d) The distance from downstream of the Trijuga River at the Chandra Canal Barrage intake dams to the Sapt Kosi is about 7km. If about 1km of embankments are constructed directly below the dam, bank erosion near Fatehpur will be arrested. Embankments are unnecessary along the remaining 6km; however, bank protection is required to prevent soil erosion in farm fields.

e) Erosion of the left bank of the Trijuga River at the Chandra Canal Barrage is slight in comparison to the right bank which, because of the spillway located on the same, is more easily eroded. Bank protection along the majority of the left bank is accordingly unnecessary. Approximately 1km of bank protection work is required on the left side directly downstream from the dam due to the existence of a village near the same.

f) The length of the Trijuga River intake dam is 350m, and about 10m of the left bank of the same requires repair.

5.6.4 Navigation

(1) Background

Access from Kathmandu to most cities except Jiri and Dhankuta in the Kosi Basin is only possible by air due to the lack of adequate serviceable roads. Common travel in the Hill and Mountain Areas is by footpaths. For trips, trade and logistics, people in the areas spend days in walking, sometimes crossing rivers to reach a destination including a nearby airport. Footpaths are used for general transportation and the network is extensively developed; the total length of footpaths is estimated at 15,000-20,000km in Nepal. Ferry services and manual ropeways also exist at many locations along rivers. In the Study Area, the Kathmandu -Dhankuta Highway is planned and is envisioned to greatly improve mobility in the area. However, it may be considerable time before the road is actually implemented.

HMG is giving attention to the development of adequate inland waterways on major rivers. This is a new policy of the government which has traditionally given development priority to roads and airways. The advantages of waterway transportation in comparison with roads and airways are considered to be the relatively small initial investment and low operational and maintenance costs.

In this connection HMG established the Inland Waterway Section under the Ministry of Works and Transportation in 1981. The Section has been conducting a project of "Inland Waterway Development" which investigates major rivers for their navigability. Special attention has been given to the Sun Kosi, Kali Gandaki and Bheri rivers.

(2) Navigation Potential

Navigation activities on the Kosi are limited to river-crossing by ferry and adventure type raft services. These utilize present uncontrolled flow of rivers and therefore, natural hazards and seasonal changes in river flow are inherent. Frequency and size of canoes used in ferry service are conditional to localities. In the case of Chatra Ghat on the Sapt Kosi, a large size canoe, approximately 10m long, is used in dry season. It takes approximately 8 minutes to cross carrying 80 persons in very crowded conditions. Long distance ferry service on a regular schedule does not exist on the Kosi.

HMG is interested in both international and domestic navigation, but for the time being domestic natigation is given more attention because of relative ease of implementation. As a land-locked country, however, accessibility from the Nepal-India border to Calcutta by river is considered a very attractive alternative transportation against roads, railroads or airways. Present cargo transportation for third country tradings[1/] is undertaken by overland trucking through Calcutta (75%) and Chittagong (5%), besides air transportation (10%). This trend will continue[2/] since air transportation will be continuously restrained by the cargo handling capacities at the Tribhuvan Airport. Average overland traffic[3/] for third countries amounts to about 450,000t/year. About 60% of the annual volume goes through the Biranj Customs Post; Calcutta is the place for shipping-out and receiving. FIG. 5-7 shows the major trucking routes in Nepal and India.

Navigation activities in north-eastern India are available from Calcutta to Farakka and Farakka to Assam, and limited distance

service near Patna. Details on frequencies, fares, and payloads of ships used for the said services are not known, but cargo movement in the north-eastern region between August '82 and July '83 amounted to 27,405 tons.

Recent surveys have indicated that inland waterway transportation in the region is no longer competitive with other modes of transportation, sharing as much as 60% till 1950 but only 3% in 1982. Such drastic change was caused by (i) loss in competition, (ii) development of roads and railways, (iii) lack of facilities for night navigation, and (iv) lack of infrastructure facilities. In order to re-utilize traditionally cost effective water borne transportion, the Government of India is now very keen on revitalizing inland waterway transportation. This new policy and its implementation would be benefical to Nepal for general trade with India.

Navigability on the Kosi with regards to a route from Calcutta to the Nepal border has been discussed very briefly elsewhere[1/], presenting 3 recommendations; namely, (i) a detailed survey of the Sapt Kosi from Chatra up to its confluence at the Ganges, (ii) installation of a lock to pass boats across the Bhimnagar Barrage, and (iii) arrangement of returning canal water used for power generation to the Sapt Kosi main stream to ensure adequate water depth for navigation.

Navigability on the Gandak River as an international waterway has also been studied[2/]. The report concluded that dry season traffic to and from Nepal could be effected by a barge similar to the Central Inland Water Transport Co-operation, India's "Cachar

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1/ "Projection Nepal's Transit Traffic for the Sixth Plan Period 1980/81 to 1984/85 Including Updated Volume Statistics for 1979/80 & 1980/81", UNCTAD/ESCAP, RAS/81/114, NEP/82/002, Ref. 83-39.

2/ "Transit Cargo Congestion and the Need for More Transhipment Facilities", UNCTADa/ESCAP/, RAS/72/077, NEP/72/077, Ref. 81-23, Feb. 1981.

3/ "Nepal Overseas Trade Statistics 1979-80", Trade Promotion Centre, Kathmandu.

Barge" operating at a draft of 90cm based on preliminary calculation, details of which were not shown in the report. The study also pointed out the necessity of some river training works to be undertaken at reasonable cost for ensuring a 90cm channel 345 days/yr (90% occurrence) up to the border of Nepal.

Recognizing the sizable navigational activities presently conducted on the Ganges River in the north-eastern region, it is concluded that navigational potential of the Kosi from its confluence at the Ganges River to the Nepal border should be confirmed through further professional investigations with the co-operation of the Government of India.

Concerning domestic navigation, a preliminary study conducted during Part A and B on the Sun Kosi, the Arun, and the Tamur suggests high potentiality based on (i) general field inspection from a helicopter, (ii) longitudinal profiles estimated from existing 1/50,000 maps as shown in FIG. 5-8, and (iii) field measurements of river cross-section and flow at 5 gauging stations on the Sun Kosi and the Tamur. Present practice of adventure type rafting on the Sun Kosi may reinforce the above preliminary judgement.

Navigation by barge with less than one meter draft may be possible in dry season (i) on the entire Sapt Kosi, (ii) up to Dalalghat on the Sun Kosi, (iii) up to Tumlingtor near Khandbari on the Arun, and (iv) up to the vicinity of Talplejung on the Tamur. Systematic technical surveys on the above 3 rivers are strongly recommended for possible subsequent detailed studies.

(3) Recommendations

Despite the importance and value of inland navigation, technical information required for evaluating the feasibility of

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1/ "Report on Inland Waterways for Nepal", A.B. Thapa, 22 Mar., 1967, Kathmandu.

2/ 'Inland Water Transport in Nepal', Report of a Mission by J.M. Deplax from 20-29 Nov., 1982 at the Request of H.M.G. of the Nepal.

both domestic and international aspects of the same is very scarce; therefore, as an initial step, preliminary investigations are urgently recommended. Separate recommendations are presented below for international and domestic aspects of inland navigation, respectively.

International Waterway Study

1) For the Kosi River from the Nepalese border to the confluence point at the Ganges River:

- longitudinal and cross-sectional profiles with leveling information
- daily discharge records
- siltation and sediment loads
- effects of current on possible scouring
- horizontal shifting of main stream
- other relevant hydrographic and hydrological survey data

2) For Bhimnagar Barrage, canals, power stations and other structures on the Sapt Kosi River:

- layout of structures describing relative horizontal distance from the river
- effective depth of flow
- location of bridges and clearance of the same
- cross-sectional and longitudinal profiles of channels

3) For the present waterway transportation services the route from the Ganges River through Farakka Barrage, Feeder Canal, Jangipur Barrage, the Bhagithi and Hooghly rivers reaching Calcutta:

- details on waterway services in terms of frequency, type of ship, fare and payload per ship
- management and operational information
- maintenance information
- future expansion programs

Collection of the above information will require the co-operation of the Government of India, and it may take some time before a detailed study can be started.

Domestic Waterway Study

Investigation of domestic navigation, however, can be expeditiously executed according to Nepal's own program. In order to effectively develop a domestic inland waterway transportation system in the Study area use of a a prototype ship for field

investigation is recommended. The following four phases are preliminarily set forth toward future commercial operation of waterway transportation.

1) First phase for preliminary study

Comprehensive investigations are to be carried out for a period of 1-2 years using a prototype ship to collect data on topography, hydrology, and navigability of the Sapt Kosi, Sun Kosi, Arun, and Tamur rivers. Investigation areas should consist of:

- the entire Sapt Kosi between the point of confluence of the last 3 rivers above and the Nepal-India border, approximately 50km
- from the confluence point up to Dalalghat on the Sun Kosi, about 170km
- from the confluence point up to Tumlingtar on the Arun, about 50km
- from the confluence point up to Phulbari on the Tamur, about 90km

The study is to determine the navigability of the 4 rivers based on analyses of the collected data and actual field surveys. Expected outputs of the Study are:

- possible navigation route
- preparation of river navigation chart
- required infrastructure works including wharf, service dock, river training, dredging, buoys and beacons for ensuring navigation route and safety
- scope of navigation services and future expansion program
- discussions on slipway or lift for ensuring passage through a multipurpose dam to be constructed in the future
- basic economic evaluation

Required equipment includes:

- a flat self-propelled barge which is about 15m long, 8m wide, 1m deep, with 30 tons cargo capacity
- a sonar
- a radar
- sets of navigation equipment & ground survey equipment
- a flow velocity meter
- a Catamaran type steel boat, diesel powered 450PS x 2, dimensions approx. 20m x 6m x 2m

The Catamaran type boat will be used for collecting data necessary for the navigability study. The flat barge

will be self-propelled for carrying cargoes during field surveys, but it can be readily used as a landing craft which will enable the survey boat to land on the shore at virtually any location along a river for loading and unloading purposes. The boat will also be used for a general ferry service after completion of the field surveys.

A detailed feasiblity study is to be conducted for a period of one year and the scope of works will include; (i) detailed implementation plan, (ii) continued test operation of the boat for collecting operational data, (iii) economic evaluation, and (iv) recommendations on institutional organization for commercial operation.

3) Third phase for construction of infrastructure

During a one year period, execution of the following is planned; (i) infrastructure construction, (ii) manpower training in the areas of operation and maintenance, and (iii) procurement of vessels.

4) Fourth phase for commercial operation

This is the last phase for starting commercial operation. All the necessary preparatory works and program adjustments are to be incorporated at this stage.

5.6.5 Inland Fishery

(1) General

Fisheries development represents a largely untapped sector in the field of water resources development and its potential should not be overlooked. It can contribute in several ways:

a) as a low cost source of supplementary protein;

b) as a source of employment and income generation; and

c) by helping establish a more ecologically balanced use of land and water resources.

Although landlocked, Nepal is blessed with sufficient water resources to permit fish production at levels which can make a significant impact on the quality and quantity of food supply in

the country. The value of fish production has long been recognized, and accordingly the Government has been including fisheries development in its five-year plans.

(2) Inland Water Resources

The latest data on physical land use shows that water bodies cover 2.84% of the total area of the country. Besides these natural water bodies, there are about 5,000ha of village tanks and ponds mostly concentrated in the southern plain, or Terai Area. An additional 198,481ha of irrigated paddy field and 750ha of man-made reservoirs add seasonal as well as perennial water bodies to the total. Moreover, the trend towards hydropower and irrigation projects will add more water bodies in future.

PROJECTED DAM RESERVOIRS

Name of Reservoirs & Pondage	Area of Water Surface (ha)
1. Sapt Kosi High Dam	14,000
2. Sun Kosi No.1	3,100
3. Sun Kosi No.2	5,500
4. Sun Kosi No.3	2,500
5. Dudh Kosi	330
6. Tamur No.1	300
7. Tamur No.2	200
8. Tamur No.3	200
9. Tama Kosi No.3	120
10. Tama Kosi No.4	100
11. Indrawati No.1	120
12. Kawala Reservoirs	4,400
Total	31,170

According to this Study, about 31,000ha of dam reservoirs would be created by Project development. Development of this water resource is feasible from both ecological and economical viewpoints.

(3) Fish Resources

A systematic detailed study on the biology and distribution of fish species in the various ecological niches of inland water

resources is still to be carried out to identify available species in Nepal. However, existing records indicate that the inland water resources of Nepal are considerably rich in fish species. A recent work, "A General Bibliography on Fish and Fisheries of Nepal" shows a total of 164 indigenous fish species distributed in various river systems and water bodies from a few hundred meters to 4,000m in altitude. Besides the indigenous fish species, seven exotic fish species of commercial value have also been introduced into the country. The three cold water species of the same (Salmo gairdeii, Samo trutta and Onchorynchus rhoduras) have disappeared, while commercially high value warm-water culture fish species (Cyprinus carpio (common carp), Ctenopharyngodon idella (grass carp), Hypopthalmichthys molitrix (silver carp) and Aristichtys nobilis (big head carp)) are being cultured along with commercially high value indigenous fish species. Besides the cultivable indigenous fish species, Schizothorax spp. Schizothoracthys spp. Tor spp. are dominant fish species in most of the hill-streams of the mid-hill and mountain regions. Many other fish species of commercial value also exist but the biology of the same has yet to be studied.

(4) Administrative Organization

The Government has built 12 fish farms, fisheries development centers and hatcheries in various parts of the country under the Fisheries Division of the Department of Agriculture. As this division is a very small, it is presently charged only with the full operation of national projects and technical support of the other fishery officers assigned to the economic development regions. Administratively the regional fishery officers and technicians are under the directors of the various regional directorates. There are about 77 fishery personnel in the country including: fisheries development officers, assistant fisheries development officers, junior technicians and junior technical assistants.

On the other hand, in 1981, the Fisheries Statistics Unit (FSU) was created under the Agricultural Statistics Division of the Department of Food and Agricultural Marketing Services (DFAMS).

This unit has sole responsibility to gather data on fisheries, including both fish farms and family operations which catch fish in lakes, rivers, paddy fields, irrigation canals, dams and barrages as their source of livelihood.

(5) Capture Fisheries

Capture fisheries in Nepal are widely scattered and unorganised. The fishermen living along the rivers and lakes use traditional fishing gear. To promote capture fisheries,experiments on induced breeding of indigenous cold water fish species such as Asala (Schizothorax/Schizothoracthys spp.), Katle (Accrosochilus hexagonalepis) and Mahaseer (Tor spp.) have been successfully carried out. Further efforts are being made to propagate the same on a mass scale for open water stocking.

(6) Culture Fisheries

Modern fish culture was initiated in the early 1950s. With the selection of suitable fish species initial steps were taken to construct a small and medium sized fish seed production center at Parawanipur and Godawari in the Kathmandu valley in 1960. At present there are 12 Fisheries Development Centers in the country which are mainly engaged in pure fish seed production and distribution of the same. Recognising the potential of inland fisheries for employment generation as well as income, the Goverment has launched an Aquaculture Development Project with financial assistance from the Asian Development Bank and technical assistance from UNDP.

Cage fish culture is recognised as being economically viable in the lakes of the Pokhara valley. Since 1978, private fish growers have undertaken cage fish culture in the same and total volume has reached about 12,000m^3. The Agriculture Development Bank has been providing credit facilities to accelerate fisheries development in ponds as well.

(7) Fish Species

Presently, the fish species being used for fish culture in Nepal are the indigenous Indian Major Carp-Rohu (Labio rohita),

Catla (Catla catla) and Mrigal (Cirrhina mrigala), exotic Chinese carp (Grass carp-Ctenopharyngodon idella, Silver carp - Hypopthalmichthys molitrix and Bighead carp - Aristichthys nobilis) and the common carp (Cyprinus carpio).

(8) Current Fish Production

Fish production in Nepal in 1979/80 was estimated by the Government at 2,900mt. This is a rough approximation as there is no systematic collection of fisheries statistics in the country. Out of this total, capture fisheries provide 2,200mt while 700mt comes from aquaculture. According to Government estimates, capture fisheries from rice fields in the Terai Area provide 1,600 mt/year (more than half of total fish production) and constitute the largest source of fish supply in Nepal. Aquaculture production mainly comes from private fish farms (650 mt/year), and the remaining from Government farms. In 1981/82 fish production was estimated to have increased to about 3,900t including 1,700t from pond fish culture.

(9) Production Target

Targets for fish production in the Sixth Plan (1980-1985) include a doubling of total fish production from about 2,900mt in 1979/80 to 6,168mt in 1984/85, and an increase in per capita fish consumption from 225g in 1979/80 to 415g in 1984/85.

An ADB study team estimates that with a high level of investment and development, 27,000mt of fish can be produced annually in Nepal by the year 2,000. This can be compared with the current annual production of about 4,000mt.

(10) Conclusions and Recommendations

With the exception of some river systems, survey of fish species in the Project area, has not been carried out systematically. However, the river systems of Nepal provide habitats for fresh water fish ranging from mountain snow trout (Asla) in the upper reaches and a variety of indigenous carp in the lower sections. Nepal is blessed with sufficient water resources to permit fish production at levels which can make a significant

impact on the quality and quantity of food supply in the country, and can also earn valuable foreign exchange.

The increasing trend toward hydropower and irrigation development is sure to add more water bodies in future. According to this study, about 31,000ha of dam reservoirs would be created at full development. These water resources should be developed in consideration of ecological and economical factors.

Recommendations for aquaculture development in Nepal, especially in the Project area, are as follows:

a) As an urgent requirement, basic studies on water resources for fishery development including natural fish ecology and existing fisheries in the Master Plan Project Area should be implemented.

b) As the lack of existing data on the basic aquatic ecology of Kosi and other river systems in the Project area makes it difficult to assess the effects of hydropower project development in the Kosi River Basin, more data should be obtained.

In addition to the above, potential for increased fish production exists through expansion as well as intensification of fish culture practices. A development program therefore should be established.

5.6.6 Tar Irrigation

(1) General

Due to the shortage of idle land in the newly reclaimed area, the major effort in agricultural development is focused on increasing crop productivity and cropping intensity. Available land has already been developed in a marginal area.

For example, in the catchment area of the Dudh Kosi River in the Study area, paddy is cultivated up to 2,500m above sea level, and pasture for animal grazing is extended nearly to the snow line of about 5,000m. Terrace fields, including paddy, developed in the Hill Area reach to the hilltops. Some selected farmlands are presently provided with irrigation water, so called tar irrigation, with water intake from local streams and small-scale run-of-river type diversion along the canal hillside.

(2) Present Conditions

According to the feasibility study reports conducted by the Department of Irrigation, Hydrology and Meteorology under the Ministry of Water Resources, 228 small and medium scale irrigation projects have been studied which cover 22 districts within Mechi, Kosi, Sagarmatha, Janakpur and Bagmati zones. The proposed area is about 131,000ha including a part of the Terai Zone (TABLE 5-33), and the size of each possible project area varies from 6-8,000ha. Among these proposed project areas, detailed survey was conducted on 17 areas as of 1983.

In the area of the above mentioned zones, 228 tar irrigation sites have been listed, in which 105 sites of 61,000ha are feasible, while 20 sites with 3,000ha are provisionally feasible. In particular, the Kosi Zone with 29 potential project sites will be given special attention, in view of concentrated development activities through the Kosi Hill Area Rural Development Programme (KHARDEP) in the Study area. In this connection, if more detailed investigation on tar irrigation is undertaken in the Study area, identification of more sites may be expected.

(3) Tar Irrigation Development

A major point to ensure the success of tar irrigation systems depends on availability of water resources. Extension of canal alignment is also an important factor to control the command area. Irrigation systems will differ depending on the topography; however, most of the irrigation systems are existing plot to plot systems.

Development of appropriate technology for tar irrigation systems using locally available materials such as rock, bamboo and wood materials is required for construction of necessary intake weirs and extension of the canal. For example, if the irrigation area is small in order to minimize the water seepage, bamboo flume systems can be considered in order to minimize water seepage.

Another possibile irrigation system for use in the Hill Area is a combination of pond and sprinkler irrigation. If small

irrigation ponds could be constructed in the upper stream and/or valley, vinyl water pipes connected with plastic sprinkler nozzles could provide sprinkler irrigation without water pressure in the case of 6-8m head or more.

This system conserves water resources and soil at a low cost and should be tested by the Government at selected model sites in the Hill area. The same are presently operated by farmers in the Andes mountain area in South America under conditions very similar to those in Nepal's Hill Area.

(4) Further Study

Under the development plan, the envisaged irrigable area will be increased on the downstream side of the proposed dam site with an upward water table after construction of dams. Therefore, potential study area for tar irrigation relating to the Study area is limited to unirrigated farmland located in the downstream area of the dam site and surrounding the dam reservoirs. The following points deliniate the major concept for further study on tar irrigation:

a) formulation of a 1:2,000 scale map for the proposed site;

b) delineation of irrigable area for gravity irrigation according to reservoir level at the proposed dam site;

c) fixation of possible canal alignment;

d) comparison study on unit water requirement, conveyance loss and field loss in the plain area and hill area;

e) study on lift irrigation using electric motors after construction of hydropower stations and dams;

f) evaluation of the suitability of the plot to plot irrigation system and overflow irrigation system;

g) design of drainage system; and,

h) pond and sprinkler irrigation system trials.

Project formulation will be studied from technical and economic aspects. The tar irrigation project, on the other hand, should take into account soil and land conservation.

Generally, in the Hill Area, distance between farmers' residences and farmland is a common factor in farming. Therefore, in formulation of irrigation areas the same will be considered in relation to the expected time spent in the fields as well as in going to and from the same .

VI. WATERSHED MANAGEMENT

6.1 General

The natural environment of the Kosi Basin in being devastated due to severe natural conditions and man-made erosion. Year after year serious erosion is progressing. Watershed management, including, among others, afforestation, soil conservation works, slope and landslide protection works, and sabo works is urged as an immediate necessity for the Kosi Basin. However, the watershed management measures require huge investments. Transportation of construction materials and manpower to the sites, particularly inaccessible sites is another substantial problem in implementing countermeasures.

Development of water resources in the Kosi Basin will facilitate the above mentioned works as many access roads will be developed for the proposed dam schemes and large capital gain will be created. Moveover, watershed management is indispensable for water resources development. The devastated basin hinders water resources utilization due to heavy siltation and large fluctuations in natural river flow due to reduction of the basin's water holding capacity. Heavy siltation also shortens the life of proposed reservoirs and damages irrigation facilities such as intakes and canals.

Watershed management should therefore be promoted in conjunction with water resource development.

6.2 Present Status

6.2.1 Present Status of the Kosi Basin

(1) Natural Erosion

Severe soil erosion in the Kosi Basin is largely due to orogenic movement in the 3 mountain ranges of the same; the Himalayan Mountains, Mahabharat and Siwalik ranges. These ranges were created by gradual upheaval in response to pressure exerted by the Indian subcontinent over a long period of time. The area is still affected by this mountain formation and the Himalaya Mountains in particular are reportedly still in the process of

upheaval. The resultant geological structure is extremely complex with numerous faults and, fold systems. Moreover, these mountain ranges are geologically young, characterized by steep cliffs and inclines and consequently, landslides etc., occur frequently.

About 10% of the Kosi Basin is covered by glacier, movement of which, in combination with heavy rainfall during rainy season from June to October, greatly contributes to severe soil erosion. Natural erosion is estimated to account for half of the erosion in the Hill Area[1/].

(2) Man-made Erosion

Deforestation of the Mountain and Hill Areas is the major man-made cause of erosion. Forest cover for the entire country's Mountain and Hill Area has decreased from 64% in 1964 to 29% in 1984[2/]. The Kosi Basin has a population of 2.6^{10^6} (1981 census) and the majority of those who live in mountain areas, rely upon firewood as their main source of fuel as well as certain tree varieties for livestock fodder, consuming the area's forest resources. As population increases therefore, forest area decreases.

With the disappearance of forest cover, exposed areas which are easily eroded expand and the water holding capacity of the soil is reduced, thus increasing sediment runoff due to rainfall and soil erosion. Moreover, cultivated terraces at higher elevations are predominantly simple and primitive with virtually no landslide or sediment runoff prevention works.

(3) Present Status of the Kosi Basin

It is estimated that $240^{10^6}m^3$ of sediment materials are produced annually in Nepal by soil erosion. About $119^{10^6}m^3$ of the above figure is said to originate from the Kosi Basin. In the Study area sedimentation figures are tabulated on the following page.

1/ FAO/UNDP Watershed Management Project Studies, 1977

2/ Country Monograph (Nepal), ESCAP, 1984

SEDIMENTATION LOAD OF MAIN RIVERS IN THE STUDY AREA

River	Catchment Area (km^2)	Total Annual Sedimentation Load (m^3/year)	Annual Sedimentation Load (m^3/year/km^2)
Sun Kosi	19,000	54 x 10^6	2,840
Arun	36,000	35 x "	970
Tamur	6,000	30 x "	5,000
Sapt Kosi	61,000	119 x "	1,950
Bagmati	2,700	2.7 x 10^6	1,000

Source: Summary of Erosion Data in Nepal, FAO/UNDP, Dept. of Soil and Water Conservation

The Team carried out the study of the landslide area in the Basin, using existing aerial photos and topographical maps in scale of 1:50,000. The results of the Study are tabulated below.

LANDSLIDE AREA IN THE KOSI BASIN

	Sun Kosi	Arun	Tamur	Sapt Kosi
C.A. (Km^2)	19,000	36,000	6,000	61,000
Estimated landslide area (km^2)	642	419	831	1,801
Ratio of landslide area (%)	3.38	1.16	13.85	2.95

6.2.2 Sediment Load of the Kosi River

Geological, topographical and meteorological conditions coupled with large deforested areas and frequent damage by glacier and water erosion indicate that a large volume of sediment runoff is produced in the Kosi Basin. Sedimentation is due not only to slippage, landslides or earth and rock movement but also to soil erosion. Soil conservation, including water conservation and river training, is particularly important in formulation of a large scale water resource development plan.

There are 2 possible methods for evaluating soil erosion and sedimentation in the Kosi Basin. One is a mathematical formula while the other is estimation based on sedimentation records from existing dams throughout the world. Sedimentation engineering documents and actual records may both be used in the formula method. As records are extremely limited in Nepal, however, the latter estimation method based on world-wide data was used whenever necessary to estimate sedimentation in the Kosi Basin.

Calculations for the erosion formula were made first (see below) and a rough estimation of the same determined. Using the sedimentation formula and comparative study of sedimentation maps and tables from different countries, sedimentation volume in the Kosi Basin was then estimated.

Erosion intensity is generally related to climate, hydrology, geology, topography, soil conditions, vegetation, and socioeconomic factors. The interrelationships of the above are very complex and formulation of an erosion process model is extremely difficult. Milos Holy, however, based on research of the same, suggested that the major determining factors in erosion intensity are hydrology, slope and slope length. On the basis of 15-year period measurements of a 19.8m long slope with an incline of 44.5%, Holy developed the following formula.

$$Sp = aq^b$$

Where,

Sp: soil loss (kg/ha)

q: surface runoff from precipitation (m^3/ha)

a, b: coefficent based on area conditions

Sheet erosion: a = 2.002 b = 1.103

Hill erosion: a = 0.210 b = 2.645

It is assumed that these two factors were developed based on the magnitudes of erosion obtained on a slant where the field tests wre conducted. Computations with respect to the hypsographic features of the Kosi Basin gave, on the other hand, a difference of elevation of approximately 1,000 to 1,500m per 14km^2, or 1.5/ 14 = approx. 40.1% for gradient.

This value is judged to be a close approximation to the value (44.5%) for the aforesaid test field. The Team accordingly made computation to determine the loss of soil by erosion, in accordance with Milos Holy's formula and obtained the following results.

$$Sp = aq^b$$

Where,

q: surface runoff due to rainfall (m^3 per hectare per year)

Sp: loss of soil (kg/ha)

a: 2.002

b: 1.103

Using Holy's formula for surface erosion, calculations of soil loss for the Kosi Basin are as tabulated below.

EROSION IN THE KOSI BASIN
(Holy's Formula)

River	Sapt Kosi	Sun Kosi	Arun	Tamur
Area	61,000km^2 100%	19,000km^2 31%	36,000km^2 59%	6,000km^2 10%
Average runoff (m^3) (1948 - 1971)	50,900x10^6 100%	22,400x10^6 44%	18,300x10^6 36	10,100x10^6 20%
q (m^3/ha.yr)	8,344.3	11,789.5	5,083.3	16,833.3
Sp (kg ha)	42,340.6	61,990.3	24,510.3	91,818.2
Spw=SpxA /(ton)	258.3x10^6	117.8x10^6	88.2x10^6	55.1x10^6
Spv= Spw÷1.7 1.7 (m^3) r=1.7t/m^3	151.9x10^6	69.3x10^6	51.9x10^6	32.4x10^6
Specific erosion (m^3/km^2)	2,490	3,647	1,442	5,400
Average erosion depth (mm)	2.49	3.65	1.44	5.40

To check the correctness of the method based on the above formula, the estimation method based on sedimentation in existing dams was applied and the Team made computations to estimate specific sedimentation in reservoirs of the Kosi Basin. The results for the different methods are summarized in TABLE 6-1.

6.3 Countermeasures

6.3.1 Soil Conservation

(1) General

Conditions related to natural and man-made erosion mentioned above are highly complex and mitigation of the same is consequently close to impossible. Yet the problem of soil conservation cannot be avoided if development of Kosi River water resources is to be continued. Soil erosion causes increased sedimentation in the lower reaches of the Kosi River which in turn reduces the life of reservoirs planned downstream, buries intake facilities, raises the level of the riverbed and increases flood damage. Lack of soil conservation measures, therefore, will result in increasing obstacles to development. Moreover continued deforestation will result in faster runoff and thus higher peak flood, damaging structures along the river and increasing erosion damage to the plain in the lower reaches.

(2) Necessity of Long-Term Policy

After identifying the major factors contributing to the complexity of soil erosion within the expansive catchment area, it will be necessary to develop a policy for each of the various causes. Accordingly large investments of capital and manpower will be required over an extended period of time.

Soil erosion, both in the Kosi Basin and throughout Nepal, however, concerns not only Nepal but also affects parts of the Indian subcontinent, constituting an international environmental conservation issue. From this perspective, soil conservation in the Kosi Basin should be treated as a large-scale project. If deforestation continues at the present rate, some claim that the

forests of Nepal will disappear within 15-20 years, and consequently long-term policy for conservation of the same should also be adopted as soon as possible.

(3) Conservation Proposal

The objectives of soil conservation from the perspective of water resource development are to reduce sediment discharge, and thereby increase the life of planned reservoirs and to stabilize the river's basin. These 2 objectives can be achieved by the following proposal.

1) Prevention of erosion

Erosion prevention work consists of slope protection works and erosion and torrent control, including the following main items in each category:

a) Slope Protection
- replanting work (including terrace canal and vegetation block)
- snow slip protection step and drainage work
- simple dam and slope grading works

b) Erosion and Torrent Control
- simple dam works
- revetment and flood control works
- simple dam and groundsill works

2) Protection works

The Team subsequently carried out a landslide protection work study at some sampled unit areas of 100km^2 from vicinity of high priority scheme sites: ... Sun Kosi No. 3, Tama Kosi No. 3 and Arun No. 3. The results of the study which are planned by basic methods using local materials are tabulated on the following page.

PROTECTION WORKS PER SAMPLES AREA 100km^2

Unit: US$

	Sun Kosi	Tama Kosi	Arun
1. Area of landslide	80ha	1,390	350ha
2. Protection works			
(1) River revetment	7,800m	18,000m	12,000m
(2) Spare works	850m	1,960m	1,300m
(3) Gabion check dams	68 sites	1,750 sites	253 sites
(4) Consolidation dam	6 sites	114 sites	17 sites
(5) Slope protection	80ha	1,390	350ha
3. Estimated cost			
(1) Mountain slope	300,000	5,056,000	1,243,000
(2) Stream and river	300,000	1,140,000	408,000
(3) Total	600,000	6,196,000	1,651,000

Although the above estimated costs fluctuated according to the sampled places, a very rough protection work cost estimate is considered to be 3^{10^6}US$ per 100km^2 including direct, indirect and maintenance costs.

(4) Watershed Management Recommendations

1) Protection works

As aforementioned, watershed management of the Kosi Basin is a large project which requires a long time and large investments. On the other hand, water resources, particularly hydropower, development in the Basin offers potentially great returns.

Development of hydropower in the basin will provide the opportunity to improve the Basin's watershed. It is recommended that after commissioning the operation of relevant power stations, at least 5% of the generated value of hydropower projects should be provided for watershed management of the Basin.

The high priority hydropower schemes, Sun Kosi No. 3, Tama Kosi No. 3 and Arun No. 3, were studied. Estimated investment cost and time required for the improvements of

their respective basins are presented in the following table. Based on the above, a rough estimation of the required investment cost is $3 10^6$US$ per 100km^2 for watershed protection and maintenance works.

INVESTMENT COST AND TIME REQUIREMENT
FOR WATERSHED IMPROVEMENT OF PRIORITY SCHEMES

	Unit	Sun Kosi No.3	Tama Kosi No.3	Arun No.3
C.A.	km^2	5,520	2,753	32,332
Installed capacity	km^2	536	123	240
Energy cost	US ¢/kwh	4.35	5.77	2.29
Expected annual sales of energy at site	10^6US$	90.0	34.8	45.0
5% of annual sales	10^6US$	4.5	1.7	2.3
Protected area[1/]	km^2	5,000	2,500	4,500
Required investment cost	10^6US$	150	75	135
Required time	year	33	44	59

1/ Protected area excludes Tibetan and glacier area.

The above expenditures are indispensable for water resources development from the viewpoint of maintenance and improvement of water resources in the devasted Basin. Furthermore, the same will create employment opportunities for local labor. With regards to present conservation in the Kosi Basin, the following table was adopted from the LRMP, Draft Land System Report, 1983, and clearly illustrates the need for watershed management.

SOIL EROSION RATE

Type of Land	Soil	t/ha/hr	($m^3/km^2/yr$)
Well managed	Forest land	5	(312)
Well managed	Bench terrace	10	(625)
Poorly managed	Sloping terraces	20	(1,250)
Degraded	Range land	40	(2,500)

To realize the above, further studies will be required. After implementation, appropriate organization should be established and a watershed management center will be required at hydropower development sites.

2) Conservation measures
(excluding sedimentation prevention)

The main conservation measures required are protection of existing forests and reforestation. This will require official promotion of replanting and at the same time restrictions of use of existing forests. The need for afforestation is further explained in 6.3.2 while other proposed conservation methods are described below.

Electrification of rural mountain communities

Fuel wood accounts for 90% of energy consumption in Nepal, with an annual consumption of $1m^3$/person. With a population of 2.6 million, annual consumption of fuel wood in the Kosi Basin is, therefore, about $2.6 10^6 m^3$, which implies rapid reduction of forest resources for energy production. Prompt development of the Kosi's abundant hydropower potential for electrification of rural communities is accordingly a priority.

Promotion of hill development

Expansion of farmland in response to population increase is causing a corresponding decrease in forest area. According to the NPC: The Sixth Plan 1981, forest area in Nepal decreased by $7,233km^2$ in 6 years from $48,230km^2$ in 1975 to $40,997km^2$ in 1980 while cultivated area increased $8,008km^2$ from $23,260km^2$ to $31,268km^2$ during the same period.

In order to reduce the conversion of forest to farmland, the production level of existing farmland must be increased. Intensive agriculture is practised in the mountain area and, although unit yield is slightly higher than in the Terai Area, improvement of the land itself and modernization of agricultural technology and farm management, etc., are necessary. If infrastructures required for improvements in yield, transportation system and etc., are established in the mountain regions, agricultural production of the same would potentially be increased within 10 years.

6.3.2 Afforestation

(1) Background

Natural erosion is estimated to account for half the erosion in the Hill Area[1/] and is partly a result of the exceptionally heavy monsoon rainfall patterns prevailing in the same. The huge amount of runoff from precipitation and snow melt, and the considerable speed of the same result in a natural erosion process which has far-reaching effects.

Man-made erosion, which is responsible for the other half of total erosion in the Hill Area, is primarily the result of high population density, friability of soils, cultivation on steep slopes without adequate soil conservation measures[2/], overgrazing of mountain pastures and forest lands, and scavenging for fuel wood and fodder. Although about 87% of all wood is used as fuel, forests are also important to the people in rural areas as a source of fodder for livestock. It has been estimated that 75% of feed requirements are met from forest grassland and trees in rural areas. This has accelerated more erosion of the hill or mountain

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1/ FAO/UNDP Watershed Management Project Studies, 1977.

2/ Although terraces are highly developed in the Hills, manpower required for adequate maintenance is high and in many areas, terraces are inefficient because of insufficient maintenance.

slopes. Forest area has declined from 45% in 1964 to 34% in 1974 and only 29% now remains[1/].

Studies by a Rural Energy Sector Study Team from the Tribhuvan University in Kathmandu indicate that if the present rate of forest destruction is continued, pressures of increasing population and fuel wood and fodder demands would result in the complete disappearance of all accessible forest in the Hills in the next 12-14 years and in the Terai Area in 15-20 years.

In short, the most critical problems arising from deforestation are those associated with loss of topsoil and potential agricultural land thereby leading to declining food crop production and secondly, the adverse effect of increased stream runoff of water supplies in the Hill area, and resultant downstream flooding effects.

Sheet, gully and landslide erosions, together with the scouring effect of torrents and streams, produce sand and silt in huge quantities, which are transported to the Terai and Gangetic plains. If these slopes are exposed to violent monsoon downpours without protective vegetation, fertile soils from the same may be lost forever and their potential usefulness permanently reduced.

Sand and silt are deposited when the speed of river flow is reduced, when rivers flow into the plains, for example, and these deposits constantly raise the riverbed. According to Nepali observers, the beds of Terai rivers are rising by 15 to 30cm annually[2/].

1/ Country Monograph (Nepal), ESCAP, 1984. Expert Group Meeting on the Integration of Environment into Development.

2/ HMG, Draft Proposals of Task Force on Land Use and Erosion Control, 1974

(2) Role of Afforestation

Stabilization of the soil is possible if appropriate measures are taken for the development of a stable land use system[1/]. Although the potential for erosion in the Kosi Basin is greater, as mentioned above, such erosion is not due to man-made causes alone. This is a natural cycle and will continue to occur[2/]. In the Hill Area, therefore, if there are no accompanying changes in land use practices, the effect of soil and water conservation works on the Kosi Basin, even if they are implemented on a large scale with high investment, will not be very significant.

In spite of this, erosion problems must not be ignored. A distinction should be made between natural, inevitable erosion and accelerated man-caused erosion. Recently much has been written about erosion in Nepal, and it is possible that the problems of erosion have been somewhat exaggerated. Rather than conducting a new study of erosion in Nepal, however, some clarification of the work already completed is required[3/]. The best method to combat soil erosion is large scale afforestation (hundred of km^2), a reduction in deforestation and better forest management.

(3) Present Afforestation Project

In order to ensure a sustained supply of fuel wood and fodder, as well as building materials for the rural population, and to improve soil and water conservation, HMG has designed and implemented many integrated development projects in the various districts, especially in the hill districts. One of the components of the same is the development of existing forests and extension of forest area by afforestation with the rural people's participation.

1/ A reconnaissance inventory of the major ecological land units and their watershed condition. Summary Report. FAO, 1980.

2/ The Sapt Kosi Unsolved Problems of Flood Control in the Nepalese Terai. HMG/FAO/UNDP, 1979

3/ F. Zollinger; Analysis of River Problems and Strategy for Flood Control in the Nepalese Terai. FAO/MHG/UNDP, NEP/74/020, IWM/WP/12

In regard to the Kosi Basin, all districts in the Hill Area are covered by afforestation programs in the above projects. Each district has its own projects exclusively involved with the afforestation program.

(4) Development Program

In the Sixth Plan (1980-85), one of the 3 objectives for the forest sector is conservation of natural resources consisting of ways and means of preventing or retarding natural disasters such as soil erosion, floods and landslides, protection of soil fertility, and safeguarding of rivers and rivulets. For this purpose, high priority has been given to works relating to soil and catchment area conservation and scientific land use and such works will be conducted with special emphasis on local participation.

Top priority has been given to community forest development and afforestation programs, which are being conducted in the mountainous region as mentioned above. The principal physical targets in the forest sector in the Draft Sixth Plan are tabulated below.

TARGET AREA FOR AFFORESTATION

Programs	Unit	Target
Conservation and Improvement of Forest	ha	82,189
Afforestation	ha	42,872

Source: The Sixth Plan (1980-85), Part 1 (A Summary), 1981

(5) Conclusion

As mentioned above it is important to acknowledge that afforestation is an urgent need of national development in Nepal. There are many countermeasures that can be used in the development approach; however, substantial investment and manpower will be required.

In these circumstances, running parallel with the present efforts of afforestation, rapid extension of fodder trees should be made

immediately through Government activities for soil conservation, and supply of fodder and fuel.

Afforestation with cuttings of fodder trees is an easy and economical task for farmers compared with planting of other trees. Fodder trees can be planted everywhere including footpaths between farm fields, surrounding farm houses, terraces and/or steep slopes.

Adaptable fodder trees should be selected and recommended by the Government for propagation and planting as a special urgent countermeasure. Such a program would be helpful to meet the farmers' basic requirements and protection of the environment at a low cost.

VII. PROJECT IMPLEMENTATION

7.1 General

Based on the existing data and information and the results of field investigation, various schemes in each sector were studied and identified. The study resulted in defintion of the parameters for all potential projects in the Study area. Economic analysis was subsequently conducted to judge whether proposed projects will contribute significantly to the development of the national economy. Evaluating the schemes due consideration of sound engineering, attractive economic indicators and the need indicated by the policies of HMG, thirteen (13) hydropower schemes and one (1) irrigation scheme were identified as optimum schemes for long term planning. From the viewpoint of implementation of the projects in the immediate future, the top two schemes, namely, the Arun 3 and Sun Kosi Multipurpose schemes, were assigned as priority schemes. These top priority projects have a definite development sequence as opposed to the other projects which are dependent upon the development needs of the country in the distant future. However complete and maximum utilization of Kosi Basin water resources will only be realized through the execution of all the identified projects.

7.2 Implementation Schedule

7.2.1 General

The top two priority projects were selected in the Master Plan Study; namely, the Sun Kosi Multipurpose scheme and Arun No.3 hydropower scheme. The Sun Kosi Multipurpose scheme is indispensable to agricultural development of the country and implementation is urgently recommended in view of the serious deficit anticipated in the national food balance in the near future.

Development of a medium scale hydropower project is also urgently required to meet forecasted demand in the 1990's. The Arun No.3 hydropower scheme, with its attractive economic viability is therefore recommended for immediate implementation. This scheme is optimum not only on a regional level in the Kosi Basin but on a national level as well with its low energy cost and expected contributions to future national socioeconomic development.

In the Master Plan period (1985-2005), there are many alternative implementation sequences involving combinations of other attractive schemes subsequent to the Arun No.3 scheme. In order to supply national energy requirements for the country from the hydropower schemes proposed in the Kosi Basin during the Master Plan period, four (4) alternatives are recommended as tabulated in TABLE 7-1, and the development program to meet power demand forecast is shown in FIG. 7-1.

As a result of the Study, Alternative-II is recommended for hydropower development for the following reasons.

(1) Arun No.3 and No.2 will generate low cost energy in comparison with other projects, which will help maintain low electric rates in the country. Consequently, agricultural and industrial use of electricity will be promoted, which will in turn, facilitate national socioeconomic development.

(2) PRR type hydropower is required to utilize water resources effectively and to meet peak demand.

(3) Arun No.3 and No.2 are SRR type schemes. This type of hydropower scheme generates substantial surplus energy both on a daily and seasonal basis. This surplus can not be used in the domestic market due the small peak regulation capacity in the country and Alternative-II is thus based on the condition of export of surplus energy.

7.2.2 Implementation Schedule for Sun Kosi Multipurpose Scheme

The scheme is large-scale with an investment cost of $550.7\,10^6$US$, and project area is extensive, covering 150km from east to west in the Terai Area. 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 numerous irrigation facilities for water supply and distribution and extension of agricultural technology. 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 are the diversion tunnel, and access road. Total length of diversion tunnel is 16.6km which will be divided into 3 or 4 work sections with some adits and the maximum section length for tunnel construction will be 9.5km. Total length of the access road is 70.5km, of which 40km crosses the Mahabarat range.

The construction period for the Project was estimated at 9 years on the basis of thorough study of a practically and economically feasible implementation schedule. In order to determine the most effective implementation sequence, the following 3 cases are considered.

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

Based on the condition that the B/C ratio should be greater than 1.0 in each stage, the following 6 categories were determined. (FIG. 7-2)

S-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.

S-2 Construction of the Kamla dam and Kamla dam power station;

S-3 Construction of irrigation facilities between the Kamla and Bhati Balon rivers;

S-4 Construction of irrigation facilities between the Bhati Balon and Kanro rivers;

S-5 Construction of irrigation facilities between the Marha and Kamla rivers; and,

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

Each category will be combined with 2-3 others. The sequence below is recommended as the most practical and economic implementation schedule

for the Sun Kosi Multipurpose Scheme. The same is considered in terms of balanced investment scale, procurement of manpower and construction materials, and water balance in each stage (TABLE 7-2).

First stage	S-1 and S-3
Construction period	7 Years
Benefit	Irrigation - 55,000ha Hydropower - 61,400kw
Construction cost	$301.0 10^6$US$
B/C	1.25
Second stage	S-2 and S-4
Construction period	7 years
Benefit	Irrigation - 24,200ha Hydropower - 32,000kw
Construction cost	$114.5 10^6$US$
B/C	1.13
Third stage	S-5 and S-6
Construction	6 years
Benefit	Irrigation - 95,400ha
Construction cost	$135.2 10^6$US$
B/C	2.53

Detailed analysis and alternative study of implementation sequence are studied in APPENDIX V. The implementation schedule and the annual disbursement schedule are shown in FIG. 7-3 and TABLE 7-3 respectively.

7.2.3 Hydropower Development Implementation Sequence

The most economical and attractive scheme among the 52 hydropower schemes in the Kosi Basin is the Arun No.3 hydropower scheme in view of its economic viability and development effects on subsequent schemes to be planned downstream on the same river. This Arun No.3 hydropower scheme can generate very inexpensive energy in spite of the long access road and can contribute to regional development providing electricity for industry in the eastern area.

After completion of the Arun No.3 scheme, Arun No.2 and No.1 schemes can be easily and economically developed in terms of access road and transmission line. Sankhuwasabha district along the Arun River is the

potential power center and energy from the 2 schemes can be supplied to the entire nation via the Trans-Nepal transmission line, presently under construction.

Although the proposed schemes on the Arun River are planned as SRR type, further study on PRR type development will be required in the next stage. Accordingly, surplus energy occuring during the day and in rainy season must be studied in view of energy export, inducement of energy consuming industries and combined operation of PRR and Reservoir type power stations.

Based on the above consideration, the following implementation scheme alternatives were prepared.

(1) Alternative-I

Alternative-I consists of sequenced development of Arun No.3, No.2 and No.1 hydropower schemes along the Arun River and Tama Kosi No.3 scheme at the final stage. This alternative will provide abundant and inexpensive energy supply with a high plant factor. Total plant factor after completion of Arun No.3, No.2 and No.1 is estimated at over 90%. The project plant factor at the final stage in 2005 is still high at 85%.

Careful investigation of demand and inducement of energy consuming industries must be undertaken to effectively utilize surplus energy.

(2) Alternative-II

This alternative proposes development of the most economical scheme, Arun No.3 and subsequent development of Arun No.2 and Tama Kosi No.3 and No.2 schemes to handle fluctuation in daily demand and to utilize surplus energy. Through this sequence, abundant inexpensive energy can be supplied at the first stage, which will contribute to development of energy consuming industries in the eastern Terai Area.

The combination of the Tama Kosi No.3 and No.2 schemes with the Arun No.3 and No.2 schemes will form an overall transmission network in Nepal.

(3) Alternative-III

This alternative provides reasonable plant factor at the first stage by developing the Tama Kosi No.3 scheme, which has a PRR type power station, immediately after the Arun No.3 scheme. Energy cost at the first stage increases in comparison with Alternative-II.

(4) Alternative-IV

Alternative-IV proposes development of Sun Kosi No.3, a reservoir type hydropower scheme, subsequent to the Arun No.3 scheme and energy supply from these two power stations until 2005. This alternative provides a reasonable plant factor; however energy cost will be slightly higher than that for other alternatives.

Alternative-II is recommended in view of early development of power stations which will generate inexpensive energy. Moreover, after improvement of the transmission network, a PRR type power station can be included in the network. The recommended implementation schedule of Alternative-II is shown in FIG. 7-4.

As large-scale projects require a substantial implementation period, small scale projects, like the Khimte Khola No. 1 and Bhote Kosi No. 1 schemes, will be considered for future feasibility study.

7.3 Development Expenditure

7.3.1 Present Status

HMG is presently preparing the Seventh Plan which commences from July 1985. Allocation of development expenditure in the public sector in the Fifth and Sixth Plan is as shown in TABLE 7-4.

Irrigation and power sectors were allocated a substantially large share in the Sixth Plan as compared to the fifth Plan with 14.1% in irrigation and 17.5% in the power sector. Approximately $204 10^6$US$ and $253 10^6$US$ is allocated for irrigation and power, respectively in the Sixth Plan at the rate of 15 NRs per US$.

7.3.2 Disbursement Schedules for Top Priority Schemes

The Team has prepared disbursement schedules for the two top priority schemes as tabulated below.

(10^6 US$)

	Sun Kosi Multipurpose				Arun No.3 Hydropower
		Stage			
	Total	①	②	③	
1988	1.9	1.9	-	-	14.0
1989	4.6	4.6	-	-	14.0
1990	5.4	4.6	0.8	-	16.0
1991	28.5	26.2	2.3	-	41.0
1992	26.7	23.4	2.4	0.9	62.0
1993	47.1	39.6	5.0	2.8	73.0
1994	56.1	48.6	5.0	2.8	51.0
1995	78.6	48.4	3.5	26.7	16.0
1996	108.5	55.3	26.3	26.8	10.0
1997	83.5	48.2	16.1	18.8	10.0
1998	44.2	-	25.5	18.8	-
1999	46.8	-	29.6	18.8	-
2000	18.8	-	-	18.8	-
Total	550.7	301.0	114.5	135.2	307.0

Note: All costs are based on price levels at the end of 1983 and do not include any taxes, duties, interest or allowance for price escalation.

Detailed cost disbursement for the Sun Kosi Multipurpose scheme is divided into 3 stages, as are other priority schemes which are expected to be developed by 2005. Cost disbursement is described in APPENDIX IV and V.

As shown in the table above, expenditure will extend over more than 10 years and the majority will be expended after 1990 when the projected scale of the Nepalese economy, as well as the government budget, is greater. With a GNP growth rate of 4-5% and the increased investment capability of HMG due to foreign aid, implementation of the proposed Sun Kosi Multipurpose and Arun No.3 schemes is considered feasible.

7.4 Manpower Development

7.4.1 Present Status

In order to achieve higher rates of investment in Nepal, HMG recognizes the need to launch a sizable training program to provide appropriate management, technical and administrative skills for implementation of its water resources development projects. According to "Water, the Key to Nepal's Development", the ED has a program underway to train 250 Nepalese engineers by 1989 at Roorkee University in India with 50 engineers expected to graduate each year for five years starting in 1984. It has also been estimated that an additional 265 engineers in the water supply and sanitation sector and 150 engineers in the irrigation sector will be required to implement the program in the coming decade. The current engineering strength in the water resources sector is listed in TABLE 7-5.

7.4.2 Required Technical and Administrative Manpower

A rough estimation of required manpower for implementation of the proposed development schemes in the Master Plan was conducted based on an on-going project, Kulekhani No.2. Estimation was carried out for the Sun Kosi Multipurpose, Arun No.3, Tama Kosi No.3 and Sun Kosi No.3 schemes as representative of other similar projects. The results are shown in TABLE 7-6.

According to the results, numerous officers and engineers in various fields are required for implementation of the proposed schemes. Substantial manpower is particularly needed for parallel implementation of the Sun Kosi Multipurpose and Arun No.3 Hydropower schemes. Accordingly, HMG's training program should be further strengthened to support project implementation.

VIII. CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

As a result of the Study, it is concluded that implementation of water resources development in the Study area is required as soon as possible to meet national needs in the power and irrigation sectors. Development of the water resources of the Kosi River will not only meet short, medium and long term national needs but will also create surpluses for export.

Among all the schemes identified in the Master Plan, the top two schemes, i.e. the schemes, Sun Kosi Multipurpose and Arun No.3 Hydropower Schemes, were selected for implementation in the immediate future. As discussed in the foregoing chapters, these two schemes are technically sound and economically feasible. It is necessary, therefore, to conduct feasibility studies on the same at the earliest opportunity.

8.2 Recommendations

(1) Recognizing that the top two priority schemes proposed in the Master Plan will contribute greatly to the economic growth and social improvement of the people in Nepal, these schemes should be implemented in close relation with projects in other sectors. Construction of access roads, telecommunication system and agricultural institutions should be implemented effectively through appropriate planning coordination among the different government agencies concerned.

(2) In view of the fact that the number of people with management and technical skills is insufficient in Nepal, the manpower training program should be strengthened in support of forthcoming projects in the Master Plan.

(3) In addition to the proposed Sun Kosi Multipurpose scheme, river training is indispensable for agricultural development in the Terai Area as small rivers in the same are eroding valuable farmland.

(4) Agricultural technology including cropping systems, crop varieties, manuring technology, processing and stocking of agricultural products and transportation systems should be improved parallel to implementation of the Sun Kosi Multipurpose scheme which is expected to significantly increase agricultural production.

(5) Watershed management works should also be conducted parallel with implementation of the two top priority schemes in the Kosi Basin and Kamla River basin for effective water resources development.

(6) Conservation and improvement of the natural environment should be considered in implementation of development schemes.

(7) The Sapt Kosi High Dam Scheme proposed in the Master Plan should be reviewed in due consideration of comprehensive development including flood control and water utilization for downstream countries, as this study dealt only with hydropower development due to insufficient data.

8.3 Further Studies for Overall Development

The Kosi River has substantial water resource development potential, exploitation of which is indispensable for the development of the entire country. For long term development of the Kosi River, the following items should be studied.

a) Meteorology and hydrology to establish reliable data;
b) Development impact, particularly rural development effects;
c) Development plans for navigation and inland fishery;
d) Benefit and cost estimation of flood control and irrigation development in downstream countries;
e) Watershed management countermeasures including afforestation, soil conservation, protection works, organization for implementation, investment cost, and etc.; and,
f) Power export potential.

8.4 Terms of Reference

In accordance with the provision of the S/W, two terms of reference for the feasibility studies of the top two priority schemes have been prepared (ATTACHMENT-I and II).

TERMS OF REFERENCE FOR THE SUN KOSI MULTIPURPOSE SCHEME (Phase I)

1. Objective and Scope

The objective of the proposed Project is to prepare a feasibility study for the Sun Kosi Multipurpose Scheme (Phase-I) for technical, economic, agricultural, and institutional aspects in adequate detail including preliminary evaluation of the costs and benefits associated with achieving full development of irrigation and hydropower.

2. Data, Surveys and Investigations

All available data and reports on engineering, agricultural, economic and socioeconomic studies shall be reviewed and evaluated and necessary supplemental studies, surveys and investigations shall be carried out as required.

3. Irrigation and Drainage

Existing and potential agricultural characteristics including land and water resources, and socioeconomic considerations shall be examined in detail as relevant. For this range of variables and reflecting anticipated marketing, agricultural and socioeconomic constraints, and in full consultation with relevant Government agencies, appropriate assumptions for future cropping patterns with and without project shall be studied and recommended. Selected cropping patterns and the size and configuration of project facilities and of the finally adopted irrigated area should be established based on incremental net present value or similar analyses, as relevant.

Crop water requirements, peak and monthly average system delivery requirements shall be estimated, fully reflecting requirements of land preparation, consumptive use and delivery and application losses. Availability of water and its adequacy for irrigation must be verified.

Drainage requirements shall be estimated fully reflecting (i) storm runoff requirements; and (ii) quality of applied water required for the anticipated range of crops and considering the soil types and subsurface conditions encountered.

A network of access roads or tracks of standards relevant to anticipated traffic to or within each sub-project area shall be proposed.

Feasibility level designs, layouts and quantities of work and materials for irrigation, drainage and road facilities shall be prepared. Wherever possible existing works, rehabilitated as necessary, should be incorporated into the network. Such designs and layouts must be substantiated by appropriate and adequate studies, surveys, mapping, subsurface exploration and materials testing programs, including the following as applicable:

(i) for the diversion dam, diversion tunnel and headworks, topographic mapping of appropriate scale and detail, and relevant subsurface investigations of the site;

(ii) for irrigation canals and drains, topographic and/or profile and cross section surveys as relevant, and adequate subsurface investigations; and,

(iii) for topographically complicated service area, at least 1:10,000 with 2.0m contour mapping should be carried out.

4. Hydropower

The possibility of installing hydropower and associated transmission line and substation shall be studied. Feasibility level layout, cost and benefit evaluation for such facilities, shall be provided. Such aspects should be easily separable from overall project cost and benefit evaluation so that the project can be taken up with or without the hydropower facilities as finally determined to be desirable. As hydropower facilities should be included in the project, description of the institutional and other requirements for implementation, operation and maintenance should be provided as well as proposals for cost recovery thereof.

5. Agricultural Support Services

Existing agricultural support services for crop production shall be estimated and details of strengthening measures recommended where

required, including institutional, technical program, budget, staff, equipment and facilities. In particular, the following are to be considered as relevant: research on extension, credit, input supply, marketing, storage and processing, and farmers' organizations.

Comprehensive but simple and relevant recommendations shall be prepared for the improvement of farming practices for the anticipated range of agricultural conditions with an eye to such recommendations forming the basis for agricultural extension in each area.

Details (including organization, budget and staff, facilities and equipment technical program) for a study pilot demonstration farm suitably situated within the Study area shall be proposed to be operated in conjunction with normal extension efforts; such facilities will deal with improved farm management, cultivation and water management practices, among others.

6. Socioeconomic Aspects

Values of relevant socioeconomic data and indices relating to the benefitted population shall be provided and the impact of the project thereon, if any, estimated including, among others: land ownership and tenure, farm size and fragmentation, employment and income levels, and distribution and others as may be applicable.

Possible social infrastructure facilities (e.g. public administration, water supply and sanitation, public health, education), needed for inhabitants shall be proposed and relevant details thereof provided. Such facilities are to be practical standards relevant to the area, and relevant to production-oriented activities.

A socioeconomic survey for the project area, to be initited by others before construction begins shall be designed. The social benefits from the project would include: a benchmark pre-construction survey and one or more later surveys at appropiate intervals.

The Government's commodity and price control, input subsidy, land registration, water rights, and cost recovery policies and regulations shall be described as they relate to the project.

7. Environmental Effects

The probable undesirable environmental effects including flo control shall be studied and methods and feasibility level designs measures required, if any, to eliminate or minimize them, shall proposed.

8. Project Implementation

In close consultation with Government agencies concerned, detailed implementation schedule and list of manpower needed each ye shall be prepared. The most suitable construction arrangements for loc conditions shall be proposed taking into account, for example, climat conditions, transportation and access problems. Additionally, t applicability of alternative construction techniques (i.e., equipme and/or labor intensive methods) to various project elements shall examined and an appropriate blend of such techniques recommended.

The capacity of the Executing Agency for construction supervisi shall be evaluated, strengthening measures shall be recommended whe necessary and the nature and extent of consulting assistance required f implementation shall be assessed.

9. Project Operation and Maintenance

Operation and maintenance arrangements shall be proposed. T capacity of Government agency(ies) concerned shall be studied and specif strengthening measures recommended where necessary to ensure continui and efficient supporting services. Operation and maintenance budge staffing, equipment and material requirements shall be estimated.

10. Project Costs

Total project and project-generated costs shall be estimated bas on quantities derived from the above mentioned feasibility level desig and layouts of all project elements. Details of such costs proper allocated among project components and subdivided by major work ite shall be provided, given foreign and domestic cost component Appropriate allowances for price escalation and physical contingenci shall be included. A firm basis for cost estimates, including adequa

backup data for cost estimates to permit evaluation of their validity, shall be provided including calculations justifying breakdown of unit costs into (i) domestic and foreign cost and (ii) materials, machinery, labor and other costs.

Time distribution of project construction costs in accordance with implementation schedule shall be estimated as well as recurring costs for project operation, maintenance and replacement.

11. Project Economic and Financial Analysis

Economic costs and time distribution in the project shall be estimated. Direct economic benefits of the project shall be estimated. Other project benefits shall be quantified possibly including, but not limited to, construction and agricultural employment, and increased value added in project-induced agricultural marketing and processing activities.

The time distribution of economic benefits shall be estimated reflecting the project implementation schedule and anticipated rates of increase in unit agricultural production under the project.

The economic viability of the project shall be indicated using standard benefit cost analysis methods, including calculation of economic rates of return and net present value.

Sensitivity tests of econome viability shall be performed considering possible variations in relevant key factors affecting project costs and benefits, implementation period, benefit lag or other significant factors.

Based on detailed evaluation of farm operation and costs, detailed farm budgets shall be prepared for several sample farms of representative sizes and pre-project conditions. Budgets for present, future without project and future with project conditions shall be prepared. Any non-crop and off-farm income shall be incorporated.

Electric rates and agricultural water charge regulations shall be studied in relation to the project and in relation to farmers' payment capacities; recommendations regarding application of such water charges in the project area shall be provided, including consideration of timing and level of cost recovery to be achieved.

TERMS OF REFERENCE FOR THE ARUN NO. 3 HYDROPOWER PROJECT

1. Objective and Scope

The objective of the proposed Arun No.3 Hydropower Project is to prepare a feasibility study for a hydropower development scheme on the Arun River located in the eastern region of Nepal. Feasibility Study covering all technical, economic aspects and environmental impacts shall be prepared in adequate detail. The study shall involve preliminary layout study for the optimum scheme and evaluation of costs and benefits from the Project.

2. General

Project layout shall be examined by reviewing the previously studied scheme, covering the potentialities upstream and downstream and comprehensive development of the Arun River shall be reviewed taking into consideration project layout, type of hydropower scheme, future electricity demand and supply system. The Feasibility Study shall be carried out in accordance with the following when and where applicable.

3. Data, Surveys and Investigations

All available data and reports on engineering, agricultural, economic and socioeconomic studies shall be reviewed and evaluated and necessary supplemental studies, surveys and investigations shall be carried out as required.

4. Hydropower

A practical engineering feasibility level layout shall be studied taking into consideration all relevant phenomena such as morphology, geology, hydrology, sedimentation rates, seismicity design of generating equipment, and electrical/mechanical system. Sufficient field work must be carried out to clearly establish all critical parameters in all applicable branches of engineering. Electric demand and annual and daily peak and average demands shall be estimated, reflecting existing and proposed electricity networks and taking losses into account. Project

scale shall be justified against the data on system development. The optimum project and its capacity should require the minimum cost for the power system expansion program. Transmission voltage and route and locations of substations shall be proposed bearing in mind the nature of the existing system and expansion planning.

The route of the access road from Dhankuta to the project sites shall be proposed and a preliminary design shall be formulated. Feasibility level designs, layouts and quantities of works and materials for the hydropower station, transmission/substation, road and associated facilities such as temporary and operating/maintenance facilities shall be prepared. Such designs and layouts and quantities must be substantiated by appropriate and adequate studies, surveys, mapping, subsurface exploration and materials testing programs, including the following as applicable:

(i) for the intake dam, intake structures, waterway, penstock and powerhouse, topographical mapping of appropriate scale and detail, and relevant subsurface investigations of the site;

(ii) for the access road, airphotogrametric mapping of appropriate scale and detail and supplemental topographical mapping as required;

(iii) for estimation of river flow and flood, installation of gauging station and river flow measurement of appropriate detail; and,

(iv) measurement of water quality, sedimentation, and suspended loads of river flow.

5. Socioeconomic Aspects

Values of relevant socioeconomic data and indexes relating to the benefit population shall be provided and the impacts of the project thereon, if any, shall be estimated, including, employment and income levels, distribution, and others as may be applicable.

6. Environmental Effects

The probable undesirable environmental effects including flood control shall be studied and methods and feasibility level designs of measures required, if any, to eliminate or minimize the same, shall be proposed.

7. Project Implementation

In close consultation with Government agencies concerned, a detailed implementation schedule and list of manpower needed each year shall be prepared. The most suitable construction arrangements for local conditions shall be proposed taking into account, for example, climatic conditions, transportation and access problems, and available materials and equipment both national and project specific. Additionally, the applicability of alternative construction techniques (i.e., equipment and/or labor intensive methods) to various project elements shall be examined and an appropriate blend of such techniques recommended.

A bar chart and critical path network drawing shall be presented showing the shortest length of time required to construct the project. The critical components of construction schedule shall be identified and the relationship of the various construction components shall be illustrated.

8. Project Operation and Maintenance

Operation and maintenance arrangements shall be proposed. The capacity of Government agency(ies) concerned shall be studied and specific strengthening measures recommended where necessary to ensure continuing, safe and efficient operation and maintenance. Operation and maintenance budget, staffing, equipment and material requirements shall be estimated.

9. Project Costs

Total project and project-generated costs, including indirect infrastructural costs, if any, shall be estimated based on quantities derived from the above mentioned feasibility level designs and layout. Details of such costs subdivided by major work items shall be provided; given foreign and domestic cost components. Appropriate allowances for

domestic cost components and for price escalation in accordance with acceptable practices shall be included and seperately, if required for foreign and local components and physical contingencies. A firm basis for cost estimates, with adequate backup data for the same to permit evaluation of their validity, shall be provided including calculations justifying breakdown of unit costs into (i) domestic and foreign cost and (ii) materials, machinery, labor and other costs.

Time distribution of project construction costs in accordance with implementation schedule shall be estimated as well as recurring costs for project operation, maintenance and replacement.

10. Project Economic and Financial Analysis

Economic costs and time distribution in the project shall be estimated. Direct economic benefits of the project shall be estimated incorporating assumptions which accord with normal bank practices. Other project benefits shall be quantified possibly including, but not limited to, construction employment, and increased value added in project-induced industrialization.

The economic viability of the project shall be indicated using standard benefit cost analysis methods, including calculation of economic rates of return and net present value, incorporating assumptions which accord with normal bank practices.

Sensitivity tests of economic viability shall be performed considering possible variations in relevant key factors affecting project costs and benefits, implementation period, benefit lag or other significant factors.

TABLES

TABLE 5-1 SELECTED DEVELOPMENT COMBINATION

Alternative	Item \ Dam	Sapt Kosi High Dam	Sun Kosi No.1	Sun Kosi No.2	Sun Kosi No.3
(1)	Dam Site	2km up-stream of Barakshetra	I	II	III
	H.W.L. (EL m)	304.8	424.6	575.0	670.5
	Dam Height (m)	239	147	166	110
	Gross Storage Capacity (Mill. m^3)	8,500	1,500	4,370	620
	Available Storage Capacity (Mill. m^3)	4,420	40	3,040	70
(2)	Dam Site	2km up-stream of Barakshetra	I	II	III
	H.W.L. (EL m)	304.8	424.6	575.0	700.0
	Dam Height (m)	239	147	166	140
	Gross Storage Capacity (Mill. m^3)	8,580	1,500	4,370	1,220
	Available Storage Capacity (Mill. m^3)	4,420	40	3,040	550
(3)	Dam Site	2km up-stream of Barakshetra	I'	IV	VIII
	H.W.L. (EL m)	334.8	475.0	625.0	774.2
	Dam Height (m)	269	160	180	170
	Gross Storage Capacity (Mill. m^3)	13,450	2,720	4,800	2,690
	Available Storage Capacity (Mill. m^3)	9,370	860	3,480	2,080

TABLE 5-2 PROPOSED OPTIMUM SCHEME OF MULTIPURPOSE DAM

River	Sun Kosi River			Tamur River	Sapt Kosi River
Name of Scheme	Sun Kosi No. 1	Sun kosi No. 2	Sun Kosi No. 3	Tamur	Sapt Kosi High Dam
1. Features					
C.A	16,200	10,396	5,520	5,085	61,000
HWL (EL. m)	424.6	575.0	700.0	487.6	304.8
LWL (EL. m)	423.0	516.0	674.0	460.0	259.0
Vg ($10^6 m^3$)	1,500	4,370	1,220	1,890	8,500
Ve ($10^6 m^3$)	40	3,040	550	760	4,420
Dam height (m)	147	166	140	153	239.0
Dam type	Concrete Gravity	Concrete Gravity	Concrete Gravity	Concrete Gravity	Concrete Gravity
2. Components					
	Power 1,357MW (Diversion Dam)1/	Power 1,110MW (Irrigation & Flood Control)	Power 536MW (Irrigation: 175,100ha)	Power 696MW	Power 3,489MW (Irrigation: 66,450ha & Flood Control)

1/ brackets indicate unclear potential conponent

TABLE 5-3 INSTALLED GENERATION CAPACITY OF PUBLIC SECTOR

Development Region	Hydro Plant (MW)	Diesel Plant (MW)	Sub-total (MW)	Share (%)
1. Central Region	108.69 1/ (97.44) 2/	19.016 (18.17)	127.706 (115.61)	83.8
2 Western Region	18.318 (13.318)	2.222 (1.829)	20.54 (15.147)	13.4
3. Mid & Far Western Region	0.345 (0.115)	0.773 (0.72)	1.118 (0.835)	0.73
4. Eastern Region	0.240 (0.160)	3.692 (2.027)	3.932 (2.187)	2.57
Total	127.593 (111.033)	25.703 (22.746)	153.296 (133.779)	100.0

1/ Installed capacity in MW

2/ Firm capacity in MW

TABLE 5-4 INSTALLED GENARATION CAPACITY OF PRIVATE SECTOR

Development Region	Hydro Plant (MW)	Diesel and Steam Plant (MW)	Sub-total (MW)
1. Central Region	0.03 3/ (0.03) 4/	5.360 (4.100)	5.390 (4.130)
2. Western Region	0	1.080 (0.890)	1.080 (0.890)
3. Mid & Far Western Region	0	0.534 (0.450)	0.534 (0.450)
4. Eastern Region	0	3.979 (3.100)	3.979 (3.100)
Total	0.03 (0.03)	10.953 (8.540)	10.983 (8.570)

3/ Installed capacity in MW

4/ Firm capacity in MW

TABLE 5-5 HISTRICAL POWER SUPPLY AND CONSUMPTION IN NEPAL

(1973/74 - 1982/83)

Year	Domestic (MWh)	Industrial (MWh)	Commercial (MWh)	Street Light & Others (MWh)	Total Utilized Energy (MWh)	Losses (MWh)	Total Supplied Energy (MWh)	Annual Rate of Growth (%)	Generated Energy (MWh)	Imported Energy (MWh)	Exported Energy (MWh)	Peak Power Demand (MW)	Annual Rate of Growth (%)	Annual Load Factor (%)
1973/74	47,710	15,757	6,514	3,218	73,199	33,885	107,084	-	101,974	8,812	3,702	29.81	-	41.01
1974/75	54,090	21,397	7,897	3,816	87,200	36,995	124,195	15.98	114,182	14,634	4,621	36.17	21.32	39.20
1975/76	61,787	32,128	9,173	4,173	107,261	42,965	150,226	20.96	130,794	25,372	5,940	40.25	11.28	42.61
1976/77	65,768	39,036	10,405	4,382	119,591	45,789	165,380	10.09	142,355	29,141	6,116	45.58	13.26	41.42
1977/78	71,348	42,751	13,068	4,488	131,655	54,724	186,379	12.70	159,623	32,726	5,970	50.63	11.08	42.02
1978/79	77,221	47,827	18,020	5,895	148,963	62,988	211,951	13.72	177,485	40,626	6,160	52.36	3.42	46.21
1979/80	74,823	52,809	25,244	9,093	161,969	67,329	229,298	8.18	195,522	38,972	5,196	56.90	8.67	46.00
1980/81	78,980	53,775	32,202	8,226	173,183	66,254	239,437	4.42	198,639	44,560	3,762	58.48	2.78	46.74
1981/82	90,625	68,054	17,834	8,521	185,034	84,991	270,025	12.77	218,449	56,759	5,183	75.05	28.33	41.07
1982/83	119,147	82,494	21,342	8,497	231,480	109,517	340,997	26 28	283,693	63,290	5,986	83.70	11.53	46.51
Average Compound Growth Rate (%)	10.70	20.19	14.09	11.39	13.65	13.92	13.73		12.04	24.49	5.48	12.15		

Source: Electric Power Statistics of Nepal, Planning Evaluation, Electricity Department
Date : June 1984

TABLE 5-6 HISTORICAL POWER SUPPLY AND CONSUPTION IN VARIOUS REGIONS OF NEPAL

Year	Power Supply and Consumption from 1975/76 to 1981/82 (GWh)										Peak Load (MW)	Losses (GWh) (%)	Annual Load Factor (%)	Import from India (GWh)	Export to India (GWh)
	Central Region		Western Region		Eastern Region		Mid & Far West. Region		Total Nepal						
	Supply	Consumption	Supply	Consumption	Supply	Consumption	Supply	Consumption	Supply	Consumption					
1975/76	118.9	81.5	7.9	6.1	20.3	17.0	3.2	2.7	150.3	107.3	40.2	43.0 (28.6%)	44.3	25.4	5.9
1976/77	129.3	87.4	10.1	8.0	21.9	20.7	4.1	3.4	165.4	119.5	45.6	45.9 (27.7%)	43.3	29.1	6.1
1977/78	144.1	95.4	11.2	9.6	24.8	21.5	6.2	5.1	186.3	131.6	50.6	54.7 (29.3%)	43.3	32.7	6.0
1978/79	160.6	105.3	13.8	10.8	30.8	27.1	6.7	5.7	211.9	148.9	52.4	63.0 (29.7%)	47.5	40.6	6.2
1979/80	179.2	120.8	15.9	12.0	26.4	23.6	7.1	5.5	228.6	161.9	56.9	66.7 (29.2%)	46.9	39.0	5.2
1980/81	177.5	118.8	14.6	12.9	31.1	25.5	8.2	6.6	231.4	163.8	58.9	67.6 (29.2%)	45.6	45.1	3.8
1981/82	202.4	130.4	17.4	13.5	40.1	32.5	10.0	8.4	269.9	184.8	72.9	85.1 (31.5%)	42.9	56.8	5.2

Source: 1983 Electric Load Forecast for Period 1983-2001,
Report No. 3/3/080883/1/6, Electricity Department

TABLE 5-7 FORECASTED ANNUAL GROWTH RATES INCORPORATING THE SCHEER MODEL FOR VARIOUS REGIONS AND REGIONAL INFORMATIONS

Year	Forecasted Annual Growth Rates (%) Eastern	C.N.P.S.	Western	Mid-West.	Far-West.
1982/83	17.858	12.749	18.298	20.082	20.788
1983/84	17.497	12.567	17.907	19.626	20.297
1984/85	17.151	12.390	17.534	19.190	19.830
1985/86	16.819	12.219	17.176	18.775	19.385
1986/87	16.500	12.053	16.833	18.378	18.960
1987/88	16.194	11.892	16.504	17.999	18.555
1988/89	15.901	11.735	16.189	17.636	18.168
1989/90	15.618	11.583	15.886	17.288	17.797
1990/91	15.346	11.435	15.595	16.955	17.442
1991/92	15.084	11.292	15.315	16.635	17.102
1992/93	14.832	11.152	15.045	16.328	16.776
1993/94	14.588	11.016	14.786	16.033	16.463
1994/95	14.354	10.884	14.535	15.749	16.163
1995/96	14.127	10.755	14.294	15.476	15.874
1996/97	13.908	10.630	14.061	15.213	15.596
1997/98	13.696	10.508	13.836	14.960	15.328
1998/99	13.492	10.389	13.619	14.715	15.071
1999/00	13.294	10.273	13.409	14.480	14.822
2000/01	13.102	10.160	13.206	14.252	14.582
2001/02	12.916	10.050	13.010	14.032	14.351
2002/03	12.737	9.942	12.819	13.820	14.128

	Regional Information				
	Eastern	C.N.P.S	Western	Mid-West.	Far-West.
Population in 1981 (Million)	5.401	3.219	3.135	1.953	1.312
Population Growth Rate (%)	2.840	2.430	2.440	3.010	3.000

Source: 1983 Electric Load Forecast for Period 1983-2001, Report No. 3/3/080883/1/6, Electricity Department

TABLE 5-8 COMMITTED EXPORT TO BE USED LOAD FORECAST

Year	Maximum Export Load (MW)	Maximum Export Energy (GWh/year)
1983/84	5.0	22.0
1984/85	5.0	22.0
1985/86	5.0	22.0
1986/87	5.0	22.0
1987/88	5.0	22.0
1988/89	5.0	22.0
1989/90	5.0	22.0
1990/91	5.0	22.0
1991/92	5.0	22.0
1992/93	5.0	22.0
1993/94	5.0	22.0
1994/95	5.0	22.0
1995/96	5.0	22.0
1996/97	5.0	22.0
1997/98	5.0	22.0
1998/99	5.0	22.0
1999/00	5.0	22.0
2000/01	5.0	22.0
2001/02	5.0	22.0

TABLE 5-9 FORECASTED POTENTIAL EXPORTS

Year	Maximum Export Load (MW)	Maximum Export Energy (GWh/Year)
1983/84	5.0	22.0
1984/85	10.0	44.0
1985/86	10.0	44.0
1986/87	15.0	66.0
1987/88	20.0	88.0
1988/89	25.0	110.0
1989/90	25.0	110.0
1990/91	25.0	110.0
1991/92	25.0	110.0
1992/93	25.0	110.0
1993/94	25.0	110.0
1994/95	25.0	110.0
1995/96	25.0	110.0
1996/97	25.0	110.0
1997/98	25.0	110.0
1998/99	25.0	110.0
1999/00	25.0	110.0
2000/01	25.0	110.0
2001/02	25.0	110.0

Source: 1983 Electric Load Forecast for Period 1983-2001, Report No. 3/3/080883/1/6, Electricity Department

TABLE 5-10 EXPECTED INTERCONNECTION DATES FOR ISOLATED LOAD CENTERS

Name of Load Center	Region	Expected Interconnection Date
1. Janakpur	Central	June 1986
2. Gaur	Central	June 1986
3. Dhankuta	Eastern	June 1986
4. Biratnagar-Rajbiraj System	Eastern	June 1986
5. Siraha	Eastern	June 1986
6. Lahan	Eastern	June 1986
7. Tulsipur/Ghorahi	Mid Western	June 1987
8. Koilabas	Mid Western	June 1987
9. Surkhet	Mid Western	June 1987
10. Nepalgunj	Mid Western	June 1987
11. Gularia	Mid Western	June 1987
12. Ilam	Eastern	June 1989
13. Bhadrapur	Eastern	June 1989
14. Dhangadhi	Far Western	June 1990
15. Mahendranagar	Far Western	June 1990

TABLE 5-11 FORECASTED ANNUAL LOAD FACTOR

Year	Annual Load Factor (%)
1982/83	48.5
1983/84	48.4
1984/85	48.6
1985/86	48.8
1986/87	49.2
1987/88	49.4
1988/89	49.7
1989/90	49.9
1990/91	50.2
1991/92	50.4
1992/93	50.6
1993/94	50.9
1994/95	51.1
1995/96	51.4
1996/97	51.6
1997/98	51.8
1998/99	52.1
1999/00	52.3
2000/01	52.6
2001/02	52.8

Source: 1983 Electric Load Forecast for Period 1983-2001, Report No. 3/3/080883/1/6, Electricity Department

TABLE 5-12 RESULTS OF 1983 TREND FORECASTS
(INTERGRATED NEPAL POWER SYSTEM)

Year	Trend Without*1 Price Elasticity		Trend Without*2 Price Elasticity and Export (BASIC)		Trend With*1 Price Elasticity		Load Factor
	(GWH)	(MW)	(GWH)	(MW)	(GWH)	(MW)	
1982-83	284.9	67.8	284.8	67.8	284.9	67.8	0.483
1983-84	344.2	81.2	344.2	81.2	328.7	77.5	0.484
1984-85	385.5	90.6	407.5	95.7	366.3	86.1	0.486
1985-86	431.6	101.0	453.6	106.1	408.0	95.4	0.488
1986-87	569.6	132.2	613.6	142.1	535.5	124.2	0.492
1987-88	659.9	152.5	725.9	167.7	617.0	142.6	0.494
1988-89	742.4	170.5	830.4	190.7	698.6	158.6	0.497
1989-90	848.6	192.3	928.6	212.4	777.7	177.9	0.499
1990-91	961.5	218.7	1,049.5	238.6	884.9	201.2	0.502
1991-92	1,079.8	244.6	1,167.8	264.5	988.4	223.9	0.504
1992-93	1,211.4	273.3	1,299.4	293.1	1,102.9	248.8	0.506
1993-94	1,357.6	304.5	1,445.6	324.2	1,229.4	275.7	0.509
1994-95	1,520.0	339.6	1,608.0	359.2	1,376.2	307.4	0.511
1995-96	1,700.0	377.6	1,768.0	397.1	1,538.9	341.8	0.514
1996-97	1,899.4	420.2	1,987.4	439.7	1,719.2	380.3	0.516
1997-98	2,120.1	467.2	2,208.1	486.6	1,918.7	422.6	0.518
1998-99	2,364.0	518.0	2,452.0	537.2	2,139.1	468.7	0.521
1999-00	2,633.2	574.8	2,721.2	594.0	2,382.6	520.0	0.523
2000-01	2,930.2	635.9	3,018.2	655.0	2,651.0	575.3	0.526
2001-02	3,257.5	704.3	3,345.5	723.3	2,946.9	637.1	0.528

Note *1 : Including Committed export to India
*2 : Including potencial export to India
Source : ED Forecast Report,1983

Source: 1983 Electric Load Forecast for Period 1983-2001, Report No. 3/3/080883/1/6, Electricity Department

TABLE 5-13 INDUSTRIAL LOADS INCLUDED IN 1983 DISAGGREGATE LOAD FORECAST

Name of Factory	Location	Region	Source of Funds	Maximum Demand (kW)	Increment of Energy Requirement (Sales) (MWh) 1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92
1. Nepal Vegetable Ghee Factory	Hetauda	Central	NIDC/Private	1,000	1,100	-	-	-	-	-	-	-	-
2. Himalaya Brewery	Kathmandu	Central	NIDC/Private	200	263	-	-	-	-	-	-	-	-
3. Dry Cell Battery Plant	Kathmandu	Central	NIDC/Union Carbide	320	840	-	-	-	-	-	-	-	-
4. Hetauda Cement Plant													
(i) Plant	Hetauda	Central	ADB/HMG	8,500	-	-	-	13,154	13,154	13,154	-	-	-
(ii) Quarry	Bhainse	Central	ADB/HMG	1,000	-	-	-	1,241	1,241	1,241	-	-	-
5. Magnesite Plant													
(i) Dead Burnt Mgn.	Lamosangu	Central	IPC	2,000	-	-	2,628	2,628	-	-	-	-	-
(ii) Refractory Brick	Birgunj	Central	IDBI (India)	1,000	-	-	-	-	1,414	1,314	-	-	-
(iii) Extraction Plant	Khairidhunga	Central	HMG	400	-	-	1,050	1,050	-	-	-	-	-
6. Paper Factory	Gaidakot	Western	Chaina/HMG	2,000	-	3,504	3,504	3,504	-	-	-	-	-
7. Lead & Zinc Mining Project	Rasuwa	Central	India/HMG/I.F.C.	2,000	-	-	-	-	-	-	2,628	2,628	-
8. Pilot Foundry Project	Patan	Central	UNIDO	1,000	-	-	1,314	1,314	-	-	-	-	-
9. Hulas Steel Industry (Pipes & Galvanizing, Etc)	Simra	Central	NIDC/Private	800	526	1,578	-	-	-	-	-	-	-
10. Balaju Textile Mill	Balaju	Central	NIDC/HMG	90	105	105	-	-	-	-	-	-	-
11. Brick Factory	Kathmandu	Central	NIDC/Private	188	-	275	275	275	-	-	-	-	-
12. Sound Equipment	Kathmandu	Central	Private	120	-	105	105	105	-	-	-	-	-
13. Beer Factory	Patan	Central	NIDC/Private	160	-	200	200	200	-	-	-	-	-
14. Paper Mill	Rupandehi	Western	NIDC/Private	2,000	-	2,750	2,450	2,450	-	-	-	-	-
15. Brown Sugar Mill	Parasi	Western	NIDC/Private	160	-	116	116	116	-	-	-	-	-
	Nawal Parasi	Western	NIDC/Private	160	-	116	116	116	-	-	-	-	-
16. Aluminium Conductor	Rupandehi	Western	NIDC/Private	160	-	186	186	186	-	-	-	-	-
17. Resin & Turpenting	Nepalgunj	Mid West.	Russia/HMG	170	-	100	100	100	-	-	-	-	-
18. Fruit Processing	Biratnagar	Eastern	NIDC/Private	80	-	-	-	58	58	58	-	-	-
19. Brown Sugar	Dhanusha	Eastern	NIDC/Private	160	-	-	-	116	116	116	-	-	-
	Sunsari	Eastern	NIDC/Private	160	-	-	-	116	116	116	-	-	-
20. Cement Factory 1/	Udaypur	Eastern	India/HMG	12,000	-	-	-	-	-	-	-	-	17,000

1/ Annual load increments of 17,000 MWh/year will also occur in 1992/93 and 1993/94 for this project.

Source: 1983 Electric Load Forecast for Period 1983-2001, Report No. 3/3/080883/1/6, Electricity Department

TABLE 5-14 NEW IRRIGATION LOADS INCLUDED IN 1983 DISAGGREGATE LOAD FORECAST

Name of Project	Region	Source of Finance	Maximum Demand (kW)	Annual Load Factor (%)	Increment of Energy Requirement (Sales) (MWh)									
					1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92
1. Narayani Lift Irrigation	Central	ADB/HMG	6,280	32.0	3,600	10,443	-	3,753	-	-	-	-	-	-
2. Lumbini I, II & III Phase (Ground Water)	Westren	IDA/HMG	3,200	30.0	1,168	1,168	2,336	2,336	-	-	-	-	-	-
3. Birgunj Ground Water (Rehabilitation)	Central	IDA/HMG	1,200	25.0	-	650	650	650	-	-	-	-	-	-
4. Rajbiraj Lift Irrigation 1/	Eastern	India	4,170	34.0	-	-	-	-	3,097	6,225	3,097	-	-	-
5. Janakpur Agriculture (Ground Water) 1/	Central	Japan/HMG	6,000	34.0	-	-	-	-	3,540	3,540	3,540	3,540	3,540	-
6. Sagarmatha Project (Ground Water) 1/	Eastern	ADB/HMG	5,610	34.0	-	-	-	-	3,340	3,340	3,340	3,340	3,340	-
7. Marchuar Lift Irrigation	Western	UNCDF	790	34.0	-	-	-	-	600	600	-	-	600	600
8. Kailali Ground Water 2/	Far Western	HMG	2,720	25.0	-	-	-	-	-	-	-	-	500	1,200

1/ The first in-service date for these projects depends on completion of the Hetauda- Biratnagar Transmission Line Project.

2/ The first in-service date of this project depends on completion of the Far-West Transmission Line Extension Project to Dhangadhi and Mahendranagar. Total energy demand will eventually grow to 6000 GWh/year

Source: 1983 Electric Load Forecast for Period 1983-2001, Report No. 3/3/080883/1/6, Electricity Department

TABLE 5-15 RESULT OF 1983 DISAGGREGATE LOAD FORECAST

Year	Region	Domestic (GWh)	Industrial (GWh)	Commercial (GWh)	Irrigation & Water Supply (GWh)	Transport (GWh)	Street Light & Others (GWh)	Self Consumption (GWh)	Total Nywl Sales (GWh)	Losses As % of Total Sales (%)	Losses (GWh)	Total Requirement (GWh)	Integrated Proportion	Nywl Integrated Load (GWh)	Committed Exports (GWh)	Total Integrated Load (GWh)	Load Factor (%)	Total Peak Load (MW)
1981/82	Central	69.3	31.6	17.7	5.0	1.1	3.5	2.2	130.4	55.3	72.0	202.4	1.00	202.4				
	Western	6.5	5.0	0.1	0.6	-	0.4	0.9	13.5	28.9	3.9	17.4	0.20	3.6				
	Eastern	10.8	20.8	-	-	-	0.5	0.3	32.4	23.7	7.7	40.1	0	0				
	Mid & Far West.	4.0	3.9	-	-	-	0.3	0.1	8.3	20.0	1.7	10.0	0	0				
												270.0		206.0	5.2	211.2	42.7	56.5
1982/83	Central	87.6	41.6	21.0	5.4	1.5	2.9	2.5	162.5	60.7	98.6	261.1	1.00	261.1				
	Western	7.1	5.5	0.1	1.8	-	0.4	0.3	15.2	28.0	4.3	19.5	0.72	14.0				
	Eastern	11.8	21.8	-	-	-	0.8	0.7	35.1	23.0	8.1	43.2	0	0				
	Mid & Far West.	4.4	4.1	-	-	-	0.3	0.2	9.0	20.0	1.8	10.8	0	0				
												334.6		275.1	6.0	281.1	48.5	66.0
1983/84	Central	92.8	45.0	33.7	16.6	1.5	3.4	3.8	196.8	55.0	108.2	305.0	1.00	305.0				
	Western	8.0	6.1	0.1	3.1	-	0.4	0.4	18.1	26.0	4.7	22.8	0.80	18.2				
	Eastern	12.9	24.0	-	-	-	0.8	0.7	38.4	22.0	8.4	46.8	0	0				
	Mid & Far West.	4.8	4.5	-	-	-	0.3	0.2	9.8	19.5	1.9	11.7	0	0				
												386.3		329.2	22.0	345.2	48.4	81.4
1984/85	Central	100.2	53.0	37.1	18.1	1.5	3.6	4.4	217.9	50.0	109.0	326.9	1.00	326.9				
	Western	8.8	9.9	0.1	5.6	-	0.5	0.5	25.4	24.0	6.1	31.5	0.80	25.2				
	Eastern	14.1	26.4	-	-	-	0.9	0.8	42.2	21.0	8.9	51.1	0	0				
	Mid & Far West.	5.3	5.1	-	-	-	0.3	0.2	10.9	19.9	2.1	13.0	0	0				
												422.5		352.1	22.0	374.1	48.6	87.8
1985/86	Central	108.2	64.7	40.8	23.4	1.6	3.8	5.4	247.9	45.0	111.6	359.5	1.00	359.5				
	Western	9.7	13.8	0.1	8.2	-	0.5	0.7	33.0	22.0	7.3	40.3	1.00	40.3				
	Eastern	15.4	29.0	-	-	-	0.9	1.0	46.3	20.0	9.3	55.6	0	0				
	Mid & Far West.	5.8	5.7	-	-	-	0.3	0.2	12.0	18.5	2.2	14.2	0	0				
												469.6		399.8	22.0	421.8	48.8	98.7
1986/87	Central	116.8	90.4	44.9	24.6	1.7	4.0	6.0	288.4	40.0	115.4	403.8	1.00	403.8				
	Western	10.7	18.0	0.1	9.2	-	0.5	0.8	39.3	20.0	7.9	47.2	1.00	47.2				
	Eastern	16.8	36.0	-	10.0	-	1.0	1.4	65.2	19.0	12.4	77.6	0.95	73.7				
	Mid & Far West	6.4	6.4	-	-	-	0.4	0.2	13.4	18.0	2.4	15.8	0	0				
												544.4		524.7	22.0	546.7	49.2	126.8
1987/88	Central	126.1	110.6	49.4	25.8	1.8	4.2	6.7	324.6	35.0	113.6	438.2	1.00	438.2				
	Western	11.8	19.8	0.1	10.3	-	0.5	0.9	43.4	19.0	8.2	51.6	1.00	51.6				
	Eastern	18.4	39.5	-	23.6	-	1.1	1.0	84.4	18.0	15.2	99.6	0.95	94.6				
	Mid & Far West.	7.0	7.0	-	-	-	0.4	0.3	14.7	17.5	2.6	17.3	0.65	11.2				
												606.7		595.6	22.0	617.6	49.4	142.7
1988/89	Central	136.0	131.8	54.3	27.1	1.9	4.6	7.0	362.5	30.0	108.7	471.2	1.00	471.2				
	Western	12.9	21.8	0.2	10.8	-	0.6	1.0	47.3	18.0	8.5	55.8	1.00	55.0				
	Eastern	20.0	43.7	-	34.8	-	1.1	2.4	102.0	17.5	17.8	119.8	0.95	113.8				
	Mid & Far West.	7.6	7.7	-	-	-	0.5	0.3	16.1	17.5	2.8	18.9	0.65	12.3				
												665.7		653.1	22.0	675.1	49.7	155.1
1989/90	Central	146.7	141.0	59.7	28.5	2.0	4.6	7.6	390.1	25.0	97.5	487.6	1.00	487.6				
	Western	14.2	24.0	0.2	11.3	-	0.6	1.1	51.4	17.5	9.0	60.4	1.00	60.4				
	Eastern	21.8	48.1	-	43.4	-	1.2	3.0	116.5	17.5	20.6	130.1	1.00	130.1				
	Mid & Far West.	8.4	8.5	-	-	-	0.6	0.4	17.9	17.5	3.1	21.0	0.65	13.7				
												707.1		699.8	22.0	721.8	49.9	165.1
1990/91	Central	158.2	150.7	65.7	29.9	2.1	4.8	8.0	419.4	25.0	104.8	524.2	1.00	524.2				
	Western	15.5	26.4	0.2	12.5	-	0.6	1.2	56.4	17.5	9.9	66.3	1.00	66.3				
	Eastern	23.7	52.9	-	52.5	-	1.3	3.6	134.0	17.5	23.4	157.4	1.00	157.4				
	Mid & Far West.	9.1	9.4	-	0.5	-	0.6	0.5	20.1	17.5	3.5	23.6	1.00	23.6				
												771.5		771.5	22.0	793.5	50.2	180.4
1991/92	Central	170.5	158.2	72.3	31.4	2.2	5.0	8.4	448.0	25.0	112.0	560.0	1.00	560.0				
	Western	17.0	29.0	0.2	13.7	-	0.7	1.3	61.9	17.5	10.8	72.7	1.00	72.7				
	Eastern	25.8	75.2	-	55.1	-	1.4	4.2	161.7	17.5	28.3	190.0	1.00	190.0				
	Mid & Far West.	10.0	10.3	-	1.7	-	0.7	0.6	23.3	17.5	4.1	27.4	1.00	27.4				
												850.1		850.1	22.0	872.1	50.4	197.5

Source: 1983 Electric Load Forecast for Period 1983-2001, Report No. 3/3/080883/1/6, Electricity Department

TABLE 5-16 LONG TERM POWER DEMAND FORECAST
(1983 - 2030)

Year	Demand	Growth Rate	Load Factor	Peak Load	
	(GWH)	(%)		(MW)	
1982-83	284.8	20.86	0.488	67.8	Same as 1983 ED's Trend Forecast (Basic Forecast)
1983-84	344.2	18.39	0.484	81.2	
1984-85	407.5	11.31	0.486	95.7	
1985-86	453.6	35.27	0.488	106.1	
1986-87	613.6	18.30	0.492	142.1	
1987-88	725.9	14.40	0.494	167.7	
1988-89	830.4	11.83	0.497	190.7	
1989-90	928.6	13.02	0.499	212.4	
1990-91	1,049.5	11.27	0.502	238.6	
1991-92	1,167.8	11.27	0.504	274.5	
1992-93	1,299.4	11.25	0.506	293.1	
1993-94	1,445.6	11.23	0.509	324.2	
1994-95	1,608.0	11.19	0.511	359.2	
1995-96	1,788.0	11.15	0.514	397.1	
1996-97	1,987.4	11.10	0.516	439.7	
1997-98	2,208.1	11.05	0.518	486.6	
1998-99	2,452.0	10.98	0.521	537.2	
1999-00	2,721.2	10.91	0.523	594.0	
2000-01	3,018.2	10.84	0.526	655.0	
2001-02	3,345.4	10.61	0.528	723.3	
2002-03	3,700.3	10.34	0.533	792.5	
2003-04	4,082.9	10.15	0.536	869.6	
2004-05	4,497.3	9.93	0.540	950.7	
2005-06	4,945.9	9.72	0.543	1,039.8	
2006-07	5,426.6	9.51	0.547	1,132.5	
2007-08	5,942.7	9.30	0.551	1,231.2	
2008-09	6,495.4	9.10	0.554	1,338.4	
2009-10	7,086.5	8.90	0.558	1,449.7	
2010-11	7,718.1	8.71	0.562	1,567.7	
2011-12	8,390.3	8.52	0.566	1,692.2	
2012-13	9,105.2	8.34	0.570	1,823.5	
2013-14	9,864.6	8.16	0.573	1,965.3	
2014-15	10,669.5	7.98	0.577	2,110.9	
2015-16	11,521.9	7.81	0.581	2,263.8	
2016-17	12,421.8	7.64	0.585	2,423.9	
2017-18	13,370.8	7.48	0.589	2,591.4	
2018-19	14,370.9	7.31	0.592	2,771.1	
2019-20	15,421.4	7.15	0.596	2,953.8	
2020-21	16,526.8	7.00	0.600	3,144.4	
2021-22	17,683.7	6.89	0.600	3,364.5	
2022-23	18,902.1	6.79	0.600	3,596.3	
2023-24	20,185.5	6.68	0.600	3,840.5	
2024-25	21,533.9	6.58	0.600	4,097.0	
2025-26	22,950.1	6.48	0.600	4,366.5	
2026-27	24,437.3	6.38	0.600	4,649.4	
2027-28	25,996.4	6.28	0.600	4,946.0	
2028-29	27,628.9	6.19	0.600	5,256.6	
2029-30	29,339.2	6.09	0.600	5,582.0	
2030-31	31,119.8	6.00	0.600	5,920.8	

TABLE 5-17 UNIT PRICE FOR COST ESTIMATE
(1 of 4)

Item		Unit Cost (US$)	Remarks
Compensation and Land Acquisition		6%: Reservoir 3%: PRR 2%: SRR	Percentage for the cost of Power House, Civil & Electric Works
Power House			
- Main Building	(m^3)	130 - 150	Building volume
- Attached Building	(%)	5%	Percentage of main building
Civil Structure			
I. Water Way			
1) Intake Dam			
- Excavation	(m^3)	12	
- Concrete	(m^3)	92	
- Others		30%	Percentage for the above
2) Intake			
- Excavation	(m^3)	12	
- Concrete	(m^3)	117	
- Reinforcement	(t)	750	
- Gate	(t)	4,170	
- Screen	(t)	2,540	
- Others	(t)	20%	Percentage for the above
3) Settling Basin			
- Excavation	(m^3)	12	
- Concrete	(m^3)	117	
- Reinforcement	(t)	750	
- Screen	(t)	2,540	
- Others		20%	Percentage for the above

TABLE 5-17
(2 of 4)

UNIT PRICE FOR COST ESTIMATE

Item		Unit Cost (US$)	Remarks
4) Headrace			
- Excavation	(m^3)	50	
- Concrete	(m^3)	130	
- Reinforcement	(t)	750	
- Grouting	(m)	230 - 1,000	
- Others		20%	Percentage for the above
5) Tank			
- Excavation (Surge Tank)	(m^3)	63	
- " (Head Tank)	(")	12	
- Concrete (Surge Tank)	(")	130	
- " (Head Tank)	(")	117	
- Reinforcement	(t)	750	
- Others		25%	Percentage for the above
6) Penstock			
- Excavation (Tunnel)	(m^3)	50	Percentage for the above
- " (Ground)	(m^3)	12	
- Concrete (Tunnel)	(")	117	
- " (Ground)	(")	117	
Reinforcement	(t)	750	
- Pipe		2,710	
- Others		20%	Percentage for the above
7) Tailrace		Same as Headrace	
8) Outlet		Same as Intake	
9) Miscellaneous		5%	Percentage for water way

TABLE 5-17
(3 of 4)

UNIT PRICE FOR COST ESTIMATE

Item		Unit Cost (US$)	Remarks
II. Reservoir or Pondage			
1) Dam (Concrete)			
- Excavation	(m^3)	12	
- Concrete	(")	80	
- Gate	(t)	4,170	
- Others		25%	Percentage for the above
2) Dam (Fill)			
- Excavation	(m^3)	8	
- Embankment	(")	7	
- Others		25%	Percentage for the above
3) Spillway (Fill)			
- Excavation	(m^3)	12	
- Concrete	(")	117	
- Reinforcement	(")	750	
- Gate	(t)	4,170	
- Others		20%	Percentage for the above
4) Miscellaneous		4% of Reservoir and Pondage	
III. Power Plant			
1) Foundation			
- Excavation	(m^3)	12	
- Concrete	(")	117	
- Reinforcement	(t)	750	
- Others		20%	Percentage for the above
IV. Miscellaneous		3% of Civil Works	
V. Temporary Facilities		20%: Reservoir 10%: PRR&SRR	Percentage for civil works

TABLE 5-17

(4 of 4)

UNIT PRICE FOR COST ESTIMATE

Item		Unit Cost (US$)	Remarks
Electric Equipment		L.S.	International Market Price
Administrative and Engineering Consultant Cost		L.S.	10% of the above total
Sub-Total			
Contingency		L.S.	10% of the above total
Access Road	(m)	310	
Grand Total			

TABLE 5-18 PROJECT PRIORITY EVALUATING SYSTEM
(1 of 3)

Evaluating Items	Weightage	Priority Grade
I. Economic Viability		
1) Unit Cost of Power	10	5 for less than 3.0 c/kKW 4 for 3.0 - 4.9 3 for 5.0 - 6.9 2 for 7.0 - 7.9 1 for more than 8
2) B/C Ratio	10	1 for less than 1.0 2 for 1.0 - 1.9 3 for 2.0 - 2.5 4 for 2.6 - 2.9 5 for greater than 3.0
3) Compliance to National Need (Size of Project)	6	5 for 100 - 499 MW 4 for 50 - 99 MW 3 for 500 - 699 MW or less than 50 MW 3 for greater than 1000 MW
4) Employment Opportunities (Long Term Basis)	3	5 for big contribution, such as creation of more than 3,000 jobs expected 3 for fair amount expected 1 for almost negligible
5) Multiplier Effects	3	5 for substantial contribution to rural development, such as supporting farm industry and others 3 for some effect 1 for negligible effect
II. Infrastructure for Construction		
1) Accessibility	5	5 for les than 50 km 4 for 50 - 69 km 3 for 70 - 89 km 2 for 90 - 110 km 1 for greater than 110 km
2) Logistics	3	5 for favorable location in obtaining manpower and material supplies 3 for relatively easy 1 for not easy

TABLE 5-18
(2 of 3)

PROJECT PRIORITY EVALUATING SYSTEM

Evaluating Items	Weightage	Priority Grade
3) Construction Period	7	5 for less than 4 years 3 for 5 - 10 years 1 for greater than 10 years
4) Transmission Line	3	5 for less than 50 km 3 for 50 - 100 km 1 for greater than 110 km
5) Construction Camp	2	5 for good location easily found 3 for relatively easy 1 for not easy
6) Permanent Community	1	5 for large community within 25 km 3 for within 26 - 50 km 1 for greater than 51 km
III. Resettlement		
1) Existing Population and Land Use to be Effected	3	5 for minimal effect, such as SRR type development 3 for PRR type development 1 for Reservoir type development
2) Compensation or Resettlement Site Selection	3	5 for SRR type 3 for PRR type 1 for Reservoir type
IV. Effects on Downstream Reaches		
1) Flood Control	1	5 for substantial contribution 3 for some 1 for negligible
2) Soil Conservation Effect 3) Sedimentation	3) 6	5 for Reservoir type 3 for PRR type 1 for SRR type
4) Fisheries Resources	3	5 for negligible negative effect, such as SRR type 3 for PRR type 1 for Reservoir type

TABLE 5-18 (3 of 3) PROJECT PRIORITY EVALUATING SYSTEM

Evaluating Items	Weightage	Priority Grade
V. Innundation Zone		
1) Agricultural Capabilities (Negative Effect)	5	5 for negligible negative effect, such as SRR type 3 for PRR type 1 for Reservoir type
2) Contribution to Fisheries Development	3	5 for Reservoir type 3 for PRR type 1 for SRR type
3) Water Quality	2	5 for SRR type 3 for PRR type 1 for Reservoir type
VI. Development Impacts		
1) Effects on the Basin (Land Use & Transportation)	5	5 for great contribution expected 3 for some amount 1 for negligible amount
2) Reservoir Resource Potentials (Multipurpose Effects Including Irrigation Development)	3	5 for great effect 3 for fair effect 1 for negligible effect
3) Regional Resource Potentials	5	5 for great contribution 3 for fair contribution 1 for negligible effect

TABLE 5-19
(1 of 4)

LIST OF HYDROPOWER SCHEMES

River	Name	Catchment Area (km^2)	Type	Inteke Water Level EL (m)	Tail Water Level EL (m)	Dam Height (m)	Tunnel Length (km)	Maxmum Discharge (m^3/s)	Installed Capacity (MW)	Construction Cost (10^6 US$)	Generated Energy (GWH)	Cost per KW (US$)	Energy Cost (cent/KWH)	Access Road (km)	B/C	[illegible]
Sun Kosi	Sun Kosi No. 1	16,200	Reservoir	424.6 (424.6)	304.8	147 V=2270x103	--	1,400	1,357	1,033	4,640	737	3.76	70	2.63	2.85
	Sun Kosi No. 2	10,396	"	555.3 (575.0)	424.6	166 V=3070x103	--	1,050	1,110	1027	4,760	925	3.65	107	2.41	244
	Sun Kosi No. 3	5,520	"	691.3 (700.0)	575.0	140 V=1930x103	--	570	536	582	2,070	1,086	4.75	20	1.95	53
	Sun Kosi No. 4	3,100	SRR	774.2	700.0	20	12.7	53	26	117	181	4,500	10.92	9	0.65	-7
Dudh Kosi	Dudh Kosi No. 1	4,100	PRR	521.2 (524.2)	424.6	104	2.60	300	228	449	978	1,969	7.76	177	1.13	10
	Dudh Kosi No. 2	3,625	SRR	746.7	524.2	18	9.50	50	87	166	690	1,908	4.07	197	1.65	16
	Dudh Kosi No. 3	3,200	"	883.9	746.7	20	5.80	45	48	129	381	2,688	5.72	203	1.17	4
	Dudh Kosi No. 4	2,300	"	1,066.8	883.9	20	5.80	32	46	123	367	2,674	5.66	209	1.18	4
	Dudh Kosi No. 5	2,200	"	1,371.6	1,066.8	20	7.50	30	73	140	580	1,918	4.08	220	1.65	15
	Dudh Kosi No. 6	2,150	"	1,524.0	1,371.6	20	5.80	30	36	119	286	3,306	7.03	226	0.95	-1
	Dudh Kosi No. 7	2,070	"	1,904.9	1,524.0	20	5.30	29	89	146	704	1,640	3.50	231	1.92	23
	Dudh Kosi No. 8	1,900	"	2,346.9	1,904.9	20	3.80	26	93	140	740	1,505	3.20	236	2.10	26
	Dudh Kosi No. 9	1,860	"	2,651.7	2,346.9	20	6.60	26	63	141	501	2,238	4.76	243	1.41	10
	Dudh Kosi No. 10	1,790	"	2,895.5	2,651.7	20	3.90	25	49	124	388	2,531	5.40	248	1.24	5

* The Construction Cost, Cost per kW and Energy Cost include the access roads cost planned independently.

TABLE 5-19
(2 of 4)

LIST OF HYDROPOWER SCHEMES

River	Name	Catchment Area (km^2)	Type	Intake Water Level EL (m)	Tail Water Level EL (m)	Dam Height (m)	Tunnel Length (km)	Maxmum Discharge (m^3/s)	Installed Capacity (MW)	Construction Cost (10^6 US$)	Generated Energy (GWH)	Cost per KW (US$)	Energy Cost (cent/KWH)	Access Road (km)	B/C	B-C
Likhu Khola	Likhu Khola No. 1	823	SRR	542.5	424.6	20	7.90	23	21	84	145	4,000	9.79	126	0.72	-3.9
	Likhu Khola No. 2	750	"	649.2	542.5	20	7.60	21	17	81	118	4,765	11.60	135	0.61	-5.4
	Likhu Khola No. 3	670	"	853.4	649.2	20	7.70	19	31	88	213	2,839	6.98	143	1.02	0
	Likhu Khola No. 4	620	"	1,036.3	853.4	20	3.80	17	25	75	176	3,000	7.20	147	0.98	0
Maulung Khola	Maulung Khola	330	SRR	609.6	424.6	20	9.30	9	13	79	92	6,077	14.60	154	0.48	-6.9
Tama Kosi	Tama Kosi No. 2	3,010	SRR	773.0	597.0	20	9.90	150	196	245	1,013	1,250	4.05	15	1.98	40
	Tama Kosi No. 3	2,753	PRR	880.9 (883.9)	773.0	60	7.00	150	123	206	603	1,675	5.77	6	1.42	15
	Tama Kosi No. 4	2,540	"	1,002.8 (1,005.8)	883.9	75	8.10	140	126	263	624	2,087	7.12	15	1.15	7
	Tama Kosi No. 5	1,950	SRR	1,219.2*	1,005.8	20	7.30	60	102	114	615	1,118	3.13	30	2.39	27
	Tama Kosi No. 6	1,900	"	1,463.0	1,219.2	20	6.30	58	113	113	686	1,000	2.78	36	2.68	32
Khimte Khola	Khimte Khola No. 1	360	SRR	1,200.00	597.0	20	7.40	10	49	66	344	1,347	3.26	25	2.14	12.8
	Khimte Khola No. 2	313	"	1,524.0	1,219.2	20	3.90	9	22	33	154	1,500	3.62	30	1.94	5.3

* The Construction Cost, Cost per kW and Energy Cost include the access roads cost planned independently.

TABLE 5-19
(3 of 4)

LIST OF HYDROPOWER SCHEMES

River	Name	Catchment Area (km^2)	Type	Intake Water Level EL (m)	Tail Water Level EL (m)	Dam Height (m)	Tunnel Length (km)	Maxmum Discharge (m^3/s)	Installed Capacity (MW)	Construction Cost (10^6 US$)	Generated Energy (GWh)	Cost per KW (US$)	Energy Cost (cent/KWH)	Access Road (km)	B/C	B-C
Bhote Kosi	Bhote Kosi No. 1	2,320	SRR	1,066.8	827.0	24	10.9	34	64	89	444	1,388	3.38	0	2.09	16
	Bhote Kosi No. 2	2,170	"	1,341.1	1,066.8	20	10.8	32	69	93	480	1,348	3.27	0	2.16	18
Balephi	Balephi	490	SRR	1,066.8	808.3	20	11.9	17	34	69	233	2,029	5.00	24	1.42	4.9
Rosi Khola	Rosi Khola No. 1	490	SRR	734.6	575.0	20	8.10	13	16	42	97	2,625	7.32	6	1.02	0.1
	Rosi Khola No. 2	420	"	883.9	734.6	20	6.20	11	13	43	76	3,308	9.56	16	0.79	-1.5
	Rosi Khola No. 3	260	"	1,112.5	883.9	20	8.40	7	12	44	73	3,667	10.19	27	0.73	-2.0
	Rosi Khola No. 4	190	"	1,371.6	1,112.5	20	6.00	5	10	31	61	3,100	8.59	28	0.87	-0.7
Indrawati	Indrawati No. 1	980	PRR	771.2 (774.2)	700.0	45	6.50	110	58	161	249	2,776	10.93	20	0.80	-5.0
	Indrawati No. 2	750	SRR	960.1	774.2	20	12.6	23	33	74	234	2,242	5.34	43	1.31	4.0
	Indrawati No. 3	370	"	1,219.2	960.1	20	7.90	12	25	42	172	1,680	4.13	51	1.72	5.1
Tamur	Tamur No. 1	5,085	Reservoir	476.0 (487.6)	344.4	153	--	650	696	846	2,750	1,216	5.20	25	1.76	109

* The Construction Cost, Cost per kW and Energy Cost include the access roads cost planned independently.

TABLE 5-19
(4 of 4)

LIST OF HYDROPOWER SCHEMES

River	Name	Catchment Area (km^2)	Type	Intake Water Level EL (m)	Tail Water Level EL (m)	Dam Height (m)	Tunnel Length (km)	Maxmum Discharge (m^3/s)	Installed Capacity (MW)	Construction Cost (10^6 US$)	Generated Energy (GWH)	Cost per KW (US$)	Energy Cost (cent/KWH)	Access Road (km)	B/C	B-C
Tamur	Tamur No. 3	4,000	PRR	560.9 (563.9)	487.6	65	--	310	186	194	812	1,043	4.04	89	2.15	38
	Tamur No. 4	3,140	SRR	661.4	563.9	20	6.40	67	51	122	356	2,392	5.79	103	1.22	4.0
	Tamur No. 5	2,560	"	822.9	661.4	20	6.00	55	70	129	489	1,843	4.46	109	1.58	13
	Tamur No. 6	2,490	"	1,005.8	822.9	20	7.40	53	76	127	535	1,671	4.01	116	1.75	16
	Tamur No. 7	2,420	"	1,249.7	1,005.8	20	6.30	52	101	138	705	1,366	3.31	122	2.13	26
Kabeli Nadi	Kabeli Nadi No. 1	580	SRR	731.5	563.9	20	10.4	12	15	71	109	4,733	11.01	105	0.63	-4.4
	Kabeli Nadi No. 2	320	"	1,005.8	731.5	20	10.0	7	15	68	105	4,533	10.94	115	0.64	-4.1
	Kabeli Nadi No. 3	180	"	1,371.6	1,005.8	20	5.50	4	12	56	81	4,667	11.68	122	0.61	-3.7
Arun	Arun No. 1	32,998	SRR	420.0	311.0	23	9.60	180	146	277	1,166	1,897	4.03	72	1.66	31
	Arun No. 2	32,881	"	616.0	420.0	18	10.4	160	239	292	1,967	1,222	2.49	85	2.65	81
	Arun No. 3	32,332	"	810.0	616.0	23	7.10	156	240	268	1,965	1,119	2.29	99	2.91	86
	Arun No. 4	32,023	"	914.4	810.0	20	8.70	154	120	244	982	2,033	4.18	115	1.59	24
	Arun no. 5	31,974	"	1,082.0	914.4	20	5.70	153	202	255	1,650	1,262	2.61	135	2.56	67
	Arun No. 6	31,398	"	1,280.1	1,082.0	20	5.70	151	238	265	1,914	1,113	2.35	151	2.84	83
Sapt Kosi	Sapt Kosi	61,000	Reservoir	289.8 (304.8)	119.3	239 V=7680x10^3	--	2,500	3,489	2,721	16,810	780	2.74	0	3.03	932

TABLE 5-20 ECONOMIC EVALUAITON OF COMBINATION OF SUN KOSI NO. 1, 2 AND 3

Item	Combination	H	J	E	K
Dam Height (m)	Sun Kosi No.1	147	195	169	160
	" No.2	166	110	163	180
	" No.3	110	110	86	170
Gross Storage Capacity ($10^6 m^3$)	Sun Kosi No.1	1,500	3,650	2,320	2,720
	" No.2	4,370	2,000	4,520	4,800
	" No.3	620	620	570	2,960
	Total	6,490	6,270	7,410	10,210
Available Storage Capacity ($10^6 m^3$)	Sun Kosi No.1	40	1,660	510	860
	" No.2	3,040	810	3,200	3,480
	" No.3	70	70	30	2,080
	Total	3,150	2,540	3,740	6,420
Installed Capacity (MW)	Sun Kosi No.1	1,357	1,789	1,557	1,520
	" No.2	1,110	784	1,076	1,060
	" No.3	432	432	348	580
	Total	2,899	3,005	2,981	3,160
Benefit (B/C)		2.51	2.32	1.23	1.97
Benefit-Cost (B-C) (10^6US$)		619	607	590	557
Energy Cost (cent/KWh)		2.74	4.04	4.14	4.70

Note: Cost is calculated excluding access roads and transmission lines.

TABLE 5-21 FEATURES OF SUN KOSI NO. 1, 2, 3

		Sun Kosi No. 1	Sun Kosi No. 2	Sun Kosi No. 3
Location		KURULE BESI	J. JANAKAPUR D. SINDHULI, V.P. DUDVHANG CHAYAKUTAR	JAKHADI PURANA GAON
HWL of Reservoir (m)		424.6	575.0	700.0 (670.5)
Dam Height (m)		147	166	140 (110)
Gross Reservoir Capacity ($10^6 m^3$)		1,500	4,370	1,220 (620)
Effective Reservoir Capacity ($10^6 m^3$)		40	3,040	560 (90)
Power	Maximum Discharge (m^3/s)	1,400	1,050	570 (570)
	Installed Capacity (MW)	1,357	1,110	541 (432)

Note: 1. Value in ( ) of Sun Kosi No. 3 indicates the optimum case taking into account hydropower only.

TABLE 5-22 **COMPARISON OF ALTERNATIVE DAM HEIGHTS**

Item			Dam Height-(m)	239	269	299
			Maximum Discharge(m^3/s)	2,500 (Adopted)	2,500	2,500
Cost						
Total Construction Cost	Ct	$x10^6$US$		2,721	3,400	4,220
Annual Cost	C=0.169xCt	"		459.8	574.6	713.2
Benefit						
Maximum Output	P	MW		3,489	3,897	4,307
Annual Energy Output	W	$x10^6$KWH		16,810	20,483	24,147
Benefit	B=Px191.8(US$/KW) +Wx0.043(US$/KWH)	$x10^6$US$		1,392	1,628	1,864
B / C	-	-		3.03	2.83	2.61
B - C	-	$x10^6$US$		932	1,053	1,151
Construction Cost						
Per KW	Ct/P	US$		780	872	980
Per KWH	Ct/w	US$		0.162	0.166	0.175
Energy Cost		¢		2.74	2.81	2.95
Plant Factor		x		55	60	64
River Water Factor		x		84	92	98

TABLE 5-23 FEATURE OF 13 HIGH PRIORITY SCHEMES

	Item	Unit	SAPT KOSI HIGH DAM	ARUN NO.3	ARUN NO.2	SUN KOSI NO.1	SUN KOSI NO.3	SUN KOSI NO.2	ARUN NO.1	BHOTE KOSI NO.1	TAMA KOSI NO.3	TAMUR NO.1	TAMA KOSI NO.2	KHIMTE KHOLA NO.1	DUDH KOSI NO.1
Type of Scheme		—	Reservoir	SRR	SRR	Reservoir	Reservoir	Reservoir	SRR	SRR	PRR	Reservoir	SRR	SRR	PRR
River		—	Sapt Kosi	Arun	Arun	Sun Kosi	Sun Kosi	Sun Kosi	Arun	Bhote Kosi	Tama Kosi	Tamur	Tama Kosi	Khimte	Dudh Kosi
Reservoir	Catchment Area	Km^2	61,000	32,332	32,881	16,200	5,520	10,396	32,998	2,320	2,753	5,085	3,010	360	4,100
	High Water Level	EL m	304.8	—	—	424.6	700.0	575.0	—	—	883.9	487.6	—	—	524.2
	Low Water Level	"	259.0	—	—	423.0	674.0	516.0	—	—	873.9	460.0	—	—	514.2
	Gross Storage Capacity	$Mill.m^3$	8,500	—	—	1,500	1,220	4,370	—	—	24	1,890	—	—	162
	Avilable Storage Capacity	"	4,420	—	—	40	550	3,040	—	—	—	760	—	—	—
	Average Runoff	m^3/s	1,633	365	398	657	280	547	405	74	154	308	168	31	227
	90% Dependable Flow	"	750	114	122	143	100	298	123	16	25	115	25	5.4	39
Dam	Type	—	Concrete Gravity	Intake Weir	Intake Weir	Concrete Gravity	Concrete Gravity	Concrete Gravity	Intake Weir	Intake Weir	Concrete Gravity	Concrete Gravity	Intake Weir	Intake Weir	Concrete Gravity
	Height	m	239	23	18	147	140	166	20	24	60	153	20	20	104
	Length	"	640	120	100	500	470	530	150	80	200	600	150	90	300
	Volume	m^3	$7,677x10^3$	$74x10^3$	$37x10^3$	$2,269x10^3$	$1,935x10^3$	$3,067x10^3$	$91x10^3$	$53x10^3$	$151x10^3$	$2,950x10^3$	$69x10^3$	$41x10^3$	$681x10^3$
	Design Flood Discharge	m^3/s	42,400			22,500	11,600	17,300			7,600	11,100			9,800
Hydropower	Intake Water Level	EL m	289.8	810.0	616.0	424.6	691.3	555.3	420.0	1,066.8	880.9	476.0	773.0	1,200.0	521.2
	Tail Water Level	"	119.3	616.0	420.0	304.8	575.0	424.6	311.0	827.0	773.0	344.4	597.0	597.0	424.6
	Gross Head	m	170.5	194.0	196.0	119.8	116.3	130.7	109.0	239.8	107.9	131.6	176.0	603.0	96.6
	Design Discharge	m^3/s	2,500	156	160	1,400	570	1,050	180	34	150	650	150	10	300
	Firm Discharge	"	2,500	114	122	572	400	1,050	123	15.8	99	460	99	5.4	38.5
	Installed Capacity	KW	3,489	240	239	1,357	536	1,110	146	64	123	696	196	49	228
	Firm Capacity	"	3,489	176	185	555	376	1,110	100	29	82	493	130	26	118
	Generated Energy	GWH	16,810	1,965	1,967	4,640	2,070	4,760	1,166	444	603	2,750	1,013	344	978
	Firm	"	9,064	1,526	1,612	1,206	826	2,761	870	257	179	1,078	295	227	259
	Seasonal	"	7,746	-	-	1,742	876	1,999	-	-	286	1,217	471	-	407
	Secondary	"	0	439	355	1,692	374	0	296	187	138	455	248	117	312
Capital Cost	Capital Cost	10^6US$	2,773	307	326	1,093	622	1,085	294	97	219	890	278	77	478
	Hydropower Station	"	2,721	234	261	1,001	576	992	254	89	204	838	240	58	394
	Transmission/Substation	"	52	39	34	60	40	58	17	8	13	45	33	11	29
	Access Roads	"	- (-)	34(99km)	31(85km)	32(70km)	6(20km)	35(107km)	23(72km)	-(-)	2(6km)	7(25km)	5(15km)	8(25km)	55(177km)
Cost per KW		US$/KW	795	1,279	1,364	805	1,160	977	2,014	1,516	1,780	1,279	1,418	1,571	2,096
Energy Cost		Cent/KWH	2.78	2.65	2.80	3.99	5.07	3.84	4.29	3.60	6.14	5.45	4.64	3.78	8.28
Economic Evaluation	Annual Cost	10^6US$	468	52	55	185	105	183	50	16	37	150	47	13	81
	I.Consideration of Potential Energy														
	Annual Benefit	10^6US$	1,392	131	130	460	192	418	78	31	50	252	81	24	86
	Benefit/Cost Ratio	-	2.97	2.52	2.36	2.49	1.83	2.28	1.56	1.94	1.35	1.68	1.72	1.85	1.06
	Annual(Benefit-Cost)	10^6US$	924	79	75	275	87	235	28	15	13	102	34	11	5
	II.Consideration of Firm and Secondary Energy														
	Annual Benefit	10^6US$	1,276	111	115	256	142	388	65	22	35	188	59	18	54
	Benefit/Cost Ratio	-	2.73	2.13	2.09	1.37	1.35	2.12	1.30	1.38	0.95	1.25	1.26	1.38	0.67
	Annual(Benefit-Cost)	10^6US$	808	59	60	69	37	205	15	6	-2	38	12	5	-12

TABLE 5-24

COSTS OF STRUCTURES OF 13 PRIORITY SCHEMES

Unit : 10^6US$

ITEM	SAPT KOSI HIGH DAM	ARUN NO.3	ARUN NO.2	SUN KOSI NO.1	SUN KOSI NO.3	SUN KOSI NO.2	ARUN NO.1	BHOTE KOSI NO.1	TAMA KOSI NO.3	TAMUR NO.1	TAMA KOSI NO.2	KHIMTE KHOLA NO.1	DUDH KOSI NO.1	REMARKS
1. Compensation and Land Acquisition	127	6	6	47	27	46	6	2	5	39	6	1	18	
2. Power house	434	15	22	148	49	107	17	5	11	81	18	3	26	
3. Dam (or Weir)	812 ($7,677 \times 10^3$)	13 (74×10^3)	5 (37×10^3)	251 ($2,269 \times 10^3$)	209 ($1,935 \times 10^3$)	329 ($3,067 \times 10^3$)	12 (91×10^3)	7 (53×10^3)	23 (151×10^3)	314 ($2,950 \times 10^3$)	10 (69×10^3)	6 (41×10^3)	79 (681×10^3)	Dam Concrete (m^3)
4. Intake Structure	38	20	10	15	9	18	12	2	2	11	10	1	4	
5. Waterway	78	62	85	47	22	37	89	28	85	23	76	10	90	
6. Penstock	113	7	13	36	16	34	5	6	4	17	10	13	10	
7. Miscellaneous Works	89	9	10	29	20	35	11	4	9	29	9	2	15	
8. Electric Equipment	404	50	50	202	92	159	44	15	20	132	46	9	61	
9. Temporary Facilities	154	12	14	52	32	55	14	5	13	47	13	3	22	
10. Administrative and Engineering Cost	225	19	22	83	48	82	21	7	17	69	20	5	33	
11. Contingency	247	21	24	91	52	90	23	8	15	76	22	5	36	
12. Access Road	0	34	31	50	6	35	23	0	2	8	5	8	55	
TOTAL	2,721	268	292	1,051	582	1,027	277	89	206	846	245	66	449	

TABLE 5-25 RIVER DISCHARGE AT DAM SITE OF 13 PRIORITY SCHEMES

(Unit: m^3/S)

Scheme	Catchment Area (km^2)	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Annual Average
Sapt Kosi High Dam	61,000	400.3	357.0	351.9	418.1	715.8	1976.1	4008.3	4712.6	3389.3	1739.6	824.3	529.8	1632.7
Arun No.3	32,332	113.4	116.8	134.6	175.1	249.0	522.8	776.5	890.2	667.7	364.8	203.6	143.1	364.8
Arun No.2	32,881	119.7	121.9	139.3	182.9	267.0	570.4	861.9	977.6	733.9	396.8	217.3	151.6	398.0
Sun Kosi NO.1	16,200	158.6	135.7	125.3	135.3	178.5	580.2	1,541	1,865	1,278	650.4	288.2	196.1	657.3
Sun Kosi No.3	5,520	65.05	53.30	52.15	61.38	84.47	298.2	715.4	866.3	608.1	297.1	144.5	91.19	280.0
Sun Kosi No.2	10,396	119.8	96.88	87.88	100.8	148.4	534.4	1,345	1,744	1,280	600.2	292.9	168.3	546.9
Arun No.1	32,998	121.1	123.0	140.3	184.6	270.9	580.5	880.1	996.2	748.1	403.6	220.2	153.4	405.1
Bhote Kosi No.1	2,320	18.79	15.76	15.17	19.49	31.17	95.06	180.4	208.4	153.5	77.16	39.50	25.51	73.76
Tama Kosi No.3	2,753	30.88	24.87	23.59	30.87	64.13	195.2	405.0	464.9	320.0	159.2	72.21	43.39	153.9
Tamur No.1	5,805	58.54	47.09	43.30	72.52	167.0	440.4	791.3	809.6	613.6	296.2	126.6	78.84	307.8
Tama Kosi No.2	3,010	33.76	27.19	25.79	33.75	70.12	213.4	442.8	508.3	349.9	174.1	78.95	47.44	168.3
Khimte Khola No.1	360	6.27	5.36	4.92	5.64	9.80	42.84	94.64	93.85	61.98	26.01	12.55	7.96	31.20
Dudh Kosi No.1	4,100	48.52	38.53	37.23	44.81	76.06	287.3	621.2	678.5	448.0	255.1	108.0	66.49	227.4

TABLE 5-26 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. Surplus (+) or Deficit (-)	(%)	+0.6	-11.9	-19.8	-38.2	-41.7	-50.7

TABLE 5-27
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 5-27
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 5-27
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 5-28

REQUIRED DIVERSION WATER FOR EACH ALTERNATIVE

Alternative	Area (ha)	Annual Water Requirement ($10^6 m^3$)	Evaporation From Reservoir ($10^6 m^3$)	Maintenance Flow ($10^6 m^3$)	Usable Local Discharge ($10^6 m^3$)	Required Additional Water ($10^6 m^3$)	Required Diversion Water (m^3/s)
Sun Kosi Diversion							
400ft intake	175,100	3,056.68	47.8	706.83	1,555.24	2,256.12	72
" "	159,100	2,776.97	47.8	706.83	1,555.24	1,976.41	63
" "	136,700	2,385.98	47.8	706.83	1,555.24	1,585.42	51
450ft intake	215,200	3,765.13	47.8	706.83	1,555.24	2,964.57	95
" "	189,800	3,312.79	47.8	706.83	1,555.24	2,512.23	80
" "	160,600	2,803.13	47.8	706.83	1,555.24	2,002.57	64
Sapt Kosi West Irrigation							
Sun Kosi - Trijuga Diversion	17,100	298.48	-	-	203.86	94.62	16.5 (Oct)
Sapt Kosi intake	20,900	364.78	-	-	203.86	160.92	21 (Oct)
Sapt Kosi East Irrigation							
Sapt Kosi intake	47,950	817.47	-	-	-	817.47	57 (Oct)
Tamur - Khadam Diversion	49,350	841.87	-	-	-	841.87	59 (Oct)

TABLE 5-29
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 5-29
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 5-29
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 5-30

(1 of 2)

ALTERNATIVE STUDY FOR IRRIGATION PLANNING

(Without Hydropower Planning)

Alternative	Diversion Tunnel Length (km)	Diversion Tunnel Max. Discharge (m^3/s)	Kamla Dam Hight (m)	Kamla Dam Ve ($10^6/m^3$)	Intake Facility Facility	Intake Facility Elevation (ft)	Net Comand Area (ha)	Main Canal Length (km)	Main Canal Max. Discharge (m^3/s)	Total Construction Cost (10^6US$)	B/C Ratio at 12%
Sun Kosi Diversion											
Case, SK-400-BK	13.9	72	51.0	492.6	Barrage	400	175,100	152.5	219	470.86	1.33
Case, SK-400-JK	13.9	63	50.5	471.4	Barrage	400	159,100	136.5	199	434.25	1.31
Case, SK-400-MK	13.9	51	50.0	451.5	Barrage	400	136,700	116.5	171	389.98	1.23
Case, SK-450-BK	13.9	95	52.6	563.6	Kamla Dam	450	215,200	155.3	26.9	652.42	1.18
Case, SK-450-JK	13.9	80	51.6	517.8	Kamla Dam	450	189,800	135.8	238	561.48	1.21
Case, SK-450-MK	13.9	64	50.5	471.8	Kamla Dam	450	160,600	116.8	210	492.27	1.17
Sapt Kosi West Irrigation											
1. Sun Kosi - Trijuga Diversion	5.0	16.5	-	-	Barrage	350	17,100	30.9	25	60.35	1.10
2. Sapt Kosi Intake											
Dam Hight H = 39m	6.4	21.0	-	-	Barrage	350	20,900	68.0	25	111.18	0.74
H = 77m	6.4	21.0	-	-	Barrage	350	20,900	68.0	25	134.92	0.59
Sapt Kosi East Irrigation											
1. Sapt Kosi Intake											
Dam Hight H = 39m	6.5	57	-	-	-	500	47,950	62.3	57	221.65	0.69
H = 77m	6.5	57	-	-	-	500	47,950	62.3	57	219.00	0.79
2. Tamur East Terai Diversion	18.0	59	-	-	Barrage	500	49,350	57.0	59	232.49	0.76

TABLE 5-30 (2 of 2)

ALTERNATIVE STUDY FOR IRRIGATION PLANNING

(SUN KOSI MULTIPURPOSE SCHEME)

(With Hydropower Planning)

Unit: 10^6 US$

Scheme		Construction Cost	Cost[1/]	Benefit[1/]	B/C	B-C
Sunkasi Multipurpose Scheme						
Marha R. - Kanro R. (Chisapani Barrage Intake Plan)	Irrigation	344.54	538.4	765.9	1.42	227.6
Net Command Area 136,700 ha	Hydro Power	111.30	176.2	253.6	1.44	77.4
	Total	455.84	714.5	1019.5	1.43	305.0
" (Kamla Dam Intake Plan)	Irrigation	432.05	675.1	899.8	1.33	224.7
Net Command Area 160,600 ha	Hydro Power	134.12	212.3	311.6	1.47	99.3
	Total	566.17	887.4	1211.4	1.37	324.0
Jhim R. - Kanro R. (Chisapani Barrage Intake Plan)	Irrigation	382.80	598.1	891.4	1.49	293.3
Net Command Area 159,100 ha	Hydro Power	124.38	196.9	307.3	1.56	110.4
	Total	507.18	795.0	1198.7	1.51	403.7
" (Kamla Dam Intake Plan)	Irrigation	493.54	771.2	1063.4	1.38	292.2
Net Command Area 189,800 ha	Hydro Power	154.84	245.1	384.5	1.57	139.4
	Total	648.38	1016.3	1447.9	1.42	431.6
Bagmati R. - Kanro R.	Irrigation	414.64	647.9	981.1	1.51	333.2
(Chisapani Barrage Intake Plan)	Hydro Power	136.06	215.4	348.2	1.62	132.8
Net Command Area 175,100 ha	Total	550.70	863.2	1329.2	1.54	466.0
" (Kamla Dam Intake Plan)	Irrigation	572.07	893.9	1205.7	1.35	311.8
Net Command Area 215,200 ha	Hydro Power	176.28	279.0	451.7	1.62	172.7
	Total	748.35	1172.9	1657.5	1.41	484.6

1/ Discounted

TABLE 5-31 CROP YIELDS UNDER PRESENT, FUTURE WITHOUT PROJECT AND FUTURE WITH PROJECT CONDITIONS

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 5-32 INCREMENTAL PRODUCTION OF MAJOR CROPS UNDER SUN KOSI DIVERSION SCHEME

Unit: 1,000mt

Crop	Production With Project	Production Without Project	Increment
Paddy	832.6	258.1	574.5
Wheat	183.9	34.6	149.3
Maize	52.5	30.6	21.9
Oilseeds	24.5	19.8	4.7
Pulses	37.8	3.9	33.9
Total	1,131.3	347.0	784.3

TABLE 5-33

TAR IRRIGATION AREA STUDIED

Zone	Feasible	Considerable (Semi-feasible)	To be Repaired	KHARDEP[1/]	Unfeasible	Not-Stated	Total Area (No.)
Bagmati	2,265 (16)	55 (1)	-	-	1,332 (9)	31 (4)	3,683 (30)
Janakpur	9,883 (14)	5,621 (6)	-	-	2,450 (1)	693 (4)	18,647 (25)
Sagarmatha	12,303 (30)	8,999 (4)	135 (3)	-	11,711 (21)	4,662 (6)	37,810 (64)
Kosi	22,295 (25)	15,275 (9)	2.960 (2)	1,009 (29)	1,789 (4)	5,215 (7)	48,537 (76)
Mechi	14,138 (20)	-	240 (1)	-	4,005 (10)	3,890 (2)	22,323 (33)
Total	60,884 (105)	29,950 (20)	3,335 (6)	1,009 (29)	21,331 (45)	14,491 (23)	131,000 (228)

1/ KHARDEP Kosi Hill Area Rural Development Programme (KHARDEP)

2/ The figure in the parenthesis is number of projects

Source: DIHM

TABLE 6-1 ESTIMATION OF SPECIFIC SEDIMENTATION IN RESERVOIR BY VARIOUS METHODS

River	Sapt Kosi	Sun Kosi	Arun	Tamur
Area	61,000km² 100%	19,000km² 31%	36,000km² 59%	6,000km² 10%
Item				
Hypsographic coefficient (x)	259.953 1/	212.538 2/	273.167 2/	330.814 2/
	= 19.0x212.538+36.0x273.167+6.0x330.814			
Use of the formula for the gneisses (m³/km²hr)	Qs=9.0X-524 =9.0x259.953 -524 =1,816	Qs=9.0X-524 =0.0x212.538 -524 =1,389	Qs=9.0X-524 =9.0x273.167 -524 =1,935	Qs=9.0X524 =9.0x330.814 -524 =2,453
Specific sediment yield Qs (m³/km²yr)	1,850	1,400	2,000	2,500
Discharge v.s. suspended bed material concentration	(2,078)	(1,303)	(183)	(2,640)
Using the upper bound of measured suspended sediment load chart in Japan	1,997	1,166	183	721
Meyor-Peter	1,576	1,358	832	6,947
R.S. Vershney's formula (of India)	837	1,138	961	1,534
Recorded measurements in India	1,500	2,000	1,700	2,800
Milos Holy's formula (of Czechoslovakia)	1,583	2,324	920	3,440
Recorded measurements of sedimentation in Japan (the Tenryu River)	280	500	350	1,200
Sediment discharge during disasters in Japan	788	1,121	1,000	1,909

1/ The calculation is based on the area proportion of Sapt Kosi to the total area of Sun Kosi, Arun and Tamur rivers combined.

2/ The figure is based on the respective basin area.

Table 7-1 Alternative Impremention Sequence for Hydropower Development

Alternative	Impremention Sequence				Installed Capacity	Plant Factor	Total Cost	Energy Cost
					(MW)	(%)	(10^6US$)	(cent/kwh)
I	AR-3	AR-2	AR-1	TA-3	841	90	1,063	3.15
II	AR-3	AR-2	TA-3	TA-2	891	76	1,067	3.25
III	AR-3	TA-3	TA-2	AR-2	891	76	1,067	3.25
IV	AR-3	SU-3			869	59	928	3.89

Note: 1. Hydropower development in the Sun Kosi Multipurpose Scheme is included in the above installed capacity and Operation Factor but excluded in total cost and energy cost.

2. Installed capacity of the diversion hydropower project is 61MW and completion year is 1967.
Installed capacity of Kamla Dam hydropower project is 32MW and completion year is 1999

3. AR;Arun, TA;Tama Kosi, SU;Sun Kosi

TABLE 7-2 STAGE DEVELOPMENT FOR SUN KOSI MULTIPURPOSE SCHEME

Combination of Divided Constuction Scope		Stage-1 ①+③	Stage-2 ②+④	Stage-3 ⑤+⑥
Net Irrigation Area (ha)		55,500	24,200	95,400
Hydropower	(kW)	61,400	32,000	-
Construction Cost	Irrigation	162.48	72.01	135.20
	Hydro Power	138.51	42.50	0
	Total	300.99	114.51	135.20
Discounted Benefit	Irrigation	310.96	135.59	534.51
	Hydro Power	280.35	67.84	0
	Total	591.31	203.43	534.51
Discounted Cost	Irrigation	253.40	117.39	211.25
	Hydro Power	218.81	62.40	0
	Total	472.21	179.79	211.25
B/C	Irrigation	1.23	1.16	2.53
	Hydro Power	1.28	1.09	-
	Total	1.25	1.13	2.53
B-C	Irrigation	57.56	18.20	323.26
	Hydro Power	61.54	5.44	0
	Total	119.10	23.64	323.26

TABLE 7-3

1 of 4

ANNUAL DISBERSEMENT SCHEDULE OF CONSTRUCTION COST (THREE STAGES)

Unit: 10^6 US$

Item	Total	1988	89	90	91	92	93	94	95	96	97	98	99	2000
1. Civil Work														
Temporary Work	69.2	-	-	-	6.5	6.5	7.9	7.0	13.9	23.3	-	3.2	-	-
Kurule Intake Dam	35.9	-	-	-	-	-	-	8.9	9.0	9.0	9.0	-	-	-
Diversion Tunnel	74.2	-	-	-	-	-	14.8	14.8	14.8	14.9	14.9	-	-	-
Kamla Dam	46.7	-	-	-	-	-	-	-	-	11.6	11.7	11.7	11.7	-
Hydropower	43.9	-	-	-	-	-	-	-	-	13.8	13.8	5.4	10.9	-
Irrigation	170.2	-	-	-	5.6	5.6	8.1	15.3	31.8	24.6	24.6	19.0	19.1	16.5
Access Road	23.4	-	-	-	7.8	7.8	7.8	-	-	-	-	-	-	-
2. O/M Facilities	14.0	-	2.5	2.6	4.0	1.5	1.7	1.7	-	-	-	-	-	-
3. Administration & Engineering	32.4	1.8	1.8	2.4	2.5	3.3	3.3	3.3	3.3	3.3	3.3	1.6	1.6	0.9
4. Physical Contengency	40.8	0.1	0.3	0.4	2.1	2.0	3.5	4.2	5.8	8.0	6.3	3.3	3.5	1.4
TOTAL	550.7	1.9	4.6	5.4	28.5	26.7	47.1	56.1	78.6	108.5	83.5	44.2	46.8	18.8

TABLE 7-3

2 of 4

ANNUAL DISBERSEMENT SCHEDULE OF CONSTRUCTION COST

(STAGES - 1)

Unit: 10^6 US$

Item	Total	1988	89	90	91	92	93	94	95	96	97	98	99	2000
1. Civil Work														
Temporary Work	39.0	-	-	-	6.5	6.5	6.5	6.5	6.5	6.5	-	-	-	-
Kurule Intake Dam	35.9	-	-	-	-	-	-	9.0	9.0	9.0	8.9	-	-	-
Diversion Tunnel	74.2	-	-	-	-	-	14.9	14.9	14.8	14.8	14.8	-	-	-
Kamla Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydropower	27.6	-	-	-	-	-	-	-	-	13.8	13.8	-	-	-
Irrigation	53.3	-	-	-	5.6	5.6	5.6	12.9	12.8	5.4	5.4	-	-	-
Access Road	23.4	-	-	-	7.8	7.8	7.8	-	-	-	-	-	-	-
2. O/M Facilities	7.6	-	2.5	2.5	2.6	-	-	-	-	-	-	-	-	-
3. Administration & Engineering	17.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.7	-	-	-
4. Physical Contengency	22.3	0.1	0.4	0.4	1.9	1.7	3.0	3.5	3.6	4.1	3.6	-	-	-
SUB-TOTAL	301.0	1.9	4.7	4.7	26.2	23.4	39.6	48.6	48.4	55.3	48.2	-	-	-

TABLE 7-3

3 of 4

ANNUAL DISBERSEMENT SCHEDULE OF CONSTRUCTION COST
(STAGES - 2)

Unit: 10^6 US$

Item	Total	1988	89	90	91	92	93	94	95	96	97	98	99	2000
1. Civil Work														
Temporary Work	15.3	-	-	-	-	-	1.3	1.3	-	9.4	-	3.3	-	-
Kurule Intake Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diversion Tunnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kamla Dam	46.7	-	-	-	-	-	-	-	-	11.7	11.7	11.7	11.6	-
Hydropower	16.4	-	-	-	-	-	-	-	-	-	-	5.5	10.9	-
Irrigation	18.0	-	-	-	-	-	2.6	2.6	2.6	2.6	2.6	2.5	2.5	-
Access Road	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. O/M Facilities	2.9	-	-	-	1.4	1.5	-	-	-	-	-	-	-	-
3. Administration & Engineering	6.7	-	-	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	-
4. Physical Contengency	8.5	-	-	0.1	0.2	0.2	0.4	0.4	0.2	1.9	1.2	1.9	2.0	-
SUB-TOTAL	114.5	-	-	0.8	2.3	2.4	5.0	5.0	3.5	26.3	16.1	25.5	29.6	-

TABLE 7-3
4 of 4

ANNUAL DISBERSEMENT SCHEDULE OF CONSTRUCTION COST
(STAGES - 3)

Unit: 10^6 US$

Item	Total	1988	89	90	91	92	93	94	95	96	97	98	99	2000
1. Civil Work														
Temporary Work	14.8	-	-	-	-	-	-	-	7.4	7.4	-	-	-	-
Kurule Intake Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diversion Tunnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kamla Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydropower	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Irrigation	99.0	-	-	-	-	-	-	-	16.5	16.5	16.5	16.5	16.5	16.5
Access Road	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. O/M Facilities	3.4	-	-	-	-	-	1.7	1.7	-	-	-	-	-	-
3. Administration & Engineering	8.0	-	-	-	-	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4. Physical Contengency	10.0	-	-	-	-	0.1	0.2	0.2	1.9	2.0	1.4	1.4	1.4	1.4
SUB-TOTAL	135.2	-	-	-	-	0.9	2.8	2.8	26.7	26.8	18.8	18.8	18.8	18.8

TABLE 7-4 ALLOCATION OF DEVELOPMENT EXPENDITURE IN THE PUBLIC SECTOR

Unit: 10^6 NRs

	Fifth Plan Period 1975-80		Sixth Plan Period 1980-85	
	Amount	%	Amount	%
1. Agriculture, Irrigation and Forest	2,349.7	26.5	6,600.0	30.4
a. agriculture	(969.4)	(10.9)	(2,300.0)	(10.6)
b. irrigation	(864.0)	(9.7)	(3,060.0)	(14.1)
c. others	(516.3)	(5.9)	(1,240.0)	(5.7)
2. Industry, Mining and Power	1,679.2	18.9	5,600.0	25.8
a. Industry & Mining	(538.0)	(6.1)	(1,700.0)	(7.8)
b. Power	(1,049.9)	(11.8)	(3,800.0)	(17.5)
c. Commerce & Others	(91.3)	(1.0)	(100.0)	(0.5)
3. Transport and Communications	2,380.6	26.8	4,230.0	19.4
a. Transport	(2,299.4)	(25.9)	(3880.0)	(17.8)
b. Communications	(81.2)	(0.9)	(350.0)	(1.6)
4. Social Services	1,027.7	11.6	1,660.0	7.6
Total	8,870.6*	100.0	21,750.0**	100.0

*: at current prices

**: at 1979/82 constant price

Source: NPC and MOF

TABLE 7-5 CURRENT ENGINERING MANPOWER IN THE WATER RESOURCES SECTOR IN NEPAL

SUB-SECTOR	ENGINEERING DISCIPLINE				
Poower	CIVIL	ELECTRI-NICAL	MECHA-NICAL	OTHER[1/]	TOTAL
-Department of Electricity	30	53	15	4	102
-Kulekhani Hydel Development Board	19	7	7	4	37
-Small Hydel Development Board	13	9	3	-	25
-Nepal Electricity Corporation	2	47	5	-	54
-Eastern Electricity Corporation	-	7	3	-	10
Sub-Total	64	123	33	8	228
Irrigaiton					
-Department of Irrigation,Hydrology and Meteorology	111	-	6	30	147
-Groundwater Development Board	9	-	4	19	32
Sub-Total	120	-	10	49	179
Water Supply and Sanitation					
-Department of Water Supply and Sewerage	36	-	1	-	37
-Water Supply and Sewerage Board	18	-	1	-	19
-Ministry of Local Development	16	-	-	-	16
Sub-Total	70	-	2	-	72
General					
-Minisrty of Water Resources	2	3	-	-	5
Total	256	126	45	57	484

Note 1/ Geologists, hydrologist, meteorologists,chemists and electronics engineers.

Sources: Water , the Key to Nepal's Development

TABLE 7-6 Estimated Required Project Office Staff for Implementation

Project / Staff	Sun Kosi Multipurpose (Phase II) Diversion tunnel 17km Kamla Dam (hight) 51m Irrigation canal 152km Access road 70km	Arun No.3 Tunnel 7.1km Access road 100km SRR Type	Tama Kosi No.3 Dam(hight) 60m Tunnel 7km Access 0 PRR Tyoe	Sun Kosi No.3 Dam(hight) 140m Access road 20km Storage Type	Kulekhani No.2 (example) Tunnel 6km SRR Type
1. Project Manager	1	1	1	1	1
2. Administration Div.					
Sr. Officer	3	3	3	3	1
Jr. Officer	6	6	6	6	2
Chief Accountant	1	1	1	1	1
Accountant	6	6	6	6	6
Supporting Officer	30	10	10	10	10
3. Civil Engineering Div.					
Sr. Engineer	8	5	5	6	3
Jr. Engoneer	32	9	9	12	5
4. Electric Div.					
Sr. Engineer	3	1	1	1	1
Jr. Engineer	6	2	2	3	2
5. Mechanic Div.					
Sr. Engineer	6	2	1	2	1
Jr. Engineer	12	4	2	4	2
6. Other Technical Assistant Surveyer, Draftman Labo. Staff etc.	60	30	25	30	20
7. Total	174	80	72	85	52