.3.11 Water Management and O&M

A part of the discharge of the Gudrung river taken at the headworks will first be used to irrigate 209 ha of paddy fields located upstream of the Tikker pond which will be the first irrigation pond, and the rest will be supplied to the five irrigation ponds one by one in order from north to south. The remaining irrigation area of 1,591 ha will be divided into four sub-irrigation areas, each of which will be commanded by an irrigation pond with a canal network.

The 209 ha of paddy fields and five irrigation ponds will be continuously fed by the primary and secondary feeder canals, but the remaining 1,591 ha will be intermittently irrigated by the four irrigation systems originating from the respective irrigation ponds.

According to the new irrigation policy of HMG/N, in which it is stipulated that in the Terai plain all the irrigation system commanding less than 2,000 ha of arable lands be turned over to the beneficiary farmers' association and all the water management and O&M be carried out by the farmers' association in its full responsibility. Furthermore, the water management and O&M of each of the existing systems: Ranikudwa, Badahara, Buddi, etc. have been carried out by a single water users' group. Therefore, similar type of provision will be applied for the new system, that is, the water management and O&M of the proposed irrigation aystem will be carried out by the Rajkudwa Water User' Association, which will be organized by all the beneficiary farmers, centering around the existing Ranikudwa water users' association, and thereby no separate organizations for water management and O&M will be established under the proposed irrigation system.

WUG, the lowest unit of WUA will be organized in every tertiary unit of about 30 ha command area. All farmers of the tertiary unit will be a member of the WUG concerned and all WUGs under the secondary canal concerned will form a secondary WUA. Similarly, an upstream WUA and five pond WUAs will be organized by the secondary WUAs concerned, and a central level WUA (CLWUA) will be formed by the upstream WUA and five pond WUAs for the proposed irrigation system.

A Chairperson and a Secretary will be elected from each WUG to the secondary level Water Users' Association (SLWUA) and they will be members of the SLWUA. Similarly, the Chairperson and the Secretary elected from each SLWUA will be members of the pond WUA (PWUA) or the primary canal upstream WUA (PUWUA) concerned, each of which has a Chairperson and two Secretaries elected from the members, and CLWUA of the entire irrigation system will be composed of a Chairperson and two Secretaries elected from each of the PUWUA and PWUAs and will have a Chairperson and two Secretaries elected from the members.

The Chairman and the Deputy Chairman of the VDC concerned will also be the ex-officio members of the CLWUA, which will also have one Chairperson and two Secretaries elected from the members.

The CLWUA will be responsible for the overall water management and O&M of the entire system including the five irrigation ponds, however it will be especially responsible for the O&M of the headworks, headrace canal, and primary and secondary feeder canals. Decisions regarding canal discharges, pond operation, rotation mode, and rotation schedule will also come under the responsibility of CLWUA. The regulations of the WUAs, including penalty clauses to violators will also be established by the CLWUA in support of the majority of the members.

The PUWUA or PWUA will take responsibility for the water management and O&M of the pond concerned and its main canal.

The SLWUA will be responsible for the water management and O&M of the secondary canals concerned and equitable distribution of water among the tertiary canals. Supervision to prevent stealing of irrigation water will also come under its responsibility.

The WUGs will be responsible for the water management and O&M of the tertiary, quaternary and field channels concerned. They will also be responsible for the equitable water distribution among quaternaries and prevention of water stealing.

CLWUA will employ a required number of gatemen for O&M of the intake gate, spillway gate and sandflush gate in the headworks, cross regulator gates in the primary canal, turnout gates in secondary canals, and intake and offtake gates in irrigation ponds. The required cost including salary of employees and repair and maintenance cost of gates and others will be collected from all the beneficiary farmers under the proposed system in proportion to their irrigated area.

Routine O&M of primary and secondary feeder canals, irrigation ponds, main, secondary and tertiary canals, such as clearing weeds, desilting, maintaining pond levees and canal sections will be timely carried out by labour contribution as decided by CLWUA and PUWUA, PWUA, SLWUA and WUG concerned.

O&M of the drainage system will also have to be carried out by the water users' organizations concerned at respective levels as in the irrigation system. That is, O&M of primary, secondary and tertiary drains will be carried out by CLWUA and PUWUA, PWUA, SLWUA and WUG concerned.

The organization chart of the proposed WUAs and WUGs is shown in Fig. 5.11 and 5.12.

CHAPTER VI PROJECT WORKS

6.1 Irrigation and Drainage Works

6.1.1 General

The project works consist of the irrigation and drainage works and the agricultural support facility works. The irrigation and drainage works comprise the construction of a headworks, including a tyrolean type weir, intake, sand excluder, etc., a headrace canal, primary and secondary feeder canals, five irrigation ponds, main, secondary, and tertiary irrigation canals, primary, secondary, and tertiary drains, major village and farm roads and related structures. The construction of tertiary canals and drains is included in the project works, taking into account such matters that in the national irrigation projects so far implemented in Nepal the tertiary canals and drains were constructed under the project budget, besides the new irrigation policy of HMG/N stipulates that they must be constructed as a part of the project works in the case of national projects.

The Ranikudwa farmers' irrigation system will be thoroughly re-constructed since the headrace, primary, secondary, and tertiary canals have not only been constructed to irrigate about 630 ha of arable lands, but also have been severely deteriorated by erosion and scouring, as a result of their steep longitudinal slopes and small water sections, besides almost all of the related structures have also seriously deteriorated because of their temporary nature. However, the headrace canal, new primary and secondary feeder canals, and main and secondary irrigation canals are mostly aligned on the existing canal routes, except for the tertiary canals which are to be newly aligned, to reduce farmland loss in the construction of such irrigation facilities.

On the other hand, in the irrigation areas other than the Ranikudwa command area all of the irrigation facilities will be newly constructed. However, some of the new small canals will be constructed on the existing canal routes to decrease farmland loss.

The four existing ponds to be improved and enlarged are Badahara, Gorusinge, Dewari and Buddi, of which their storage capacities will be largely increased by heightening the existing levees and enlarging the existing pond areas. In addition, a new pond, namely Tikker pond will be constructed by embanking dikes and levees around the basin.

To provide the drainage facilities which will match the above-mentioned irrigation facilities, Ghorahi natural drain will be used as a primary drain after it has been widened, and other small natural drains will be utilized as secondary drains after they have been improved. However, the tertiary drains will be newly constructed.

The major village and farm roads will be improved to gravel metalling roads which will have a total width of 3.5 m, of which 2.5 m will be metalled with gravels.

6.1.2 Proposed Works

The following irrigation and drainage works will be implemented to realize the formulated agricultural development:

1) Construction of Gudrung headworks including a 40 m long tyrolean type weir, intake, sand excluder, spillway, etc.;
2) Construction of a 450 m long headrace canal consisting of a 420 m long closed conduit and 30 m long sand excluder including a spillway and wasteway;
3) Construction of 20.8 km of feeder canals, consisting of 15.5 km of primary feeders, 5.3 km of secondary feeders, and 278 related structures;
4) Improvement and enlargement of four existing ponds and the construction of a new pond;
5) Construction of irrigation canals of 88.3 km in length, consisting of main canals of 4.5 km, secondary canals of 26.8 km, tertiary canals of 57.0 km and 1,032 related structures;
6) Construction of drainage canals of 69.2 km in length, of which 18.6 km is a primary drain, namely the improvement of the Ghorahi natural drain and 24.2 km are secondary drains, the improvement of small natural drains; and
7) 49.5 km improvement of the major village and farm roads.

6.2 Agricultural Support Facility Works

6.2.1 General

In order to attain the target of the formulated agricultural development plan for the effective use of the irrigation and drainage facilities constructed, a farmers' association center (FAC) will be constructed at the center of the project area along with five village farmers' cooperative offices, which will be provided for each of the five VDCs concerned.

FAC will consist of an office and a meeting hall for both the central level farmers' cooperative (CLFC) and the central level water users' association (CLWUA), a multipurpose warehouse and a drying yard for cereal crops. The village farmers' cooperative office will have an office and meeting room for VDC level farmers' cooperative (VLFC) and water users' association (VLWUA) and a multipurpose godown.

The agricultural support facilities lands will be granted by beneficiary farmers through the VDCs concerned. The constructed agricultural support facilities will be handed over to the farmers' association which consists of the farmers' cooperatives and WUAs, and will be operated and maintained by them under the advice and guidance of District Agricultural Development Office (DADO) and District Irrigation Office (DIO) without the financial assistance or subsidy of HMG/N.

6.2.2 Proposed Works

The following agricultural support facilities will be constructed to strengthen the farmers' association consisting of the farmers' cooperatives and WUAs:

1) a farmers' association center on 3,000 m^2 of land, which will consist of:
   (1) an office (50 m^2) and a meeting hall (75 m^2) for the central level FC and WUA; and
   (2) a multipurpose warehouse (200 m^2) and drying yard (1,000 m^2)

2) five VDC farmers' cooperative offices, each of which will include:
   (1) an office (40.m^2) and a meeting room (50 m^2) for VDC level FC and WUA; and
   (2) a multipurpose godown (160 m^2)

6.3 Implementation Program

6.3.1 General

The project works are divided into the irrigation and drainage works and the agricultural support facility works. The regular construction of the irrigation and drainage works will commence in November 1994 and will be completed in about twenty months by the Contractor allocated through an international tender (ICB) after the pre-construction arrangements, including budget arrangements by the executing agency, the detailed design by a consulting firm, tender for the work, and the preparatory work by the Contractor, including mobilization of its staff and equipment. The agricultural support facilities will be constructed keeping pace with the construction progress of the irrigation and drainage works. The executing agency of the project will be DOI under the Ministry of Water Resources, and the daily management and supervision of the works will be conducted by the project office to be newly provided by DOI. The completed irrigation and drainage facilities and agricultural support facilities will be handed over to the farmers' association comprising farmers' cooperatives and WUAs organized by the beneficiary farmers in line with the present irrigation policy of HMG/N, and the management and O&M will be carried out by the association which shall be totally responsible for these tasks.

6.3.2 Implementation Schedule

(1) Pre-arrangements for Implementation
A budget arrangement for the project is urgently required in order to implement both the detailed design and the construction on time. The arrangement is to commence at the latest in August 1993 and the detailed design requiring seven months will begin in November 1993. The detailed design will include a review of the feasibility study, topo-survey of the proposed pond areas and canal routes, geological and soil mechanical investigation on leakage and seepage of the proposed pond areas, detailed design of both the irrigation and drainage facilities and the agricultural support facilities, preparation of tender documents for construction of the project works including agricultural support facilities, etc.

The major pre-construction works will include the selection of contractor(s) and land acquisition required for the construction work. Tendering of the work will commence in June 1994, and the land acquisition will have to be settled in parallel with the tender work .

(2) Construction Period

The construction of the project facilities will commence in October 1994 and will be completed after twenty months. However, the construction period of the project will be twenty-one months from the time of contract signing between the executing agency and the contractor(s). The construction of the agricultural support facilities, which is involved in the irrigation and drainage works contract, is to be carried out, keeping pace with the construction progress of the irrigation and drainage works. The project office shall be constructed in the early stage of construction for smooth construction management and supervision, including quality and progress control, particularly in the early stages of construction.

The implementation time schedule of the project is shown in Fig. 6.1.

6.3.3 Organization and Management

(1) Executing Agency and Project Office

DOI will be the executing agency for the implementation of the project works, and therefore will be required to coordinate with the ministries and governmental agencies concerned, particularly the Department of Forests (DOF) and the Department of Agricultural Development (DOAD) including these district offices, and the District Administration Office for the project activities. DOI has sufficient capability and ample experience in the implemention of irrigation projects, including the detailed design and construction supervision and management.

For smooth and proper implementation of the project it was proposed to establish a project office in a branch of the Butwal Tubewell Office, located in Chanauda along the East-West Highway, prior to the commencement of the detailed design work. The proposed organization for the project implementation is presented in Fig. 6.2.

(2) Operation and Maintenance (O&M) of the Completed Facilities

In line with the present irrigation policy of HMG/N, it was proposed that the management and O&M of the completed project facilities be carried out by the farmers' association consisting of the farmers' cooperatives and WUAs, which will be organized by the beneficiary farmers, who shall be totally responsible for these tasks and any expenses under the advice and guidance of both DIO and DADO.

The proposed organization for the O&M stage is presented in Fig. 6.3.

6.4 Project Cost

6.4.1 Conditions of Cost Estimate

The project cost is composed of the following three items:

(i) Direct construction cost of the project facilities comprising the irrigation and drainage works and agricultural support facility works, including the physical contingency;
(ii) Associated costs consisting of project administration expenses and engineering services costs; and
(iii) Price contingencies.

The project cost is estimated at the price level of March 1993. The exchange rate applied was US$ 1 to NRs.50.0. The project cost is divided into foreign currency (F.C) and local currency (L.C) components in accordance with the origin of the materials. The estimated cost is, however, expressed in Nepalese Rupees for both local and foreign currency components.

Physical contingency is estimated at 20 % of the direct construction cost, taking into account the accuracy of investigation, survey and design carried out for the project works in the feasibility study. The annual price escalation rate is assumed at 3.9 % for the foreign currency component and 12.0 % for local currency component, referring to a guideline of ADB.

6.4.2 Initial Investment Cost

The initial investment consists of the following costs:

(1) Direct construction cost for irrigation and drainage works
The direct construction cost is composed of the following three items:

(i) Construction cost of irrigation and drainage facilities for 1,800 ha of arable lands;
(ii) Improvement cost of major existing village and farm roads of 49.5 km; and
(iii) Physical contingency for the above works.

The direct construction cost is estimated at unit price basis, i.e., by means of multiplying unit prices of works and quantity of the corresponding work. The total direct construction cost is estimated at NRs.390.3 million (equivalent to US$ 7.8 million), consisting of NRs.190.0 million (equivalent to US$ 3.8 million) for foreign currency component and NRs. 200.3 million for local currency component.

(2) Direct construction cost of agricultural support facilities
The direct cost is estimated at NRs.14.2 million (equivalent to US$ 0.3 million), consisting of NRs. 3.6 million for a farmers' association center and NRs.10.6 million for five VDC farmers' cooperative offices. The total cost of NRs.14.2 million is

divided into NRs.4.7 million (equivalent to US$ 0.1 million) for foreign currency portion and NRs.9.5 million for local currency portion.

The cost is estimated referring to the unit construction costs of the similar facilities in other projects in Terai plain.

(3) Administration expenses

The administration expenses include the direct project administration cost of DOI at the project site and the compensation cost for the crops, lands and houses to be severely affected by the construction works. The administration expenses are estimated at NRs.10.1 million (equivalent to US$ 0.2 million) in local currency component.

No land acquisition cost is budgeted for the lands required for the project facilities, since the lands will be provided by the beneficiary farmers and DOF free of cost. All the lands required by the project facilities are estimated at about 159.6 ha, including about 110 ha for five irrigation ponds and about 0.6 ha for agricultural support facilities, of which about 115.6 ha is located in the state owned forests.

(4) Engineering services cost

The required engineering services include detailed design, additional surveys and investigations, construction supervision and training of Nepalese engineers. The required consultant input is 179 M/M, consisting of 59 M/M for expatriates and 120 M/M for nationals. The engineering cost including topo-surveys for the proposed canals and ponds and additional geological /soil mechanical investigations for the ponds is estimated at NRs.80.0 million (equivalent to US$ 1.6 million), consisting of NRs.55.0 million (equivalent to US$ 1.1 million) in foreign currency component and NRs.25.0 million in local currency component.

(5) Disbursement schedule and price contingency

A price contingency is estimated at NRs.106.3 million (equivalent to US$ 2.1 million), consisting of NRs.23.8 million (equivalent to US$ 0.5 million) for foreign currency portion and NRs.82.5 million for local currency portion, from the disbursement schedule and price escalation. The annual disbursement schedule is shown in Table 6.2.

(6) Initial investment cost of the project

The initial investment cost for the project, which is detailed in Table 6.1, is summarized below:

(Unit: NRs.Million)

Description	F/C	L/C	Total
A. Direct Construction Cost			
(1) Irrigation and drainage works	190.0	200.3	390.3
(2) Agricultural support facility works	4.7	9.5	14.2
B. Associated Cost			
(1) Administration cost	0	10.1	10.1
(2) Engineering services cost	55.0	25.0	80.0
C. Physical Contingency	38.9	42.0	80.9
Sub-total	288.6	286.9	575.5
D. Price Contingency	23.8	82.5	106.3
Total	312.4	369.4	681.8

6.4.3 Operation and Maintenance Cost and Replacement Cost

(1) Operation and maintenance cost

The annual operation and maintenance cost of the project includes personnel expenses for water management, and operation and maintenance of constructed irrigation and drainage facilities, labour and material costs for repair and maintenance of the irrigation facilities, etc. The annual operation and maintenance cost is estimated at NRs.2.4 million (equivalent to US$ 0.05 million), which is equivalent to 0.6 % of the direct construction cost of the irrigation and drainage facilities and corresponding to NRs.1,350 per ha, out of which NRs.410 per ha (about 30 %) will be able to be paid by labour work of the member farmers . The O&M cost comprises NRs.0.4 million for water management and NRs.2.0 million for repair and maintenance of the facilities.

(2) Replacement cost

The replacement cost of the steel gates installed is estimated at NRs.1.8 million (equivalent to US$ 0.04 million) per time in local currency portion, on the assumption that the economic useful life of steel gates attached to the structures is 20 years and that of other facilities is 50 years.

CHAPTER VII PROJECT EVALUATION

7.1 General

The evaluation of the Rajkudwa Irrigation Project was made through assessment of the project feasibility from economic, financial, socio-economic, and environmental aspects. The economic feasibility was assessed by the Economic Internal Rate of Return (EIRR), and its sensitivity analysis. The financial evaluation was carried out by analyzing the effect of the project to the farm economy for typical farmers. The indirect benefit and socio-economic and environmental impacts by the implementation of the project were also assessed.

7.2 Economic Evaluation

7.2.1 Basic Considerations

The economic evaluation was made on the following basic assumptions:

i) The economic effective life of the project is 50 years
ii) All prices were expressed in constant 1993 prices
iii) The exchange rate of US$ 1.00 = NRs. 50.0 = Yen 115 was applied (in March 1993)

Tariff and trade restrictions have brought a distortion between the price of traded commodities and non-traded commodities. In order to evaluate the project costs and benefits using international market prices, a Standard Conversion Factor (SCF) was applied to the prices of non-traded goods and services. The SCF of 0.89 in Nepal was applied in this project evaluation.

From the viewpoint of the international economy, the transfer payments such as contract tax, duty, subsidy and interest were considered as a domestic monetary movement which did not cause production. These transfer payments are, therefore, excluded from the project costs for the economic analysis.

The economic prices of tradable agricultural outputs (paddy, wheat, and maize) and farm inputs (urea, triple super phosphate, and potassium chloride) were estimated on the basis of the IBRD projections of world market prices for 2000. The domestic cost elements such as transport, handling, and processing down to the farm-gate level, multiplied by the SCF were deducted from the world market prices in order to compute the farm-gate prices.

The shadow wage rate for the unskilled and farm labours was estimated at 0.70, considering the present employment opportunities in Nepal.

7.2.2 Economic Cost

The economic project cost was estimated by means of deducting transfer payment from the financial project cost, multiplying SCF to non-traded cost and applying shadow wage rate

for unskilled labour cost. The economic construction cost was estimated to be NRs. 462.84 million as shown in Table 7.1.

Economic annual operation and maintenance (O&M) cost was estimated at NRs. 1,870,000. Gates for irrigation facilities were assumed to be replaced every 20 years. The economic replacement cost was estimated at NRs. 1,450,000.

7.2.3 Economic Irrigation Benefit

The economic irrigation benefit is defined as the difference between net profits from agricultural production in the with-project and without-project conditions in the future. The annual irrigation benefit was estimated at NRs. 67.56 million at the full development stage as follows:

(unit: 1,000NRs)

Crop	Without-Project	With-Project	Incremental Benefit
Paddy	18,840	59,040	40,200
Wheat	6,220	21,020	14,800
Maize	330	0	-330
Pulses	930	0	-930
Oilseed	620	2,280	1,660
Vegetables	360	12,520	12.160
Total	27,300	94,860	67,560

The irrigation benefit is expected to increase year to year and reach the full benefit in five years after the completion of project works.

7.2.4 Economic Internal Rate of Return (EIRR)

The EIRR was calculated on the basis of cost-and-benefit flow as presented in Table 7.3. The calculated result is :

EIRR = 11.4 %

A sensibility analysis was carried out to evaluate the soundness of the project against unexpected adverse changes in the future as shown below:

Case 1: Reduction of irrigation benefit by 10 %
Case 2: Cost overrun by 10 %
Case 3: Combination of Case (1) and (2)
Case 4: Reduction of irrigation benefit by 20 %
Case 5: Cost overrun by 20 %
Case 6: Combination of Case (4) and (5)

The results are presented below.

Case	EIRR (%)	Case	EIRR (%)
Base case	11.4		
Case 1	10.4	Case 4	9.3
Case 2	10.5	Case 5	9.8
Case 3	9.6	Case 6	7.9

7.3 Financial Analysis

7.3.1 Farm Budget Analysis

In order to evaluate the project in terms of farmers' economy, the farm budget analysis of different sizes of farmers were made under the "with" and "without" project conditions (Table 7.4). The annual net farm income of the average farmer (farm size of 0.84 ha) is expected to increase by 4.7 times, from NRs 5,460 under the without-project condition up to NRs. 25,720 under the with-project condition. Even in case of the marginal farmers (farm size of 0.34 ha), the net farm income will increase from NRs. 3,020 up to NRs. 12,680.

7.3.2 Capacity to Pay

After completion of the irrigation and drainage facilities, the O&M will be managed by a water users' association organized by the beneficiary farmers. The annual O&M cost was estimated at NRs. 2,430,000 or NRs. 1,350 per ha, out of which NRs.730,000 or NRs.410 per ha will have to be paid in cash, and the remaining will be able to be paid by the labour works of the member farmers. On the other hand, the average annual incremental net profit per ha is expected to be about NRs. 24,000. Since the per ha O&M cost to be shared by the farmers in cash is equivalent to only 1.7 % of the net profit, the farmers will have the sufficient capacity to pay the O&M cost.

7.4 Socio-Economic Impacts

In addition to the direct benefit accounted for in the economic evaluation, the project will bring various secondary and intangible benefits and favourable socio-economic impacts as described below.

(1) Increase of employment opportunities

It is estimated that the project will generate employment opportunities during the construction period since most of the manpower will be supplied from the farmers in and around the project area. The experiences in construction works would be greatly useful for O&M work of the irrigation facilities.

In addition, the project creates the increase of farm labour by the proposed intensive use of farm lands. The farm labour requirement will be increased by 130,000 man-days per year: from 292,000 man-days under the without-project condition to 422,000 man-days under the with-project condition as shown in Table 7.5. The ratio of farm labourers to the total available labor force in the project area is expected to increase from the present 13 % up to 19 % under the with-project condition.

(2) Self sufficiency of food and the improvement of nutritious status of villagers

The stable supply of irrigation water and introduction of improved farming practices will not only increase the crop production but also improve the nutritious status of villagers. The marginal farmers (size of 0.33 ha) will be able to produce sufficient food grains for themselves, and moreover, they will be able to sell about 10 % of their

production for cash income. The increase of vegetable production will also provide an improved nutritious conditions for the villagers. The increase of marketable paddy and wheat in the project area will contribute to mitigate the food deficit in other regions.

(3) Activation of agro-processing and marketing system
Increase of paddy and wheat production will give large profits to rice millers, flour millers and merchants. Increase of mustard seed production enriches oil millers. By these agro-processing, the regional economy will be activated.

(4) Aqua-culture in ponds
The ponds constructed for irrigation will possibly be used for aqua-culture. Fish is a favourite food of the people in the area. Aqua-cultural extension services are being provided by the Bhairahawa fishery development center and Buddi agricultural service center. JICA is providing a project-type technical cooperation for aqua-culture. According to an estimation based on the field survey and related information, it is expected that a pond of one hectare will bring NRs. 4,900 of net profit per year.

(5) Usage of agricultural by-products
By-products such as straw, rice bran, mustard cake, etc. will be utilized for feeding livestock animals and fish, as well as cooking fuels and manure for farming.

(6) Multipurpose use of irrigation water
Irrigation water supplied by canals will be also used for domestic use for villagers and livestock animals.

(7) Activation of village community and people's participation
A farmers' cooperative center building and five village community buildings will be built in five VDCs in the project area. These facilities will play a great role in activating inter-village communications. The proposed water users' association which will be organized by beneficiary farmers for water management and operation and maintenance of the irrigation and drainage facilities and the proposed farmers' cooperatives will increase the opportunities of people's participation for sustainable use of the facilities.

(8) Improvement of local transportation
The local transportation will be greatly improved by the upgrading of the existing village and farm roads, resulting in smooth transport of farm inputs and outputs, convenient village life, and closer relations between villages.

7.5 Environmental Considerations

7.5.1 Basic Concept of Environmental Conservation

The environmental conservation on the implementation of the project shall conform to the following basic concept;

i) The project will not bring about serious adverse effects to the present environment in and around the project area, and

ii) In case that some undesirable impacts might be expected, appropriate countermeasures are to be applied in order to minimize or to keep the impacts within a permissible extent.

7.5.2 Social Environment

(1) Socio-economic issues

Since the project is aimed at irrigating existing non-irrigated and partially irrigated paddy fields, no substantial change will be caused in the villagers' life, economic activities, institutions, and customs. No existing water right has been confirmed for the Gudrung river besides that for the Ranikudwa irrigation system.

Since the four irrigation ponds have been proposed to be enlarged and one newly constructed in the project area, the inundation areas will be extended into the governmental forest by about 122 ha in total. It was however confirmed by the field survey of the feasibility study that no one lived in the inundation area, therefore, no resettlement or compensention was required for this project.

Regarding seepage/leakage of the five ponds, the Tikker pond with a water surface area of 51.5 ha, the biggest one among the proposed five ponds, will not bring serious seepage and maldrain issues to the downstream farmlands, since it was estimated by the Additional Geotechnical and Soil Mechanical Surveys that the overall seepage loss of the Tikker pond would be 1.5 mm a day, corresponding to 8.9 l/sec of percolation rate. It was also confirmed that the other four existing ponds will have a less negative impact to the present invironment around the enlarged ponds because of less seepage losses compared to that of the Tikker pond.

It was confirmed in the series of farmers' meetings held during the study period that the farmers would offer their lands for the construction of the irrigation and drainage facilities of the project. Irrigation water to the existing irrigated area during the construction period could be supplied by the existing canal systems or by temporary by-pass canals.

(2) Health and Sanitary Issues

Dosage amount of fertilizers and agro-chemicals will be considerably increased by extension of intensive agriculture. It is therefore necessary to give adequate guidance and instructions to farmers in order to avoid adverse effects by the increase of the farm inputs.

In general, water related epidemics may increase along with the introduction of irrigated agriculture. However, since malaria control and sanitary instruction for villagers have been well carried out by the concerned agencies, the project will not bring adverse effects on public health.

Drinking water for domestic use almost depends on ground water provided by shallow tube-wells or dug wells. After construction of the Gudrung headworks at Pattharkot, the recharge of groundwater by the river may decrease, however, the recharge from irrigation water may increase. There is only one dug-well in Pattharkot that might be affected by the project. Monitoring of the water table in the dug-well is therefore recommended.

(3) Historical and Cultural Assets and Landscape

It was confirmed that there was no historical, archeological, scientific and scenic values or assets in the project area including adjacent forests.

7.5.3 Natural Environment

(1) Biological and Ecological Issues

For the construction and the improvement of five irrigation ponds, natural forest of 110 ha is to be submerged. The timber resources of the forest to be lost by inundation are estimated as follows:

Forest type:	Sal and Terai hardwood	
Stoking:	Most area is 40 - 70% in crown closure	
Number of stems per ha:	total	726
	> 50 cm	18
	25 - 50 cm	35
	12.5 - 25 cm	58
	< 12.5 cm	615
Stem volume in m^3 per ha:	total	115
	up to 10 cm	83
	up to 20 cm	61
Growth rate per ha:	3.8 m^3/ha/year	

There are 6,400 ha of forest lands in the study area (12,000 ha). The inundated forest area occupies only 1.7 % of the total forest land, and no paddy fields and houses will be submerged by the ponds according to the survey for this feasibility study. The forest is generally in the matured stage and ranked in a medium class in forest resources. Hence, the small change in land use will not significantly affect the present ecological system in and around the objective area.

(2) Soil and Land Resources

The project will bring about no land devastation, soil erosion, soil salinization or soil contamination.

(3) Hydrological, Atmospheric and Water quality issues

There is no significant adverse effect on hydrological condition, atmospheric condition and water quality. Countermeasures for sedimentation in the headworks, canals and irrigation ponds have been worked out in the facility design and the O&M plan.

The forest trees which occupy 28.5 % of the catchment areas of five ponds will be cut or submerged. In order to maintain the function of irrigation ponds, a soil conservation facilities would be provided in need.

Guidance on the proper application of agro-chemicals should be given by JTs and JTAs to farmers so as not to give harmful effects on fish.

7.5.4 Measures for Adverse Impacts

As mentioned above, it was justified that the project would not significantly affect the environmental conditions. However, considering unexpected impact, the following monitoring and measures are recommended:

- Monitoring of the water table in a 10 m deep dug-well in Pattharkot. In the case that the water table becomes too low for use due to the construction of the proposed headworks, necessary countermeasures should be taken as soon as possible;
- Establishment of a process for reporting and clearing up the cause of contamination of fish ponds;
- Public health education for villagers on water-related infectious diseases;
- Provision of soil conservation works on the upstream side of the irrigation ponds, if necessary; and
- In the case that land is acquired from small scale or particular farmers for the construction of canals and related structures, necessary coordination including compensation, reallocation of lands, etc. shall be carried out by the chairman of VDC or the chief of the Ward concerned.

7.6 Project Justification

The project is justified to be economically feasible with an EIRR of 11.4 %. The financial analysis indicates that farmers' income will be substantially increased by the project and it will have enough capacity to pay and share the O&M cost of the project facilities. Therefore, the living standard of villagers will be greatly improved.

This project will be, without any doubt, a pilot or model for the implementation of small/medium size pond irrigation projects or schemes in the Terai plain. In the project area, some existing irrigation systems have been operated successfully by the farmers themselves, which is a great advantage for the introduction of a new irrigation project in the objective area.

The project aims at not only increasing crop production but also bringing about positive socio-economic impacts: for example increase of employment opportunities, improvement of the nutritious condition of villagers, activation of agro-processing, promotion of aqua culture, implementation of the project by people's participation, etc. On the other hand, the project will not significantly affect the social and natural environment in and around the project area

Thus, the project is justified to be feasible in terms of economy, socio-economy and engineering.

CHAPTER VIII CONCLUSION AND RECOMMENDATION

Conclusion

1. The project aims at raising farmers' income and uplifting their living standards by stably increasing such agricultural production as paddy, wheat, mustard, and vegetables and creating employment opportunities by constructing irrigation and drainage facilities commanding 1,800 ha of farm lands and agricultural support facilities in the project area enclosed by Gudrung river, Belwagurdwa river and Kondre river or Pattharkot--Gorsinge zonal road and Gorsinge--Chitratawa district road.

The annual direct benefits of the project expected are as follows:

1) Agricultural incremental benefit;	about NRs.67.6 million
2) Production increase	
paddy	5,050 ton
wheat	1,410 ton
mustard	200 ton
vegetables	3,710 ton
3) Agricultural incremental benefit of average farmer's household;	about NRs.20,300
4) Incremental employment opportunity;	about 130 thousand man-days

2. In light of the present situation of the project area, the project consists of the following works:

1) Construction of headworks including tyrolean type diversion weir and headrace canal;
2) Construction of main, secondary and tertiary irrigation canals and related structures in the command area (630 ha) of the existing Ranikudwa farmers' irrigation system;
3) Construction of a new irrigation pond and the enlargement of four existing irrigation ponds;
4) Construction of primary and secondary feeder canals and related structures, supplying discharge of Gudrung river to the five irrigation ponds;
5) Construction of main, secondary and tertiary irrigation canals and related structures for the new irrigation area of 1,170 ha;
6) Construction of primary, secondary and tertiary drains and related structures, matching the scale of the irrigation facilities;
7) Improvement of major village and farm roads for purposes of O&M of irrigation and drainage facilities, transport of agricultural inputs and production, etc.;
8) Construction of a farmers' association center comprising of an office and a meeting hall for central level farmers' cooperative and water users' association, a drying yard for cereals and a multipurpose warehouse, and five nos. of VDC level farmers' cooperative office consisting of an office, a meeting room and a godown;
9) Provision of consulting services including additional surveys and investigations, detailed design and construction supervision;
10) Operation, management and administration of the project; and
11) Extension of irrigated farming techniques and technical guidance and training to farmers about irrigated farming.

3. The project is not only technically viable, but also economically and financially sound. The project will have little negative impact on the present natural environment in the project area, though the state-owned natural forest will be partly cleared and reduced by about 122 ha, in constructing an irrigation pond of 55.5 ha and enlarging the four existing ponds by 66.5 ha. Besides, no specific animal or plant is found in the natural forest. Even if the project had a little negative impact on the present environment, it would be compensated by the positive impact of implementing the project.

Recommendation

1. It is recommended that HMG/N should implement the project immediately after the detailed design, understanding that the project is a pond irrigation project storing a part of the excess discharge of a small river and thereby playing the role of a pilot project for implementation of a considerable number of pond irrigation projects or schemes of which the water resources are small or medium-rivers running in the Terai plain.

2. It is recommended that DOI should estimate more reliable water availability figures for the Gudrung river from more accurate monthly hydrographs to be prepared through continuous observation of both the daily and hourly rainfall in Pattharkot and Basantapur and the daily discharge of the Gudrung river at the proposed headworks site, particularly continuous measurement of the river discharge for a flood cycle, since the source of the Gudrung river is a small river of which the flood shape shows an extremely inverse V.

3. It is also recommended that the emphasis in the detailed design should be placed on the following:

1) To carry out an accurate topographic survey on both the proposed routes of the primary and secondary feeder canals and the main, secondary, and tertiary irrigation canals and the proposed pond areas, since the northern most one third and next one third of the project area have steeply sloping land with an average slope of over 1/200 and over 1/600, respectively;

2) To produce a proper structural design of the ponds, particularly the dikes and their foundation, taking into due consideration the safety of the ponds in terms of the seepage, piping and sliding, because the initial success of the project depends on the fact that the excess discharge of the Gudrung river can be efficiently stored in the proposed five irrigation ponds including a new pond; and

3) To design a supply system and irrigation systems (distribution systems), enabling simple water management and easy O&M of the irrigation facilities.

4. Because the success of the project depends on both the sustainable use of the constructed irrigation and drainage facilities and agricultural support facilities and the establishment of irrigation farming by beneficiary farmers, it is recommended that the constructed irrigation and drainage facilities and agricultural support facilities should be handed over to WUAs and farmers' cooperatives newly organized by the beneficiary farmers, respectively and then the management and O&M of such facilities should be carried out by the same associations and cooperatives which shall be totally responsible for these tasks under the technical guidance of DOI and DOAD, through steps involving the beneficiary farmers in the detailed design and construction works of the project as already practiced in the field survey

and investigation of this feasibility study. This recommendation follows HMG/N's present irrigation policy stipulating that in the Terai plain government irrigation systems commanding less than 2,000 ha of irrigation area shall be handed over to farmers' associations organized by beneficiary farmers and the O&M of the systems shall be carried out by the farmers' associations. Therefore, it is recommended that HMG/N carries out the following measures prior to the detailed design:

1) Advice and guidance to the VDCs concerned about their relief measures for the farmers whose farmlands will decrease owing to the acquisition of construction sites for the irrigation and drainage facilities and agricultural support facilities;

2) Technical guidance and necessary coordination for establishing WUAs and farmers' cooperatives in line with the proposed organization;

3) Technical guidance and training of farmers to enable them to become acquainted with the proposed less control-rotative irrigation method and practice;

4) Expansion of agricultural extension services by DADO and the Buddi Agricultural Extension Service Center for early return on the project by the proposed irrigation farming;

5) Timely supply of agricultural inputs, particularly fertilizer by District AICs; and

6) Expansion of agricultural loans by ADB/N to the beneficiary farmers whose initial investment will be considerably increased by introducing irrigation farming.

TABLES

Table 1.1 List of Study Team and Counterpart

Name	Position
A. Study Team	
1. K Takeda	Team Leader / O&M Expert
2. Y. Mase	Irrigation & Drainage Engineer (Deputy Team Leader)
3. N. Sambe	Meteo-Hydrologist
4. M. Ikeda	Hydrogeologist
5. Y. Mizuguchi	Pedologist
6. F. Nagao	Agronomist
7. K. Yamada	Structural Design Engineer
8. H. Ishikawa	Agro-economist
B. Counterpart Personal	
1. Mr. P. Poudel	Coordinator, Department of Irrigation
2. Mr. S. B. Regmee	Chief Counterpart Personal, Department of Irrigation
3. Mr. B. Rayamajhi	Project Manager, Rajkudwa Irrigation Project
4. Mr. K. D. Adhikali	Irrigation Engineer , Department of Irrigation, Kapilvastu
5. Mr. K. L. Shrestha	Agronomist, Department of Agriculture
6. Mr. P. B. Shah	Meteo-Hydrologist, Butwal Tube-well Project
7. Mr. S. P. Khan	Hydrogeologist, Bhairahawa Ground-water Project
8. Mr. B. B. Rawal	Agro-economist, Bhairahawa Ground-water Project

Table 2.1 Country Data of Nepal

Description		Source & Remark
1. Total Area	147,181 km^2	(A)
Land Use; Agriculture	26,533 km^2 (18%)	
Forest	55,334 km^2 (38%)	
Snow	22,463 km^2 (15%)	
Pasture	19,785 km^2 (13%)	
Water	4,000 km^2 (3%)	
Settlement & Roads	1,033 km^2 (1%)	
Others	18,033 km^2 (12%)	
2. Population		
Total Population	18,462,081 persons	(A), Preliminary Results of Population Census in 1991.
Male	9,220,914 persons	
Female	9,241,167 persons	
Growth Rate per Annum (1981 to 1991)	2.08 %	
Population Density	125 persons/km^2	
Economically Active Population (1981)	6,851,000 persons	(B), Population Census in 1981.
Agriculture, Forestry & Fishery	6,244,000 persons	
3. Gross Domestic Product (GDP)		
GDP at Current Price (1991/92)	NRs.130,685 million	(C), Tentative Estimate
Agriculture	NRs.67,029 million	
Non-Agriculture	NRs.63,656 million	
Per Capita GDP (1991/92)	NRs.7,080 (US$166)	
Growth Rate in Real Price (1984/85-1991/92)	4.9 %	
4. Foreign Trade (1991/92)		(D), Provisional
Export	NRS.13,939	
Agricultural Commodities	NRs.2,678	
To India	NRs.1,569	
Import	NRs.32,951	
Agricultural Commodities	NRs.8,386	
From India	NRs.11,816	
Balance	NRs.19,012	
Agricultural Commodities	NRs.5,708	
With India	NRs.10,247	
5. Foreign Money Exchange Rate (at March of 1993)	US$ = NRs.50 Indian Rupee = NRs.1.60 Japanese Yen = NRs.0.42	(D),Approximate Rate
6. Fiscal Year	16th of July to 15th of July	
7. Irrigated Area		(E)
Total	943,000 ha	
Water Source		
Surface Water	833,000 ha	
Groundwater	110,000 ha	

Source (A): Statistical Pocket Book Nepal 1992, CBS.
(B): Statistical Year Book of Nepal 1991, CBS.
(C): Nepal in Figures 1992, CBS.
(D): Nepal Rastra Bank
(E): Agricultural Statistics of Nepal, DFAMS, 1990.

Table 3.1 Population, Households, Labor Force and Cultivated Area in the Study Area

Name of V.D.C.	Population			Total	Family	No. of Farm Household			Labor Force		Cultivated Area		
Ward No. & Village Name	Total	Male	Female	Household	Size	Landowner	Landless	Total	EAP*	Agriculture	Total	Paddy	Upland
1 MAHENDRAKOT V.D.C.											(ha)		
1.1 Pachkaiya,Kapasi	470	223	247	54	8.7	54			241		57		
1.2 Basantapur,Jhagarrhawa	670	340	330	95	7.1	55			343		34		
1.3 Bhelai East	930	470	460	130	7.2	91			476		51		
1.4 Bhelai West	550	270	280	85	6.5	60			282		22		
1.5 Tikker	320	162	158	60	5.3	60			164		17		
1.6 Birpur,Khayarbhatti	1,090	575	515	200	5.5	164			558		86		
1.7 Patharkot Gaon	985	468	517	144	6.8	144			504		114		
1.8 Patharkot Bazaar	575	285	290	98	5.9	65			294		61		
1.9 Changhat	295	145	150	53	5.6	53			151		64		
TOTAL	5,885	2,938	2,947	919	6.4	746	70	816	3,013	2,673	506	506	0
2 DUBIYA V.D.C.													
2.1 Mumy	261	127	134	59	4.4	58			134		99		
2.2 Mumy	187	93	94	36	5.2	36			96		53		
2.3 Ghanchaura,Uttardada	337	165	172	49	6.9	49			173		55		
2.4 Dubiya	415	225	190	60	6.9	60			212		52		
2.5 Ghanchaura,Mukauli	330	180	150	68	4.9	67			169		137		
TOTAL	1,530	790	740	272	5.6	270	0	270	783	777	396	366	30
3 JAYANAGAR D.V.C.													
3.1 Bakadaria	600	325	275	80	7.5	80			307		71		
3.2 Bakadaria	500	275	225	60	8.3	60			256		51		
3.3 Purena	1,000	450	550	60	16.7	60			512		57		
3.4 Gorusinge	200	110	90	70	2.9	70			102		126		
3.5 Gorusinge	200	125	75	40	5.0	30			102		58		
3.6 Gorusinge	306	150	156	47	6.5	45			157		67		
3.7 Gorusinge	560	290	270	75	7.5	55			287		87		
3.8 Gorusinge	377	189	188	35	10.8	35			193		39		
3.9 Badahara	1,200	650	550	131	9.2	131			614		121		
TOTAL	4,943	2,564	2,379	598	8.3	566	15	581	2,531	2,452	677	635	42
4 BUDDHI V.D.C.													
4.1 Buddi	730	353	377	131	5.6	131			374		95		
4.2 Buddi	500	257	243	75	6.7	75			256		46		
4.3 Kasnar,Bhairampur,Kilauri	506	283	223	85	6.0	85			259		49		
4.4 Jitpur,Nayabasti	648	335	313	100	6.5	100			332		68		
4.5 Paschim tola,Chaura	594	303	291	109	5.4	109			304		47		
4.6 Pratrappur	186	101	85	30	6.2	26			95		24		
4.7 Chaurangi,Debari,Miltole	509	282	227	108	4.7	108			261		46		
4.8 Gelwar,Debara	354	173	181	71	5.0	71			181		39		
4.9 Morma	294	170	124	51	5.8	51			151		33		
TOTAL	4,321	2,257	2,064	760	5.7	756	0	756	2,212	2,199	447	447	0
5 RAJPUR V.D.C.													
5.1 Pakarchata	725	400	325	62	11.7	53			371		65		
5.2 Pakarchata	637	337	300	65	9.8	65			326		42		
5.3 Chauri	1,267	700	567	183	6.9	183			649		226		
5.4 Islam Nagar	622	337	285	113	5.5	113			318		85		
5.5 Bichawapur	660	350	310	65	10.2	50			338		75		
5.6 Pakarchati	693	375	318	70	9.9	48			355		51		
5.7 Rajpur	745	387	358	53	14.1	49			381		50		
5.8 Magurgadh	715	372	343	103	6.9	103			366		87		
5.9 Mohammad Nagar	780	402	378	100	7.8	100			399		135		
TOTAL	6,844	3,660	3,184	814	8.4	764	30	794	3,504	3,415	816	800	16
6 MAHUWA V.D.C.													
6.1 Mahuwa	661	352	309	122	5.4	122			338		178		
6.2 Panditpur,Semarhawa	547	290	257	90	6.1	90			280		103		
6.3 Shivpura,Bhirihawa	473	246	227	80	5.9	68			242		83		
6.4 Laxmipur	390	199	191	64	6.1	64			200		104		
6.5 Laxmanpur	382	187	195	78	4.9	78			196		79		
6.6 Laxmanpur	554	268	286	93	6.0	36			284		27		
6.7 Kohanauliya	384	200	184	92	4.2	92			197		92		
6.8 Kohanauliya	342	180	162	48	7.1	28			175		18		
6.9 Nayanagar,Shrigung	179	94	85	40	4.5	40			92		50		
TOTAL	3,912	2,016	1,896	707	5.5	618	65	683	2,003	1,933	734	690	44
7 DHANKAULI V.D.C.													
7.1 Dhankauli	957	555	402	157	6.1	106			490		189		
7.2 Malawa	820	450	370	150	5.5	68			420		101		
7.3 Bijgauri	628	303	325	115	5.5	80			322		93		
7.4 Bhagani,Gajani	520	250	270	85	6.1	48			266		40		
7.5 Hardasdihawa	400	215	185	60	6.7	60			205		67		
7.6 Piparhawa,Dharihawa Pokarhawa,Haradhawa	502	202	300	75	6.7	67			257		58		
7.7 Alinagar,Debpur,Logaranta	475	275	200	108	4.4	108			243		100		
7.8 Dharmapur,Bhagawanpur, Siripur	579	379	200	65	8.9	55			296		65		
7.9 Chatradchi,Motinagar, Baikunthapur,Janakpur Muthurapur	941	541	400	268	3.5	268			482		271		
TOTAL	5,822	3,170	2,652	1,083	5.4	860	160	1,020	2,981	2,805	984	984	0
GRAND TOTAL	33,257	17,395	15,862	5,153	6.45	4,580	340	4,920	17,028	16,253	4,560	4,428	132

Remark EAP: Economically Active Population
Source: District Development Committee

Table 3.2 Planted Area and Production in the Study Area

Crops/Conditions	Planted Area (ha)	Unit Yield (ton/ha)	Production (ton)
Summer Crops			
Paddy			
Partially Irrigated	1,300	2.22	2,886
Non-Irrigated	3,130	1.42	4,445
Subtotal	4,430	1.65	7,331
Maize(Upland)			
Non-Irrigated	90	1.33	120
Pulses(Upland)			
Non-Irrigated	40	0.56	22
Total	4,560	-	-
Winter Crops			
Wheat			
Partially Irrigated	320	1.70	544
Non-Irrigated	640	0.98	627
Subtotal	960	1.22	1,171
Oilseed			
Partially Irrigated	70	0.71	50
Non-Irrigated	260	0.46	120
Subtotal	330	0.51	169
Pulses			
Partially Irrigated	50	0.66	33
Non-Irrigated	380	0.56	213
Subtotal	430	0.57	246
Potato/Vegetables			
Partially Irrigated	80	-	-
Total	1,800	-	-
Spring Crops			
Maize			
Partially Irrigated	40	1.72	69
Grand Total	6,400	-	-
Cropping Intensity (%)	140		

Table 4.1 Estimated Discharge of the Related Rivers

Gudrung River

Catchment area = 29 sq.km

unit : cumec

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Jan.	0.234	0.246	0.245	0.388	0.242	0.262	0.294	0.206	0.202	0.215	0.188	0.341	0.189	0.302	0.204
Feb.	0.331	0.296	0.182	0.214	0.212	0.188	0.184	0.204	0.279	0.205	0.195	0.209	0.355	0.197	0.201
Mar.	0.235	0.189	0.185	0.269	0.193	0.172	0.179	0.172	0.185	0.211	0.181	0.235	0.195	0.184	0.171
Apr.	0.281	0.173	0.166	0.342	0.190	0.194	0.157	0.180	0.222	0.216	0.241	0.146	0.205	0.171	0.152
May	0.205	0.157	0.473	0.339	0.339	0.348	0.190	0.562	0.287	0.158	0.189	0.290	0.549	0.270	0.170
Jun.	1.525	1.678	3.677	1.175	1.079	0.242	4.144	0.553	1.012	0.294	2.159	0.850	1.038	1.851	1.829
Jul.	7.240	3.330	4.113	6.174	3.803	1.845	4.727	5.373	3.702	5.898	4.213	4.849	3.468	2.395	2.110
Aug.	2.604	2.803	4.731	5.083	3.724	4.368	1.691	2.658	3.876	5.094	4.528	2.873	2.704	6.463	2.492
Sep.	2.123	1.940	1.966	4.722	3.217	5.627	2.575	3.568	3.437	3.175	2.709	4.483	1.551	3.038	1.054
Oct.	0.498	0.724	0.478	0.248	0.278	1.728	0.742	0.943	0.677	0.450	0.204	0.647	1.947	0.214	1.648
Nov.	0.227	0.211	0.221	0.362	0.281	0.204	0.209	0.218	0.474	0.206	0.191	0.236	0.221	0.202	0.286
Dec.	0.242	0.290	0.211	0.244	0.244	0.457	0.257	0.313	0.436	0.209	0.229	0.221	0.264	0.460	0.182
Mean	1.312	1.003	1.387	1.630	1.150	1.303	1.279	1.246	1.232	1.361	1.269	1.282	1.057	1.312	0.875

unit : cumec

	Minimum	Maximum	Mean
Jan.	0.188	0.388	0.251
Feb.	0.182	0.355	0.230
Mar.	0.171	0.269	0.197
Apr.	0.146	0.342	0.203
May	0.157	0.562	0.302
Jun.	0.242	4.144	1.540
Jul.	1.845	7.240	4.216
Aug.	1.691	6.463	3.713
Sep.	1.054	5.627	3.012
Oct.	0.204	1.947	0.762
Nov.	0.191	0.474	0.250
Dec.	0.182	0.460	0.284
			1.247

Kondre River

Catchment area = 33 sq.km

unit : cumec

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Jan.	0.246	0.257	0.247	0.403	0.250	0.270	0.301	0.212	0.206	0.219	0.194	0.355	0.197	0.305	0.212
Feb.	0.346	0.306	0.188	0.221	0.218	0.192	0.188	0.210	0.285	0.208	0.202	0.218	0.371	0.202	0.208
Mar.	0.248	0.196	0.192	0.284	0.198	0.176	0.182	0.176	0.187	0.215	0.188	0.246	0.204	0.188	0.177
Apr.	0.296	0.180	0.173	0.350	0.197	0.201	0.160	0.187	0.229	0.223	0.252	0.153	0.217	0.176	0.158
May	0.224	0.165	0.507	0.356	0.354	0.365	0.198	0.591	0.300	0.162	0.198	0.307	0.545	0.283	0.180
Jun.	1.568	1.765	3.916	1.302	1.089	0.255	4.362	0.575	1.053	0.310	2.260	0.889	1.080	1.973	1.971
Jul.	7.677	3.364	4.173	6.504	3.976	1.913	4.884	5.668	3.752	6.240	4.300	5.042	3.578	2.312	2.093
Aug.	2.517	2.737	4.822	5.203	3.737	4.461	1.613	2.719	3.954	5.273	4.628	2.817	2.594	6.799	2.470
Sep.	2.075	1.921	1.909	4.878	3.250	5.854	2.550	3.536	3.388	3.136	2.665	4.612	1.534	2.983	1.027
Oct.	0.373	0.712	0.435	0.254	0.289	1.718	0.773	0.878	0.612	0.466	0.215	0.572	1.896	0.224	1.642
Nov.	0.238	0.221	0.230	0.381	0.296	0.211	0.216	0.224	0.491	0.214	0.201	0.249	0.229	0.211	0.297
Dec.	0.253	0.307	0.219	0.247	0.248	0.470	0.266	0.321	0.446	0.216	0.272	0.232	0.277	0.475	0.188
Mean	1.338	1.011	1.418	1.699	1.175	1.340	1.308	1.275	1.242	1.407	1.298	1.308	1.060	1.344	0.885

unit : cumec

	Minimum	Maximum	Mean
Jan.	0.194	0.403	0.258
Feb.	0.188	0.371	0.237
Mar.	0.176	0.284	0.204
Apr.	0.153	0.350	0.210
May	0.162	0.591	0.316
Jun.	0.255	4.362	1.624
Jul.	1.913	7.677	4.365
Aug.	1.613	6.799	3.756
Sep.	1.027	5.854	3.021
Oct.	0.215	1.896	0.737
Nov.	0.201	0.491	0.261
Dec.	0.188	0.475	0.296
			1.274

Note: Results of the Tank Model Method

Table 4.2 Cropwise Gross Irrigation Water Requirements

	Paddy rice		Wheat		Winter vegetables		Mustard		Spring vegetables	
	Total (mm)	Peak (//sec/ha)	Total (mm)	Peak (//sec/ha)	Total (mm)	Peak (//sec/ha)	Total (mm)	Peak (//sec/ha)	Total (mm)	Peak (//sec/ha)
1978	282	1.147	363	0.559	205	0.440	223	0.486	534	1.420
1979	256	1.170	305	0.559	169	0.416	171	0.464	648	1.481
1980	202	0.855	426	0.559	274	0.558	266	0.486	446	1.134
1981	139	0.486	265	0.530	164	0.517	146	0.400	472	1.352
1982	375	1.484	348	0.559	223	0.517	209	0.486	544	1.481
1983	336	0.997	347	0.559	218	0.639	196	0.486	499	1.225
1984	391	1.055	355	0.559	213	0.639	194	0.464	624	1.382
1985	306	0.998	364	0.559	232	0.483	216	0.486	470	0.972
1986	107	0.330	313	0.559	209	0.462	206	0.486	500	1.106
1987	277	1.080	423	0.559	271	0.639	261	0.486	578	1.389
1988	212	0.863	397	0.559	252	0.639	235	0.486	520	1.331
1989	150	0.444	344	0.540	208	0.639	199	0.486	527	1.481
1990	318	1.064	366	0.559	219	0.547	227	0.486	397	0.972
1991	307	1.393	365	0.559	236	0.639	214	0.486	586	1.389
1992	347	1.145	363	0.559	237	0.464	226	0.486	619	1.229
80%	336	1.147	366	0.559	237	0.639	227	0.486	586	1.420

Table 4.3 Analysis of Conceivable Irrigation Development Plans

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Available water source	Gudrung without ponds	Gudrung 1/ with ponds	Kondre Upper	Kondre Lower	Gudrung (with ponds)+ Kondre (Lower)	Northern Ponds 2/ (8 ponds)	Integrated operation of all water sources	Alternative 2, 4 & 6 Independent operation
Irrigable area in rainy S. (ha)	340	1,800	210	295	2,095	60	2,155	2,155
Irrigable area in winter S. (ha)	480	1,130	280	385	1,515	60	1,575	1,575
Irrigable area in spring S. (ha)	140	100	95	135	235	0	235	235
Cropping intensity	282	168	279	276	184	200	184	184
Evaluation								
1. The project area will be covered by a single irrigation system	No	Almost yes	No	No	Almost Yes	No	Yes	No
2. Available water	Medium	Large by ponds	Small	Medium	Large	Very small	Large	Large, Medium, Very small
3. Elevation of intake site	High (Most of area is irrigable)	High (Most of area is irrigable)	Low (North of E-W high-way area is irrigable)	Low (South of E-W high-way area is irrigable)	(Almost all area is irrigable)	High (Irrigated area Limited)	(Entire area is irrigable)	(Entire area is irrigable)
4. Loss of existing cultivated field due to headrace channel construction	Almost no	Almost no	About 5 km	Almost no	Almost no	Almost no	Almost no	Almost no
5. Water management	Easy	Easy	Easy	Easy	Complicated & difficult, Not practical for O & M by farmers	Easy	Complicated & very difficult. Not practical for O & M by farmers	Easy
6. Construction cost (US$ /ha)	High	Low	Extremery high	Extremery high	High	Medium	High	High

Conclusion

Alt.-2 is sole irrigation development plan to be taken up for agricultural development and socio-economic improvement in the study area from technical and socio-economic view points. Alt.-1, Alt.-3 and Alt.-4, which are not provided with irrigation pond have little possibility in realization, since the respective irrigation areas are very small compared to the size or capacity of the required headworks and headrace canal. Alt.-6 is not attractive because of too small irrigation area. Furthermore, Alt.-5, Alt.-7 and Alt.8 are also less attractive because each of them is based on two medium size headworks and two lengthy headrace canals despite that the respective irrigable areas (2,095 ha , 2,155 ha and 2,155 ha) are not so increased in comparison with that of Alt.-2.

Remark 1/; Gudrung ponds: Rehabilitation of 4 existing ponds and construction of one new pond. They will be connected to the Gudrung irrigation system by canals.
Remark 2/; North-West ponds : Isolated existing cultivated lands will be irrigated by 4 rehabilitated existing ponds and 4 new ponds independently.

Table 5.1 Alternative Study for the Proposed Cropping Pattern

Items / Alternative Cropping Pattern	Pattern - A				Pattern - B				Pattern - C				Pattern - D				Pattern - E			
	Summer	Winter	Spring	Total	Summer	Winter	Spring	Total	Summer	Winter	Spring	Total	Summer	Winter	Spring	Total	Summer	Winter	Spring	Total
Total Cropped Area (ha)	100	100	100	300	200	200	100	500	1,130	1,130	100	2,360	1,500	1,130	100	2,730	1,800	1,130	100	3,030
Cropping Intensity (%)				300%				250%				209%				182%				168%
Gross Production Value																				
1. Paddy																				
Cropped Area (ha)	100			100	200			200	1,130			1,130	1,500			1,500	1,800			1,800
Unit Yield (t/ha)	4.5				4.5				4.5				4.5				4.5			
Production (tons)	450			450	900			900	5,085			5,085	6,750			6,750	8,100			8,100
Production Value (Rp.x,000)	4,347			4,347	8,694			8,694	49,121			49,121	65,205			65,205	78,246			78,246
Production Cost (Rp.x,000)	1,067			1,067	2,134			2,134	12,059			12,059	16,008			16,008	19,210			19,210
Total Net Income (Rp.)	3,280			3,280	6,560			6,560	37,062			37,062	49,197			49,197	59,036			59,036
Net Income per ha (Rp/ha)	32,798			32,798	32,798			32,798	32,798			32,798	32,798			32,798	32,798			32,798
2. Wheat																				
Cropped Area (ha)		60		60		120		120		680		680		680		680		680		680
Unit Yield (t/ha)		3.0				3.0				3.0				3.0				3.0		
Production (tons)		180		180		360		360		2,040		2,040		2,040		2,040		2,040		2,040
Production Value (Rp.x,000)		2,540		2,540		5,080		5,080		28,784		28,784		28,784		28,784		28,784		28,784
Production Cost (Rp.x,000)		686		686		1,371		1,371		7,769		7,769		7,769		7,769		7,769		7,769
Total Net Income (Rp.)		1,854		1,854		3,709		3,709		21,015		21,015		21,015		21,015		21,015		21,015
Net Income per ha (Rp/ha)		30,905		18,543		30,905		18,543		30,905		18,598		30,905		14,010		30,905		11,675
3. Oilseeds																				
Cropped Area (ha)		20		20		40		40		225		225		225		225		225		225
Unit Yield (t/ha)		1.2				1.2				1.2				1.2				1.2		
Production (tons)		24		24		48		48		270		270		270		270		270		270
Production Value (Rp.x,000)		358		358		716		716		4,026		4,026		4,026		4,026		4,026		4,026
Production Cost (Rp.x,000)		156		156		311		311		1,751		1,751		1,751		1,751		1,751		1,751
Total Net Income (Rp.)		202		202		404		404		2,275		2,275		2,275		2,275		2,275		2,275
Net Income per ha (Rp/ha)		10,111		2,022		10,111		2,022		10,111		2,013		10,111		1,517		10,111		1,264
4. Vegetables																				
Cropped Area (ha)		20	100	120		40	100	140		225	100	325		225	100	325		225	100	325
Unit Yield (t/ha)		12.0	12.0			12.0	12.0			12.0	12.0			12.0	12.0			12.0	12.0	
Production (tons)		240	1,200	1,440		480	1,200	1,680		2,700	1,200	3,900		2,700	1,200	3,900		2,700	1,200	3,900
Production Value (Rp.x,000)		1,075	5,376	6,451		2,150	5,376	7,526		12,096	5,376	17,472		12,096	5,376	17,472		12,096	5,376	17,472
Production Cost (Rp.x,000)		304	1,522	1,826		609	1,522	2,130		3,424	1,522	4,946		3,424	1,522	4,946		3,424	1,522	4,946
Total Net Income (Rp.)		771	3,854	4,625		1,542	3,854	5,396		8,672	3,854	12,526		8,672	3,854	12,526		8,672	3,854	12,526
Net Income per ha (Rp/ha)		38,543	38,543	46,252		38,543	38,543	26,980		38,543	38,543	11,085		38,543	38,543	8,351		38,543	38,543	6,959
Total Production Value																				
Total Cropping Area (ha)	100	100	100	300	200	200	100	500	1,130	1,130	100	2,360	1,500	1,130	100	2,730	1,800	1,130	100	3,030
Total Income (Rp. x,000)	3,280	2,827	3,854	9,961	6,560	5,655	3,854	16,069	37,062	31,963	3,854	72,879	49,197	31,963	3,854	85,014	59,036	31,963	3,854	94,853
Net Income per ha (Rp/ha)	32,798	28,274	38,543	99,615	32,798	28,274	38,543	80,343	32,798	28,285	38,543	64,494	32,798	28,285	38,543	56,676	32,798	28,285	38,543	52,696
(US$/ha)	656.0	565.5	770.9	1,992.3	656.0	565.5	770.9	1,606.9	656.0	565.7	770.9	1,289.9	656.0	565.7	770.9	1,133.5	656.0	565.7	770.9	1,053.9

Crops	Unit Price (Rp./kg)	Production Cost (Rp./ha)	Unit Labor Requirement (man-day/ha)	Unit Water Requirement (m3/ha)
Paddy	9.66	10,672	145	3,360
Wheat	14.11	11,425	109	3,660
Oilseed	14.91	7,781	91	2,270
Vegetables (w)	4.48	15,217	206	2,370
Vegetables (s)	4.48	15,217	206	5,860

Crops	Cropped Area (ha)	Total Labor Req. (man-days)	Total Water Req. (x,000 m3)	Cropped Area (ha)	Total Labor Req. (man-days)	Total Water Req. (x,000 m3)	Cropped Area (ha)	Total Labor Req. (man-days)	Total Water Req. (x,000 m3)	Cropped Area (ha)	Total Labor Req. (man-days)	Total Water Req. (x,000 m3)	Cropped Area (ha)	Total Labor Req. (man-days)	Total Water Req. (x,000 m3)
Paddy	100	14,500	336.0	200	29,000	672.0	1,130	163,850	3,796.8	1,500	217,500	5,040.0	1,800	261,000	6,048.0
Wheat	60	6,540	219.6	120	13,080	439.2	680	74,120	2,488.8	680	74,120	2,488.8	680	74,120	2,488.8
Oilseed	20	1,820	45.4	40	3,640	90.8	225	20,475	510.8	225	20,475	510.8	225	20,475	510.8
Vegetables (w)	20	4,120	47.4	40	8,240	94.8	225	46,350	533.3	225	46,350	533.3	225	46,350	533.3
Vegetables (s)	100	20,600	227.0	100	20,600	227.0	100	20,600	227.0	100	20,600	227.0	100	20,600	227.0
	300	47,580	875.4	500	74,560	1,523.8	2,360	325,395	7,556.6	2,730	379,045	8,799.8	3,030	422,545	9,807.8
		475.8	8.8		372.8	7.6		288.0	6.7		252.7	5.9		234.7	5.4
Unit Production Value (Rp / man-day or m3)		209.36	11,379		215.51	10,545		223.97	9,644		224.28	9,661		224.48	9,671

Table 6.1 Breakdown of Investment Cost

(Unit: NRs. Thousand)

Description	Unit	Q'ty	Amount		
			F.C.	L.C.	Total
I. Direct Construction Cost					
1. Irrigation and Drainage Facilities					
(1) Headworks			23,280	11,537	34,817
Earthworks	L.S		(3,968)	(4,850)	(8,818)
Closed conduit & Structures	L.S		(19,312)	(6,687)	(25,999)
(2) Headrace			12,733	6,120	18,853
Earthworks	km	0.45	(515)	(630)	(1,145)
Structures	km	0.45	(12,218)	(5,490)	(17,708)
(3) Supply System			51,655	51,741	103,396
1) Primary Feeder Canal			42,411	41,429	83,840
Earthworks	km	15.5	(5,042)	(6,162)	(11,204)
Concrete flume works	km	4.6	(21,297)	(20,761)	(42,058)
Structures	L.S		(16,072)	(14,506)	(30,578)
2) Secondary Feeder Canal			9,244	10,312	19,556
Earthworks	km	5.3	(1,753)	(2,142)	(3,895)
Concrete flume works	km	1.5	(5,782)	(6,340)	(12,122)
Structures	L.S		(1,709)	(1,830)	(3,539)
(4) Irrigation System			19,289	34,107	53,396
1) Main Irrigation Canal			4,000	3,917	7,917
Earthworks	km	4.5	(1,431)	(1,748)	(3,179)
Structures	L.S		(2,569)	(2,169)	(4,738)
2) Secondary Irrigation Canal			8,631	10,546	19,177
Earthworks	km	26.8	(4,085)	(4,993)	(9,078)
Structures	L.S		(4,546)	(5,553)	(10,099)
3) Tertiary Irrigation Canal			6,658	19,644	26,302
Earthworks	km	57.0	(0)	(11,907)	(11,907)
Structures	L.S		(6,658)	(7,737)	(14,395)
(5) Drainage System			32,655	38,245	70,900
1) Primary Drainage Canal			17,349	20,158	37,507
Earthworks	km	18.6	(15,282)	(18,678)	(33,960)
Structures	L.S		(2,067)	(1,480)	(3,547)
2) Secondary Drainage Canal			9,875	10,813	20,688
Earthworks	km	24.2	(7,005)	(8,562)	(15,567)
Structures	L.S		(2,870)	(2,251)	(5,121)
3) Tertiary Drainage Canal			5,431	7,274	12,705
Earthworks	km	26.4	(0)	(2,181)	(2,181)
Structures	L.S		(5,431)	(5,093)	(10,524)
(6) Irrigation Pond			33,928	38,196	72,124
1) Tikker (new construction)			17,827	19,409	37,236
Earthworks	L.S		(14,623)	(17,872)	(32,495)
Structures	L.S		(3,204)	(1,537)	(4,741)
2) Badahara			1,448	1,585	3,033
Earthworks	L.S		(969)	(1,185)	(2,154)
Structures	L.S		(479)	(400)	(879)
3) Gorusinge			3,029	3,184	6,213
Earthworks	L.S		(2,292)	(2,801)	(5,093)
Structures	L.S		(737)	(383)	(1,120)
4) Dewari			3,341	4,309	7,650
Earthworks	L.S		(2,973)	(3,633)	(6,606)
Structures	L.S		(368)	(676)	(1,044)
5) Buddi			8,283	9,709	17,992
Earthworks	L.S		(7,011)	(8,569)	(15,580)
Structures	L.S		(1,272)	(1,140)	(2,412)
(7) Village cum Service Roads			15,973	19,300	35,273
Earthworks	km	49.5	(15,271)	(18,664)	(33,935)
Structures			(702)	(636)	(1,338)
(8) Project Office	nos.	1	518	1,052	1,570
Sub-total (Item 1.)			190,031	200,298	390,329
2. Farmers' Cooperative Offices					
(1) Farmers' Cooperative Center	nos.	1	1,183	2,401	3,584
(2) VDC Farmers' Cooperative Offices	nos.	5	3,517	7,140	10,657
Sub-total (Item 2.)			4,700	9,541	14,241
Total (Iem I.)			194,731	209,839	404,570
II. Physical Contingency		20%	38,946	41,968	80,914
III. Administration	L.S		0	10,093	10,093
IV. Engineering Services	L.S		54,950	25,000	79,950
V. Price Contingency			23,833	82,479	106,312
Grand Total			312,460	369,379	681,839

Table 6.2 Disbursement Schedule

(Unit: NRs. Thousand)

Description	Total Project Cost			1993			1994			1995			1996		
	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
1. Construction Works															
(1) Irrigation and Drainage Facilities															
1) Headworks	23,280	11,537	34,817	0	0	0	3,259	1,615	4,874	20,021	9,922	29,943	0	0	0
2) Headrace	12,733	6,120	18,853	0	0	0	0	0	0	12,733	6,120	18,853	0	0	0
3) Supply System	51,655	51,741	103,396	0	0	0	0	0	0	51,655	51,741	103,396	0	0	0
4) Irrigation System	19,289	34,107	53,396	0	0	0	0	0	0	9,645	17,053	26,698	9,645	17,053	26,698
5) Drainage System	32,655	38,245	70,900	0	0	0	0	0	0	10,776	12,621	23,397	21,879	25,624	47,503
6) Irrigation Ponds	33,928	38,196	72,124	0	0	0	0	0	0	22,731	25,591	48,323	11,196	12,605	23,801
7) Village cum Service Roads	15,973	19,300	35,273	0	0	0	0	0	0	6,389	7,720	14,109	9,584	11,580	21,164
8) Project Office	518	1,052	1,570	26	53	79	492	999	1,492	0	0	0	0	0	0
(2) Farmers' Cooperative Offices															
1) Agricultural cooperative center	1,183	2,401	3,584	0	0	0	0	0	0	1,183	2,401	3,584	0	0	0
2) VDC farmers' cooperative offices	3,517	7,140	10,657	0	0	0	0	0	0	1,161	2,356	3,517	2,356	4,784	7,140
Sub-total (Item 1.)	194,731	209,839	404,570	26	53	79	3,751	2,615	6,366	136,294	135,526	271,820	54,660	71,646	126,306
2. Physical Contingency	38,946	41,968	80,914	5	11	16	750	523	1,273	27,259	27,105	54,364	10,932	14,329	25,261
3. Administration	0	10,093	10,093	0	606	606	0	3,633	3,633	0	3,633	3,633	0	2,220	2,220
4. Engineering Services	54,950	25,000	79,950	12,216	6,107	18,324	24,899	11,643	36,541	11,070	4,500	15,570	6,765	2,750	9,515
Sub-total (Item 1.- 4.)	288,627	286,900	575,527	12,248	6,776	19,023	29,400	18,414	47,814	174,622	170,765	345,388	72,356	90,946	163,302
5. Price contingency	23,833	82,479	106,312	0	0	0	1,147	2,210	3,356	13,886	43,443	57,329	8,800	36,826	45,627
Grand Total	312,460	369,379	681,839	12,248	6,776	19,023	30,547	20,623	51,170	188,508	214,208	402,716	81,157	127,772	208,929

Note Price level: 1993
Price escalation rate: Foreign Currency; 3.9%
Local Currency; 12.0%

Table 7.1 Economic Construction Cost and Disbursement

Item	Financial Cost (x 1000 NRs.)	Construction Conversion Factor	Economic Cost (x 1000 NRs.)	Disbursement Schedule 1993 (x 1000 NRs.)	1994 (x 1000 NRs.)	1995 (x 1000 NRs.)	1996 (x 1000 NRs.)
I Construction Works							
1. Headworks							
(1) Earthworks	8,818	74%	6,526	0	3,898	23,947	0
(2) Structure	25,999	82%	21,319				
2. Headrace							
Earthworks	1,145	74%	847	0	0	15,368	0
Structure	17,708	82%	14,521				
3. Supply System							
(1) Primary Feeder Canal							
Earthworks	11,204	74%	8,291	0	0	67,853	0
Concrete flume works	42,058	82%	34,488				
Structures	30,579	82%	25,074				
(2) Secondary Feeder Canal							
Earthworks	3,895	74%	2,883	0	0	15,724	0
Concrete flume works	12,121	82%	9,940				
Structures	3,539	82%	2,902				
4. Irrigation System							
(1) Main Irrigation Canal							
Earthworks	3,179	74%	2,353	0	0	3,119	3,119
Structures	4,737	82%	3,885				
(2) Secondary Irrigation Canal							
Earthworks	9,079	74%	6,718	0	0	7,500	7,500
Structures	10,099	82%	8,282				
(3) Tertiary Irrigation Canal							
Earthworks	11,907	74%	8,811	0	0	10,307	10,307
Structures	14,395	82%	11,804				
5. Drainage System							
(1) Primary Drainage Canal							
Earthworks	33,960	74%	25,131	0	0	9,253	18,786
Structures	3,547	82%	2,908				
(2) Secondary Drainage Canal							
Earthworks	15,568	74%	11,520	0	0	5,187	10,532
Structures	5,120	82%	4,199				
(3) Tertiary Drainage Canal							
Earthworks	2,181	74%	1,614	0	0	3,380	6,863
Structures	10,524	82%	8,629				
6. Irrigation Ponds							
(1) Earthworks	61,928	74%	45,827	0	0	36,305	17,882
(2) Structures	10,196	82%	8,361				
7. Village cum Service Road							
(1) Earthworks	33,935	74%	25,112	0	0	10,483	15,725
(2) Structures	1,338	82%	1,097				
8. Project Office	1,570	72%	1,130	57	1,074	0	0
9. Farmers' Cooperative Offices							
(1) Agricultural cooperative center	3,584	72%	2,580	0	0	2,580	0
(2) VDC farmers' cooperative offices	10,657	72%	7,673	0	0	2,532	5,141
10. Physical Contingency (20%)	80,914		62,884	11	994	42,708	19,171
II. Administration and Engineering Services							
11. Administration	10,093	87%	8,781	527	3,161	3,161	1,932
12. Engineering Services	79,950	96%	76,752	15,099	29,267	19,930	12,456
Total (Item 1.- 12.)	575,527	80%	462,840	15,694	38,395	279,338	129,413

Table 7.2 Economic Irrigation Benefit

	Without Project			With Project			Increment	
	Area	Return	Total	Area	Return	Total	Area	Benefit
	ha	NRs/ha	1,000NRs	ha	NRs/ha	1,000NRs	ha	1,000NRs
Paddy								
Full Irrigated	0			1,800	32,798	59,036	1,800	59,036
Partially Irrigated	837	14,763	12,357	0			-837	-12,357
Non-irrigated	854	7,586	6,478	0			-854	-6,478
Total	1,691		18,835	1,800		59,036	109	40,201
Wheat								
Full Irrigated	0			680	30,905	21,015	680	21,015
Partially Irrigated	306	17,450	5,340	0			-306	-5,340
Non-irrigated	116	7,546	875	0			-116	-875
Total	422		6,215	680		21,015	258	14,800
Maize								
Partially Irrigated	25	13,295	332	0			-25	-332
Total	25		332	0			-25	-332
Pulses								
Partially Irrigated	78	4,054	316	0			-78	-316
Non-irrigated	195	3,161	616	0			-195	-616
Total	273		933	0			-273	-933
Oilseeds								
Full Irrigated	0			225	10,112	2,275	225	2,275
Partially Irrigated	77	6,769	521	0			-77	-521
Non-irrigated	29	3,312	96	0			-29	-96
Total	106		617	225		2,275	119	1,658
Vegetables								
Full Irrigated	0			325	38,543	12,526	325	12,526
Partially Irrigated	50	7,286	364	0			-50	-364
Total	50		364	325		12,526	275	12,162
Total	2,567		27,297	3,030		94,853	463	67,557

Table 7.3 Economic Cost and Benefit Stream

(Unit:1000 NRs.)

No.	Year	Cost				Incremental Benefit	Balance
		Construction	O & M	Replacement	Total		
1	1993	15,694			15,694		-15,694
2	1994	38,395			38,395		-38,395
3	1995	279,338			279,338		-279,338
4	1996	129,413			129,413	10,942	-118,471
5	1997		1,886		1,886	27,023	25,137
6	1998		1,886		1,886	40,534	38,648
7	1999		1,886		1,886	54,046	52,160
8	2000		1,886		1,886	60,801	58,915
9	2001		1,886		1,886	67,557	65,671
10	2002		1,886		1,886	67,557	65,671
11	2003		1,886		1,886	67,557	65,671
12	2004		1,886		1,886	67,557	65,671
13	2005		1,886		1,886	67,557	65,671
14	2006		1,886		1,886	67,557	65,671
15	2007		1,886		1,886	67,557	65,671
16	2008		1,886		1,886	67,557	65,671
17	2009		1,886		1,886	67,557	65,671
18	2010		1,886		1,886	67,557	65,671
19	2011		1,886		1,886	67,557	65,671
20	2012		1,886		1,886	67,557	65,671
21	2013		1,886		1,886	67,557	65,671
22	2014		1,886		1,886	67,557	65,671
23	2015		1,886		1,886	67,557	65,671
24	2016		1,886	1,449	3,335	67,557	64,222
25	2017		1,886		1,886	67,557	65,671
26	2018		1,886		1,886	67,557	65,671
27	2019		1,886		1,886	67,557	65,671
28	2020		1,886		1,886	67,557	65,671
29	2021		1,886		1,886	67,557	65,671
30	2022		1,886		1,886	67,557	65,671
31	2023		1,886		1,886	67,557	65,671
32	2024		1,886		1,886	67,557	65,671
33	2025		1,886		1,886	67,557	65,671
34	2026		1,886		1,886	67,557	65,671
35	2027		1,886		1,886	67,557	65,671
36	2028		1,886		1,886	67,557	65,671
37	2029		1,886		1,886	67,557	65,671
38	2030		1,886		1,886	67,557	65,671
39	2031		1,886		1,886	67,557	65,671
40	2032		1,886		1,886	67,557	65,671
41	2033		1,886		1,886	67,557	65,671
42	2034		1,886		1,886	67,557	65,671
43	2035		1,886		1,886	67,557	65,671
44	2036		1,886	1,449	3,335	67,557	64,222
45	2037		1,886		1,886	67,557	65,671
46	2038		1,886		1,886	67,557	65,671
47	2039		1,886		1,886	67,557	65,671
48	2040		1,886		1,886	67,557	65,671
49	2041		1,886		1,886	67,557	65,671
50	2042		1,886		1,886	67,557	65,671
51	2043		1,886		1,886	67,557	65,671
52	2044		1,886		1,886	67,557	65,671
53	2045		1,886		1,886	67,557	65,671
54	2046		1,886		1,886	67,557	65,671
Total(1000NRs)		462,840	94,301	2,898	560,039	3,300,968	2,740,929
EIRR =		11.44%					

Table 7.4 Farm Budget

Farm Type		Large Farmer (size:6.81ha)			Medium Farmer (size:3.05ha)			Small Farmer (size:1.32ha)			Marginal Farmer (size:1.32ha)			Average (0.84ha)		
			Cropped	Total		Cropped	Total		Cropped	Total		Cropped	Total		Cropped	Total
Crop		Profit	Area	Profit	Profit	Area	Profit	Profit	Area	Profit	Profit	Area	Profit	Profit	Area	Profit
		NRs/ha	ha	NRs	NRs/ha	ha	NRs	NRs/ha	ha	NRs	NRs/ha	ha	NRs	NRs/ha	ha	NRs
																0
(A) Without Project Conditions																
Paddy	P.I.	4,225	3.07	12,979	5,197	1.38	7,150	7,504	0.60	4,468	8,802	0.15	1,350	6,817	0.38	2,583
	N.I	598	3.22	1,926	1,461	1.44	2,107	3,510	0.62	2,191	4,664	0.16	750	2,900	0.40	1,152
Wheat	P.I.	3,742	0.74	2,770	4,170	0.33	1,382	5,811	0.14	834	6,735	0.04	249	5,323	0.09	486
	N.I.	127	0.94	120	384	0.42	162	1,607	0.18	294	2,441	0.05	115	1,165	0.12	136
Maize	P.I.	4,956	0.09	459	5,643	0.04	234	7,275	0.02	130	8,194	0.00	38	6,789	0.01	77
Pulses	P.I.	4,036	0.13	523	4,670	0.06	271	6,176	0.03	155	7,023	0.01	45	5,728	0.02	92
	N.I.	2,993	0.57	1,717	3,547	0.26	911	4,863	0.11	541	5,604	0.03	161	4,471	0.07	316
Oilseeds	P.I.	6,915	0.17	1,152	7,526	0.07	561	8,978	0.03	290	9,795	0.01	81	8,545	0.02	176
	N.I.	3,166	0.41	1,289	3,697	0.18	674	4,959	0.08	391	5,669	0.02	115	4,583	0.05	230
Vegetables	P.I.	5,781	0.19	1,070	7,135	0.08	591	10,352	0.04	371	12,163	0.01	112	9,394	0.02	214
Total			9.53	24,003		4.27	14,045		1.85	9,665		0.48	3,016		1.18	5,462
(B) With Project Conditions			(size:6.67ha)			(size:2.99ha)			(size:1.29ha)			(size:0.33ha)			(size:0.83ha)	
Paddy	F.I	13,817	6.67	92,159	14,877	2.99	44,482	17,394	1.29	22,438	18,810	0.33	6,207	16,644	0.83	13,815
Wheat	F.I	8,810	3.29	29,003	9,347	1.24	11,581	11,245	0.49	5,480	12,314	0.09	1,108	10,680	0.31	3,349
Oilseeds	F.I	12,598	0.83	10,504	13,267	0.37	4,959	14,857	0.16	2,396	15,751	0.04	650	14,384	0.10	1,492
Vegetable	F.I	45,126	0.43	19,404	44,625	0.43	19,189	48,188	0.23	11,224	50,192	0.09	4,718	47,127	0.15	7,063
Total			11.23	151,070		5.03	80,210		2.17	41,538		0.56	12,683		1.40	25,718
(C) Increment			1.70	127,067		0.76	66,166		0.32	31,872		0.08	9,667		0.22	20,256

Note: F.I. : Full Irrigated
P.I. : Partially Irrigated
N.I. : No-irrigated

Table 7.5 Labor Requirement for Farming Activities

Crop	Condition	Requirement	Cropped Area	Total Requirement
		man-day/ha	ha	man-day
(1) Without Project Conditions				
Paddy	P.I.	133	837	111,321
	N.I.	118	854	100,772
Wheat	P.I.	94	306	28,764
	N.I.	85	116	9,860
Maize	P.I.	93	25	2,325
Pulses	P.I.	86	78	6,708
	N.I.	75	195	14,625
Oilseeds	P.I.	83	77	6,391
	N.I.	72	29	2,088
Vegetables	P.I.	186	50	9,300
Total			2,567	292,154
(2) With Project Conditions				
Paddy	F.I.	145	1,800	261,000
Wheat	F.I.	109	680	74,120
Oilseeds	F.I.	91	225	20,475
Vegetables	F.I.	206	325	66,950
Total			3,030	422,545
(3) Increase				130,391

Note: F.I. : Fullirrigated
P.I. : Partially Irrigated
N.I. :Non-irrigayed

FIGURES

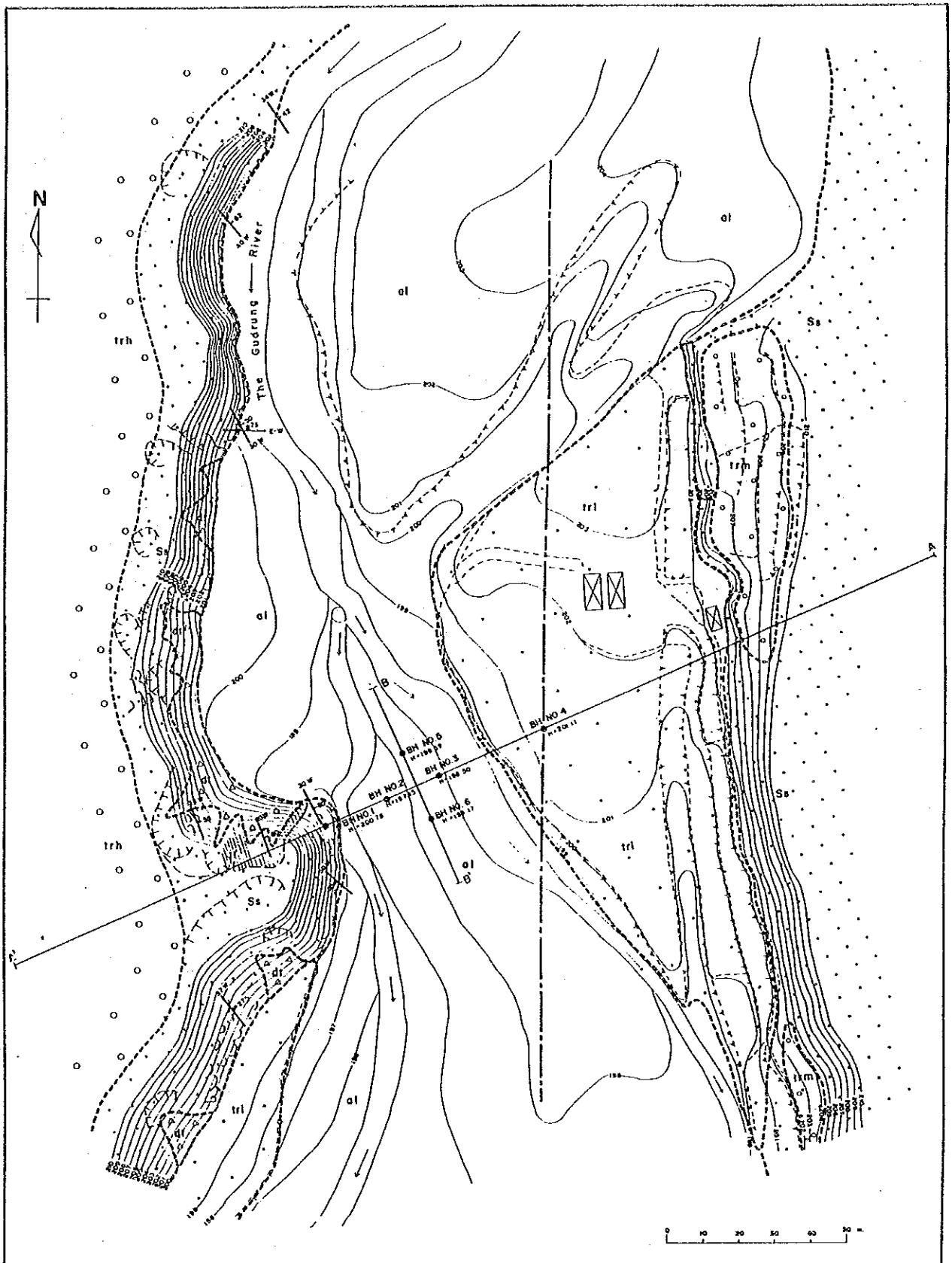

Fig. 3.1 Geological Map of the Gudrung Headworks Site

The legend is shown in Figure 2.

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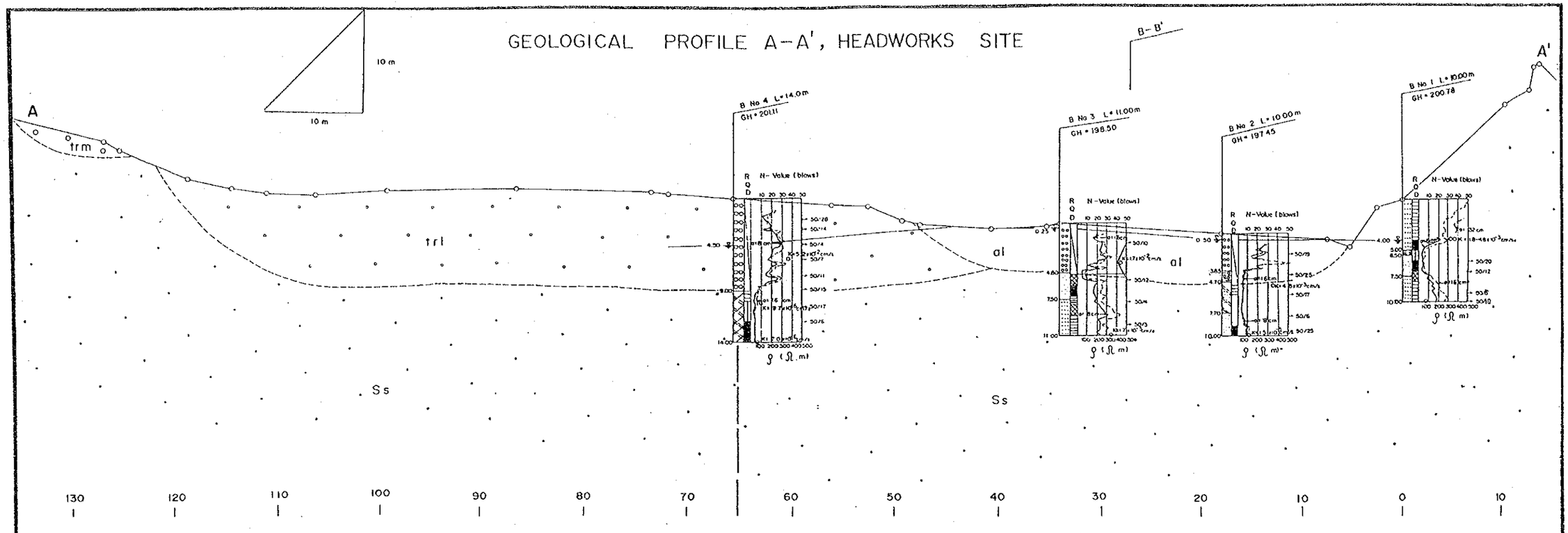

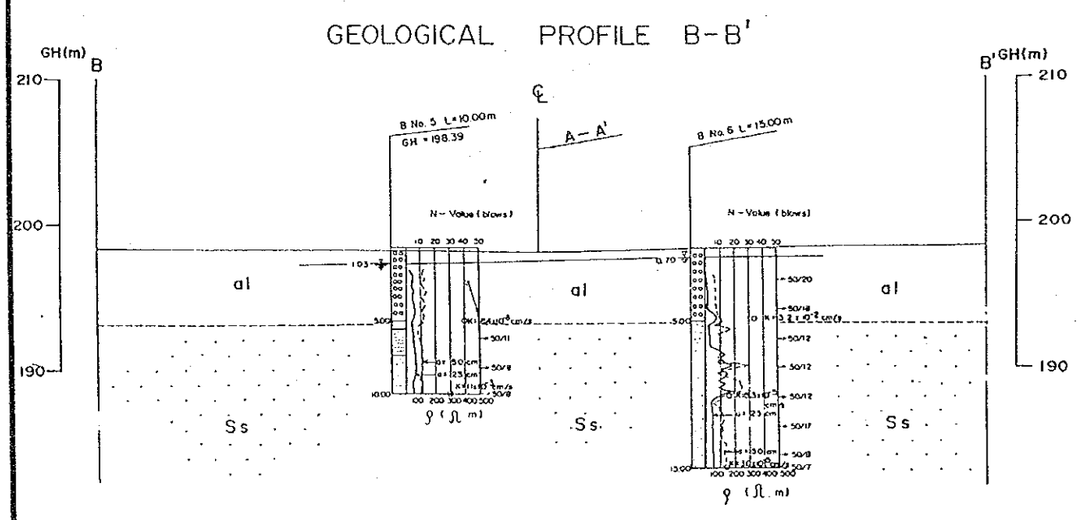

LEGEND

Age		Formation	Symbol	Constituents, Rock Quality	Thickness
QUATERNARY	HOLOCENE	alluvium	al	boulder, pebble, sand	5 m+
		talus	dt	breccia, sand, silt	2~3 m+
		newer fan deposits	fdn	boulder, pebble, sand, silt	—
	PLEISTOCENE	lower terrace deposits	trl	boulder, pebble, sand, silt	2~9 m
		middle terrace deposits	trm	boulder, pebble, sand, silt	2~5 m
		older fan deposits	fdo	boulder, pebble, sand, silt	—
		higher terrace deposits	trh	boulder, pebble, sand, silt	2~5 m
NEOGENE TERTIARY		Siwalik Group	Ss	alternation of coarse to medium sandstone, fine sandstone and siltstone (+calcareous)	—

Geological Boundaries

Fault

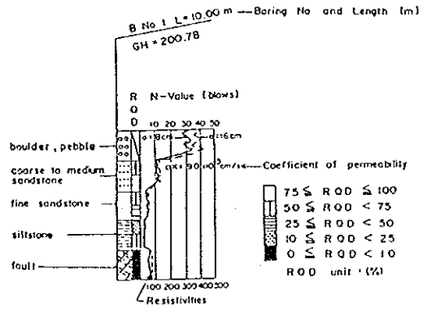

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Fig. 3.2 Geological Profiles at the Gudrung Headworks Site

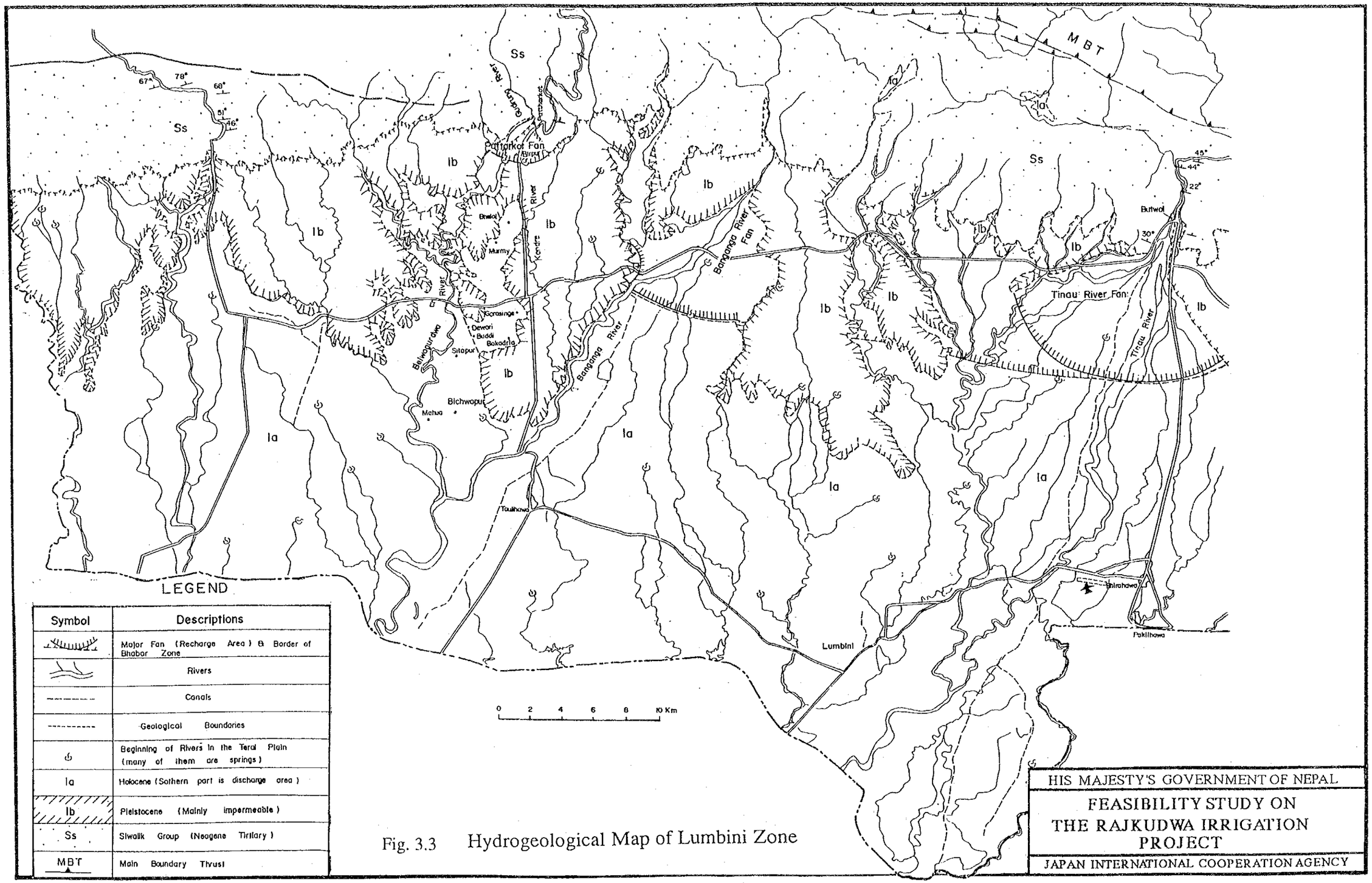
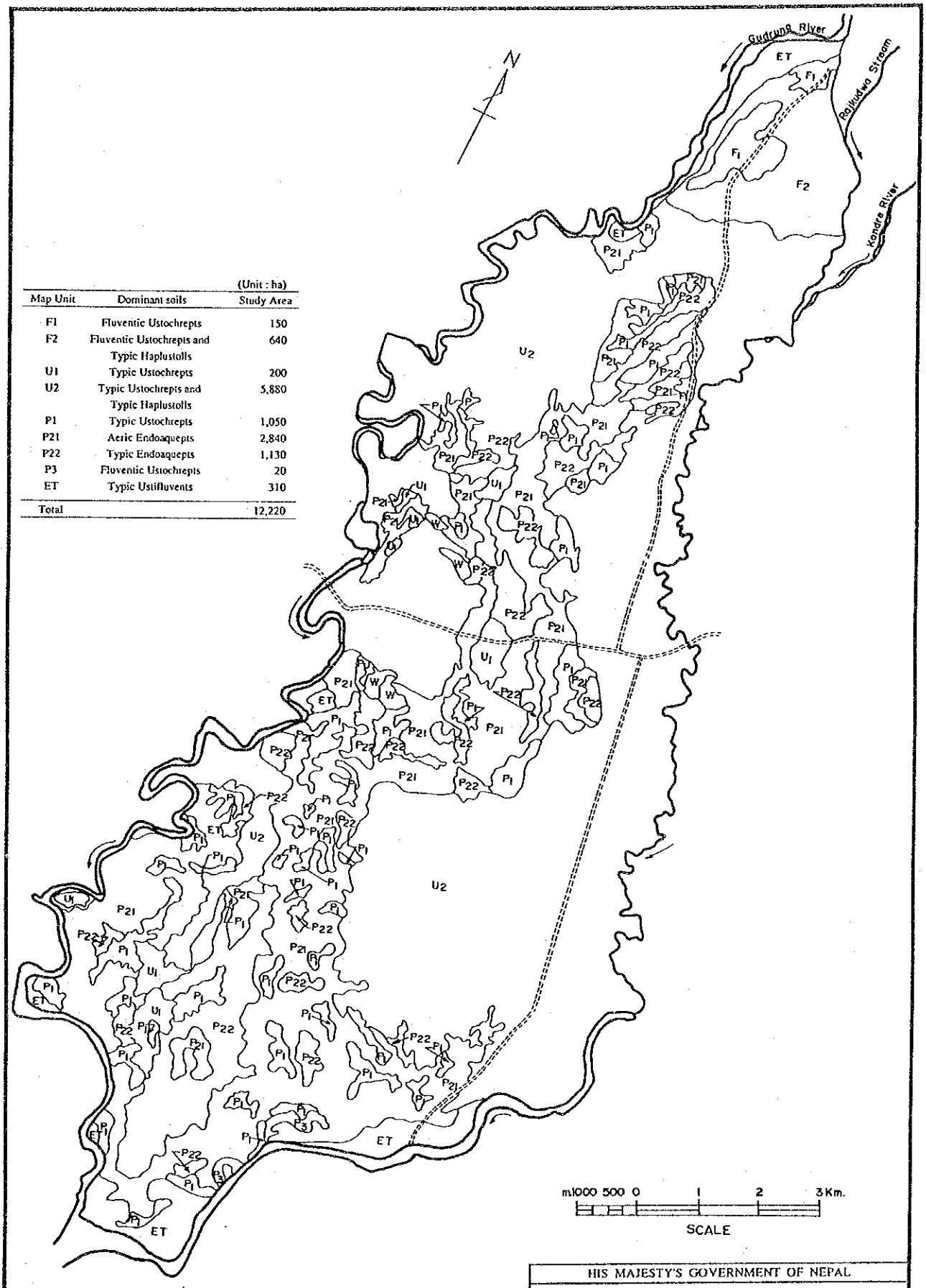


Fig. 3.3 Hydrogeological Map of Lumbini Zone



(Unit : ha)

Map Unit	Dominant soils	Study Area
F1	Fluventic Ustochrepts	150
F2	Fluventic Ustochrepts and Typic Haplustolls	640
U1	Typic Ustochrepts	200
U2	Typic Ustochrepts and Typic Haplustolls	5,880
P1	Typic Ustochrepts	1,050
P21	Aeric Endoaquepts	2,840
P22	Typic Endoaquepts	1,130
P3	Fluventic Ustochrepts	20
ET	Typic Ustifluvents	310
Total		12,220

Fig. 3.4 Soil Map

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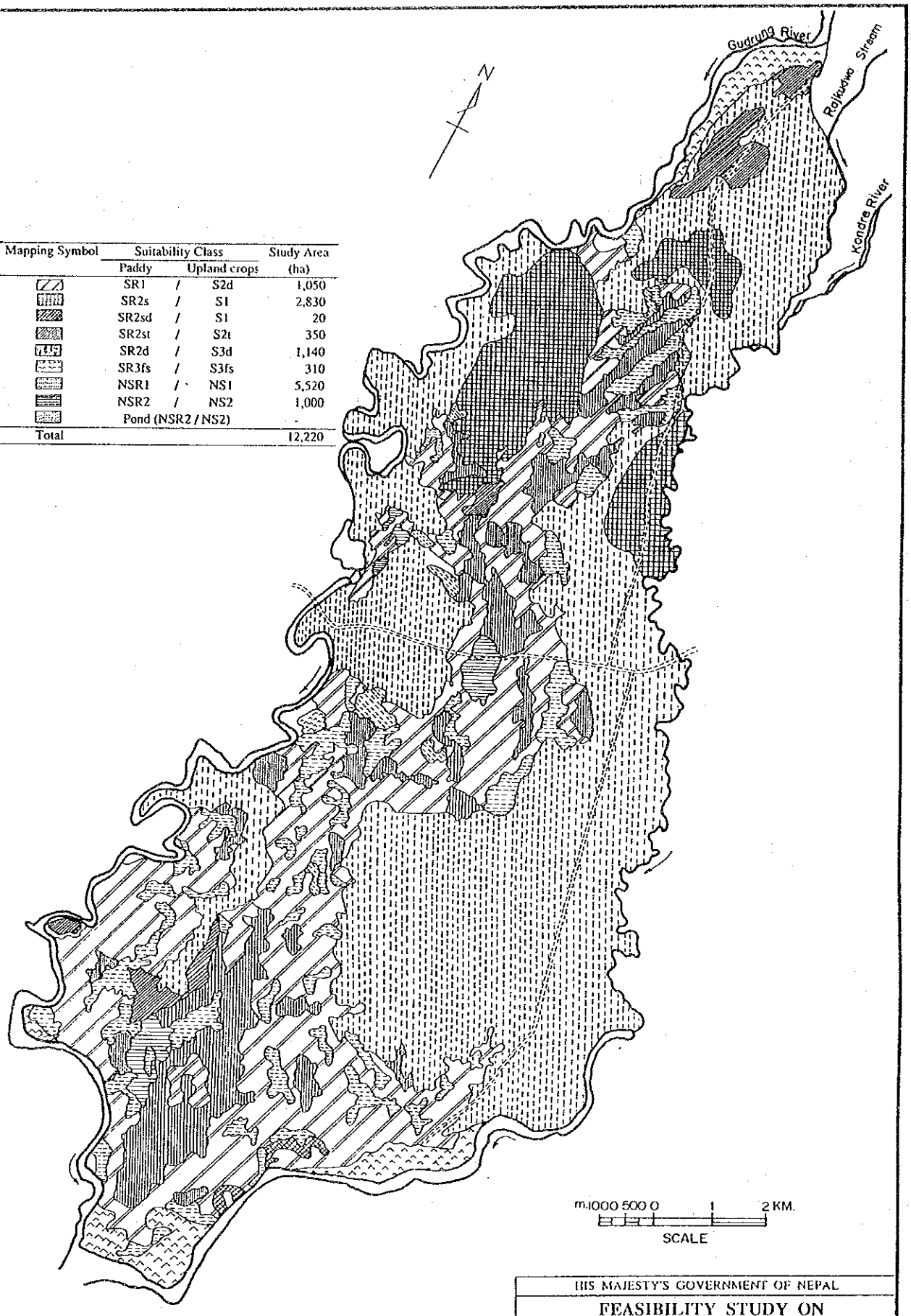

Mapping Symbol	Suitability Class			Study Area
	Paddy		Upland crops	(ha)
	SR1	/	S2d	1,050
	SR2s	/	S1	2,830
	SR2sd	/	S1	20
	SR2st	/	S2t	350
	SR2d	/	S3d	1,140
	SR3fs	/	S3fs	310
	NSR1	/	NS1	5,520
	NSR2	/	NS2	1,000
	Pond (NSR2 / NS2)			-
Total				12,220

Fig. 3.5 Land Evaluation (Irrigation Suitability) Map

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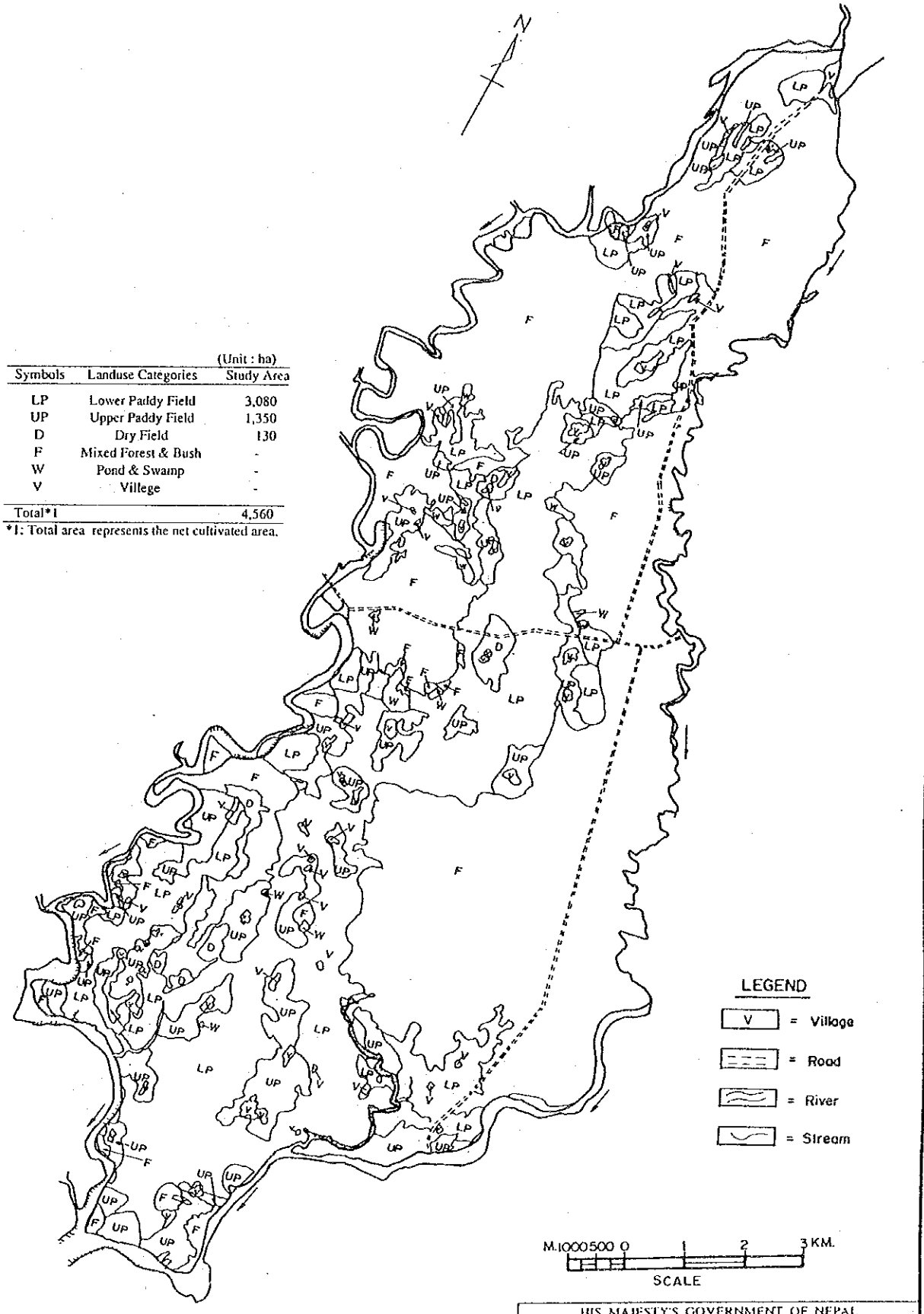

(Unit : ha)

Symbols	Landuse Categories	Study Area
LP	Lower Paddy Field	3,080
UP	Upper Paddy Field	1,350
D	Dry Field	130
F	Mixed Forest & Bush	-
W	Pond & Swamp	-
V	Villege	-
Total*1		4,560

*1: Total area represents the net cultivated area.

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Fig. 3.6 Present Landuse Map

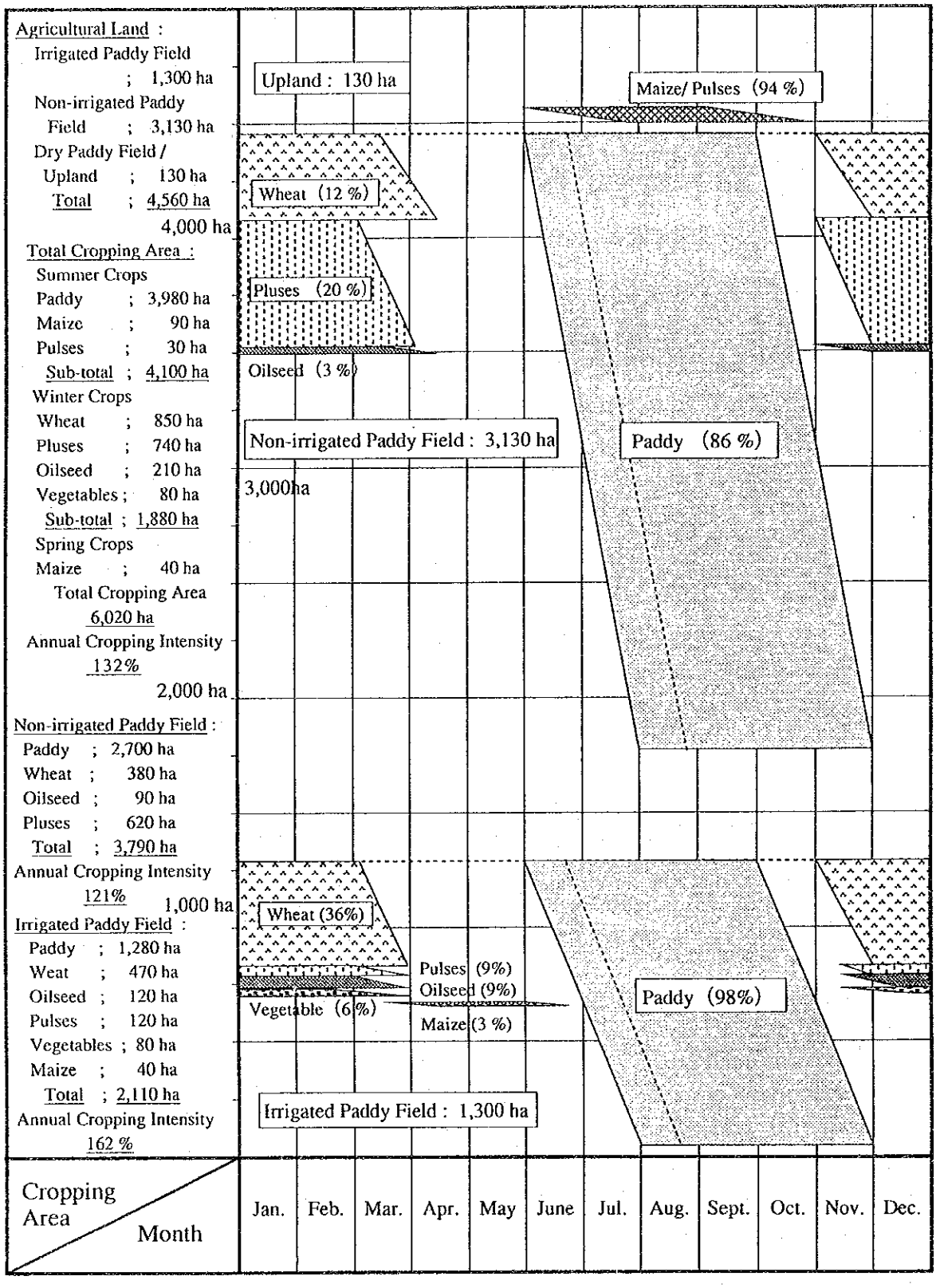

Fig. 3.7 Present cropping Pattern

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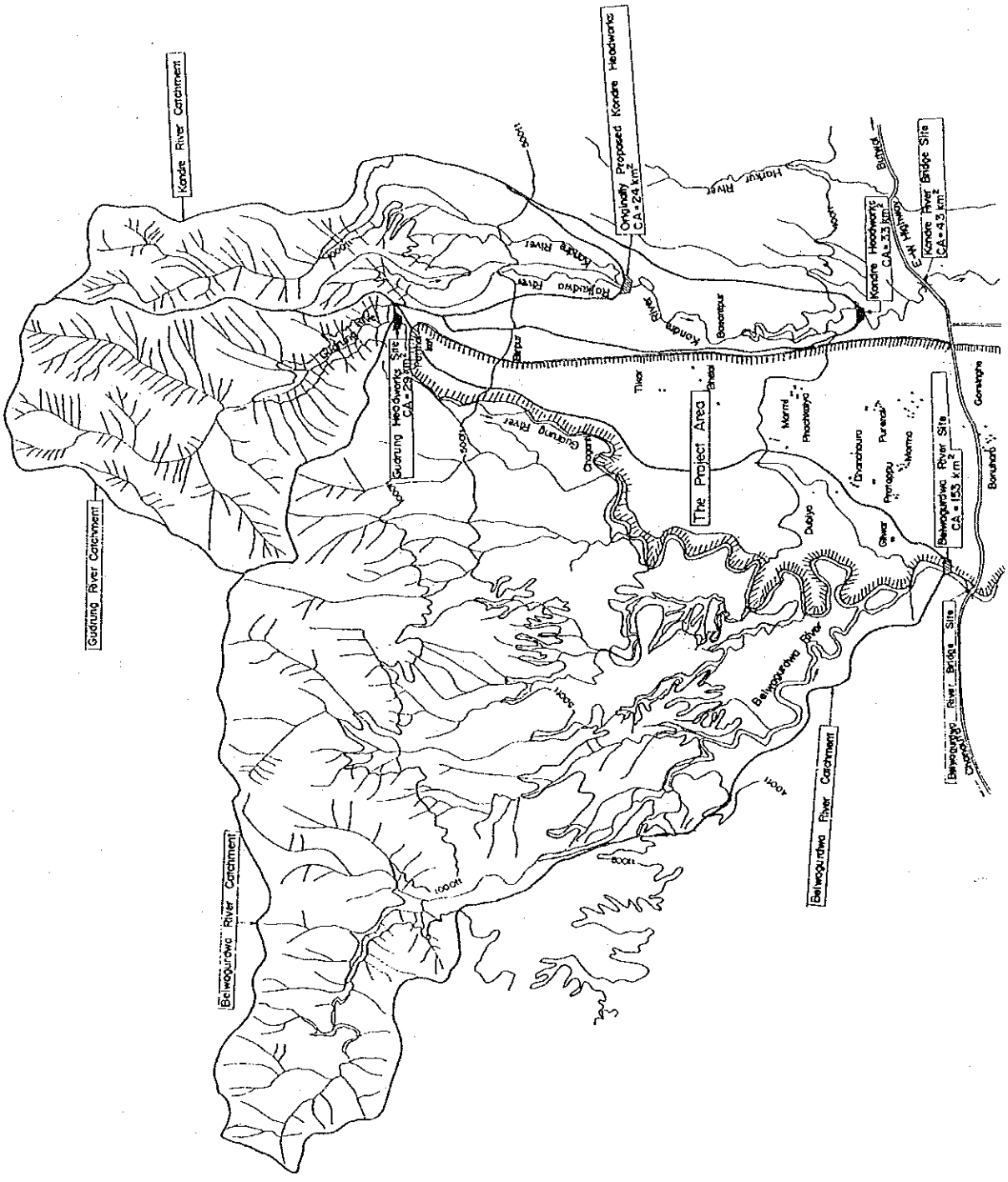

Fig. 4.1 Catchment Area of the Relevant Rivers

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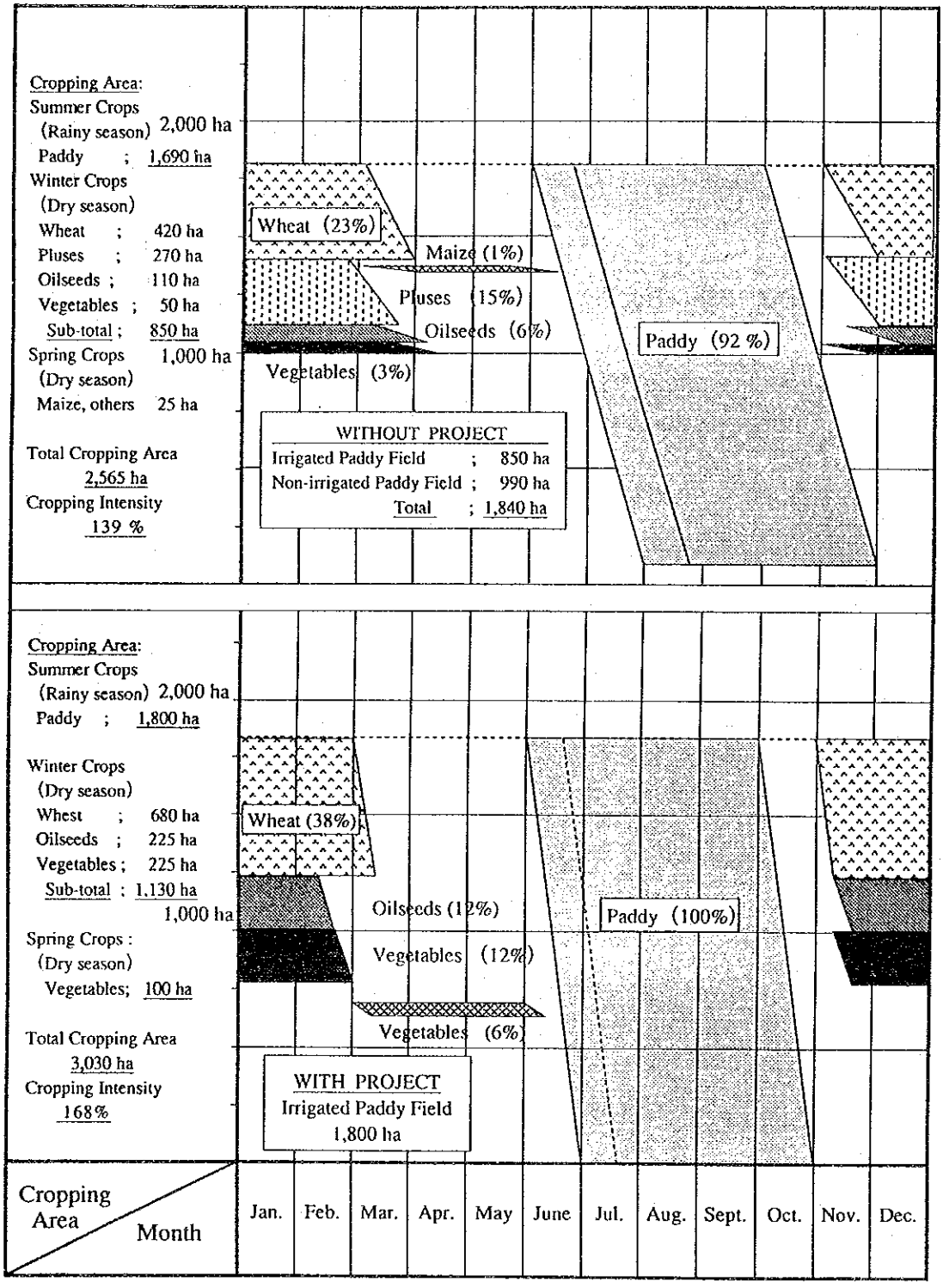

Fig. 5.1 Proposed Cropping Pattern

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