3.4.3 Required Irrigation Water for Each Plan and Additional Water

Required irrigation water for each plan was calculated on the basis of the areas formulated in section 3.3.4 and the results of the same are presented in TABLE 5-3-12.

(1) Sun Kosi Multipurpose Scheme

As shown in TABLE 5-3-12, total annual required irrigation water under the plan is about $2,386 10^6 m^3$ for the standard year 1969 when the command area between the Kanro and Marha is at a minimum (136,700ha). Total annual discharge of the Kamla River during the same year was $1,555 10^6 m^3$ and thus adequate irrigation water supply cannot be provided by the natural flow of the Kamla River alone.

(2) Sapt Kosi West Irrigation Scheme

The Sapt Kosi West Irrigation Scheme involves two alternative plans; namely, the Sun Kosi-Trijuga Diversion Plan and the Sapt Kosi Intake Plan. The net command area of the former is greater than that of the latter, amounting to 17,100ha, with a total water requirement of $298.5 10^6 m^3$ for the standard year, 1969. Available discharge from the Trijuga River for irrigation purposes is about $203.9 10^6 m^3$, indicating an annual shortage of $94.6 10^6 m^3$. Accordingly, intake from the Kosi Basin will be required to supplement Trijuga flow.

(3) Sapt Kosi East Irrigation Scheme

As mentioned under Planning Criteria, natural flow utilized for irrigation in this Master Plan will be derived from the Kamla and Trijuga rivers. Accordingly, supply from another basin system will be required as the irrigation water of the plan cannot be fulfilled by the natural flow from the said rivers alone.

3.5 Irrigation Development Planning

3.5.1 Sun Kosi Multipurpose Scheme

(1) Intake Site and Diversion Tunnel Route

The intake site and diversion route to provide the required water supply for the Terai Area irrigation plan from the Sun Kosi

to the upstream portion of the Kamla River tributary has been planned in consideration of the technical, topographical and economic factors discussed below. Two alternative plans were studied for the diversion route, one with a hydropower generation component and one without, and the economic feasibility of each plan is analysed in 3.5.1 (6).

1) Intake site

Sedimentation in the Kurule site vicinity is as described in APPENDIX VI, 1. 'Watershed Management', and annual sediment flow is estimated at $46 10^6 m^3$. As a result, the life of diversion facilities is shortened and maintenance costs are increased, thereby greatly affecting the life of the Project itself. Accordingly, siltation was an important consideration in determination of the intake site.

The Kurule site is topographically well suited for intake dam construction due to its location in a steep ravine carved through the mountain range and visible outcrops of rock on both banks. In addition, an appropriate site for the desilting pond exists downstream where the river suddenly widens.

The probable flood discharge with a 10,000 year return period at the Kurule site is $19,000 m^3/s$ and flood level at the same under these conditions is El.327m or 20m above the riverbed at the present river section. If a dam with spillway gate dimensions of H = 15m, C = 14m is planned, a flood water level of El.338m is required to ensure safe discharge of $19,000 m^3/s$ flood. Dam height for the same would be 48.9m above dam foundation and intake water level would be 338m.

Near the same portion, a separate large development project, the Sun Kosi No.1 Project, is planned for future implementation at the same Kurule site and includes a 147m high dam and a 1,357MW hydropower plant. This project will be developed for energy export to neighbouring countries rather than for domestic demand. Accordingly, any decrease

in the development potential of the said large hydropower project must be carefully avoided in planning the intake dam for diversion.

Several alternative methods may be considered for establishment of both dams. In the present plan, the diversion intake dam site has been planned 480m downstream from the proposed large hydropower project dam site. This will allow intake of required water from the tailrace downstream even if a high dam and powerhouse are later constructed upstream.

In this plan, about 20m of sediment deposit will accumulate in future on the riverbed of the proposed large project dam site, hindering dam construction work. Accordingly, survey and study of the relationship between the diversion intake dam and the high dam will be required at the next stage Feasibility Study.

The diversion intake dam is planned with a height of 48.9m and spillway gates. Although construction costs are lower in the case of an overflow dam, the dam's intake and settling pond would be submerged during floods due to the high flood water level. In order to obtain constant diversion quantity in rainy season, a dam height of 8-9m above the riverbed is required. However, the possibility that in future the Sapt Kosi High Dam may be designed at the HWL proposed by India (El.335.28m) should be taken into consideration.

2) Diversion route

Based on the above intake elevation, 2 alternative tunnel routes were considered; one from the diversion intake site to Khankhop village with diversion power generation potential, and one from the intake site to the upper stream of the Kaharukhola River, a tributary of the Kamla River, with no power generation component. The said tunnels are designed as non-pressure-type with lengths of 16.6km and 13.9km, respectively (FIG. 5-3-4).

The main boundary fault crosses the Mahabarat Range from east to west about 4km from the diversion route on the Terai side. However, as the fault is a narrow 10m where it crosses above the diversion route, no major obstacles are expected with regards to the same in tunnel construction. Although the Project implementation schedule has a significant effect on tunnel length, the tunnel can be built in sections by construction of the adit at the fault site and at the Sun Kosi tributary, the Sarung Khola River. In this case, the maximum tunnel length is 9,500m.

(2) Kamla Dam

A site approximately 8km upstream from Chisapani village was selected for the Kamla Dam. This site is the same as that surveyed under FAO in 1972, in the "Feasibility Study of Irrigation Development in the Terai Plain". Topographically there is no other suitable dam site available in the area.

As the geological conditions of the Kamla dam site are poor, a gravel-sand fill-type dam has been planned. Although it is necessary to adopt a 1/10,000 year probable return period flood, almost no flood records are available for the Kamla River and consequently design flood volume cannot be calculated. Under the present Project therefore, design flood was estimated at 1.3 times the previous maximum flood (3,800m^3/s) or 5,000m^3/s.

Observation of soil erosion and sedimentation in the Kamla basin was not collected during field survey. However, sediment flow of the Kamla River basin which consists of the Mahabarat and Siwalik ranges is assumed to be greater than that in the Sun Kosi basin. Specific sediment was estimated at 3,000m^3/km^2/year. As the catchment area at the site is 1,450km^2, dead storage capacity is 220 x 10^6m^3. Main features of the Kamla Dam for each plan with different diversion water are as shown in TABLE 5-3-13.

Further study of both design flood and aforementioned sedimentation will be required at the next Feasibility Study level.

(3) Irrigation Facilities

Two alternative sites are considered for the main canal intake; namely, Chisapani village (El.400ft) and the Kamla Dam site (El.450ft). Irrigation area should be as large as available irrigation water supply and soil conditions permit. However, in the case of El.450ft for intake directly downstream from Kamla Dam, the main canal on the right bank, about 12.8km in length, must be constructed in the mountains. Moreover, a tunnel about 2km in length must be constructed on the left bank to supply irrigation water to the Terai Area. The resultant cost of these works is high and the plan less economical than that for an intake level of El 400ft. Under the present Project, the two sites will be planned as alternatives (FIG. 5-3-5).

The planned route of the main canal is crossed by numerous rivulets springing from the Siwalik range. Moreover, the main canal alignment area is covered by highly permeable soils formed by sediments from the Siwalik range. In order to reduce resultant conveyance loss, all main canals will be lined.

The Project area is long and narrow, about 140km from left to right and consequently the main canal extensions are also long. Main canal sections were therefore changed to ensure an economical plan with an average command area of 13,000ha.

There are several types of facilities which may be used in the main canal for crossing intersecting rivers. However, as the map scale used in planning was 1/50,000 and confirmation of topographical details was thus impossible, the siphon-type method was adopted for major river crossings.

Siphon extension was determined by estimation of the flood discharge of intersecting rivers based on the Creagar Equation, and subsequent reduction of river width to the section necessary to handle the above flood discharge by means of guide banks. However, use of siphons for crossing all intersecting rivers results in a longer construction period, increased construction cost and hence poor economic feasibility. Accordingly, siphons will be used on major intersecting rivers only.

In the case of smaller rivers, the main canal will intercept the same and river flow will be channeled into a drainage canal to be constructed alongside the main canal and drained into nearby rivers which have siphon facilities. Terminal facilities for irrigation are shown in FIG. 5-3-6, as a model system. In accordance with planning and design criteria and factors discussed above, a summary of the irrigation plan is given in TABLE 5-3-14.

Rivers in the Study area are natural rivers with no bank protection or training works, and the river courses of the same change with each flood. The present Plan was designed with river courses assumed as constant and unchanging. If change occurs in the same, however, agricultural production will be extensively damaged, the main canal will be greatly affected, and operation and maintenance costs will increase. Accordingly, study of river training to stabilize the river courses should be conducted in the Feasibility Study. River training is an indispensable component of agricultural development in the Terai Area, both to prevent erosion of existing farmland and to reduce the area of flood inundation. With river training, development of a large area of new arable land will be made possible.

(4) Hydropower Planning

1) General

Hydropower development effectively increases the development benefit of the Sun Kosi Multipurpose Scheme.

As mentioned below, two hydropower generation plants have been planned. One is a diversion power station with an installed capacity of 61MW and the other is the Kamla Dam Power Station with an installed capacity of 32MW. These medium scale hydropower plants will greatly contribute to rural development in the project area by providing economical and high quality energy.

A transmission line with substation is planned to connect the two plants with the Hetauda-Biratnagar line.

Proposed capacity of the said line is 132KV and total length for both plants is 32KM.

2) Diversion power station plan

A hydropower station plan is proposed using effective water head (approximately 102.5m) between the intake level at the Sun Kosi River and the diversion water discharge point on the Kamla side. High quality firm energy is obtainable at the said station due to constant year-round flow of diversion water ($72m^3/s$). An annual installation operation factor of 95% is therefore planned. Installation capacities depending on different diversion water for each plan are shown in TABLE 5-3-15.

3) Kamla dam power station plan

High water level of the Kamla Dam reservoir varies from El 177m -179.6m according to the different plans and the level of the Kamla Dam immediately downstream is El 137.2m, allowing a possible head of approximately 40m.

The Kamla Dam will discharge irrigation water required for the command area and also for the downstream area (compensation flow for downstream water utilization). Total monthly average discharge from the Kamla Dam will be 35.6-$208.8m^3/s$ with monthly fluctuations occurring to meet irrigation requirement.

Based on the optimization study, an annual installation operation factor of about 65% is adopted and maximum design discharge is planned at 100-$140m^3/s$ according to each plan. Installation capacities of the Kamla Dam power station are shown in TABLE 5-3-15.

4) Optimum development scale

Optimum scale of hydropower plants has been determined mainly from irrigation planning study. The optimum development scale of two hydropower plants are shown in TABLE 5-3-16 and 5-3-17.

(5) Diversion Water Analysis

1) Downstream maintenance flow

A water use agreement for the Kosi River was reached between Nepal and India. However, except for the Sapt Kosi which flows through the Study area, no agreement has yet been made with India regarding use of other rivers in the Study area. Consequently, even though construction of a high dam is planned in the upper streams of the Bagmati, Kamla and Kankai rivers, respectively, implementation of the same has not been carried out. For this reason, irrigation planning for the present Project was undertaken in consideration of responsibility for discharge to the downstream area of the Kamla River.

Minimum discharge for the Kamla River in 1969, the 1/10 probability year, occured from March to May with an average of about $7m^3/s$ while maximum discharge occured in August at $165m^3/s$, indicating a large seasonal fluctuation in the same. Several assumptions of downstream discharge conditions were assumed and the present Project was planned accordingly. The entire dry season Kamla River flow of $7m^3/s$ is designated for downstream discharge as is 50% of water volume exceeding the same. Water volume exceeding the natural flow of $50m^3/s$ will be stored in the reservoir and used for irrigation.

2) Need for Diversion and the Kamla Dam

Irrigable area by Kamla natural flow alone

Minimum natural flow in the Kamla River occurs from March-May at approximately $7m^3/s$. If the maintenance flow for the downstream Kamla is not considered, irrigable area is 25,000ha of the existing Kamla Irrigation Project and crop intensity is 125%.

Moreover, in the case of Kamla River High Dam construction and storage of Kamla River natural flow by the same, the amount of water available for irrigation annually is $800.56 10^6 m^3$ with total Kamla River natural discharge,

evaporation from the reservoir and maintance flow to the downstream area estimated as follows:

- Annual Kamla natural flow	1555.24	10^6m^3
- Evaporation from the Kamla reservoir	47.85	"
- Downstream maintenance flow	706.83	"
- Available irrigation water	800.56	"

Total annual water requirement for irrigation, on the other hand, is 17,460m^3/ha, which means that only about 45,900ha can be irrigated. Available irrigation water is thus insufficient even for the 136,700ha of "Case SK-400-BK" plan, the smallest command area in the Sun Kosi Multipurpose Scheme, and accordingly, diversion from the Sun Kosi River is necessary.

Irrigable area by diversion water from Kurule intake site

Monthly average natural discharge flow at the Sun Kosi River Kurule site is minimum in April at 130.5m^3/s and maximum in August at 1,886.1m^3/s. After completion of the SU-3 Dam Plan envisioned under the power generation plan, discharge at the Kurule site will be regulated, becoming 177.2m^3/s in April and 1,696.5m^3/s in August. The irrigable area for each month assuming that the entire minimum discharge flow of April is diverted from the Kurule site to the Kamla without the Kamla Dam is as presented in TABLE 5-3-18. According to the same, the irrigable area during the driest month (April) is minimum at 113,000ha without the SU-3 Project and 153,000ha with Project.

The area of the Chisapani Barrage Intake Plan between the Marha and Kanro rivers, which has the smallest command area of those determined (3.3.4 'Determination of Project Area') is 136,700ha, and diversion water required after subtraction of Kamla River flow is 158.6m^3/s. Accordingly, natural flow of the Kurule site alone without SU-3 is insufficient to supply irrigation water for the entire plan. Even with the SU-3 Project, irrigable area is 153,000ha, while irrigable area of the above Plan is only 136,700ha

(FIG. 5-3-7). As described hereunder, a dam for regulation of irrigation water supply to the Kamla River is required for the Sun Kosi-Kamla Multipurpose Scheme.

3) Water Balance for Each Plan

Minimum diversion water

Required irrigation water for each plan is as shown in TABLE 5-3-12. Diversion water and Kamla Dam scale according to different diversion volumes from the Kurule intake dam were studied with consideration for the above water requirements as well as evaporation in the Kamla Dam reservoir and maintenance flow downstream. Kamla reservoir evaporation and downstream maintenance flow used in calculations were determined on the basis of the assumptions explained hereunder.

Although, in general, Kamla reservoir evaporation is calculated by surface area for the monthly average water level, as this was the Master Plan, the surface area for the annual average reservoir level was designated at 3,200ha and monthly evaporation was calculated from the same.

Downstream maintenance discharge conditions were assumed as follows:

a) All Kamla natural flow will be discharged downstream should the same be less than 7.0m^3/s; and,

b) Should Kamla River natural flow (Q) exceed 7m^3/s, a maximum of 50m^3/s will be discharged downstream.

Monthly Kamla Dam reservoir evaporation, downstream maintenance flow and Kamla natural flow are presented in TABLE 5-3-19. Based on the above mentioned assumptions, annual water balance of the Kamla Dam for "Case, SK-400-BK" and "Case, SK-450-BK" plans is shown in TABLE 5-3-20.

In the case of "Case, SK-400-BK" plan, total annual water requirement (outflow) at the Kamla dam site under the Chisapani Intake Plan is 3811.36 10^6m^3, while total amount to

be supplied to the Kamla Dam[1/] (inflow), when diversion from the Sun Kosi River is 70m3/s, is 3,761.77$10^6$m3. This leaves a water shortage of 49.59$10^6$m3 (3,761.77 - 3,811.36 = 49.59). In the Kamla Dam Intake Plan likewise a shortage of 127.30 10^6m3 occurs with a diversion of 90m3/s, necessitating supplementary supply greater than that of the above diversion volumes.

Results of the study of other plans for annual water balance according to the above procedure are presented in TABLE 5-3-21 and FIG. 5-3-8.

Minimum diversion water requirements for each plan based on the above results are presented below.

- Chisapani Barrage Intake Plan

Bagmati River - Kanro River	71.6m3/s
Jhim River - Kanro River	62.7m4/s
Marha River - Kanro River	50.3m3/s

- Kamla Dam Intake Plan

Bagmati River - Kanro River	94.4m3/s
Jhim River - Kanro River	63.5m3/s

Water balance for different diversion

If the minimum diversion volume of 72m3/s for Case SK-400-BK Plan is increased, inflow into and discharge from the Kamla Dam reservoir are as shown in TABLE 5-3-22 (5). According to the same, maximum shortage of diversion water occurs in May at 492.57$10^6$m3 at a diversion rate of 72m3/s. Even when diversion is increased to 100m3/s, a shortage of 268.59$10^6$m3 occurs in the same month of May. Accordingly, dams with the following storage capacities are required for each diversion capacity of Case SK-400-BK Plan.

Diversion Capacity	Available Storage Capacity
72m3/s	492.57 10^6m/3
80m3/s	427.57 10^6m/3
90m3/s	348.07 10^6m/3
100m3/s	268.59 10^6m/3

1/ Inflow of Kamla Dam = Diversion water + Kamla natural flow

Water balance for different diversion

If the minimum diversion volume of $72m^3/s$ for Case SK-400 BK Plan is increased, inflow into and discharge from the Kamla Dam reservoir are as shown in TABLE 5-3-22 (5). According to the same, maximum shortage of diversion water occurs in May at 492.57 10^6m^3 at a diversion rate of $72m^3/s$. Even when diversion is increased to $100m^3/s$, a shortage of 268.59 10^6m^3 occurs in the same month of May. Accordingly, dams with the following storage capacities are required for each diversion capacity of Case SK-400-BK Plan.

Diversion Capacity	Available Storage Capacity
$72m^3/s$	492.57 $10^6m/3$
$80m^3/s$	427.57 $10^6m/3$
$90m^3/s$	348.07 $10^6m/3$
$100m^3/s$	268.59 $10^6m/3$

Inflow and outflow of diversion water for other plans are shown in TABLE 5-3-22 and the Mass Curve for the same in FIG. 5-3-9.

(6) Optimization of Each Plan

As mentioned above, Kamla Dam scale varies in correspondence with the different diversion capacities of each plan within the Sun Kosi Multipurpose Scheme. Accordingly in order to determine the most economic combination of the same, the following 3 factors were thoroughly studied:

a) Optimum combination of Kamla Dam and diversion water;

b) Optimization of "with power generation" by diversion water and "without power generation"; and,

c) Analysis of "with Kamla Dam" which will regulate diversion water from the Sun Kosi River and "without Kamla Dam".

1) Optimum Combination of Kamla Dam and Diversion Water

With diversion power generation

Diversion tunnel length under this plan is 16.6km where water diverted to the Kamla River tributary is to be used for

power generation, and minimum diversion water for each plan is as discussed in "(5) Diversion Water Analysis". Should diversion water be increased, the Kamla Dam reservoir volume would be smaller and thus construction costs reduced.

The economic feasibility of construction costs for the diversion tunnel and the Kamla Dam combined was reviewed. For example, in the case of the Chisapani Intake Plan between the Bagmati and Kanro rivers, diameter of the diversion tunnel is 5.25m with minimum diversion water of 72m^3/s, while Kamla Dam height is 51m, requiring total construction cost of 172.4$10^6$US$. The cost of the Kamla Dam combined with different diversion capacities in comparison with minimum diversion capacity, increases the greater the diversion capacity becomes. Similarly, calculations for other plans showed that the combination of minimum diversion capacity with Kamla Dam scale resulted in optimum economic feasibility (TABLE 5-3-23).

Without diversion power generation

The diversion tunnel length under this plan is 13.9km. The plan was studied according to the same procedures presented in 1) With Diversion Power Generation and the results are shown in TABLE 5-3-24.

2) Optimization of With Power Generation and Without Power Generation

Minimum diversion water from the Sun Kosi River for each plan is as given below.

Plan	Intake Elevation (ft)	Diversion Water (m^3/s)
Marha R. -Kanro R.	400	51
	450	64
Jhim R. - Kanro R.	400	63
	450	80
Bagmati R. - Kanro R.	400	72
	450	95

Tunnel length in the case of power generation at the Kamla River tributary, and in the case of no power generation is 16.6km and 13.9km, respectively. With the hydropower plan, the B/C ratio is greater than that for without hydropower plan, and economic feasibility of overall plans for irrigation and hydropower increases (FIG. 5-3-10).

The B/C ratio of the 400ft intake plan (Chisapani Barrage Intake Plan) is better than the 450ft intake plan (Kamla Dam Intake Plan), because the main canal from the Kamla Dam intake site to the Terai Area is about 12.8km along the right bank through the mountains and also requires an additional 2.1km tunnel on the left bank. As substantial construction costs will be required for the same, the economic feasibility of this plan is inferior to that of the former plan.

3) Analysis of With Kamla Dam and Without Kamla Dam

As mentioned in "(5) 2) b Irrigable Area with Diversion Water from Kurule Intake Site", irrigable area with diversion water from the Sun Kosi River alone consists of the 136,700ha of the Chisapani Barrage Intake Plan, which is the command area between the Marha and Kanro rivers in the case of regulated diversion under SU-3. About 160m^3/s of diversion water would be required for this plan with a tunnel construction cost of $183.29\,10^6$US$.

On the other hand, in the case of regulation of diversion water by the Kamla Dam which has the same command area of 136,700ha, diversion water requirement would be 51m^3/s while total construction cost would be $146.4\,10^6$US$, as shown in the table below. Construction cost with the Kamla Dam is thus considerably less than that for the former.

CONSTRUCTION COST

(10^6US$)

Marha R. - Kanro R. (400ft Intake Plan)	Diversion Water (m^3/s)	Diversion Tunnel	Kamla Dam	Total
With Kamla Dam	51	82.50	63.90	146.40
Without Kamla Dam	160	183.29	-	183.29

(7) Description of Diversion Scheme

1) Irrigation command area

The command area of the Sun Kosi Diversion Scheme lies between the Bagmati and Kanro rivers in the Study area, and six case studies were carried out for the same. Four rivers flow through the above area; namely, the Jhim, Marha, Kamla and Bhate Baron rivers. These comparatively large rivers form the boundaries of alternative command area studies. The Jhim River forms the eastern boundary of the existing Bagmati Phase I Project, while the Marha forms the eastern boundary of Bagmati Phase II.

Although the Kamla River will receive diversion water from the Sun Kosi, there is an existing irrigation project on both banks of the same. The gross command area of this project is 65,000ha; however the net command area is only 25,000ha for both right and left banks combined. The same is being planned as a supplementary irrigation system.

The Bhati Baron River forms the western boundary of the command area for the existing Rajhiray pump canal project. The Kanro River forms the western boundary of the Chaudra canal project, and also the eastern boundary of the above Rajbiray pump canal project (FIG. 5-3-3).

The Sun Kosi Diversion Scheme proposed in this Master Plan covers the command area of the above existing projects and is envisioned to provide a year-round irrigation system to the entire area by means of gravity irrigation.

Two alternative cases were planned for the command area of this new project. Case, SK-450 involves enlargement of the command area as far as topography permits and an intake water level of 450ft in the Kamla River. Case, SK-400, on the other hand, proposes an alternative intake level of 400ft.

The following three cases of command area were studied for each of the above two alternative plans and results are presented in TABLE 5-3-7.

- Bagmati - Kando rivers
- Jhim - Kando rivers
- Marha - Kando rivers

2) Project Facilities

The major components of the Sun Kosi Diversion Irrigation Scheme with 2 alternative intake plans are presented below.

Chispani Barrage Intake Plan (400ft intake plan)

Water source	Kamla River and Sun Kosi River
Diversion facility	
Intake facility	concrete gravity dam (Dam Height: 48.9m)
Diversion tunnel	non-pressure (ℓ = 16.6km)
Diversion power station	effective head 102.5m capacity of power generation 43,500-61,400kW
Kamla Dam type	fill type dam
height	42.8-45.2m
Transmission line	132kV ℓ = 32km
Intake facility for main canal	barrage
Intake facility elevation	122m (400ft) from sea level
Main canal (right bank)	
Type	open canal (lined)
Length	42.4-78.4km
Max. discharge	87-135m^3/s
Main canal (left bank)	
Type	open canal (lined)
Length	74.1km
Max. discharge	84m^3/s
River crossing	siphon: right bank 9-17 left bank 16
Net command area	136,700-175,100ha

Kamla Dam Intake Plan (450ft intake plan)

Water source	Kamla River and Sun Kosi River
Diversion facility	
Intake facility	concrete gravity dam (Dam Height: 48.9m)
Diversion tunnel	non-pressure (ℓ = 16.6km)
Diversion power station	effective head 87m capacity of power generation 54,600-81,100kW
Kamla Dam type	fill type dam
height	44.9-47.9m
Transmission line	132kV ℓ = 32km
Intake facility for main canal	Kamla Dam directed intake system
Intake facility elevation	137m (450ft) from sea level
Main canal (right bank)	
Type	open canal (lined)
Length	50.7-89.2km
Max. discharge	97-165m^3/s
Main canal (left bank)	
Type	open canal (lined) and tunnel
Length	66.1km
Max. discharge	104m^3/s
River crossing	siphon; right bank 10-18 left bank 17
Net command area	160,600-215,200ha

3.5.2 Sapt Kosi West Irrigation Scheme

(1) Alternative Plans

Two plans can be considered for irrigation of the Study area; A-plan and B-plan as listed below.

- A-Plan: Sun Kosi - Trijuga Diversion Plan (Case, SW-ST Diversion Plan)
- B-Plan: Sapt Kosi Intake Plan (Case, SW-Dam Intake Plan)

A-Plan consists of diversion from the reservoir of the Sapt Kosi High Dam upon completion of construction of the same, while B-Plan which is unrelated to the said dam involves independent intake from the Sapt Kosi River for irrigation.

In the case of the latter, the main canal must cross the Trijuga River and either siphon or barrage structures may be considered for use as river crossing facilities. Of the two alternatives, a siphon plan will require a larger tunnel diameter for diversion from the Sapt Kosi River as natural flow from the Trijuga River cannot be utilized. The Trijuga River catchment area at the siphon crossing point is 696km^2 and flood volume of the same is estimated at about 3,500m^3/s. Therefore large guide banks will consequently be required at the siphon site, reducing the economic feasibility of the plan. Based on the results of comparative study of the barrage and siphon alternatives, construction of a barrage at Trijuga was judged most economically feasible for Plan B.

(2) Sun Kosi - Trijuga Diversion Plan

1) Intake site and diversion tunnel

The intake site is located in the upper Sun Kosi, 35km upstream from the confluence of the three Sapt Kosi tributaries; the Sun Kosi, Arun and Tamur rivers. The Sun Kosi river makes a wide curve to the south at this point, and the distance required for diversion to the Trijuga River is thus shortest at 5km. Moreover, the main boundary fault (MBF), which crosses the Siwilik range from east to west, runs along the north side of the intake site without crossing the diversion route. The site is thus considered economically suitable for construction of intake facilities.

2) Intake facilities

These facilities are designed to supply irrigation water from the Sapt Kosi High Dam reservoir. The water level of the reservoir has large variation, ranging from HWL of 304.8m to LWL of 259.0m. When intake elevation is the same as LWL, pressure will occur within the diversion tunnel during intake at HWL. Both the pressure and non-pressure method may be used for intake structures in this case. Under the Sun Kosi-Trijuga diversion plan, a non-pressure structure with an energy killer gate was selected in consideration of safety and economic feasibility.

3) Barrage

A site 3km upstream from the existing Chandra Barrage was selected for the diversion plan barrage to maximize the delineated area. As the objective command area elevation ranges from 240ft in the south (Kosi West Irrigation Project Boundary) and 400ft in the north (Churia foothills), intake elevation was determined at 350ft. The area below elevation 300ft is already covered by the existing main canal under the Trijuga/Chandra Irrigation Project; however, the said project does not provide year-round irrigation.

The area around El.400ft in the foothills is crossed by numerous small rivers with their catchment area in the Churia Hills, and is composed of highly permeable sandy soil. Accordingly, the hillside area is considered both economically and practically unsuitable as a site for construction of a main canal.

Based on the above factors, the optimum main canal alignment follows approximately along the 350ft contour.

(3) Sapt Kosi Intake Plan

1) Intake site and diversion tunnel

An irrigation dam will be constructed about 4km upstream from the existing Chatra Intake and intake will occur at the same. The distance from this site to the NS-2 area is comparatively short and diversion tunnel length will be only about 6.4km. Moreover, as the MBF which crosses the Sapt Kosi runs along the north side of the proposed intake site, crossing of the fault is unnecessary.

2) Intake elevation

In order to cover a command area of 17,100ha, the main canal intake elevation at the Trijuga River new barrage site is designated at 106.7m (350ft) as aforementioned. A 41.3km open canal and 6.4km diversion tunnel will run from the Trijuga River new barrage site to the Sapt Kosi intake dam, requiring a total hydraulic head of 14.7m. Accordingly, an

intake elevation of 121.4m (106.7 + 14.7) will be required for the Sapt Kosi River intake dam.

3) Others

The NS-2 area is the delta portion of the Trijuga and Sapt Kosi rivers between the Trijuga River and Gindheri Khola. This area is frequently damaged by the flood waters of the Sapt Kosi River and accordingly, river training works are required to protect the same. Information regarding flood damage in this area was unobtainable during field survey. An embankment height of 3m will be assumed for planning the said works.

(4) Analysis of Diversion Water

1) A-Plan (Sun Kosi - Trijuga Diversion Plan)

Discharge data for the Trijuga River were unavailable during the Study period. However, annual discharge at the new Trijuga River barrage site was estimated on the basis of discharge data for the Kamla River and, as presented in TABLE 5-3-25, the same amounted to $613.19 10^6 m^3$. As the total annual irrigation water requirement for the Project command area of 17,100ha is $298.48 10^6 m^3$, the above absolute discharge is sufficient to cover the entire command area. However, large fluctuations occur in natural discharge, only a portion of which is actually available for use. Thus, of the Trijuga River's $613.19 10^6 m^3$ natural flow, only $203.86 10^6 m^3$ is available for irrigation, resulting in a shortage of $94.62 10^6 m^3$.

As shown in TABLE 5-3-26, peak monthly water requirement reaches a maximum in April, and a diversion tunnel is required to supply about $16.4 m^3/s$. However, diversion water is required during the 4-month period from February to May only, when over 95% of diversion water would be used, while for the rest of the year diversion is almost unnecessary.

2) B-Plan (Sapt Kosi Intake Plan)

As in A-Plan, the maximum irrigation water requirement in the NS-1 area is April, at 16.5m3/s. In addition irrigation water requirement for the same period in the 3,800ha NS-2 area is 4.5m3/s, with a resultant maximum diversion requirement of 21m3/s from the Sapt Kosi River (TABLE 5-3-26).

(5) Description of the Sapt Kosi West Irrigation Scheme

1) Command area

As aforementioned, there are two alternative plans; the Sun Kosi - Trijuga Diversion Plan and Sapt Kosi River Intake Plan. The irrigation command area can also be divided into 2 alternative cases. One covers 17,100ha between the Kanro and Sapt Kosi rivers in the southern portion of the Trijuga River, while the other consists of the above plus the following two command areas.

- Delta area with approximately 2,700ha in the downstream reaches of the Gindheri Khola
- Delta area with approximately 1,100ha on the left bank in the downstream reaches of the Trijuga River

The existing Trijuga Chandra Canal Project which is located in the above command area, will be included in irrigation planning under the Master Plan. The Sapt Kosi West Irrigation Scheme consists of 2 alternative diversion plans with major components as given below:

Sun Kosi - Trijuga Diversion Plan
(to be commenced after completion of Sapt Kosi High Dam)

Water source	Trijuga River and Sun Kosi River
Diversion facility	
Intake facility	intake with energy killer gate
Diversion tunnel	non-pressure (ℓ = 5km)
Intake facility for main canal	barrage
Intake facility elevation	El.107m (350ft)
Main canal	
Type	open canal (lined)
Length	30.9km
Max. discharge	21.5m3/s

River crossing	siphons (5)
Net command area	17,100ha
Sapt Kosi Intake Plan	
Water source	Trijuga River and Sun Kosi River
Diversion facility	
Intake facility	concrete gravity dam (Dam Height: 39m or 77m)
Diversion tunnel	non-pressure (ℓ = 6.4km)
Intake facility for main canal	barrage
Intake facility elevation	El.107m (350ft)
Main canal (right bank)	
Type	open canal (lined)
Length	68km
Max. discharge	26m^3/s
River crossing	siphons (13)
Net command area	20,900ha

3.5.3 Sapt Kosi East Irrigation Scheme

(1) Alternative Plans

The following two plans can be considered for irrigation in the Study area.

- C-Plan: Sapt Kosi Intake Plan (Case, SE-Dam Intake)
- D-Plan: Tamur - Eastern Terai Diversion Plan (Case, SE-TT Diversion)

C-Plan consists of diversion of irrigation water from the same site as the diversion site in the Sapt Kosi West Irrigation Scheme B-Plan on the left bank of the Sapt Kosi. D-Plan, on the other hand, proposes supply of irrigation water from the Tamur River to the Terai Area on the left bank of the Sapt Kosi via a diversion tunnel. The said tunnel is long and must cross the MBF which runs through the Mahabarat range at a point where the fault width is about 100m. The latter plan will thus require greater cost and construction work. However, as the total irrigation water supply is insufficient to cover the left bank of the Sapt Kosi River, the said plan can not be disregarded.

Both C-Plan and D-Plan were studied for the Sapt Kosi East Irrigation Scheme as described above.

(2) Sapt Kosi Intake Plan

1) Intake site and diversion tunnel

The intake site is the same as that for the Sapt Kosi West Irrigation Scheme B-Plan. The diversion route extends approximately 6.5km from the intake site to the Ratnari Khola foothills on the Sapt Kosi left bank, without crossing the MFB in the Mahabarat range.

2) Intake elevation

An intake elevation of 152m (500ft) will be required for the main canal at Ratnari Khola (the diversion tunnel outlet) to cover the maximum command area. As the hydraulic head of the 6.5km diversion tunnel is 6.5m, the intake elevation was designed at 158.5m (520ft).

3) Others

The catchment area of Ratnari Khola which will serve as the diversion tunnel outlet, is small (14km^2) and accordingly natural flow from the same can not fulfill irrigation water requirements. Diversion water will therefore be conveyed via a siphon across the Ratnari Khola to flow directly into the proposed main canal. An overflow facility will be provided to channel overflow from the diversion tunnel to the Ratnari Khola.

(3) Tamur - Eastern Terai Diversion Plan

1) Intake site and diversion tunnel

The intake site is located 2.5km upstream from the Dharan-Dhankuto Road which crosses the Tamur River. This site is the same as the Mulghat Dam site surveyed in 1982 by Electrowatt Engineering Services, LTD., Zurich.

The diversion tunnel route is planned from the above intake site to the foothills of the Khadam Khola which flows through the center of the Study area of the Sapt Kosi East. As natural flow of the Khadom Khola is small, the same has not been considered for irrigation water use under the present Master Plan. However, catchment area at the barrage

site is 86km^2 and intake from the same should be studied at the feasibility study level.

2) Intake elevation

Although diversion tunnel outlet elevation in the foothills of the Khadam Khola is about 1,000ft, an elevation of 500ft is required for the main canal intake at the barrage site in order to cover a command area of 49,350ha. Elevation of the said intake dam site on the Tamur River was therefore designated at EL 311m in consideration of flood volume and sediment load.

(4) Analysis of Diversion Water

Local flows in the Study area are all small rivers and, as mentioned in Planning Criteria, have not been considered for irrigation water supply usage. All irrigation water supply will accordingly depend on diversion water from the Sapt Kosi and Tamur River. Water requirement in the command area peaks in October with a maximum of 1.016ℓ/sec/ha in the new plan area, including Components SR1, SR2, and of 2.204ℓ/sec/ha in the sandy area along the Sapt Kosi referred to as Component SR3 (TABLE 5-3-27).

Diversion water requirement for each plan is as presented below:

- C-Plan (Sapt Kosi Intake Plan): 57m^3/sec
- D-Plan (Tamur-Eastern Terai Diversion Plan): 59m^3/sec

(5) Description of the Irrigation Scheme

The irrigation benefit area is located between the Sapt Kosi River and Ratuwa River which is the western boundary of the Kankai Irrigation Project, and has potential irrigation area of 65,800ha. The said area consists of 3 parts; i) a long strip between the existing Sunsari - Morang Irrigation Project to the south and the forest zone to the north, covering 29,500ha, ii) a triangular zone located between the Bakra River which is the border line between the Sunsari - Morang Irrigation Project to the west and the Ratuwa River to the east, covering 26,900ha, and iii) the sandy area located along the Sapt Kosi River in which irrigation facilities

such as the Sunsari-Morang Irrigation Project have already been constructed, covering 9,400ha.

The plan is divided into 2 alternatives according to water source. Major components of the same are given below.

Sapt Kosi Intake Plan

Water source	Sapt Kosi River
Diversion facility	
Intake facility	concrete gravity dam[1/]-1 (dam height: 39m or 77m)
Diversion tunnel	non-pressure (ℓ = 6.5km)
Intake facility for main canal	direct intake to main canal
Intake facility elevation	El.152m (500ft)
Main canal	
Type	open canal (lined)
Length	57.3km
Max. discharge	57m^3/s
River crossing	siphons (18)
Net command area	47,950ha

Tamur Eastern Terai Diversion Plan

Water source	Tamur River
Diversion facilities	concrete gravity dam[2/] (dam height: 68m)
Diversion tunnel	non-pressure (ℓ = 18km)
Intake facility for main canal	barrage
Intake facility elevation	152m (500ft)
Main canal	
Type	open canal (lined)
Length	57km
Max. discharge	59m^3/s
River crossing	siphons 15 Nos.
Net command area	49,350ha

1/ The proposed intake dam for the Sapt Kosi Intake Plan is not compatible with the Sapt Kosi High Dam Electricity Generation Project because this intake dam will raise water level of the tailrace of the hydropower project.

Detailed comparative study will be required at the Feasibility Study stage.

1/ The diversion intake dam proposed in the Tamur River-East Terai Diversion Plan will be submerged by the Sapt Kosi High Dam Project and detailed review will be made at the the Feasibility Study stage.

3.6 COST ESTIMATE

3.6.1 General

In general, construction costs required for development vary greatly depending on construction season, development scale, location, topography and climatic condition. Unit costs for similar projects in Nepal as well as in other southeast Asian countries were considered in calculations for the Study. Construction cost is composed of three areas; i) direct construction cost, ii) engineering service and administration, and iii) physical contingency. Engineering service and administration cost is assumed to comprise 10% of direct costs while physical contingency is estimated at 8% of the above 1) and 2).

3.6.2 Cost Estimate for Each Scheme

Results of estimation of construction cost for each scheme are shown in TABLE 5-3-28 to 5-3-30.

Each item includes engineering service, administration, and physical contingency and calculations were performed according to the following conditions:

a) Intake dams include desilting pond and spillway;

b) Diversion tunnels include intake facilities;

c) Power stations include head tank, penstock, powerhouse and tailrace;

d) Transmission lines include substation; and,

e) Other irrigation facilities include drainage canals, guide banks for siphon, main secondary canals, and other structures required for irrigation.

3.6.3 Cost Allocation for Common Facilities

Main construction work items for the Sun Kosi Diversion Scheme are as listed below.

- Access Road
- Kurule Intake Dam
- Diversion Tunnel
- Diversion Power Station
- Kamla Dam
- Kamla Dam Power Station
- Transmission Line
- Irrigation Facilities
- Chisapani Barrage

Of the above, facilities for irrigation purposes alone include the last two, while those for hydropower alone are forth, sixth and seventh. The remaining items are common facilities used for both hydropower generation and irrigation. Although there are several possible methods for allocating communal facilities among costs for separate irrigation and hydropower components, costs for the same under the present Study were allocated by the method below.

$$\text{Cost allocated to Irrigation} = A \times \frac{Bi - Ci}{(Bi - Ci) + (Bp - Cp)}$$

$$\text{Cost allocated to Hydropower} = A \times \frac{Bp - Cp}{(Bi - Ci) + (Bp - Cp)}$$

where;

A: communal facility cost
Bi: total irrigation benefit
Ci: total cost of facilities for irrigation alone
Bp: total hydropower benefit
Cp: total cost of facilities for hydropower alone

The results of the Study are presented in TABLE 5-3-31.

3.7 Benefit Cost Analysis of Each Scheme

Alternative plans for each scheme have been carefully studied from technical and economic aspects, the results of which are listed in TABLE 5-3-32.

According to the said table, the most beneficial plan for each scheme is the Chisapani Intake Plan (B/C=1.54) between the Bagmati and Kanro rivers for the Sunkosi Multipurpose Scheme, the Sun Kosi-Trijuga Diversion Plan (B/C=1.10) for the Sapt Kosi West Irrigation Scheme and the Sapt Kosi River Intake Plan (B/C=0.79, Dam Height=77m) for the Sapt Kosi East Irrigation Scheme. However, as the intake dam for the Sapt Kosi Intake Plan is used in both the Sapt Kosi West and East Schemes, independent economic evaluation of each of these 2 schemes is not possible. Possible combinations of the 2 are shown in TABLE 5-3-33 and the optimum plan for each scheme is as follows:

	B/C
- Sun Kosi Diversion Scheme	
- Chisapani Barrage Intake Plan (B-K)	1.54

- Sapt Kosi West Irrigation Scheme
  - Sun Kosi-Trijuga Irrigation Scheme 1.10
- Sapt Kosi East Irrigation Scheme
  - Tamur - Terai Irrigation Scheme 0.76

The above benefit and cost analysis was calculated with a discount rate of 12%. In this case, the Sapt Kosi East Scheme has a B/C value of less than 1 and is thus judged economically unfeasible. The remaining two schemes, on the other hand, have B/C values greater than 1 and are thereby considered feasible. Of these two schemes, Case SW-ST Diversion Plan involves intake from the Sapt Kosi High Dam upon completion of the same and diversion to the Trijuga River. The said dam, however, is presently being studied under this Master Plan and in view of the substantial amount of time this large scale project will require, Case SW-ST Diversion Plan was not selected as a high priority scheme.

"Case SK-400 BK" Plan, on the other hand, is totally independent of the Sapt Kosi High Dam Project and is judged to have optimum economic feasibility. Moreover, large increases in agricultural production may be expected under the same, thus contributing to improvement of the national economy as well as to regional development as shown in FIG. 5-3-11.

3.8 Top Priority Scheme

3.8.1 Sun Kosi Multipurpose Scheme (Case SK-400-BK)

(1) Introduction

The Sun Kosi Multipurpose Scheme (Case SK-400-BK) has the highest priority among varoius schemes in the Kosi River Water Resources Development Master Plan. It is a multipurpose project aimed at irrigation and hydropower development. The scheme will contribute greatly to the integrated socioeconomic development of Nepal by creating a substantial increase in agricultural production through modernized irrigation of approximately 175,000ha and an attractive hydropower development scheme. Irrigation water for the scheme is supplied from the Sun Kosi River basin which is diverted through a 16.6km long diversion tunnel.

The said scheme is divided into two implementation phases as follows:

Phase I: a) Sun Kosi Diversion with a 16.6km tunnel and Kurule diversion dam

b) Two hydropower plants with total installation capacity of 93,400kW

c) Kamla Dam with storage capacity of $493 10^6 m^3$

d) Irrigation facilities for net command area of 175,100ha

Phase II: e) Sun Kosi No.3 Dam
Dam height: 140m
Gross storage volume: $1,220 10^6 m^3$
Effective storage volume: $560 10^6 m^3$

f) Hydropower station with installed capacity of 541MW

(2) Outline of the Scheme

1) Irrigation method/project strategy

Year-round irrigation utilizing the abundant water resources of the Sun Kosi River was adopted as the optimum method for agricultural development in the irrigation Study area. Gravity irrigation was selected for minimization of operation and maintenance costs after completion. The plan accordingly proposes conversion of existing and on-going supplementary irrigation projects and pump-lift irrigation systems in the Study area to the year-round irrigation method and gravity type.

2) Proposed irrigation area

The study area of this scheme is located on both sides of the Kamla River which receives diversion water from the Sun Kosi River and extends approximately 140km in length from west to east and approximately 30km from north to south between the left bank of the Bagmati River and the right bank of the Kanro River.

Case SK-400-BK Plan is the most economical plan based on optimization study and proposes an intake level at the Kamla River of El.400ft. The outline of the irrigation scheme is shown in TABLE 5-3-34 while existing and on-going irrigation projects in the command area are shown in TABLE 5-3-35.

TABLE 5-3-35 EXISTING AND ON-GOING PROJECTS WITHIN SUN KOSI DIVERSION IRRIGATION SCHEME COMMAND AREA

Description		Case Sk-400-BK	
Bagmati	Phase I	Gross	21,300
		Net	16,000
	Phase II	Gross	29,900
		Net	22,400
Kamla		Gross	65,400
		Net	25,000
Rajbiraj Pump Canal		Gross	16,450
		Net	11,700
Total		Gross	133,050
		Net	75,100
Sun Kosi Diversion Irrigation Scheme		Gross	233,400
		Net	175,100
Percentage of Area Covered by Existing Projects		Gross	57%
		Net	43%

3) Diversion and dam plan

Kurule Dam

A diversion dam is planned at a diversion point (Kurule) on the Sun Kosi River. The dam will be a concrete gravity type with spillway gates in consideration of heavy silting, huge flood discharge on the Sun Kosi River and security of the intake.

Design flood discharge at the dam site will be 19,000m^3/s, with a probable flood of 10,000 year return period. Dam height will be 48.9m for discharge safety in floods of 19,000m^3/s. Twelve roller gates 14m in width and 15m high are proposed for spillway gates considering estimated conditions upon completion of the envisioned Sapt Kosi High Dam. With an intake level of El.338m and a dam height of 48.9m, the above diversion dam will not be affected

even by the Sapt Kosi High Dam proposed by India (Height: 269m; HWL El.335.3m).

A height of 147m is proposed for the Kurule High Dam in the Master Plan and the diversion dam site for the Kurule Diversion Dam is accordingly 480m downstream from the prospective site of the former.

Diversion Tunnel

The total proposed length of the diversion tunnel from the Kurule site on the Sun Kosi River to a point upstream on a tributary of the Kamla River is approximately 16.6km. Tunnel capacity will be 72m^3/s and internal diameter will be 5.25m.

Study of tunnel excavation on the topographical map revealed that the longest lengths of tunnel for excavation will be 9.5km with some adit tunnels also proposed. In this case, tunnel construction will require 5 years.

Another important point of tunnel excavation is the Main Boundary Fault (MBF) which runs parallel to the Mahabarat mountain range. The Study Team undertook field reconnaissance to confirm the MBF at the diversion tunnel route. Results show that the MBF crosses at a point 4km from the end of the tunnel on the Kamla side while the width of the fault cross section is comparatively narrow (about 10m). It would therefore be possible to plan an adit tunnel near this point, while no particular difficulties should arise in tunnel construction itself.

Large desilting ponds are proposed at the beginning of the tunnel on the Sun Kosi River side. At the terminus of the tunnel on the Kamla side, a hydropower plant with installation capacity of 61MW will be planned using the gross head of 125m which can be obtained between the intake level at the Sun Kosi River and the discharge point upstream of the Kamla River.

An access road approximately 40km in length connecting the dam site on the Sun Kosi River and the power station site on the Kamla side will be required.

Kamla Dam

The Kamla Dam site is located 8km upstream from Chisapani Village on the Kamla River. However, as the geological conditions of the site are relatively poor, it is considered that with a gravel fill type dam, the maximum possible height will be 60m. In addition, topographical conditions of the site will allow the advantage of a large reservoir pocket on the upstream reaches of the site.

The dam will not only regulate natural flow of the Kamla River but also reserve diverted water which will be diverted constantly at $72m^3/s$ from the Sun Kosi River to the Kamla River, throughout the year, and discharge necessary irrigation water at the required time from the reservoir. Main features of the Kamla Dam are presented in the following table.

TABLE 5-3-36 **FEATURES OF KAMLA DAM**

Description	Unit
Catchment Area	$1,450km^2$
High Water Level (H.W.L)	El.177.5m
Low Water Level (L.W.L)	El.163.0m
Gross Storage Volume (Vg)	$676 10^6 m^3$
Effective Storage Volume (Ve)	$456 10^6 m^3$
Dam Type	gravel fill
Dam Height	50.5m
Dam Volume	$3,200 10^3 m^3$

One major consideration in Kamla Dam planning is the existence of a large number of paddy fields in the envisioned

reservoir area. The high water level is El.178.0m, at which level paddy is estimated at 30% of the submerged area (4,400ha). Moreover, those paddy fields located in the vicinity of the river are reported to be frequently submerged even at present due to river flooding, while soil conditions of the same are sandy and thus poor for agricultural purposes.

In planning the Kamla Dam therefore, protection of existing paddy fields in the vicinity of the proposed reservoir by dike works or embankment will be required in order to improve the present situation and thus ensure stable agricultural production in the area.

A hydropower station will be planned at the Kamla Dam with an installation capacity of 32,000kW using a head between the water level of the reservoir and the water level of Kamla Dam downstream.

4) Hydropower Plans

Diversion power station plan

A hydropower station plan is proposed using effective water head (approximately 102.5m) between the intake level at the Sun Kosi River and the diversion water discharge point on the Kamla side. Installation capacity of the same is 61,400kW.

High quality firm energy would be obtained at the said station due to constant year-round flow of diversion water ($72m^3/s$). An annual installation operation factor of 95% is therefore planned.

Kamla Dam power station plan

High water level of the Kamla Dam Reservoir is El.178m and that immediately downstream of the Kamla Dam is El.137.2m, allowing a possible head of approximately 40m.

The Kamla Dam will discharge irrigation water required for the command area and also the discharge for downstream (compensation flow for downstream water utilization). Total

monthly average discharge from the Kamla Dam will be 42-180m^3/s, with monthly fluctuations to meet irrigation requirement.

3.8.2 Stage Development Plan for Sun Kosi Multipurpose Scheme

(1) Concept of Stage Development

The Sun Kosi Multipurpose Scheme is a large scale project which aims to irrigate a net command area of 175,100ha in the Sapt Kosi Eastern Zone in the Study Area which covers a broad expanse 140km from east to west. Total project cost amounts to 550 million US$. Although with such large scale projects maximum economic effectiveness is theoretically obtained through complete development in a short period of time, many difficulties arise in actual implementation which prevent such an approach. Among these are financial arrangement, manpower, development of irrigation facilities, and extension of agricultural technology.

Accordingly, division of the project into realistic stage development was studied to determine the most practical implementation plan under the present Study. The main principle in determining appropriate stages is that the resultant B/C should be greater than 1.0.

(2) First Stage Development Plan Study

Study of intake facilties was first required to determine whether the Sun Kosi Diversion Scheme or the Kamla Dam would be selected. In the case of independent development for each plan the following would apply:

- Case-A Sun Kosi Diversion alone 55,500ha
  (Q max = 72m^3/s)
- Case-B Kamla Dam alone 45,900ha
  (effective reservoir capacity 492,600,000m^3)

Benefit/Cost was calculated as below with the condition that formulation of a hydropower project is feasible for Case-A but not for Case-B (TABLE 5-3-37).

- Case-A B/C = 591.31/472.21 = 1.25
- Case-B B/C = 257.17/268.27 = 0.96

Based on the above results, it was determined that in Project formulation, independent development of Case-A is feasible while Case-B is not.

(3) Stage Development Plan

Although the Sun Kosi Diversion Plan is an attractive project with high benefit potential, numerous complications can be forseen in implementation of the same, such as financial arrangement, procurement of equipment, and labor, due to the project's large scale. In order to determine the most effective implementation sequence therefore, the following 3 cases were studied.

- Case-a: 5 implementation stages
- Case-b: 3 implementation stages
- Case-c: 2 implementation stages

Each case was evaluated according to the aforementioned prerequisite that B/C is greater than 1, while work items were divided into the following 6 categories and allotted to the respective stages of the same (FIG. 5-3-12).

1) Construction of access road, Kurule intake dam, diversion tunnel, diversion power station and transmission line. This category includes implementation of Sun Kosi diversion related facilities and the hydropower component only. Irrigation facilities are implemented subsequently while irrigation benefit is generated by the existing Kamla Irrigation Project.

2) Construction of Kamla dam and Kamla dam power station prerequisite to constructon of the Kamla dam and power station.

3) Construction of irrigation facilities between the Kamla and Bhati Balon rivers.

4) Construction of irrigation facilities between the Bhati Balon and Kanro rivers.

5) Construction of irrigation facilities between the Marha and Kamla rivers.

6) Construction of irrigation facilities between the Bagmati and Marha rivers.

Economic analysis of each stage was calculated as an individual project according to section 3.6.3, 'Cost Allocation for Common Facilities'. Results of calculation for the above 6 categories and Case-a to Case-c, in each of the aforementioned stages are presented in TABLE 5-3-38 to 5-3-39. Each case was studied from the viewpoint of food demand, finanical arrangement and average cost for construction. Based on the results of this study, the optimum implementation plan includes construction of intake dam, diversion tunnel, diversion power station, transmission line, and irrigation facilities between the Kamla and Bhati Balon rivers in Stage I; construction of the Kamla Dam, Kamala Dam power station and irrigation facilities between the Bhati-Balon and Kanro rivers in Stage II; and construction of all irrigation facilities on the Kamla River right bank in Stage III (TABLE 5-3-39, Case-b).

3.8.3 Implementation and Annual Disbursement Schedules of Construction Cost

The present Project is large-scale with an investment cost of 550.7 10^6US$. Accordingly, it is necessary to formulate an implementation schedule which is both technically and economically feasible.

Critical work sections essential to smooth implementation of the present Project include the diversion tunnel, Kurule intake dam, and access road. As there is presently no road from the Terai Area to the Kurule site, commencement of Kurule intake dam construction will only be possible upon completion of the access road. Similarly, before access road construction, diversion tunnel work will only proceed from the Kamla River side. Total length of the access road is 70.5km, of which 40km crosses the Mahabarat range. As with the diversion tunnel, construction of the latter section will proceed from the Kamla River side only.

If this plan were to be implemented in a short period of time, the number of temporary facilities and equipment required would substantially increase, making arrangement of sufficient funds, equipment and manpower extremely difficult. To avoid such problems, therefore, the Project should be broken down into several work items for stage implementation.

The construction period for the Project was estimated at 13 years on the basis of thorough study of a practically and economically feasible

implementation schedule. Therefore, taking into account the above mentioned issues and according to the Stage Development Plan, the implementation schedule has been prepared as shown in FIG. 5-3-13. According to the implementation schedule, the annual disbursement schedule has been prepared and is attached as TABLE 5-3-40.

3.9 Operation and Maintenance

3.9.1 General

With effective project management for agricultural development, not only is stable agricultural production maintained but early benefits of increased production may also be realized through stage implementation. The management system for any project must be suited to the content and scale of the project itself. In the case of the highest priority plan under the Master Plan, "Case SK-400-BK" Plan, total investment cost is high ($550 10^6$US$) and, as mentioned in section 7-2, various problems may be expected in implementation of the same with regards to financal arrangement, equipment procurement and manpower. It is therefore necessary to divide project implementation into a series of stages.

For the above reasons, the most effective management system for full development is one which ensures smooth implementation at each stage. The following divisions are recommended as components of the said system in order to check the content of management activity.

- Operation and maintenance division including field control unit
- Extension service division
- Credit and marketing division
- Administration and finance division

The function of the operation and maintenance division in facilitating maintenance required for facilities is described below.

3.9.2 Operative Divisions

(1) Regional Divisions

In order to promote smooth implementation of operation and maintenance activities, the entire area should be divided into blocks as follows:

a) Irrigation plan unit
2000 - 3000ha

b) On-farm irrigation service unit
40 - 50ha

(2) Function of Operation and Maintenance Divisions

Proposed functions of the above are:

- collection of data on cultivation and farming conditions in each irrigation block
- establishment of annual activity plan and O&M activity guide
- management and integration of engineering activities and the extension service and cooperative and marketing divisions
- preparation of the annual budget and procurement
- planning of irrigation water requirement and determination of canal flow
- checking and improvement of the O/M manual

(3) Field Operation Control Unit

Proposed functions of the Field Operation Control Unit are:

- conducting detailed field activity in each area
- reviewing crop progress and measuring irrigation effect
- study of the trend of detailed O/M activities within the irrigation block and formulatation of future improvement plans

(4) Within-block Field Operations

Proposed field operations within each block consist of:

- distribution of irrigation water from secondary canals to the Irrigation Service Unit
- canal gate operation
- canal water level recording
- field water level (irrigation) recording in the Irrigation Service Unit
- weeding and cleaning along the irrigation and drainage canals
- checking irrigation water excess or shortage within the Irrigation Service Unit
- repair and improvement of facilities in the off-season and during emergencies
- technical support of farmers with regards to maintenance in the Irrigation Service Unit
- maintenance of road network along the canals

Actual operation and maintenance should be closely regulated by extension service workers, while field channels for Irrigation Service Units (40-50ha) should be constructed by the farmers themselves. Farmers should be advised by the O/M Division.

3.9.3 Water Service Fee

Irrigation Service fees for benefited farmers would vary depending on the sources and irrigation systems. In the case of privately owned tubewells, water charge would be based on the cost of fuel, maintenance cost and depreciation. Under the Government's Deep Tube Well Project at Marangua in the Sarlahi district, for example, water users are charged at the rate of NRs 16.00/hr with a discharge capacity of 0.75-1.5m^3/s. .

Relatedly, under government gravity irrigation projects, in accordance with existing government regulations, farmers are charged by the Land Revenue Division, Ministry of Finance, at a rate of NRs 40.00/big ha/crop season regardless of the kind of crop (NRs 60/ha/crop). Collection of fees start not later than one year after completion of construction work.

Amounts collected would, in the initial stage, be used mainly to cover operation and maintenance costs. Later the charges would be used to recover, in progressive steps and over a reasonable period of time, the investment cost of the Project. Accordingly Water Users' Associations would be obliged to seek increasing voluntary contributions from the members for maintenance and repair of the irrigation works. Due consideration should be given to farmers' ability to pay and their successive willingness to participate in the Water Users' Associations.

Arbitration of disputes would be done according to established rules and regulations by an arbitrations committee consisting of the respective Water Users' Association's leader, the District Panchayat and the District Judge.

TABLE 5-1-1 GENERAL CONDITIONS OF SOIL TYPES IN THE TERAI AREA

	Active Alluvial Deposits (Entisols)	Recent Alluvial Deposits (Inceptisols)	Older Alluvial Deposits (Mollisols)
Location	Lower ground adjacent to the major river	Slightly higher ground	The upper piedmont of Siwalik region
Drainage	Subject to severe or occasional river flooding	Variable	Good to rapid
Texture	Coarse sand to loamy soils	Sandy loam to silty clay loam	Sandy loamy soils
Dominant Slope	Less than 1°	0.5 to 1°	1 to 5° (except some areas)
Present Condition	Only occasional agricultural production due to sandy soil and flooding	Suitable agricultural land and high population density	Agricultural and forest land and soil erosion area
Fertility	Low	Most suitable area for agriculture	High fertility; good agricultural land with irrigation and erosion control
Potential for Irrigation	Occasional severe flooding precludes heavy capital investment in irrigation. Dike construction for flood protection will be expensive.	With irrigation agricultural production should be increased	With erosion control and irrigation these soils could be utilized for agriculture
Total Area	107,800ha (14%)	503,120ha (68%)	13,306 ha (18%)

Source: Based on LRMP

TABLE 5-1-2 LAND SYSTEM DESCRIPTION IN THE TERAI AREA

Land System	Land Form	Land Unit	Dominant Soil	Dominant Slope	Dominant Texture	Depth of Water Table	Drainage
1	Active Alluvial Plain (deposition)	1a Present River channel					
		1b Sand and gravel bars	Ustorthents Psamments	<1°	Sandy/ Cobbly	0 - 2m	subject to severe river flooding
		1c low terrace	Ustifluvents Fluvaquents	<1°	Sandy	0 - 2m	variable; subject to severe river flooding
		1d higher terrace	Ustochrepts Haplaquepts	<1°	Loamy	0 - 4m	variable; subject to occasional river flooding
2	Recent Alluvial Plain "Lower Piedmont" (depositional and erosional)	2a depressional	Haplaquepts	<1/2°	Fine loamy	0 - 2m	Poor
		2b intermediate position; level	Haplaquepts (Aeric)	<1/2°	Loamy	0 - 6m	imperfect
		2c intermediate position, undulating	Haplaquepts Ustochrepts	<1°	variable	dependent on position	variable; low areas subject to flooding
		2d high position	Haplustolls Ustochrepts	<1°	Loamy	1 - 10m	modelately well
3	Alluvial Fan Apron Complex "Upper Piedmont" (erosional)	3a very gentle slopes	Haplustolls Dystochrepts Ustochrepts	<1°	Loamy	1 - 10m	modelately well
		3b gentle slopes	Haplustolls	1 - 5°	Loamy/ Bouldery	2 - 10m	rapid
		3c undulating	Haplustolls	1 - 3°	Loamy	2 - 10m	well
		3d highly dessected	Ustochrepts	0 - 20°	Loamy	>2m	rapid

TABLE 5-1-3 LAND SYSTEM CLASSIFICATION IN TERAI AREA

Unit: ha

Land Unit	Jhapa	Morang	Sunrari	Saptari	Shiraha	Dhanusha	Mahotari	Salrahi	Total
1a	-	-	2,040	1,670	-	-	-	-	3,710
1b	6,210	4,940	4,090	7,780	4,510	4,580	2,810	3,590	38,510
1c	570	940	7,190	2,570	670	350	530	790	13,610
1d	3,890	7,810	14,660	7,850	3,400	2,940	4,900	6,520	51,970
2a	5,640	7,080	2,670	35,130	9,000	11,160	6,140	5,840	82,660
2b	22,410	48,520	36,920	31,680	49,690	29,210	17,450	23,490	259,370
2c	7,710	34,540	23,210	5,230	3,900	23,620	16,920	28,420	143,550
2d	-	1,630	-	240	940	510	12,760	1,460	17,540
3a	10,750	12,910	4,250	1,130	8,360	14,670	12,280	5,040	69,390
3b	2,450	9,390	1,600	1,910	710	260	-	-	16,320
3c	3,050	11,070	1,170	5,830	11,350	3,530	1,150	1,620	38,770
3d	-	3,570	-	1,840	2,870	300	-	-	8,580
	62,680	142,400	97,800	102,860	95,400	91,130	74,940	76,770	743,980

TABLE 5-1-4 SOIL PROFILE DESCRIPTION
(1 of 5)

1. Profile Number: No. 2
2. Date of Examination: 18th December 1983
3. Soil/Classification: Haplaquents
4. Location: Gouradah
5. Land System Unit: 2b
6. Drainage: Good
7. Parent Material: Alluvial Deposit
8. Vegetation or Land Use: Paddy Field
9. Irrigation Water Availability: None
10. Others:

Horizon	Depth (cm)	Description
Ap	0 - 14	gray (5Y 5/1); sandy loam, single grain structure; slightly hard, friable, slightly plastic, fine roots; clear boundary
Ac	14 - 28	yellowish grey (2.5Y 5/1); sandy loam; massive structure; slightly hard, slightly sticky and slightly plastic, fine roots; clear boundary
C_1	28 - 52	light yellow (2.5Y 7/2); sand, single grain structure; soft, loose, non-sticky and non-plastic; clear boundary
Aib	52 - 72	grayish yellow brown (10YR 4/2), fine sand; single grain structure; slightly hard, friable, non sticky and non-plastic; clear boundary
IIc	72 - 100	pale yellow (2.5Y 8/3), sand, single grain structure; slightly hard, firm non-sticky and non-plastic; yellowish brown; common median district.

TABLE 5-1-4 SOIL PROFILE DESCRIPTION
(2 of 5)

1. Profile Number: No. 9
2. Date of Examination: 17th December 1983
3. Soil/Classification: Ustochrepts
4. Location: Hathimura (15.5km NNW from Biratnagar)
5. Land System Unit: 2c
6. Drainage: Good
7. Parent Material: Alluvial Deposit
8. Vegetation or Land Use: Paddy Field (Paddy single)
9. Irrigation Water Availability: None
10. Others:

Horizon	Depth (cm)	Description
Ap	0 - 30	dull yellowish brown (10YR 4/3); silty loam; massive structure; very hard, firm, slightly sticky and slightly plastic; fine roots; smooth boundary
C	30 - 40	grayish yellow (2.5Y 6/2); silt and silty loam; single grain structure; non-sticky and non-plastic; very clear boundary
Aib	40 - 68	brownish black (10YR 2/2); silty clay loam; massive structure; hard, firm, sticky and plastic; abrupt smooth boundary
IIB_{21}	68 - 100	grayish yellow brown (10YR 4/2); silty clay; massive structure; hard, friable, sticky and plastic; clear boundary
IIB_{22}	100 - 115	dull yellowish brown (10YR 5/4) to yellowish brown (10YR 5/6); silty clay; slighty hard, firm, sticky and plastic

TABLE 5-1-4 SOIL PROFILE DESCRIPTION
(3 of 5)

1. Profile Number:	No. 13
2. Date of Examination:	20st December 1983
3. Soil/Classification:	2c
4. Location:	Birdipur (East bank of Kamala River)
5. Physiography:	Ustipsamments
6. Drainage:	Rapid
7. Parent Material:	Alluvial Deposit
8. Vegetation or Land Use:	Paddy Field (Tabacco/Maize or Paddy/Wheat)
9. Irrigation Water Availability:	Canal
10. Others:	Much gravel under 20cm

Horizon	Depth (cm)	Description
Ap	0 - 10	dull yellowish brown (10YR 5/3); loamy sand; single grain structure; slightly hard, friable, non-sticky and non-plastic, fine roots; clear boundary
Ic	20 - 22	dull yellowish brown (10YR 5/4); fine sand; loose, non-sticky and non-plastic, transition layer for Ap to C; clear boundary
IIc	22 - 50	dull yellow orange (10YR 7/3); loose sand; many small and medium gravels, loose, non-sticky and non-plastic

TABLE 5-1-4 SOIL PROFILE DESCRIPTION
(4 of 5)

1. Profile Number: No. 20
2. Date of Examination: 21st December 1983
3. Soil/Classification: 2a
4. Location: Banauli (SW from Janakpur)
5. Physiography: Haplaquepts
6. Drainage: Poor
7. Parent Material: Alluvial Deposit
8. Vegetation or Land Use: Paddy Field (Paddy/Khosure[1]//wheat)
9. Irrigation Water Availability: River
10. Others:

Horizon	Depth (cm)	Description
Ap	0 - 11	dull reddish brown (2.5Y 4/3); loam; massive structure; hard, friable, slightly sticky and slightly plastic; very fine roots; clear boundary
B_2	11 - 34	dark olive (5Y 4/3); clay loam; massive structure; very hard, firm, sticky and plastic; clear boundary
C_1	34 - 49	grayish olive (5Y 5/3); fine sand; single grain structure; slightly hard, friable, non-sticky and non-plastic; clear boundary
C_2	49 - 76	grayish olive (5Y 6/2); sand; single grain structure; soft, loose, non-sticky, and non-plastic; clear boundary
IIB	76 - 100	yellowish brown (2.5Y 5/6, 2.5Y 5/3); silty clay; hard, firm, sticky and plastic

1/ winter pulse crop

TABLE 5-1-4 (5 of 5)

SOIL PROFILE DESCRIPTION

1. Profile Number:	No. 21
2. Date of Examination:	22nd December 1983
3. Soil/Classification:	3a
4. Location:	Hathler
5. Physiography:	Haplustolls/Dystochrepts
6. Drainage:	Good
7. Parent Material:	Alluvial Deposit
8. Vegetation or Land Use:	Paddy Field (Paddy-Tabasco/Mustard)
9. Irrigation Water Availability:	None
10. Others:	If irrigation water is available Paddy-Tabacco-Maize crop can be grown

Horizon	Depth (cm)	Description
Ap	0 - 18	greyish yellow brown (10YR 4/2); sandy loam; massive structure; hard, firm, slightly sticky, and plastic, many fine roots; clear boundary
B	18 - 44	brown (10YR 4/4); loam massive structure; hard, firm, slightly sticky, and plastic; abrupt smooth boundary
B	44 - 88	brown (10YR r/r); silty loam, massive structure; hard, firm, slightly sticky and slightly plastic; smooth boundary
C	88 - 115	yellowish brown (10YR 5/8); sand; single grain structure; soft, very friable, non-sticky, and non-plastic

TABLE 5-1-5 RESULT OF WATER ANALYSIS IN THE MAIN RIVER

River	pH	Electrical Conductivity umhos/cm 25°C	Cations (me/1)				Anions (me/1)			
			Ca	Mg	Na	K	CO_3	HCO_3	C1	SO_4
Bagmati	7.5	222.2	1.80	0.48	0.31	0.11	0.08	1.86	0.60	ND
Kamla1/	7.2	300.1	2.80	0.64	0.30	0.11	0.25	2.75	0.80	ND
Bati Bharon1/	7.3	305.0	2.00	1.28	0.64	0.11	0.33	2.79	0.60	ND
Trijuga	7.4	277.1	1.72	1.32	0.38	0.13	0.25	2.51	0.50	ND
Sapt Kosi	7.3	150.7	0.92	0.40	0.22	0.08	NIL	1.14	0.60	ND
Tamur	7.5	82.5	0.44	0.32	0.15	0.05	NIL	0.55	0.40	ND
Kankai	7.4	121.2	0.80	0.24	0.24	0.08	NIL	0.76	0.40	ND
Sun Kosi1/	7.4	119.1	0.60	0.32	0.17	0.05	NIL	0.80	0.40	ND

Note: ND = Not determined

1/ = Does not determine precipitation with $BaCl_2$ for SO_4

TABLE 5-1-6 AREA OF EACH IRRIGATION SCHEME FOR IRRIGATION SUITABILITY CLASSIFICATION

Unit: ha

Irrigation Suitability Classification	Bagmati Irrigation Area	Kamla Right Bank	Kamla-Bhati Balon Area	Bhati Balon Khanro Area	Khanro-Sapt Kosi Area	Sapt Kosi-Kankai Area	Total
Diversified Crops-Arable (Suitable)	30,070 (41)	38,100 (37)	9,940 (14)	890 (2)	2,920 (13)	25,130 (43)	107,050 (29)
Wetland Rice-Arable (Suitable)	31,000 (43)	45,310 (43)	39,260 (56)	14,160 (35)	12,380 (58)	25,650 (44)	167,750 (45)
Diversified Crops-Arable (Moderately Suitable)	1,380 (2)	2,120 (2)	9,770 (14)	470 (1)	150 (1)	1,340 (2)	15,230 (4)
Wetland Rice-Arable (Moderately Suitable)	3,870 (5)	12,290 (12)	7,330 (10)	21,280 (53)	2,540 (12)	2,640 (4)	49,950 (14)
Nonarable Area	5,280 (7)	4,180 (4)	3,320 (5)	2,580 (6)	2,780 (13)	3,040 (5)	21,180 (6)
River Channel	1,300 (2)	1,700 (2)	600 (1)	800 (2)	600 (3)	1,000 (2)	6,000 1/ (2)
Total	72,900 (100)	103,700 (100)	70,220 (100)	40,180 (100)	21,370 (100)	58,800 (100)	371,570 (100)

Source: based on Land Capability Map, LRMP

Note: Figures in brackets show percentage of area in same classified soil condition
1/ Not including present river chnnel of Bagmati, Kamla, Bhati Balon, Khanro, Sapt Kosi and Kankai rivers

TABLE 5-1-7 CHARACTERISTICS OF EACH SECTION BY ANALYSIS OF LAND SAT IMAGE

Characteristics	Section					
	I	II	III	IV	V	VI[1/]
Soil Texture	Sandy	←	←	←	Clayey	←
Soil Color	Light	←	←	←	Dark	←
Irrigation Potential	Difficult	←	←	←	Easy	←
Soil Profile Development	Poor	←	←	←	Good	←

1/ Soil characteristics of Section VI can not be distinguish due to vegitation cover.

TABLE 5-1-9 CULTIVABLE LAND IN THE PROJECT AREA

Area	Physical Area (km^2) (1)	Cultivable Land (km^2) (2)	Ratio (2)/(1)	Physical Area Distribution	Cultivable Land Distribution
			(%)	(%)	(%)
Mountain					
1. Taplejung	3,020	150	5.0		
2. Sankhuwa Sabha	2,510	13.5	5.4		
3. Solukhumbu	2,930	8.0	2.7		
4. Dolakha	1,980	90	4.5		
(Sub-total)	(10,440)	(455)	(4.4)	(25.0)	(3.4)
Hill					
1. Illam	1,370	930	67.9		
2. Panchthar	1,370	505	36.9		
3. Terhathum	820	591	72.1		
4. Dhankhuta	1,680	852	50.7		
5. Bhojpur	1,840	243	13.2		
6. Khotang	1,720	141	8.2		
7. Udaypur	2,470	700	28.3		
8. Okhal-dhunga	1,270	129	10.2		
9. Ramechap	1,370	674	49.2		
10. Sindhu-palchok	2,600	130	5.0		
11. Kavre	1,270	579	45.6		
12. Sindhuli	2,590	269	10.4		
(Sub-total)	(20,370)	(5,743)	(28.2)	(48.9)	(42.6)
Terai					
1. Jhapa	1,480	1,191	80.5		
2. Morang	1,814	1,092	60.2		
3. Sunsari	1,360	813	59.8		
4. Saptari	1,250	1,086	86.9		
5. Siraha	1,140	957	83.9		
6. Dhanusha	1,190	798	67.1		
7. Mahottari	1,250	815	65.2		
8. Sarlahi	1,380	529	38.3		
(Sub-total)	(10,864)	(7,281)	(67.0)	(26.1)	(54.0)
Total	41,674	13,479	32.3	100.0	100.0

Source: Nepal Agriculture Sector Strategy Study, Vol. II, Appendix 1.8, ADB, 1982

TABLE 5-1-10 FOREST RESOURCES IN THE PROJECT AREA (1974/75)

(Unit: ha)

Type of Forest Forest Division	Uninvated Forest	Invated Forest	Total Forest
Janakpur			
Protected F.	84,544.60	2,563.78	87,108.38
Production F.	23,163.42	-	23,163.42
Special F.	326.09	-	326.09
Limited Use F.	3,540.20	2,745.73	6,285.93
Alienable F.	-	225.20	225.20
Sub-total	111,574.31	5,534.71	117,109.02
Hanumannagar			
Protected F.	116,148.18	3,914.92	120,063.20
Production F.	4.329.29	66.21	4,395.50
Special F	-	-	-
Limited Use F.	4,339.65	1,503.00	5,842.65
Alienable F.	-	-	-
Town Planning Area	200.00	171.13	371.13
Sub-total	125,017.12	5,655.26	130,672.38
Biratnagar			
Protected F.	22,080.00	2,611.00	24,691.00
Production F.	20,516.00	1,026.00	21,542.00
Special F.	3,325.00	81,000	3,406.00
Limited Use F.	13,659.00	147.00	13,806.00
Alienable F.	1,146.00	405.00	1,551.00
Sub-total	60,726.00	4,270.00	64,996.00
Mechi			
Protected F.	8,519.00	3,977.00	12,496.00
Production F.	10,048.00	6,880.00	16,928.00
Special F.	-	-	-
Limited Use F.	573.00	-	-
Alienable F.	2,286.00	4,515.00	6,801.00
Border Clearance	187.00	441.00	628.00
Sub-total	21,613.00	15,813.00	37,426.00
Project Area			
Protected F.	231,291.78	13,066.70	244,358.48
Production F.	58,056.71	7,972.21	66,028.92
Special F.	3,651.09	81.00	3,732.09
Limited Use F.	22,111.55	4,395.73	26,507.58
Alienable F.	3,432.00	5,145.20	8,577.20
Town Planning Area	200.00	171.13	371.13
Border Clearance	187.00	441.00	628.00
Total	318,930.43	31,272.97	350,203.40

Note: Limited Use Forest is defined as degraded forest being used for village requirements and no longer suitable for the production of commercial timber.

Special Forest is defined as being those areas of forest allocated to game reserves, wildlife sanctuaries, etc.

Border Clearance areas are mostly productive forest being cleared in a settlement zone along the border with India

Alienable Forest is made up of small isolated areas which the Forest Department feels could be released for agricultural use, in order to tidy up the boundaries of major forest reserves.

Source: Land Investigation Report, 2031, Forest Resources Survey Office.

TABLE 5-1-11 COVERAGE OF STUDY AREA

District	District Area (ha)	Mapped Area (ha)	Coverage (%)
Sarlahi	125,900	77,107	61.2
Mahottari	100,200	75,291	75.1
Saptari	136,300	126,246	92.6
Dhanusha	118,000	113,500	96.2
Siraha	118,800	118,750	100.0
Sunsari	125,700	97,862	77.9
Morang	185,500	146,586	79.02
Jhapa	160,600	153,639	95.7
Total	1,071,000	908,981	84.9

Source: Compiled from LRMP, Land Utilization Report, Oct. 1983 Table 5.6

TABLE 5-1-12 LAND USE -- FOREST IN THE TERAI AREA

Unit: ha

Zone	District	Forest Types										All Forest Type	(%)	Total Land Use	(%)	Gross Area	(%)
		H	(%)	Hd	(%)	S	(%)	PF	(%)	PI	(%)						
Central	Darlahi	2,653.8	3.4	2,172.5	2.8	-	-	280.0	0.4	-	-	5,106.3	6.6	72,429.1	93.4	77,535.4	100.0
	Mahottari	3,232.6	4.3	2,035.0	2.8	-	-	63.8	0.1	-	-	5,331.4	7.2	70,149.1	92.8	75,540.5	100.0
	Danusha	2,808.8	2.5	657.6	0.6	325.0	0.3	18,466.8	16.3	-	-	22,258.2	19.7	91,039.6	80.3	113,297.8	100.0
Sub-total		8,695.2	3.3	4,865.1	1.8	325.0	0.1	18,810.6	7.1	-	-	32,695.9	12.3	233,617.8	87.7	266,373.7	100.0
Eastern	Shiraha	76.3	0.1	872.6	0.7	-	-	231,108.0	19.5	-	-	24,056.9	20.3	94,691.9	79.7	118,748.18	100.0
	Saptari	1,922.6	1.5	556.3	0.4	-	-	24,071.8	19.1	-	-	26,550.7	21.0	99,561.9	79.0	126,112.6	100.0
	Sunsari	6,222.6	6.4	162.5	0.1	-	-	-	-	-	-	6,385.1	6.5	91,476.7	93.5	97,861.8	100.0
	Morung	27,603.5	18.9	2,193.8	1.5	-	-	523.8	0.4	-	-	30,321.1	20.8	115,508.2	79.2	145,829.3	100.0
	Jhapa	13,097.7	8.5	1,949.9	1.3	-	-	26.3	0.0	2,871.3	1.9	17,946.2*	11.7	135,441.2	88.3	153,387.4	100.0
Sub-total		48,924.7	7.6	5,734.1	0.9	-	-	47,729.9	7.4	2,871.3	0.4	105,260.0	16.4	536,679.9	83.6	641,939.9	100.0
Grand total		57,619.9	6.3	10,599.2	1.2	325.0	0.0	66,540.5	7.3	2,871.3	0.3	137,955.9	15.2	770,357.7	84.8	908,313.6	100.0

Note: H: Hardwood
Hd: Hardwood, degraded by heavy lopping
S: Shrub
PF: Protected forest
PI: Plantation
*/: About 8,000ha will be located on the east side of the Kankai River.

Source: LRMP (Unpublished)

TABLE 5-1-13 LAND USE IN THE TERAI AREA

Land Use Category	Area (ha)	Proportion (%)				
1. Total area	1,071,000	(100.0)				
2. Mapped area	909,000	(84.9)	(100.0)			
3. Cultivated land	695,000		(76.5)	(100.0)	(100.0)	
4. Wet land	367,000			(52.8)		
5. Upper wet land	165,000			(23.7)		
6. Other farmland	163,000			(23.5)		
7. Net cropped area	587,000				(84.4)	(100.0)
8. Fallow land	108,000				(15.6)	
9. Paddy crop area	514,000					(87.6)
10. Other crop area	73,000					(12.4)
11. Forest	138,000		(15.1)			
12. Hardwood	57,600					(41.7)
13. Protection forest	66,500					(48.2)
14. Other Forest land	13,900					(10.1)
15. Land put to non-agricultural uses (rivers, canals, roads, urban area, etc.)	76,000		(8.4)			

Note: Figure based on the report of LRMP, 1980

TABLE 5-2-1 PRESENT CROPPED AREA AND CHANGING TREND

Zone	Crop	Present Area (Approx.) 1,000ha	Ratio Against All Nepal (%)	Trend/Change in Cropped Area in 1970-83
TERAI	Paddy	1,000	78.0	stable
	Wheat	314	65.0	obvious increase
	Maize	150	24.0	stable
	Millet	21	16.5	stable
	Barley	4.5	18.5	decrease & fluctuation
HILL	Paddy	250	20.0	slight increase
	Wheat	150	32.0	increase
	Maize	323	68.0	slight increase
	Millet	92	71.0	stable
	Barley	10	45.0	stable
MOUNTAIN	Paddy	25	2.0	slight increase
	Wheat	16	3.0	decrease
	Maize	40	8.0	stable
	Millet	16	12.5	stable
	Barley	9	36.5	stable
ALL NEPAL	Paddy	1,275	100.0	stable
	Wheat	480	100.0	obvious increase
	Maize	477	100.0	slight increase in recent years
	Millet	129	100.0	stable
	Barley	23.5	100.0	fluctuation

Note: Figures under "Present Area" are for 1983.

TABLE 5-2-2 **PRESENT CROP PRODUCTION AND CHANGING TREND**

Zone	Crop	Present Product (Approx.) 1,000t	Ratio to National Production (%)	Trend/Change in Cropped Production in 1970-83
TERAI	Paddy	1,760	77	fluctuation
	Wheat	361	63	notable increase
	Maize	227	31	stable[1/]
	Millet	18	15	no large change[3/]
	Barley	5.5	23	fluctuation
HILL	Paddy	470	21	stable
	Wheat	196	34	notable increase
	Maize	434	60	stable[2/]
	Millet	87	72	slight decrease
	Barley	9.3	40	slight decrease
MOUNTAIN	Paddy	49	2	stable
	Wheat	17	3	decrease
	Maize	57	9	decrease
	Millet	16	13	slight decrease
	Barley	8.5	37	decrease
ALL NEPAL	Paddy	2,279	100	fluctuation
	Wheat	574	100	notable increase
	Maize	718	100	fluctuation
	Millet	121	100	slight decrease
	Barley	23.3	100	stable[1/]

1/ with the exception of a few low production years
2/ except 1979/80
3/ except 1978/79

TABLE 5-2-3

FOOD BALANCE ACCORDING TO AGRO-CLIMATIC ZONES 1981/1982

(Unit: metric ton)

Regions	Rice		Wheat		Maize		Millet & Buckwheat		Barley		Total	
Mountain Zone		%		%		%		%		%		%
Present												
Production	25,875		13,308		54,526		13,138		7,102		113,949	
Requirement	30,544		29,457		70,896		20,190		9,020		160,107	
	-4,669	-15.3	-16,149	-54.8	-16,370	-23.1	-7,052	-34.9	-1,918	-21.3	-46,158	-28.8
Midland												
Present												
Production	285,041		142,103		404,299		75,484		7,749		9,14,676	
Requirement	349,114		101,978		442,660		93,328		13,926		1,001,006	
	-64,073	-18.4	+40,125	+39.3	-38,361	-8.7	-17,844	-19.1	-6,177	-44.4	-86,330	-8.6
Terai												
Present												
Production	1,012,861		264,574		182,471		15,499		4,563		4,79,968	
Requirement	716,216		141,219		198,947		20,037		10,092		1,086,511	
	+296,645	+41.4	+123,355	+87.4	-16,476	-8.3	-4,538	-22.6	-5,529	-54.8	+393,457	+36.2
Total												
Present												
Production	1,323,777		419,985		641,296		104,121		19,414		2,508,593	
Requirement	1,095,874		272,654		712,503		133,555		33,038		2,247,624	
	+227,903	+20.8	+147,331	+54.0	-71,207	-10.0	-29,434	-22.0	-13,624	-41.2	+260,969	+11.6

Note: (+) Surplus production
(-) Deficit

Source: Department of Food and Agriculture Marketing Services, Agric. Statistics Division

TABLE 5-2-4 SUMMARY OF FUTURE FOOD BALANCE IN NEPAL

		1981	1985	1990	1995	2000	2005
1. Projected Population	('000)	14,658	16,345	18,685	21,630	25,203	29,614
2. Annual Population Growth Rate	(%)	2.76	2.76	2.76	2.85	2.99	3.15
3. Projected Cereal Requirement							
a. Per Capita Annual Consumption	(kg)	150.0	156.4	164.4	172.4	180.4	188.4
b. Total National Requirement (Edible Form)	('000mt)	2,198.7	2,556.3	3,071.9	3,729.1	4,546.7	5,579.2
c. Cereal Crop Production Requirement	('000mt)	3,773	4,486	5,211	6,311	7,683	9,406
4. Projected Cereal Crop Production	('000mt)	3,695	3,950	4,170	4,323	4,477	4,641
5. Food Balance	('000mt)	+22	-534	-1,032	-1,988	-3,206	-4,765
6. Percentage of Food Balance	(%)	+0.6	-11.9	-19.8	-38.2	-41.7	-50.7

TABLE 5-2-5 PRESENT CROPPING PATTERNS IN STUDY AREA

Cropping Pattern			Area	Cropping Ratio	Remarks
Early Summer	Wet Season	Winter			
-	Paddy	-	198,732	28.6	165 days
Paddy	Paddy	-	15,100	2.2	irrigated
Jute	Paddy	-	29,947	4.3	"
-	Paddy	Oilseed/ Mixed	47,367	6.8	
-	Paddy	Oilseed/ Mixed	74,242	10.7	winter crops are relayed
-	Paddy	Wheat	69,773	10.2	irrigated
Maize/Millet	Paddy/ Maize/	-	21,346	3.1	"
-	Millet				
-	Maize	Mustard/ Tobacco	15,093	2.2	
Paddy	Paddy	Mixed Cereals	32,038	4.6	irrigated
Jute/Maize	Paddy	Wheat, etc.	25,733	3.7	"
-	Misc.	Misc.	11,944	1.7	
-	Misc.	-	35,830	5.2	
Sugar cane/Pigeon pea			7,420	1.1	perennial
Fallow	Fallow	Fallow	108,556	15.6	
Total			695,429	100.0	

Note: Figures have been analysed and processed based on the data obtained from Land Resources Mapping Project.

TABLE 5-2-6 PRESENT CROP AREA, PRODUCTION AND PRODUCTIVITY IN THE STUDY AREA

Crops	Area Cultivated (ha)				Cropping Intensity (%)	Average Yield/ha (kg)	Total Product (MT)	Share of Total Cropped Area
	Early Summer	Wet Season	Winter	Total				
Paddy	47,138	547,460		594,598	(85.5)	1,730	1,028,655	62.0
Wheat			96,374	96,374	(13.9)	1,104	106,397	10.1
Maize	23,396	16,164		39,560	(5.7)	1,411	55,819	4.1
Millet	662	13,879		14,541	(2.1)	898	13,058	1.5
Barley			1,750	1,750	(0.2)	769	1,346	0.2
Tobacco		1,951	8,601	10,552	(1.5)	754	7,956	1.1
Jute	52,968			52,968	(7.6)	1,673	88,615	5.5
Oilseeds			68,884	68,884	(9.9)	646	44,499	7.2
Pulses			66,249	66,249	(9.5)	350	23,187	6.9
Sugar cane				6,015	6,015	(0.8)	22,046	132,607
Potato			6,850	6,850	(1.0)	6,257	42,860	0.7
Total	124,164	579,454	254,723	958,341	(137.8)			100.0

Source: All Nepal Food and Cash Crops, Expected Area and Products as of Present Year 2034-2040, Agricultural Statistics of Nepal (1977), Ministry of Food and Agriculture.

TABLE 5-2-7 ESTIMATED LIVESTOCK POPULATION IN THE IRRIGATION STUDY AREA, 1982/83

	Nepal 1/	Sarlahi 2/	Mahottari 2/	Dhanusa 2/	Siraha 3/	Saptari 4/	Sunsari 5/	Morang 2/	Jhapa 2/	Total
Cattle										
Bullock	473,000	47,405	57,391	53,207	70,445	45,589	40,371	75,968	78,785	469,161
Cow	816,500	24,215	27,010	31,901	50,725	36,125	22,418	21,408	46,737	260,539
Calf & Others	1,083,000	23,795	23,347	37,307	38,871	31,604	26,527	69,370	58,090	308,911
Total	2,372,500	95,415	107,748	122,415	160,041	113,318	89,316	166,746	183,612	1,038,611
Buffalo										
Male Buffalo	27,000	2,469	1,194	2,302	815	3,386	6,171	13,128	18,011	47,476
Female Buffalo	903,500	12,947	17,398	12,341	16,305	17,358	15,845	12,972	16,353	121,519
Calf & Others	682,000	11,579	11,594	15,702	16,134	14,174	16,074	23,505	14,657	123,419
	1,588,200	26,995	30,186	30,345	33,254	34,918	38,090	49,605	49,021	292,414
Goat										
Billy Goat	N.A.	5,604	11,394	8,163	18,533	9,498	9,579	11,110	20,472	94,353
Nanny Goat	N.A.	32,985	47,486	40,111	44,241	37,031	33,091	35,858	36,518	307,294
Castrated Kid	N.A.	10,137	6,962	3,617	13,032	14,689	9,512	10,304	20,048	88,301
Female Kid	N.A.	18,246	20,556	16,790	13,183	13,261	14,804	15,316	20,289	132,445
Total	N.A.	66,945	86,398	68,681	88,989	74,479	66,986	72,588	97,327	622,393
Others										
Sheep	N.A.	50	-	190	400	1,524	3,478	6,577	-	12,219
Pig	N.A.	1,713	1,943	467	4,248	1,712	10,433	10,924	6,882	38,322
Chicken	N.A.	38,149	48,100	22,817	50,932	18,503	N.A.	130,495	101,828	410,824
Duck	N.A.	2,958	4,285	3,237	11,729	7,092	-	31,391	9,682	70,374

1/ Agricultural Statistics of Nepal 1977, Dept. of Food and Agricultural Marketing Services, Ministry of Agriculture.

2/ Statistics on Population of Livestock and Animal Products in Some Districts of Nepal 1981, Dept. of Food and Agric. Marketing Services, Ministry of Agriculture

3/ Veterinary Hospital Siraha, 1983

4/ Livestock Development and Animal Health Division, Saptari 1984

5/ Central Bureau of Statistics

Note: N.A. not available

TABLE 5-2-8

NO. OF FARM HOUSEHOLDS AND AREA BY LEGAL STATUS OF HOLDING AND BY SIZE OF HOLDING IN THE PROJECT DISTRICTS, 1971

			Sarlahi	Mahottari	Dhanusha	Siraha	Saptari	Sunsari	Morang	Jhapa	Total
Individual Holder	No. of H.H		23,632	45,521	36,603	48,846	44,485	23,527	30,807	25,816	279,237
	Area in ha	Wet	28,629.5	63,249.6	35,382.5	61,287.6	69,220.4	43,994.3	62,315.0	77,833.3	441,912.2
		Dry	14,251.9	9,527.4	12,829.1	18,093.6	15,361.4	24,060.3	17,008.4	5,921.6	116,803.7
Corporation	No. of H.H		392	-	70	21	7	42	14	280	826
	Area in ha	Wet	845.4	-	10.8	14.9	2.6	66.9	-	699.5	1,640.1
		Dry	27.4	-	39.0	1.3	0.8	41.5	23.9	28.6	162.5
Government	No. of H.H		-	126	-	-	-	-	84	7	217
	Area in ha	Wet	-	23.6	-	-	-	-	45.6	26.8	96.0
		Dry	-	32.6	-	-	-	-	98.3	3.2	134.1
Cooperative	No. of H.H		-	56	-	-	7	7	14	7	91
	Area in ha	Wet	-	64.8	-	-	16.3	-	-	9.7	90.8
		Dry	-	-	-	-	3.5	1.2	29.6	2.5	36.8
Others	No. of H.H		203	175	133	105	-	1,008	3,031	70	4,725
	Area in ha	Wet	134.8	122.0	48.7	60.5	-	1,625.1	5,554.6	166.2	7,711.9
		Dry	111.8	6.4	79.2	15.1	-	426.8	1,163.4	0.3	1,803.0
Total Area of Holding	Agri. H.H		24,227	45,878	36,806	48,972	44,499	24,584	33,950	26,180	285,096
	Area in ha	Wet	29,609.7	63,460.0	35,442.0	61,363.0	69,239.3	45,686.4	67,915.2	78,735.5	451,451.1
		Dry	14,391.1	9,296.4	12,967.6	18,110.1	15,365.7	24,529.7	18,323.7	5,956.1	118,940.4

Note: H.H: Household
Wet: Wet season
Dry: Dry season

Source: National Sample Census of Agriculture 1971/72, Central Bureau of Statistics 1976

TABLE 5-2-9 SUMMARY OF LAND HOLDING BY TENURE IN THE PROJECT DISTRICTS, 1971

	Land Owner	Tenant	Owner-cum-Tenant	Landless Farmers	Total
1. No. of Households	187,530	31,801	59,780	5,985	285,096
(%)	(65.8)	(11.1)	(21.0)	(2.1)	(100.0)
2. Area Operated (ha)					
1) Wet Season	292,570.4	57,668.0	101,212.5	0	451,450.9
(%)	(64.8)	(12.8)	(22.4)	(0.0)	(100.0)
2) Dry Season	83,803.1	8,668.0	26,469.4	0	118,940.4
(%)	(70.5)	(7.3)	(22.2)	(0.0)	(100.0)
3. Average Holding (ha)					
1) Wet Season	1.560	1.813	1.693	0	1.584
2) Dry Season	0.447	0.273	0.443	0	0.417

Source: National Sample Census of Agriculture 1971/72, Central Bureau of Statistcs 1976.

TABLE 5-2-10

NO. OF AGRICULTURAL HOUSEHOLDS AND
LAND HOLDING STATUS BY SIZE IN PROJECT DISTRICTS, 1971

	Sarlahi	Mahottari	Dhanusha	Siraha	Saptari	Sunsari	Morang	Jhapa	Total	Ratio (%)
Landless	1,414	868	189	224	399	868	1,148	875	5,985	2.1
Upto 0.5ha	5,246	19,215	15,575	15,862	10,766	2,499	3,899	896	73,948	25.9
0.5-1.0ha	5,250	7,994	7,098	9,870	8,659	2,779	3,654	1,162	46,466	16.3
1.0-2.0ha	6,083	8,036	7,385	11,207	11,410	6,118	8,400	6,895	65,534	23.0
2.0-3.0ha	2,765	3,955	3,227	5,404	6,426	5,460	8,113	7,553	42,903	15.1
3.0-4.0ha	1,309	1,820	1,596	2,506	2,730	2,842	3,710	3,283	19,796	6.9
4.0-5.0ha	679	987	665	1,484	1,407	1,484	1,715	1,477	9,898	3.5
5.0-10.0ha	1,071	2,051	763	1,995	2,009	2,037	2,842	3,311	16,079	5.6
10.0-20.0ha	385	889	259	385	637	406	420	686	4,067	1.4
20.0 & Over	35	63	49	35	56	91	49	42	420	0.2
Total	24,227	45,878	36,806	48,972	44,499	24,584	33,950	26,180	285,096	100.0

Source: National Sample Census of Agriculture 1971/72, Central Bureau of Statistics 1976

TABLE 5-2-11 AGRICULTURE STATIONS AND FARMS IN THE PROJECT DISTRICTS AND VICINITY

Name of Station/ Farm and Location	Districts Covered	Research Outreach Program	Service Capability	Supply of Seeds, Seedlings, Operational Livestock and Poultry	Status
1. Agriculture Station, Tarahara	Morang Sunsari Saptari	FFT [a]; verification trials on cropping pattern; mini kit evaluation; technical support	Soil testing, plant protection; seed testing and inspection	Cereals, vegetables, mango, litchi, guava	Multipurpose units in cereals, horticulture, livestock and fishery; major emphasis on extension support testing site for NHQ[b] adaptive research
2. Hardinath Farm [c] Janakpur	Dhanusa Mahottari Siraha	FFT	Soil testing, plant protection	Wheat, paddy	Seed multiplication and demonstration farm with a demonstration fruit orchard testing site for national research
3. Horticulture Farm Janakpur				Fruit grafts, vegetable seeds and seedlings	Demonstration for horticultural crops
4. Oilseed Development Project, Nawalpur	Sarlahi	FFT verification trials on cropping patterns; technical support		Oilseeds	Research and extension, demonstration for multicropping system combined oilseed
5. Horticulture Farm Malangawa	Sarlahi			Fruit grafts, seedlings	Research and extension, demonstration fruit orchard
6. Janakpur Agricultural Development Project Naktajbij	Dhanusa Mahottari Sarlahi	FFT, verification trials on cropping pattern, technical support, economical evaluation	Soil testing, plant protection, installation of tubewell	Wheat, paddy	Research and extension demonstration and training of field crops
7. Seed Multiplication Farm, Tarahara	Morang Sunsari Saptari		Seed testing and inspection	Cereals, green manure	Seed multiplication and demonstration
8. Agriculture Station, Parwanipur	Bara Parsa Rautahat	FFT; mini kit outreach program	Seed testing; soil testing; plant protection	Cereals, fruits, vegetable seeds and seedlings, fingerlings, poultry	Multipurpose research station with horticulture, fishery and poultry units; NHQ for rice research;
9. Vrindavan Herbal Farm, Hetauda	Makawanpur		Essential oil extraction	Medicinal herbs seeds and seedlings	production of medicinal herbs and extraction of essential oil, indigenous medicinal plants preserve

a/ FFT Farmers' Field Trial
b/ NHQ National Headquarters
c/ May serve as a testing site for national program

Source: Nepal Agriculture Sector Strategy Study, 1982, ADB

TABLE 5-2-12 NUMBER OF AGRICULTURAL EXTENSION PERSONNEL IN THE TERAI AREA

District	Agricultural Extension					Fishery Development			Other Programs				
	ADO	AADO	JT	JTA	PLAA	JT	JTA	PLAA	ADO	AADO/ PO	JT	JTA	PLAA
Sarlahi	1		10	26	100	1	1	9		3	5		25
Mahattari	1		10	28	78		4	5					
Dhanusa	1	1	10	28	103	1	2	10		2			
Siraha		1	10	26	112		1	2					
Saptari	1	1	14	34	114	2		2	1	3	2		
Sursari		2	10	16	52			5					
Morang	1	4	11	20	66	1	1	4					
Jhapa	1	1	13	15	51	1	1	4					
Total	6	10	88	193	676	6	10	41	1	8	7		25

Note:

ADO Agricultural Development Office
AADO Assistant Agricultural Development Officer
JT Junior Technician
JTA Junior Technical Assistant
PLAA Panchayat Level Agricultural Assistant
PO Production Officer Under Crop Production Program

TABLE 5-2-14 NUMBER OF SAJHA INSTITUTIONS IN 8 TERAI DISTRICTS

Region/District	Number of Sajha Institutions in Operation			
	'1976/77	'1977/78	'1978/79	'1979/80
Jhapa	25	19	20	20
Moragn	36	19	20	20
Sunsari	39	17	18	18
Siraha	52	22	23	23
Dhanusa	66	24	25	25
Mohotari	65	16	17	17
Sarlahi	62	27	28	28
8 Districts	392	169	177	177
Nepal: Total	1,053	513	533	532

Source: Ministry of Agriculture

TABLE 5-2-15

SUMMARY OF HOUSEHOLD POPULATION AND AGE GROUP
IN THE PROJECT DISTRICTS, 1981

	Total Population	Total No. of H.H. 1/	Farm H.H. Population	No. of Farm H.H.	Family Size	Age Group of Household Population 0-9	10-14	15-59	60 & Over
Sarlahi	398,766	71,667	342,755	61,601	5.56	126,285	42,119	50,406	398,766
Mahottari	361,054	64,262	324,339	57,727	5.62	114,798	33,815	190,139	22,302
Dhanusha	432,569	79,785	345,764	63,774	5.42	130,135	43,856	236,473	22,105
Siraha	375,358	68,644	329,964	60,342	5.47	113,932	35,957	204,734	20,735
Saptari	379,055	68,646	293,361	53,127	5.52	117,170	37,648	205,042	19,195
Sunsari	344,594	58,187	245,852	41,514	5.92	106,352	41,989	178,746	17,507
Morang	534,692	91,045	438,830	74,722	5.87	165,759	67,185	278,618	23,130
Jhapa	479,743	81,113	377,727	63,865	5.91	147,650	64,508	247,020	20,565
Total	3,305,831	583,349	2,698,592	476,672	5.67	1,022,081	367,077	1,748,715	167,958

1/ Household

Source: Population Census, 1981, Central Bureau of Statistics

TABLE 5-2-16 LABOR AVAILABLE IN ONE FARM HOUSEHOLD IN THE PROJECT DISTRICTS

Age Group	Family Member	Labor Force Rate (%)	Available Labor Force
Male			
0 - 9	0.89	0	0
10 - 14	0.35	50	0.18
15 - 59	1.55	100	1.55
60 & over	0.15	50	0.08
Female			
0 - 9	0.86	0	0
10 - 14	0.28	40	0.11
15 - 59	1.45	80	1.16
60 & over	0.14	40	0.06
Total			
0 - 9	1.75	0	0
10 - 14	0.63	46	0.29
15 - 59	3.00	90	2.71
60 - over	0.29	48	0.14
Total	5.67	55	3.14

TABLE 5-2-17
(1 of 2)

MANPOWER REQUIREMENT FOR ALL CROPS PRESENTLY PRODUCED IN THE STUDY AREA

(Unit: man-day)

	Item	Area	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1.	Manpower Requirement/ha														
1)	Local Rainfed Paddy	1						7.65	41.40	19.87	10.36	10.36	4.87	28.49	123.0
2)	Improved Summer Paddy	1			8.90	35.83	23.85	9.25	27.14	17.03					122.0
3)	Improved Rainfed Paddy	1								18.58	44.72	13.35	13.35	33.0	123.0
4)	Improved Rainfed Paddy	1						9.13	37.64	22.35	10.44	10.44	31.14	1.86	123.0
5)	Local Rainfed Paddy	1	1.51					3.36	31.60	33.89	5.38	5.39	10.38	31.49	123.0
6)	Improved Rainfed Paddy	1							16.99	47.99	12.51	12.51	31.14	1.86	123.0
7)	Improved Summer Paddy	1			21.60	42.1	08.35	9.85	40.1						122.0
8)	Wheat	1	1.79	2.59	17.95	35.23							20.20	14.24	92.0
9)	Wheat, Other	1	3.26	1.27	48.16	4.05							23.11	12.15	92.0
10)	Relayed Mixed Crops	1	1.00	5.62	33.38							0.31	1.69	1.00	43.0
11)	Jute	1			30.81	26.47	23.15	11.57	25.00	90.00					207.0
12)	Jute or Maize	1			37.26	30.57	23.0	1.00	71.81	43.36					207.0
13)	Summer Maize	1		25.75	20.75	22.0	10.50	14.50	20.50						114.0
14)	Rainy Maize & Misc. Crops	1					3.48	20.40	31.12	20.00		22.17	12.83		110.0
15)	Tobacco	1	9.50	9.80	19.20						4.32	24.92	27.80	19.46	115.0
16)	Relayed Oilseeds	1	7.70	13.30									2.00		23.0
17)	Oilseeds	1	2.33	18.67									14.67	16.33	52.0
18)	Winter Pulses	1	17.00	2.00								6.69	25.31		51.0
19)	Sugar Cane	1		1.00	20.50	11.00	20.50					72.15	77.90	16.95	220.0
20)	Tobacco, Maize, Millet			25.75	20.75	22.00	10.50	14.50	20.50						114.0

TABLE 5-2-17
(2 of 2)

MANPOWER REQUIREMENT FOR ALL CROPS PRESENTLY PRODUCED IN THE STUDY AREA

(Unit: man-day)

Item	Area	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
2. Net Manpower Requirement/ha throughout the Project Area														
1) Local Rainfed Paddy	28.58%						2.186	11.831	5.678	2.961	2.961	1.392	8.142	35.151
2) Improved Summer Paddy	2.17			0.193	0.778	0.518	0.201	0.589	0.370					2.649
3) Improved Rainfed Paddy	6.48								1.204	2.897	0.865	0.865	2.138	7.969
4) Improved Rainfed Paddy	17.47						1.597	6.582	3.908	1.826	1.826	5.445	0.325	21.509
5) Local Rainfed Paddy	3.07	0.046					0.103	0.970	1.040	0.165	0.165	0.319	0.967	3.775
6) Improved Rainfed Paddy	8.31							1.411	3.987	1.039	1.039	2.587	0.155	10.218
7) Improved Summer Paddy	4.61			0.995	1.940	0.385	0.454	1.847						5.621
8) Wheat	10.03	0.180	0.260	1.801	3.535							2.027	1.429	9.232
9) Wheat, Other	3.70	0.121	0.041	1.782	0.150							0.855	0.450	3.399
10) Relayed Mixed Crops	4.61	0.046	0.259	1.538							0.041	0.078	0.046	1.981
11) Jute	4.31			1.327	1.140	0.997	0.498	1.077	3.076					8.915
12) Jute or Maize	3.70			1.329	1.131	0.851	0.037	2.657	1.604					7.659
13) Summer Maize	3.07		0.790	0.637	0.675	0.322	0.445	0.629						3.498
14) Rainy Maize & Misc. Crops	9.04					0.315	1.844	2.813	1.808		2.004	1.160		9.944
15) Tobacco	2.17	0.206	0.213	0.417						0.094	0.541	0.603	0.422	2.456
16) Relayed Oilseeds	10.68	0.822	1.420									0.214		2.856
17) Oilseeds	6.81	0.159	1.272									0.999	1.112	3.542
18) Winter Pulses	1.72			0.292	0.034						0.115	0.435		0.876
19) Sugar Cane	1.07	0.011	0.219	0.117	0.219						0.770	0.831	0.181	2.348
20) Tobacco, Maize, Millet	0.33	0.086	0.069	0.073	0.035	0.048	0.068							0.379
Total Labor Requirement/ha		1.677	4.543	10.551	9.637	3.436	7.433	30.406	23.475	8.982	10.300	17.810	15.367	143.617
3. Available Labor Force/ha		35.756	32.296	35.756	34.603	35.756	34.603	35.756	35.756	34.603	35.756	34.603	35.756	421.0
4. Balance (3-2)		+34.079	+27.753	+25.205	+24.966	+32.320	+27.170	+5.350	+12.281	+25.621	+25.456	+16.793	+20.389	
5. Surplus (+) & Deficit (-) Ratio %		+95.3	+78.0	+70.5	+72.1	+90.4	+78.5	+15.0	+34.3	+74.0	+71.2	+48.5	+57.0	

Available Labor Force/ha = 0.58 (Farm Household/ha) x 3.14 (Average Available Labor Force/Farm Household) x 20 day x 0.95 (Available Ratio) = 34.603 man-day (per 30 day-month)

TABLE 5-2-18
(1 of 2)

DRAFT ANIMAL REQUIREMENT FOR ALL CROPS PRESENTLY PRODUCED IN THE STUDY AREA

(Unit: animal-man-day)

	Item	Area	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1.	Draft Animal Requirement/ha														
1)	Local Rainfed Paddy	1						9.18	36.76	2.06			1.22	6.78	56.0
2)	Improved Summer Paddy	1			13.71	25.72	8.57		5.52	4.48					58.0
3)	Improved Rainfed Paddy	1								24.44	23.56			8.00	56.0
4)	Improved Rainfed Paddy	1						14.22	26.67	7.11			6.86	1.14	56.0
5)	Local Rainfed Paddy	1	1.14					5.24	27.05	15.71				6.86	56.0
6)	Improved Rainfed Paddy	1							23.56	24.44			6.86	1.14	56.0
7)	Improved Summer Paddy	1			25.71	22.29			10.00						58.0
8)	Wheat	1			1.30	2.70							34.20	19.80	58.0
9)	Wheat, Others	1			3.40	0.60							37.03	16.97	58.0
10)	Relayed Mixed Crops	1		0.54	3.46										4.0
11)	Jute	1			53.33	24.67			5.00	5.00					88.0
12)	Jute or Maize	1			65.00	13.00			6.00	4.00					88.0
13)	Summer Maize	1		39.00	17.00	8.00	4.00	2.00	2.00						72.0
14)	Rain Maize & Misc Crops	1					6.24	31.20	22.56	8.00		2.54	1.46		72.0
15)	Tobacco	1		0.80	3.20						4.60	34.50	6.90		50.0
16)	Relayed Oilseeds	1	1.46	2.54											4.0
17)	Oilseeds	1	0.66	3.34									26.00	26.00	56.0
18)	Winter Pulses	1			2.00							11.08	36.92		50.0
19)	Sugar Cane	1										46.40	46.40	9.20	102.0
20)	Tobacco, Maize, Millet			39.00	17.00	8.00	4.00	2.00	2.00						72.0

TABLE 5-2-18
(2 of 2)

DRAFT ANIMAL REQUIREMENT FOR ALL CROPS PRESENTLY PRODUCED IN THE STUDY AREA

(Unit: animal-man-day)

Item	Area	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
2. Net Animal Labor Requirement/ha throughout the Project Area														
1) Local Rainfed Paddy	28.58						2.623	10.505	0.589			0.349	1.983	16.004
2) Improved Summer Paddy	2.17			0.298	0.558	0.186		0.120	0.097					1.259
3) Improved Rainfed Paddy	6.48								1.583	1.526			0.518	3.627
4) Improved Rainfed Paddy	17.47						2.487	4.664	1.243			1.200	0.199	9.793
5) Local Rainfed Paddy	3.07	0.035					0.161	0.830	0.482				0.211	1.719
6) Improved Rainfed Paddy	8.31							1.957	2.030			0.570	0.095	4.652
7) Improved Summer Paddy	4.61			1.184	1.027			0.461						2.672
8) Wheat	10.03			0.130	0.271							3.431	1.986	5.818
9) Wheat, Others	3.70			0.126	0.022							1.370	0.628	2.146
10) Relayed Mixed Crops	4.61		0.025	0.159										0.184
11) Jute	4.31			2.297	1.062			0.215	0.215					3.789
12) Jute or Maize	3.70			2.405	0.481			0.222	0.148					3.256
13) Summer Maize	3.07		1.197	0.522	0.246	0.123	0.061	0.061						2.210
14) Rainy Maize & Misc. Crops	9.04					0.564	2.820	2.039	0.723		0.230	0.132		6.508
15) Tobacco	2.17		0.017	0.069						0.100	0.749	0.150		1.085
16) Relayed Oilseeds	10.68	0.156	0.271											0.427
17) Oilseeds	6.81	0.045	0.227									1.771	1.771	3.814
18) Winter Pulses	1.72			0.034							0.190	0.634		0.858
19) Sugar Cane	1.07										0.495	0.495	0.098	1.088
20) Tobacco, Maize, Millet	0.33		0.130	0.056	0.027	0.013	0.007	0.007						0.240
Total Draft Animal Requirement		0.236	1.867	7.280	3.694	0.886	8.159	21.081	7.110	1.626	1.664	10.102	7.444	71.149
3. Available Draft Animals per ha		12.369	11.172	12.369	11.970	12.369	11.970	12.369	12.369	11.970	12.369	11.970	12.369	145.555
4. Balance (3-2)		+12.133	+9.305	+5.089	+8.276	+11.483	+3.811	-8.712	+5.259	+10.344	+10.705	+1,868	+4.925	
5. Surplus % (+) & Defficit (-)		+98.1	+83.3	+41.1	+69.1	+92.8	+31.8	-70.4	+42.5	+86.4	+86.5	+15.6	+39.8	

Available Draft Animal Force/ha = 0.63 (Average Available Draft Animal Force/ha) x 20 day x 0.95 (Available Ratio) = 11.97 animal man-day (per 30 day-month)

Note: Draft Animal Requirement is calculated with conversion of single draft animal.

TABLE 5-2-19 FUTURE CROPPING PATTERNS (WITH PROJECT)
IN THE EASTERN STUDY AREA

Early Summer	Wet Season	Winter	%
Jute	-	Potato	1
Jute	-	Oilseeds	4
Pulses	Paddy	Oilseeds	11
Pulses	Paddy	Wheat	6
-	Paddy	Wheat	29
Maize	Paddy	-	15
-	Paddy	Pulses	8
Paddy	Paddy	-	25
	- Sugar cane -		1
Total			100%

TABLE 5-2-20 FUTURE CROPPING PATTERNS (WITH PROJECT)
IN THE WESTERN STUDY AREA

Early Summer	Wet Season	Winter	%
Pulses	-	Potato	1
Pulses	-	Tobacco	1
Pulses	Paddy	Oilseeds	14
Pulses	Paddy	Wheat	3
-	Paddy	Wheat	32
Maize	Paddy	-	15
-	Paddy	Pulses	8
Paddy	Paddy	-	25
	- Sugar cane -		1
Total			100%

TABLE 5-2-21 PROPOSED CROPPING INTENSITY AND ANTICIPATED YIELD IN THE EASTERN STUDY AREA

Crops	Cropping Intensity (%)	Anticipated Yield (kg/ha)
Wet Season Paddy (Medium Variety)	83	4,000
Wet Season Paddy (Early Variety)	11	4,000
Early Summer Paddy	25	3,500
Wheat	35	3,000
Maize	15	2,000
Oilseeds	15	1,000
Summer Pulses	17	800
Winter Pulses	8	800
Jute	5	2,500
Potato	1	15,000
Sugar Cane	1	30,000
Total	216%	

TABLE 5-2-22 PROPOSED CROPPING INTENSITY AND ANTICIPATED YIELD IN THE WESTERN STUDY AREA

Crops	Cropping Intensity (%)	Anticipated Yield (kg/ha)
Wet Season Paddy (Medium Variety)	83	4,000
Wet Season Paddy (Early Variety)	14	4,000
Early Summer Paddy	25	3,500
Wheat	35	3,000
Maize	15	2,000
Oilseeds	14	1,000
Summer Pulses	19	800
Winter Pulses	8	800
Tobacco	1	15,000
Potato	1	1,000
Sugar Cane	1	30,000
Total	216%	

TABLE 5-2-23 TARGET YIELD OF CROP WITHOUT/WITH PROJECT

Crop	Present Status kg/ha	Without Project kg/ha	With Project kg/ha
Wet Local Paddy	1,479	1,479	-
Improved Wet Paddy	2,200	2,876	4,000
Improved Summer Paddy	2,200	2,876	3,500
Wheat	1,140	1,443	3,000
Maize	1,411	1,411	2,000
Millet	898	898	-
Barley	769	769	-
Tobacco	754	754	1,000
Jute	1,673	1,673	2,500
Oilseeds	646	646	1,000
Pulses	350	350	800
Sugar Cane	22,046	22,046	30,000
Potato	6,257	6,257	1,500

TABLE 5-2-24
(1 of 2)

MANPOWER REQUIREMENT FOR ALL CROP PRODUCTION AT FULL DEVELOPMENT: EASTERN STUDY AREA

(Unit: man-day)

Item	Area	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1. Manpower Requirement/ha														
1) Improved Rainfed Paddy	1						9.95	45.95	16.79	12.66	19.02	68.64		173.0
2) Improved Rainfed Paddy	1						15.07	47.31	16.81	17.31	72.70	3.80		173.0
3) Improved Summer Paddy	1		1.88	59.52	17.09	17.09	34.42	33.00						163.0
4) Winter Pulses	1				44.00							25.07	6.93	76.0
5) Summer Maize	1	15.50	20.50	25.00	17.00	1.00	49.00							128.0
6) Wheat	1	2.30	1.40	63.59	45.41							32.62	3.68	149.0
7) Summer Pulses	1			18.10	16.30	1.60	49.88	8.12						94.0
8) Oilseeds	1		32.00								14.25	14.75		61.0
9) Jute	1		8.70	47.53	11.93	22.93	12.06	159.85						263.0
10) Potato	1	30.80	77.20	4.00							42.75	46.81	28.44	230.0
11) Sugar Cane	1		1.00	20.50	11.00	20.50					86.65	92.40	16.95	249.0

TABLE 5-2-24
(2 of 2)

MANPOWER REQUIREMENT FOR ALL CROP PRODUCTION AT FULL DEVELOPMENT: EASTERN STUDY AREA

(Unit: man-day)

Item	Area	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
2. Net Manpower Requirement/ha throughout the Eastern Study Area														
1) Improved Rainfed Paddy	83.0%						8.259	38.130	13.936	10.508	15.787	56.971		143.591
2) Improved Rainfed Fed Paddy	11.0						1.658	5.204	1.849	1.904	7.997	0.418		19.030
3) Improved Summer Paddy	25.0		0.470	14.880	4.273	4.273	8.605	8.250						40.751
4) Winter Pulses	8.0				3.520							2.006	0.554	6.080
5) Summer Maize	15.0	2.325	3.075	3.750	2.550	0.150	7.350							19.200
6) Wheat	35.0	0.805	0.490	22.257	15.894							11.417	1.288	52.151
7) Summer Pulses	17.0			3.077	2.771	0.272	8.480	1.380						15.980
8) Oilseeds	15.0		4.800								2.138	2.213		9.151
9) Jute	5.0		0.435	2.377	0.597	1.147	0.603	7.993						13.152
10) Potato	1.0	0.308	0.772	0.040							0.428	0.468	0.284	2.300
11) Sugar Cane	1.0		0.010	0.205	0.110	0.205					0.867	0.924	0.170	2.491
Total Manpower Requirement		3.438	10.052	46.586	29.715	6.047	34.955	60.957	15.785	12.412	27.217	74.417	2.296	323.877
3. Available Manpower/ha 1/		67.382	60.861	67.382	65.208	67.382	65.208	67.382	67.382	65.208	67.382	65.208	67.382	793.367
4. Balance (3-2)		+63.944	+50.809	+20.796	+35.493	+61.335	+30.253	+6.425	+51.597	+52.796	+40.165	-9.209	+65.086	
5. Rate of Labor Surplus % (+) & Deficit (-)		+94.9	+83.5	+30.9	+54.4	+91.0	+46.4	+9.5	+76.4	+81.0	+59.0	-14.1	+96.6	+96.6

1/ Available Manpower Force/ha = 1.093 (Farm Household/ha) x 3.14 (Average Available Labor Force/Farm Household) x 20 days x 0.95 (Available Ratio) = 65.208 (30 day = month)

TABLE 5-2-25 (1 of 2)

MANPOWER REQUIREMENT FOR ALL CROP PRODUCTION AT FULL DEVELOPMENT: WESTERN STUDY AREA

(Unit: man-day)

Item	Area	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1. Manpower Requirement/ha														
1) Improved Rainfed Paddy	1						9.95	45.95	16.79	12.66	19.02	68.64		173.0
2) Improved Rainfed Paddy	1						15.07	47.31	16.81	17.31	72.70	3.80		173.0
3) Improved Summer Paddy	1		1.88	59.52	17.09	17.09	34.42	33.00						163.0
4) Winter Pulses	1				44.00							25.07	6.93	76.0
5) Summer Maize	1	15.50	20.50	25.00	17.00	1.00	49.00							128.0
6) Wheat	1	2.30	1.40	63.59	45.41							32.62	3.68	149.0
7) Summer Pulses	1			18.10	16.30	1.60	49.88	8.12						94.0
8) Oilseeds	1		32.00								14.25	14.75		61.0
9) Tobacco	1	21.35	14.65						2.90	20.15	39.58	15.68	9.69	124.0
10) Potato	1	30.80	77.20	4.00							42.75	46.81	28.44	230.0
11) Sugar Cane	1		1.00	20.50	11.00	20.50					86.65	92.40	16.95	249.0

TABLE 5-2-25 (2 of 2) MANPOWER REQUIREMENT FOR ALL CROP PRODUCTION AT FULL DEVELOPMENT: WESTERN STUDY AREA

(Unit: man-day)

Item	Area	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
2. Net Manpower Requirement/ha throughout the Eastern Study Area														
1) Improved Rainfed Paddy	83.0%						8.259	38.130	13.936	10.508	15.787	56.971		143.591
2) Improved Rainfed Paddy	11.0						1.658	5.204	1.849	1.904	7.997	0.418		19.030
3) Improved Summer Paddy	25.0		0.470	14.880	4.273	4.273	3.605	8.250						40.751
4) Winter Pulses	8.0				3.520							2.006	0.554	6.080
5) Summer Maize	15.0	2.325	3.075	3.750	2.550	0.150	7.350							19.200
6) Wheat	35.0	0.805	0.490	22.257	15.894							11.417	1.288	52.151
7) Summer Pulses	19.0			3.439	3.097	0.304	9.447	1.543						17.860
8) Oilseeds	14.0	4.480									1.995	2.065		8.540
9) Tobacco	1.0	0.214	0.147						0.029	0.202	0.396	0.157	0.097	1.242
10) Potato	1.0	0.308	0.772	0.040							0.428	0.468	0.284	2.300
11) Sugar Cane	1.0		0.010	0.205	0.110	0.205					0.867	0.924	0.170	2.491
Total Manpower Requirement		8.132	4.964	44.571	29.444	4.932	35.349	53.127	15.814	12.614	27.470	74.426	2.393	313.236
3. Available Manpower/ha 1/		67.382	60.861	67.382	65.208	67.382	65.208	67.382	67.382	65.208	67.382	65.208	67.382	793.367
4. Balance (3-2)		+59.250	+55.897	+22.811	+35.764	+62.450	+29.859	+14.255	+51.568	+52.594	+39.912	-9.218	+64.989	
5. Rate of Labor Surplus % (+) & Deficit (-)		+87.9	+91.8	+33.9	+54.8	+92.7	+45.8	+21.2	+76.5	+80.7	+59.2	-14.1	+96.4	

1/ Available Manpower Force/ha = 1.093 (Farm Household/ha) x 3.14 (Average Available Labor Force/Farm Households) x 20 days x 0.95 (Available Ratio) = 65.208 (30 day = month)

TABLE 5-2-26 (1 of 2) DRAFT ANIMAL REQUIREMENT FOR ALL CROP PRODUCTION AT FULL DEVELOPMENT: EASTERN STUDY AREA

(Unit: animal-man-day)

Item	Area	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1. Draft Animal Requirement/ha														
1) Improved Rainfed Paddy	1						15.36	29.76	2.88			18.00		66.0
2) Improved Rainfed Paddy	1						22.40	25.60			17.10	0.90		66.0
3) Improved Summer Paddy	1		2.91	45.01			8.00	8.00						64.0
4) Winter Pulses	1				10.00							38.40	9.60	58.0
5) Summer Maize	1	26.00	26.00	16.00			6.00							74.0
6) Wheat	1			5.84	4.16							51.84	2.16	64.0
7) Summer Pulses	1			26.70	21.30		9.04	0.96						58.0
8) Oilseeds	1		6.00								24.00	24.00		54.0
9) Jute	1		15.60	62.40			2.10	11.90						92.0
10) Potato	1	6.40	13.60								62.25	15.75		98.0
11) Sugar Cane	1										53.40	53.40	9.20	116.0

TABLE 5-2-26
(2 of 2)

DRAFT ANIMAL REQUIREMENT FOR ALL CROP PRODUCTION AT FULL DEVELOPMENT: EASTERN STUDY AREA

(Unit: animal-man-day)

Item	Area	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
2. Net Draft Animal Requirement/ha throughout the Eastern Study Area														
1) Improved Rainfed Paddy	83.0%						12.749	24.701	2.390			14.940		54.780
2) Improved Rainfed Paddy	11.0						2.464	2.816				0.099		5.379
3) Improved Summer Paddy	25.0		0.728	11.253			2.000	2.000						15.981
4) Winter Pulses	8.0				0.800							3.072	0.768	4.640
5) Summer Maize	15.0	3.900	3.900	2.400			0.900							11.100
6) Wheat	35.0			2.044	1.456							18.144	0.756	22.400
7) Summer Pulses	17.0			4.539	3.621		1.537	0.163						9.800
8) Oilseeds	15.0		0.900								3.600	3.600		8.100
9) Jute	5.0		0.780	3.120			0.105	0.595						4.600
10) Potato	1.0	0.064	0.136								0.623	0.158		0.981
11) Sugar Cane	1.0										0.534	0.534	0.092	1.160
Total Draft Animal Requirement		3.964	6.444	23.356	5.877		19.755	30.275	2.390		4.757	40.547	1.616	138.921
3. Available Draft Animal Force/ha 1/		23.294	21.032	23.294	22.543	23.294	22.543	23.294	23.294	22.543	23.294	22.543	23.294	274.252
4. Balance (3-2)		+19.330	+14.588	-0.062	+16.666	+23.294	+2.788	-6.981	+20.904	+22.543	+18.537	+18.004	+21.678	
5. Rate of Labor Surplus % (+) & Deficit (-)		+83.0	+69.4	-0.3	+73.9	+100.0	+12.4	-30.0	+87.9	+100.0	+79.6	+79.9	+93.1	

1/ Available Draft Animal Force/ha = 1.186 (Estimated Available Draft Animal Force/ha) x 20 days x 0.95 (Available ratio) = 22.543 animal-man-day (30 day = month)

TABLE 5-2-27 (1 of 2)

DRAFT ANIMAL REQUIREMENT FOR ALL CROP PRODUCTION AT FULL DEVELOPMENT: WESTERN STUDY AREA

(Unit: animal-man-day)

Item	Area	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1. Draft Animal Requirement/ha														
1) Improved Rainfed Paddy	1						15.36	29.76	2.88			18.00		66.0
2) Improved Rainfed Paddy	1						22.40	25.60			17.10	0.90		66.0
3) Improved Summer Paddy	1		2.91	45.01			8.00	8.00						64.0
4) Winter Pulses	1				10.00							38.40	9.60	58.0
5) Summer Maize	1	26.00	26.00	16.00			6.00							74.0
6) Wheat	1			5.84	4.16							51.84	2.16	64.0
7) Summer Pulses	1			26.70	21.30		9.04	0.96						58.0
8) Oilseeds	1		6.00								24.00	24.00		54.0
9) Tobacco	1	1.10	4.90							23.00	23.00			52.0
10) Potato	1	6.40	13.60								62.25	15.75		98.0
11) Sugar Cane	1										53.40	53.40	9.20	116.0

TABLE 5-2-27 (2 of 2) DRAFT ANIMAL REQUIREMENT FOR ALL CROP PRODUCTION AT FULL DEVELOPMENT: WESTERN STUDY AREA

(Unit: animal-man-day)

Item	Area	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
2. Net Draft Animal Requirement/ha throughout the Western Study Area														
1) Improved Rainfed Paddy	83.0%						12.749	24.701	2.390			14.940		54.780
2) Improved Rainfed Paddy	11.0						2.464	2.816				0.099		5.379
3) Improved Summer Paddy	25.0		0.728	11.253			2.000	2.000						15.981
4) Winter Pulses	8.0				0.800							3.072	0.768	4.640
5) Summer Maize	15.0	3.900	3.900	2.400			0.900							11.100
6) Wheat	35.0			2.044	1.456							18.144	0.756	22.400
7) Summer Pulses	19.0			5.073	4.047		1.718	0.182						11.020
8) Oilseeds	14.0		0.840								3.360	3.360		7.560
9) Tobacco	1.0	0.011	0.049							0.230	0.230			0.520
10) Potato	1.0	0.064	0.136								0.623	0.158		0.981
11) Sugar Cane	1.0										0.534	0.534	0.092	1.160
Total Draft Animal Requirement		3.975	5.653	20.770	6.303		19.831	29.699	2.390	0.230	4.747	40.307	1.616	135.521
3. Available Draft Animal Force/ per/ha 1/		23.294	21.032	23.294	22.543	23.294	22.543	23.294	23.294	22.543	23.294	22.543	23.294	274.252
4. Balance (3-2)		+19.319	+15.379	+2.524	+16.240	+23.294	+2.712	-6.405	+20.904	+22.313	+18.547	-17.764	+21.678	
5. Rate of Labor Surplus % (+) & Deficit (-)		+82.9	+73.1	+10.8	+72.0	+100.0	+12.0	-27.5	+89.7	+99.0	+79.6	-78.8	+93.1	

1/ Available Draft Animal Force/ha = 1.186 (Estimated Available Draft Animal/ha) x 20 days x 0.95 (Available ratio) = 22.543 animal-man-day (30 day - month)

TABLE 5-2-28 MEASUREMENT FOR INCREMENTAL PRODUCT OF MAJOR CROPS BY 2005

Unit: 1,000mt

	Cereal Crops				Other Crops	
	Paddy	Wheat	Maize	Total	Oilseeds	Pulses
1. Bagmati - Kanro Irrig. Plan 1/						
a. Without Project	258.08	34.62	30.64	323.34	19.79	3.86
b. With Project	832.60	183.86	52.53	1,068.99	24.51	37.83
c. Incremental Product	574.52	149.24	21.89	745.65	4.72	33.97
2. Sun Kosi - Trijuga Div. Plan 2/						
a. Without Project	25.20	3.38	2.99	31.57	1.93	0.38
b. With Project	81.31	17.96	5.13	104.40	2.39	3.69
c. Incremental Product	56.11	14.58	2.14	72.83	0.46	3.31
3. Tamur - East Terai Div. Plan 3/						
a. Without Project	72.75	9.76	8.60	91.11	5.58	1.08
b. With Project	228.74	51.82	14.81	295.37	7.40	9.87
c. Incremental Product	155.99	42.06	6.21	204.26	1.82	8.79
4. Total 4/						
a. Without Project	356.03	47.76	42.23	446.02	27.30	5.32
b. With Project	1,142.65	243.64	72.47	1,468.76	34.30	51.39
c. Incremental Product	786.62	205.88	30.24	1,022.74	7.00	46.07

1/ Irrigation command area of 175,100ha
2/ " 17,100ha
3/ " 49,350ha
4/ " 241,550ha

TABLE 5-2-29 NEPAL RESETTLEMENT COMPANY PROGRESS REPORT: 1980

S. No.	Particulars	Unit	Nawalpur	Banke	Bardiya	Kanchanpur	Jhapa	Nawalparasi	Kailali	Sarlahi	Dhankuta	Total
1.	Land Available	Ha.	3866	4486	5668	5938	2584	3756	2817	267	-	29,382
2.	Families Resettled	No.	1504	1520	2712	2548	1286	2876	1003	235	-	13,684
3.	Land Distribution	Ha.	3155	3676	3703	3675	1995	3280	648	247	-	20,379
4.	Cotton Growing	Ha.	23	486	341	7	-	-	-	-	-	857
5.	Clearfelled Area	Ha.	3866	4486	3990	4090	2501	3464	950	267	-	23,614
6.	Irrigation											
	(a) Bamboo Boring	No.	-	-	-	-	9	-	-	-	-	9
	(b) Tube-well Boring	No.	-	9	25	28	-	-	-	-	-	64
	(c) Lift Irrigation	No.	1	14	1	-	-	1	-	-	-	17
	(d) Shallow Boring	No.	-	5	-	-	-	-	-	-	-	5
7.	Establishment of Health Post	No.	2	1	2	1	1	-	1	-	-	8
8.	Schools	No.	13	18	17	12	11	6	1	-	-	78
	(a) Primary	No.	7	15	13	9	7	6	1	-	-	58
	(b) Lower Secondary	No.	3	2	3	2	3	-	-	-	-	13
	(c) Secondary	No.	3	1	1	1	1	-	-	-	-	7
9.	Cooperative Society	No.	2	-	2	1	1	1	-	-	-	7
10.	Post Office	No.	2	1	2	1	1	1	-	-	-	8
11.	Road Construction	Km.	123	78	118	90	95	37	25	7	-	567
12.	Drinking Water											
	(a) Hand Pumps	No.	2	85	148	294	48	97	59	1	-	734
	(b) Wells	No.	-	37	74	-	23	12	-	7	-	153
13.	Distribution of Fruit Saplings	No.	5363	1235	7679	7492	17382	3360	41	1910	-	44,462
14.	Radio Listening Centre	No.	-	-	1	-	1	-	-	-	-	2
15.	Bio-gas Plant	No.	1	1	1	1	1	-	-	-	-	5
16.	Development of Market Centers	No.	1	1	1	1	1	-	-	-	-	5
17.	Farmer's Club	No.	1	1	1	-	1	-	-	-	-	4
18.	Food Received from WFP	M.T.	-	290	1412	3154	1095	2149	846	-	-	8,946
19.	Initiation of the Project	Fiscal year	2020/21	2022/23	2026/27	2026/27	2026/27	2032/33	2032/33	2034/35	2036/37	-

Source: Nepal Resettlement Company (An Introduction), 2037

TABLE 5-2-30

RESETTLEMENT PROGRAM DURING THE SIXTH FIVE YEAR PLAN PERIOD
(F.Y. 1980/81 to 1984/85)

S. No.	Particulars	Project Unit	Kanchap-pur	Kailali	Bardiya Twata	Nawat-parasi	Sarlahi	Dhankuta Jorpati	Jhapa	Central Office	Total
1.	Land Available	Ha.	1313	2722	1980	1100	2000	105	2200	Supervision	12,220
2.	Families to be Resettled	No.	700	1650	1200	1000	2240	490	2000		9280
3.	Land Distribution	Ha.	1050	2475	1800	1000	2240	102	2000		10,667
4.	Food Distribution	Mt.	992	2342	1696	2130	3174	678	-	Control	11,012
5.	Hand Pumps and Wells (For Drinking Water)	No.	48	110	80	66	150	-	146		600
6.	Road Construction	Km.	30	66	48	35	90	-	-		269
7.	Civil Works (a) Houses)	No.	4	4	5	-	5	5	-		23
8.	Cadastral Survey	Ha.	6848	5617	7618	5532	3167	-	1326	and	30,108
9.	Agri. Development Program										
	(a) Area to be Covered by Improved Seeds	Ha.	5525	3350	6320	6000	1710	-	4450		27,365
	(b) Crop Diversification	No.	8	-	4	-	15	-	-		27
	(c) Animal Husbandry Development Program	No.	150	100	100	-	200	-	-		550
	(d) Kitchen Gardening	Ha.	79	164	155	-	-	-	70		468
	(e) Bee Keeping	Bee hive No.	275	-	40	200	-	4	160		679
	(f) Sheep Rearing	No.	-	-	-	-	90	-			90
	(g) Distribution of Chicken	No.	10,000	-	-	4000	7000	4400	4000		29,400
	(h) Sericulture	No.	-	-	-	50	-	-	-		50
	(i) Distribution of Pigs	No.	-	-	-	-	-	320	-		320
	(j) Trial on Papaya		-	-	-	-	-	-	-		-
10.	Distribution of Fruit Saplings and Plantation	No.	3500	12,375	7000	10,000	8500	1500	10,000		52,875
11.	Land Area to Provide Irrigation Facility	Ha.	400	500	500	-	-		200		1600
12.	Cottage Industry	No.	50	-	-	-	-	100			150
13.	Agricultural Extension Services	To be continued round the plan period.									

Source: Nepal Resettlement Company (An Introduction), 2037

TABLE 5-3-2 EXISTING & ONGOING IRRIGATION DEVELOPMENT

	Command Area (ha)					Under Irrigation (ha)				
	Surface Water	Ground Water	Pumping	Total	Intensity	Surface Water	Ground Water	Pumping	Total	Irrigation Crop Intensity (%)
Bagmati	68,000				180					
Kamla	25,000				125	25,000				115
Rajbiraj Pump Canal			11,700		230					
Kasi West Canal	11,300				230	3,000				115
Trijuga/Chandra Canal	8,200				150	6,800				115
Sunsari-Morang	66,000				230	17,000				130
Kankai	8,000				190	3,000				190
Manusmara	5,800				180	3,200				145
Hardinath	2,000					2,000				-
Sagarmata		9,800			180					
Sarlahi		1,000	500		-		1,000	500		-
Mahottari		700			-		700			-
Dhanusa	600	100			-	600	100			-
Siraha		4,700			-		4,700			-
Saptari	900				-	900				-
Sunsari	1,400				-	1,400				-
Morang	8,200				-	8,200				-
Total	205,400	16,300	12,200	233,900		71,100	6,500	500	78,100	
(%)	(87.8)	(7.0)	(5.2)	(100)					(33.3)	

TABLE 5-3-4 (1 of 2) CALCULATION OF 10-YEAR RETURN PERIOD OF PRECIPITATION (SAPT KOSI WESTERN ZONE)

n	Year	Xi	Xi - Xo	$(Xi - Xo)^2$
1	1974	1,655	390	152,100
2	1978	1,588	323	104,329
3	1970	1,565	300	90,000
4	1975	1,377	112	12,544
5	1973	1,366	101	10,201
6	1976	1,306	41	1,681
7	1971	1,287	22	484
8	1979	1,203	- 62	3,844
9	1977	1,121	- 144	20,736
10	1969	988	- 277	76,729
11	1972	869	- 396	156,816
12	1980	860	- 405	164,025

1/ Data: Hardinath Meteorological Station

2/ Calculation Method: Iwai Method

3/ Xi : Precipitation

$$Xo : \sum_{i=1}^{n} Xi \cdot 1/n = 1.265$$

$$X = Xo + (1/a)\,\varepsilon \qquad \text{normal variable}$$

$$= Xo + \sqrt{\frac{2}{n} \cdot \sum_{i=1}^{n} (xi - Xo)^2} \times \varepsilon = 935.4$$

Precipitation of 1969 is the nearest value to the 10-year return period value (935.4mm).

TABLE 5-3-4 CALCULATION OF 10-YEAR RETURN PERIOD
2 of 2 OF PRECIPITATION (SAPT KOSI EASTERN ZONE)

n	Year	Xi	Xi - Xo	$(Xi - Xo)^2$
1	1975	1,412	260	67,600
2	1974	1,403	251	63,001
3	1973	1,270	118	13,924
4	1978	1,203	51	2,601
5	1977	1,148	- 4	16
6	1976	1,090	- 62	3,844
7	1980	1,049	- 103	10,609
8	1971	1,025	- 127	16,129
9	1979	1,011	- 141	19,881
10	1972	905	- 247	61,009

1/ Data: Tarahara Station

2/ Calculation Method: Iwai Method

3/ Xi : Precipitation

$$Xo : \sum_{i=1}^{n} Xi \cdot 1/n = 1.152$$

$$X = Xo + (1/a)\,\varepsilon$$

$$= Xo + \sqrt{\frac{2}{n} \cdot \sum_{i=1}^{n} (xi - Xo)^2} \times \varepsilon = 945.9$$

Precipitation of 1972 is the nearest value to the 10-year return period value (945.9mm).

TABLE 5-3-7 PROPOSED PROJECT AREA ALTERNATIVE PLAN

Item		Gross Area (ha)			Net Area (ha)		
		Right Bank	Left Bank	Total	Right Bank	Left Bank	Total
I. Sun Kosi Diversion							
400 feet Intake Plan	1	143,900	89,500	233,400	107,900	67,200	175,100
	2	122,600	89,500	212,100	91,900	67,200	159,100
	3	92,700	89,500	182,000	69,500	67,200	136,700
450 feed Intake Plan	1	176,600	110,400	287,000	132,400	82,800	215,200
	2	142,700	110,400	253,100	107,000	82,800	189,800
	3	103,700	110,400	214,100	77,800	82,800	160,600
II. Sapt Kosi West							
Sun Kosi-Trijuga Diversion Plan		-	-	22,800	-	-	17,100
Sapt Kosi Intake Plan		-	-	27,900	-	-	20,900
III. Sapt Kosi East							
Sapt Kosi Intake Plan		-	-	63,700	-	-	47,950
Tamur-Eastern Terai Diversion Plan		27,400	38,700	66,100	20,350	29,000	49,350

1 Bagmati River - Kanro River
2 Jhim River - Kanro River
3 Marha River - Kanro River

TABLE 5-3-8 CALCULATION OF ETo (SAPT KOSI WESTERN ZONE)
1 of 2

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Wind Velocity	(km/day)	72.0	98.4	132.0	213.6	261.8	252.0	232.8	201.6	160.8	79.2	64.8	60.0
RH Means	(%)	77.1	71.2	54.9	50.1	66.2	75.1	81.5	83.3	84.0	80.9	75.8	76.5
Kp		1.0	1.0	1.0	0.85	0.85	0.9	0.9	0.9	1.0	1.0	1.0	1.0
Epan	(mm/day)	2.2	3.3	5.5	6.9	6.9	4.8	5.1	4.2	3.9	3.9	3.0	2.3
ETo=Kp x Epan	(mm/day)	2.2	3.3	5.5	5.9	5.9	4.3	4.6	3.8	3.9	3.9	3.0	2.3

Note: Basic year used for Epan data was 1969.
The average data from 1971 to 1980 was used for other factors.

TABLE 5-3-8 CALCULATION OF ETo (SAPT KOSI WESTERN ZONE)
2 of 2

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Wind Velocity	(km/day)	108.0	139.2	194.4	261.6	360.0	283.2	235.2	225.6	148.8	103.2	98.4	96.0
RH Means	(%)	78.0	74.0	58.5	53.5	57.5	73.5	82.0	73.5	81.5	82.0	80.5	83.0
Kp		1.0	1.0	0.85	0.85	0.85	0.9	0.9	0.9	1.0	1.0	1.0	1.0
Epan	(mm/day)	2.5	3.3	4.9	6.0	7.7	5.4	4.7	3.6	3.9	3.2	2.5	1.9
ETo=Kp x Epan	(mm/day)	2.5	3.3	4.2	5.1	6.5	4.9	4.2	3.2	3.9	3.2	2.5	1.9

Note: Basic year used for Epan data was 1972.
The average data from 1971 to 1980 was used for other factors.

TABLE 5-3-9
1 of 4

LIST OF CROP COEFFICIENT (SAPT KOSI WESTERN ZONE)

	Jan.			Feb.			Mar.			Apr.			May			Jun.		
Summer Paddy							1.1	1.1	1.1	1.1	1.1	1.1	1.18	1.25	1.25	1.13	1.0	1.0
Rainy Paddy (Midium duration)																1.1	1.1	1.1
Rainy Paddy (Short duration)																	1.1	1.1
Winter Pulses	0.86	0.98	1.1	1.1	1.1	1.1	1.1	0.895	0.67	0.67								
Maize				0.55	0.55	0.69	0.635	0.79	0.79	0.935	0.935	1.1	1.1	0.97	0.97	0.84	0.84	0.84
Wheat	0.86	0.98	1.1	1.1	1.1	0.885	0.885	0.67	0.67	0.67								
Summer Pulses									0.48	0.6	0.6	0.6	0.77	0.94	0.90	0.90	0.90	0.69
Oilseed	1.1	1.01	1.01	0.92	0.92													
Tabacco	1.0	1.0	0.917	0.333														
Potato	1.1	1.01	1.01	0.92	0.92													

TABLE 5-3-9 LIST OF CROP COEFFICIENT (SAPT KOSI WESTERN ZONE)
2 of 4

	Jul.			Aug.			Sep.			Oct.			Nov.			Dec.		
Summer Paddy																		
Rainy Paddy (Midium duration)	1.1	1.1	1.1	1.1	1.075	1.075	1.075	1.05	1.05	1.025	1.025	1.025	1.0					
Rainy Paddy (Short duration)	1.1	1.1	1.1	1.1	1.075	1.075	1.075	1.025	1.025	1.025	1.0	1.0						
Winter Pulses														0.56	0.62	0.74	0.86	
Maize																		
Wheat													0.56	0.56	0.74	0.74	0.86	
Summer Pulses																		
Oilseed												0.52	0.685	0.685	0.685	0.985	0.985	0.985
Tabacco									0.083	0.667	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Potato												0.52	0.56	0.685	0.685	0.75	0.985	0.985

TABLE 5-3-9
3 of 4

CROP COEFFICIENT (SAPT KOSI EASTERN ZONE)

	Jan.			Feb.			Mar.			Apr.			May				Jun.	
Summer Paddy						1.1	1.1	1.1	1.1	1.1	1.175	1.175	1.25	1.1	1.0	0.95		
Rainy Paddy (Midium duration)																	1.1	1.1
Rainy Paddy (Short duration)																	1.1	1.1
Winter Pulses	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5								
Maize				0.55	0.55	0.675	0.65	0.8	0.8	0.94	0.94	1.1	1.1	1.075	1.075	1.05	1.05	1.05
Wheat	0.955	1.05	1.05	1.05	1.05	0.85	0.88	0.66	0.66	0.66								
Summer Pulses									0.5	0.62	0.62	0.78	0.925	0.925	0.895	0.85	0.85	0.65
Oilseed	1.05	0.89	0.89	0.73	0.73													
Jute							0.5	0.5	0.64	0.61	0.76	0.905	0.89	1.05	1.05	0.9	0.9	0.7
Potato	1.05	0.965	0.88	0.88														
Sugar Cane	0.758	0.855	0.975	0.975	0.975	0.975	0.9875	0.9875	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05

TABLE 5-3-9
4 of 4

CROP COEFFICIENT (SAPT KOSI EASTERN ZONE)

	Jul.		Aug.			Sep.			Oct.			Nov.			Dec.		
Summer Paddy																	
Rainy Paddy (Midium duration)	1.1	1.1	1.1	1.1	1.075	1.075	1.075	1.05	1.0	1.0	1.0	1.0	0.95				
Rainy Paddy (Short duration)	1.1	1.1	1.1	1.1	1.075	1.075	1.05	1.0	1.0	0.95	0.95						
Winter Pulses														0.125	0.875	1.0	1.0
Maize																	
Wheat														0.61	0.765	0.765	0.86
Summer Pulses																	
Oilseed												0.56	0.72	0.72	0.72	0.955	0.955	0.955
Jute	0.7	0.7															
Potato												0.56	0.61	0.72	0.72	1.0	0.955	1.05
Sugar Cane	1.05	1.05	0.875	0.875	0.875	0.875	0.875	0.875	0.875	0.7	0.63	0.63	0.63	0.737	0.737	0.757	0.785	0.785

TABLE 5-3-10
(1 of 10)

WATER REQUIREMENT FOR CROP (SAPT KOSI WESTERN ZONE) - SUMMER PADDY

	Mar.		Apr.			May			Jun.			
ET crop (mm/day)	-	-	0.76	5.68	6.49	6.49	6.96	7.38	7.38	4.86	3.76	0.54
Percolation	-	-	0.83	5.60	6.40	6.30	6.20	6.00	6.16	5.20	4.11	0.55
Land Preparation	-	-	12.00	12.00	-	-	-	-	-	-	-	-
Nursery	0.15	0.30	0.26	0.04	-	-	-	-	-	-	-	-
Effective Rainfall	0.01	0.02	0.06	0.99	1.12	1.12	1.27	1.27	1.27	4.98	4.36	0.62
Total	0.14	0.28	13.79	22.33	11.77	11.67	11.89	12.11	12.27	5.08	3.51	0.47
Gross W.R. (mm/day) I.E. = 75%	0.19	0.37	18.39	29.77	15.69	15.56	15.85	16.14	16.35	6.77	4.68	0.63
Converted Flow (/sec/ha)	0.02	0.04	2.13	3.45	1.82	1.80	1.83	1.87	1.89	0.78	0.54	0.07

TABLE 5-3-10
(2 of 10)

WATER REQUIREMENT FOR CROP (SAPT KOSI WESTERN ZONE)
- RAINY PADDY (MEDIUM DURATION)

	Jun.			Jul.		Aug.			Sep.			Oct.			Nov.
ET crop (mm/day)	-	-	-	1.01	3.04	3.97	4.09	4.09	4.19	4.10	4.10	4.00	3.80	2.40	0.60
Percolation	-	-	-	0.72	2.24	3.04	3.10	3.52	3.30	3.40	3.80	4.40	4.56	3.63	1.28
Land Preparation	-	-	-	4.80	4.80	4.80	-	-	-	-	-	-	-	-	-
Nursery	0.01	0.09	0.20	0.20	0.10	0.01	-	-	-	-	-	-	-	-	-
Effective Rainfall	0.01	0.10	0.12	0.70	1.81	4.16	4.37	4.37	3.14	3.14	3.14	0.29	0.28	0.17	0
Total	-	-	0.08	6.03	8.37	7.66	2.82	3.24	4.35	4.36	4.78	8.11	8.08	5.86	1.88
Gross W.R. (mm/day) I.E. = 75%	-	-	0.11	8.04	11.16	10.21	3.75	4.31	5.80	5.81	6.43	10.81	10.77	7.81	2.51
Converted Flow	-	-	0.01	0.93	1.29	1.18	0.43	0.50	0.67	0.67	0.73	1.25	1.25	0.90	0.29

TABLE 5-3-10
(3 of 10)

WATER REQUIREMENT FOR CROP (SAPT KOSI WESTERN ZONE)
- RAINY PADDY (SHORT DURATION)

	Jun.			Jul.			Aug.			Sep.			Oct.		Nov.
ET crop (mm/day)	-	-	-	1.01	3.04	3.97	4.09	4.09	4.19	4.00	4.00	3.20	1.56	0.20	
Percolation	-	-	-	0.72	2.24	3.04	3.10	3.52	3.30	3.40	3.80	3.52	1.92	0.30	
Land Preparation	-	-	-	4.80	4.80	4.80	-	-	-	-	-	-	-	-	
Nursery	0.01	0.09	0.20	0.20	0.10	0.01	-	-	-	-	-	-	-	-	
Effective Rainfall	0.01	0.10	0.12	0.70	1.81	4.16	4.37	4.37	3.14	3.14	3.14	0.23	0.12	0.01	
Total	-	-	0.08	6.03	8.37	7.66	2.82	3.24	4.35	4.26	4.66	6.49	3.36	0.49	
Gross W.R. (mm/day) I.E. = 75%	-	-	0.11	8.04	11.16	10.21	3.75	4.31	5.80	5.68	6.21	8.65	4.48	0.65	
Converted Flow	-	-	0.01	0.93	1.29	1.18	0.43	0.50	0.67	0.66	0.72	1.00	0.52	0.08	

TABLE 5-3-10
(4 of 10)

WATER REQUIREMENT FOR CROP (SAPT KOSI WESTERN ZONE)
- WINTER PULSES

	Nov.		Dec.			Jan.			Feb.			Mar.			Apr.
ET crop (mm/day)	0.21	1.25	1.70	1.98	1.89	2.16	2.42	3.63	3.63	3.63	6.05	4.92	3.69	1.98	
Effective Rainfall	0.01	0.08	0.09	0.09	0.21	0.21	0.21	0.19	0.19	0.19	0.25	0.25	0.25	0.54	
Total	0.20	1.17	1.61	1.89	1.68	1.95	2.21	3.44	3.44	3.44	5.80	4.67	3.44	1.44	
Gross W.R. (mm/day) I.E. = 49%	0.40	2.39	3.29	3.85	3.43	3.97	4.51	7.02	7.02	7.02	11.84	9.54	7.01	2.94	
Converted Flow	0.05	0.28	0.38	0.45	0.40	0.46	0.52	0.81	0.81	0.81	1.37	1.10	0.81	0.34	

TABLE 5-3-10
(5 of 10)

WATER REQUIREMENT FOR CROP (SAPT KOSI WESTERN ZONE)
- MAIZE

		Feb.			Mar.			Apr.			Feb.			May		Jun.
ET crop (mm/day)	0.60	1.67	2.28	3.49	4.35	4.35	5.52	5.52	6.49	6.49	5.72	5.72	3.61	2.42	0.29	
Effective Rainfall	0.07	0.19	0.21	0.32	0.32	0.32	1.25	1.25	1.25	2.37	2.37	2.37	6.13	4.11	0.49	
Total	0.53	1.48	2.07	3.17	4.03	4.03	4.27	4.27	5.24	4.12	3.35	3.35	-	-	-	
Gross W.R. (mm/day) I.E. = 49%	1.08	3.02	4.22	6.47	8.21	8.21	8.71	8.71	10.69	8.41	6.84	6.84	-	-	-	
Converted Flow (l/sec/ha)	0.13	0.35	0.49	0.75	0.95	0.95	1.01	1.01	1.24	0.97	0.79	0.79	-	-	-	

TABLE 5-3-10
(6 of 10)

WATER REQUIREMENT FOR CROP (SAPT KOSI WESTERN ZONE)
- WHEAT

	Nov.		Dec.			Jan.			Feb.			Mar.			Apr.
ET crop (mm/day)	0.84	1.70	1.70	1.98	1.89	2.16	2.42	3.63	3.63	2.92	4.87	3.69	3.22	0.49	
Effective Rainfall	0.06	0.09	0.09	0.09	0.25	0.25	0.25	0.23	0.23	0.23	0.32	0.32	0.28	0.14	
Total	0.78	1.61	1.61	1.89	1.64	1.91	2.17	3.40	3.40	2.69	4.55	3.37	2.94	0.35	
Gross W.R. (mm/day) I.E. = 49%	1.59	3.29	3.29	3.85	3.35	3.89	4.43	6.94	6.94	5.49	9.28	6.87	6.00	0.71	
Converted Flow (l/sec/ha)	0.18	0.38	0.38	0.45	0.39	0.45	0.51	0.80	0.80	0.64	1.07	0.79	0.69	0.08	

TABLE 5-3-10
(7 of 10)

WATER REQUIREMENT FOR CROP (SAPT KOSI WESTERN ZONE)
- SUMMER PULSES

	Mar.		Apr.			May			Jun.		
ET crop (mm/day)	0.66	2.66	3.54	3.54	4.54	5.55	5.31	3.87	2.90	0.74	
Effective Rainfall	0.07	0.76	1.01	1.01	2.01	2.01	2.01	5.05	3.79	1.26	
Total	0.59	1.90	2.53	2.53	2.53	3.54	3.30	-	-	-	
Gross W.R. (mm/day) I.E. = 49%	1.20	3.88	5.16	5.16	5.17	7.22	6.73	-	-	-	
Converted Flow (/sec/ha)	0.14	0.45	0.60	0.60	0.60	0.84	0.78	-	-	-	

TABLE 5-3-10
(8 of 10)

WATER REQUIREMENT FOR CROP (SAPT KOSI WESTERN ZONE)
- OILSEED

	Oct.		Nov.		Dec.			Jan.			Feb.	
ET crop (mm/day)	0.51	1.54	2.06	2.06	2.67	2.67	2.67	2.42	2.42	2.42	2.28	0.76
Effective Rainfall	0.38	0.09	0.12	0.12	0.10	0.10	0.10	0.23	0.23	0.23	0.17	0.06
Total	0.13	1.45	1.94	1.94	2.17	2.17	2.17	2.19	2.19	2.19	2.11	0.70
Cross W.R. (mm/day) I.E. = 49%	0.27	2.96	3.95	3.95	4.42	4.42	4.42	4.47	4.47	4.47	4.31	1.43
Converted Flow (/sec/ha)	0.03	0.34	0.46	0.46	0.51	0.51	0.51	0.52	0.52	0.52	0.50	0.17

TABLE 5-3-10
(9 of 10)

WATER REQUIREMENT FOR CROP (SAPT KOSI WESTERN ZONE)
- TABACCO

	Sep.		Oct.			Nov.			Dec.			Jan.			Feb.
ET crop (mm/day)	0.17	1.35	2.55	2.55	2.43	2.43	2.79	2.14	2.53	2.53	2.02	2.02	1.49	0.81	
Effective Rainfall	0.28	1.01	1.51	1.51	0.12	0.12	0.12	0.10	0.10	0.10	0.22	0.22	0.21	0.07	
Total	-	0.34	1.04	1.04	2.31	2.31	2.67	2.04	2.43	2.43	1.08	1.08	1.28	0.74	
Gross W.R. (mm/day) I.E. = 49%	-	0.69	2.13	2.13	4.71	4.71	5.45	4.16	4.96	4.96	3.68	3.68	2.61	1.51	
Converted Flow (/sec/ha)	-	0.08	0.25	0.25	0.55	0.55	0.63	0.48	0.57	0.57	0.43	0.43	0.30	0.17	

TABLE 5-3-10
(10 of 10)

WATER REQUIREMENT FOR CROP (SAPT KOSI WESTERN ZONE) - POTATO

	Oct.		Nov.			Dec.			Jan.			Feb.	
ET crop (mm/day)	0.51	1.26	2.06	2.06	1.73	2.27	2.27	2.42	2.22	2.22	2.28	0.76
Effective Rainfall	0.29	0.07	0.09	0.09	0.07	0.07	0.07	0.18	0.18	0.18	0.12	0.04
Total	0.22	1.19	1.97	1.97	1.66	2.20	2.20	2.24	2.04	2.04	2.16	0.72
Gross W.R. (mm/day) I.E. = 49%	0.45	2.43	4.01	4.01	3.38	4.48	4.48	4.57	4.17	4.17	4.41	1.47
Converted Flow (/sec/ha)	0.52	0.28	0.46	0.46	0.39	0.52	0.52	0.53	0.48	0.48	0.51	0.17

TABLE 5-3-11
1 of 3

WATER REQUIREMENT IN THE IRRIGATION STUDY AREA
(SAPT KOSI WESTERN AREA)

Unit: ℓ/sec/ha

Crops	(I/C) %	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Summer Paddy	(25)			0.194	0.570	0.465	0.116						
Rainy Paddy (Medium duration)	(83)						-	0.632	0.578	0.542	0.935	0.080	
Rainy Paddy (Short duration)	(14)						-	0.106	0.097	0.096	0.073		
Winter Pulses	(8)	0.037	0.065	0.087	0.009							0.001	0.030
Maize	(15)		0.047	0.134	0.163	0.119	-						
Wheat	(35)	0.151	0.264	0.296	0.009							0.020	0.142
Summer Pulses	(20)			0.009	0.106	0.141	-						
Oilseed	(14)	0.072	0.034								0.001	0.064	0.072
Tobacco	(1)	0.004	0.001							-	0.002	0.006	0.006
Potato	(1)	0.005	0.003								0.002	0.004	0.005
Total		0.269	0.414	0.720	0.877	0.725	0.116	0.738	0.675	0.638	1.013	0.176	0.254

TABLE 5-3-11
2 of 3

WATER REQUIREMENT IN THE IRRIGATION STUDY AREA
(SAPT KOSI EASTERN AREA - SR1 and SR2)

Unit: ℓ/sec/ha

Crops	(I/C) %	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Summer Paddy	(25)		0.001	0.259	0.449	0.519	0.074						
Rainy Paddy (Medium duration)	(83)						0.003	0.389	0.357	0.564	0.850	0.075	
Rainy Paddy (Short duration)	(14)						0.002	0.107	0.054	0.091	0.028		
Winter Pulses	(8)	0.042	0.064	0.049	0.001							0.001	0.022
Maize	(15)		0.045	0.101	0.128	0.123							
Wheat	(35)	0.189	0.247	0.219	0.007								0.100
Summer Pulses	(17)			0.007	0.079	0.133							
Oilseed	(15)	0.075	0.026									0.050	0.056
Tute	(5)			0.017	0.029	0.038							
Potato	(1)	0.005	0.001									0.004	0.004
Sugar Cane	(1)	0.004	0.007	0.009	0.008	0.008						0.002	0.003
Total		0.313	0.391	0.661	0.701	0.821	0.079	0.496	0.411	0.655	0.878	0.132	0.185

TABLE 5-3-11
3 of 3

WATER REQUIREMENT IN THE IRRIGATION STUDY AREA
(SAPT KOSI EASTERN AREA - SR3)

Unit: ℓ/sec/ha

Crops	(I/C) %	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Summer Paddy	(25)		0.001	0.365	0.927	0.956	0.263						
Rainy Paddy (Medium duration)	(83)						0.014	0.673	1.167	1.432	1.891	0.183	
Rainy Paddy (Short duration)	(14)						0.005	0.191	0.192	0.235	0.062		
Winter Pulses	(8)	0.052	0.079	0.061	0.001							0.001	0.029
Maize	(15)		0.057	0.126	0.159	0.154							
Wheat	(35)	0.234	0.306	0.275	0.009								0.122
Summer Pulses	(17)			0.009	0.099	0.164							
Oilseed	(15)	0.093	0.033									0.062	0.069
Tute	(5)			0.021	0.036	0.047							
Potato	(1)	0.007										0.005	0.005
Sugar Cane	(1)	0.006	0.009	0.011	0.010	0.009						0.003	0.004
Total		0.392	0.485	0.868	1.241	1.330	0.282	0.864	1.359	1.674	1.953	0.254	0.229

TABLE 5-3-12
1 of 3

REQUIRED IRRIGATION WATER FOR EACH PLAN

SUN KOSI MULTIPURPOSE SCHEME

		Marha R. - Kanro R.				Jhim R. - Kanro R.				Bagmati R. - Kanro R.			
		400ft Intake 136,700 ha		450ft Intake 160,600 ha		400ft Intake 159,100 ha		450ft Intake 189,800 ha		400ft Intake 175,100 ha		450ft Intake 215,200 ha	
	ℓ/sec/ha	m^3/s	10^6m^3	m^3/s	10^6m^3	m^3/s	10^6m^3	m^3/s	10^6m^3	m^3/s	10^6m^3	m^3/s	10^6m^3
Jan.	0.269	36.77	98.49	43.20	115.71	42.80	114.63	51.06	136.75	47.10	126.56	57.89	155.05
Feb.	0.414	56.59	136.91	66.49	160.85	65.87	159.35	78.58	190.09	72.49	175.37	89.09	215.53
Mar.	0.720	98.42	263.62	115.63	309.71	114.55	306.82	136.66	366.02	126.07	337.67	154.94	415.00
Apr.	0.877	119.89	310.74	140.85	365.07	139.53	361.66	166.45	431.45	153.56	398.03	188.73	498.19
May	0.725	99.11	265.45	116.44	311.86	115.35	308.95	137.61	368.56	126.95	340.12	156.02	417.88
Jun.	0.116	15.89	41.10	18.63	48.29	18.46	47.84	22.06	57.06	20.31	52.65	24.96	64.70
Jul.	0.738	100.88	270.21	118.52	317.45	117.42	314.49	140.07	375.17	129.22	346.11	158.82	425.38
Aug.	0.675	92.27	247.14	108.41	290.35	107.39	287.64	128.12	343.14	118.19	316.57	145.26	389.06
Sep.	0.638	87.21	226.06	102.46	265.58	101.51	263.10	121.09	313.87	111.71	289.56	137.30	355.89
Oct.	1.013	138.48	370.90	162.69	435.74	161.17	431.67	192.27	514.97	177.37	475.04	218.00	583.88
Nov.	0.176	24.06	62.36	28.27	73.26	28.00	72.58	33.40	86.59	30.82	79.88	37.88	98.17
Dec.	0.254	34.72	93.00	40.79	109.26	40.41	108.24	48.21	129.12	44.48	119.12	54.66	146.40
Total			2,385.98		2,803.13		2,776.97		3,312.79		3,056.68		3,765.13

TABLE 5-3-12
2 of 3

REQUIRED IRRIGATION WATER FOR EACH PLAN
(SAPT KOSI WEST IRRIGATION SCHEME)

	Sun Kosi-Trijuga Diversion 17,100 ha			Sapt Kosi Intake 20,900 ha	
	ℓ/sec/ha	m^3/s	10^6m^3	m^3/s	10^6m^3
Jan.	0.269	4.60	12.32	5.62	15.06
Feb.	0.414	7.08	17.13	8.65	20.93
Mar.	0.720	12.31	32.98	15.05	40.30
Apr.	0.877	15.00	38.87	18.33	47.51
May	0.725	12.40	33.21	15.15	40.58
Jun.	0.116	1.98	5.14	2.42	6.28
Jul.	0.738	12.62	33.80	15.42	41.31
Aug.	0.675	11.54	30.92	14.11	37.79
Sep.	0.638	10.91	28.28	13.33	34.56
Oct.	1.013	17.32	46.40	21.17	56.71
Nov.	0.176	3.01	7.80	3.68	9.53
Dec.	0.254	4.34	11.63	5.31	14.22
Total			298.48		364.78

TABLE 5-3-12
3 of 3

REQUIRED IRRIGATION WATER FOR EACH PLAN
(SAPT KOSI EAST IRRIGATION SCHEME)

		Sapt Kosi Intake 1 40,900 ha		Tamur-East Terai Deversion 2 42,300 ha		Along the Sapt Kosi River 3 7,050 ha			Total 1 + 3 47,950 ha		Total 2 + 3 49,350 ha	
	ℓ/sec/ha	m^3/s	10^6m^3	m^3/s	10^6m^3	ℓ/s/ha	m^3/s	10^6m^3	m^3/s	10^6m^3	m^3/s	10^6m^3
Jan.	0.313	12.80	34.29	13.24	35.46	0.392	2.76	7.40	15.56	41.69	16.00	42.86
Feb.	0.391	15.99	38.69	16.54	40.01	0.485	3.42	8.27	19.41	46.96	19.96	48.28
Mar.	0.661	27.03	72.41	27.96	74.89	0.868	6.12	16.39	33.15	88.80	34.08	91.28
Apr.	0.701	28.67	74.31	29.65	76.86	1.241	8.75	22.68	37.42	96.99	38.40	99.54
May	0.821	33.58	89.94	34.73	93.12	1.330	9.38	25.11	42.96	115.05	44.11	118.23
Jun.	0.079	2.00	5.19	3.34	8.66	0.282	1.99	5.15	3.99	10.34	5.33	13.81
Jul.	0.496	20.29	54.34	20.98	56.19	0.864	6.09	16.31	26.38	70.65	27.07	72.50
Aug.	0.411	16.81	45.02	17.39	46.56	1.359	9.58	25.66	26.39	70.68	26.97	72.22
Sep.	0.655	26.79	69.44	27.71	71.82	1.674	11.80	30.59	38.59	100.03	39.51	102.41
Oct.	0.878	35.91	96.18	37.14	99.47	1.953	13.77	36.88	49.68	133.06	50.91	136.35
Nov.	0.132	5.40	13.99	5.58	14.47	0.254	1.79	4.64	7.19	18.63	7.37	19.11
Dec.	0.185	7.57	20.27	7.83	20.96	0.229	1.61	4.32	9.18	24.59	9.44	25.28
Total			614.07		638.47			203.40		817.47		841.87

TABLE 5-3-13 MAIN FEATURES OF KAMLA DAM (MARHA RIVER - KANRO RIVER)
1 of 3

Item		400ft Intake Irrigation Area: 136,700 ha				450ft Intake Irrigation Area: 160,600 ha			
Diversion Water	m^3/s	80	70	60	51	90	80	70	64
Dead Storage Capacity	10^6m^3	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0
Available Storage Capacity	"	191.6	271.0	350.5	451.5	259.0	338.4	417.9	471.8
Total Storage Capacity	"	411.6	491.0	570.5	671.5	479.0	558.4	637.9	691.8
Low Water Level	m	163.0	163.0	163.0	163.0	163.0	163.0	163.0	163.0
High Water Level	"	169.8	172.2	174.5	177.0	171.9	174.1	176.2	177.5
Elevation of Dam Crest	"	172.8	175.2	177.5	180.0	174.9	177.1	179.2	180.5
Dam Height	"	42.8	45.2	47.5	50.0	44.9	47.1	49.2	50.5
Dam Crest Length	"	594.2	604.6	621.0	680.5	603.0	617.0	671.5	684.3
Inundated Area	km^2	27.2	32.2	36.6	41.7	31.6	35.9	40.1	42.8

TABLE 5-3-13 MAIN FEATURES OF KAMLA DAM (JHIM RIVER ~ KANRO RIVER)
2 of 3

Item		400ft Intake Irrigation Area: 159,100 ha				450ft Intake Irrigation Area: 189,800 ha		
Diversion Water	90	80	70	63	100	90	80	
Dead Storage Capacity	$10^6 m^3$	220.0	220.0	220.0	220.0	220.0	220.0	220.0
Available Storage Capacity	"	249.7	329.2	408.7	471.4	358.1	438.3	517.8
Total Storage Capacity	"	469.7	549.2	628.7	691.4	578.1	658.3	737.8
Low Water Level	m	163.0	163.0	163.0	163.0	163.0	163.0	163.0
High Water Level	"	171.6	173.9	176.0	177.5	174.7	176.7	178.6
Elevation of Dam Crest	"	174.6	176.9	179.0	180.5	177.7	179.7	181.6
Dam Height	"	44.6	46.9	49.0	50.5	47.7	49.7	51.6
Dam Crest Length	"	601.5	615.3	667.0	684.3	625.0	678.3	690.1
Inundated Area	km^2	31.1	35.5	39.7	42.8	37.0	40.9	45.0

TABLE 5-3-13 MAIN FEATURES OF KAMLA DAM (BAGMATI RIVER - KANRO RIVER)
3 of 3

Item		400ft Intake Irrigation Area: 175,100 ha				450ft Intake Irrigation Area: 215,200 ha			
Diversion Water		100	90	80	72	120	110	100	95
Dead Storage Capacity	10^6m^3	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0
Available Storage Capacity	"	268.6	348.1	427.6	492.6	364.9	444.4	523.8	563.6
Total Storage Capacity	"	488.6	568.1	647.6	712.6	584.9	664.4	743.8	783.6
Low Water Level	m	163.0	163.0	163.0	163.0	163.0	163.0	163.0	163.0
High Water level	"	172.2	174.4	176.4	178.0	174.9	176.8	178.7	179.6
Elevation of Dam Crest	"	175.2	177.4	179.4	181.0	177.9	179.8	181.7	182.6
Dam Height	"	45.2	47.4	49.4	51.0	47.9	49.8	51.7	52.6
Dam Crest Length	"	604.6	620.0	676.0	697.3	629.0	679.0	690.7	695.4
Inundated Area	km^2	32.2	36.4	40.5	43.8	37.4	41.3	45.2	47.1

TABLE 5-3-14 SUMMARY OF EACH PLAN (SUN KOSI MULTIPURPOSE SCHEME)

Sun Kosi Multipurpose Scheme	Intake Facility for Main Canal		Net Command Area		Main Canal		Siphon	
	Intake Facility	Intake Elevation ft		ha	Length km	Max. Discharge m^3/s	Nos	Total Length (m)
Marha River			Right	69,500	42.4	87	9	581.0
- Kanro River			Lift	67,200	74.1	84	16	875.1
	Barrage	400	Total	136,700	116.5	171	25	1,456.1
"			Right	77,800	50.7	97	10	477.6
			Left	82,800	66.1	104	17	651.8
	Kamla Dam	450	Total	160,600	116.8	201	27	1,129.4
Jhim River			Right	91,900	62.4	115	14	981.0
- Kanro River			Left	67,200	74.1	84	16	875.1
	Barrage	400	Total	159,100	136.5	199	30	1,856.1
"			Right	107,000	69.7	134	15	784.6
			Left	82,800	66.1	104	17	651.8
	Kamla Dam	450	Total	189,800	135.8	238	32	1,436.4
Bagmati River			Right	107,900	78.4	135	17	1,647.0
- Kanro River			Left	67,200	74.1	84	16	875.1
	Barrage	400	Total	175,100	152.5	219	33	2,522.1
"			Right	132,400	89.2	165	18	1,278.4
			Left	82,800	66.1	104	17	651.8
	Kamla Dam	450	Total	215,200	155.3	269	35	1,930.2

TABLE 5-3-15 MAIN FEATURES OF HYDROPOWER PLANNING

Diversion Water & Irrigation (m^3/s)	Command Area (ha)	Effective Head (m)	Max. Design Discharge (m^3/s)	Installation Capacity (kW)	Annaul Generated Energy (MWH)	Load Factor (%)
Diversion Power Station						
51	136,700	102.5	51	43,500	362,000	95
64	160,600	102.5	64	54,600	454,000	95
63	159,100	102.5	63	53,700	447,000	95
80	189,800	102.5	80	68,300	666,000	95
72	175,100	102.5	72	61,400	599,000	95
95	215,200	102.5	95	81,100	675,000	95
Kamla Dam Power Station						
51	136,700	31.5	100	26,200	148,100	64
64	160,600	31.9	110	29,200	168,300	66
63	159,100	31.9	110	29,200	167,800	66
80	189,800	32.1	130	34,800	20,200	66
72	175,100	32.0	120	32,000	184,500	66
95	215,200	32.5	140	37,900	224,400	67

TABLE 5-3-16 HYDROPOWER OF DIVERSION POWER STATION

Discription	Item	Dimension
1. Kurule Intake Dam	Type	Concrete Gravity
	Crest Level	EL 340.0 m
	Crest Length	EL 316.0 m
	Dam Hight	48.9 m
	Dam Volume	177 $10^3 m^3$
	Spillway Gate (H x L) (Designed flood discharge 19,000m^3/s)	15x14x12
2. Head Race Tunnel	Length	16.6 km
	Diameter	5.25 m
	Design Discharge	72 m^3/s
3. Hydropower	Intake Water Level	EL 338.0 m
	Tailrace Water Level	EL 213.0 m
	Gross Head	215.0 m
	Effective Head	102.5 m
	Design Discharge	72.0 m^3/s
	Installation Capacity	61,400 kW
	Annual Generated Energy	511,000 MWH
	Installation Operation Factor	95.0 %
4. Construction cost	Power Facilities	37.34 10^6US$
	Allocation Cost of Common Facilities	53.94 10^6US$
	Total	92.28 10^6US$
5. Economic Analysis	Discounted Cost (C)	158.3 10^6US$
	Discounted Benefit (B)	280.4 10^6US$
	B-C	122.1 10^6US$
	B/C	1.77 10^6US$

TABLE 5-3-17 HYDROPOWER OF KAMLA DAM POWER STATION

Discription	Item	Dimension	
1. Kamla Dam	Type	Gravel Fill	
	Catchment Area	1,450	km^3
	Dead Storage Capacity	220.0	$10^6 m^3$
	Available Storage Capacity	492.6	$10^6 m^3$
	Total Storage Capacity	712.6	$10^6 m^3$
	Low Water Level	EL 163.0	m
	High Water Level	EL 178.0	m
	Crest Level	EL 181.0	m
	Crest Length	EL 697.3	m
	Dam Hight	51.0	m
	Dam Volume	3,278.0	$10^3 m^3$
	Inandated Area	43.8	km^2
2. Hydorpower	Intake Water Level	EL 171.0	m
	Tailrace Water Level	EL 137.2	m
	Gross Head	33.8	m
	Effective head	32.8	m
	Design Discharge	120.0	m^3/s
	Installation Capcity	32,000	kW
	Annual Generated Energy	184,500	MWH
	Installation Operation Factor	65.8%	
3. Construction Cost	Power Facilities	25.30	10^6US$
	Allocation Cost of Common Facilities	19.48	10^6US$
	Total		
4. Economic Analysis	Discounted Cost (C)	57.1	10^6US$
	Discounted Benefit (B)	67.8	10^6US$
	B-C	10.7	10^6US$