HIS MAJESTY'S GOVERNMENT OF NEPAL

MINISTRY OF WATER RESOURCES

MASTER PLAN STUDY
ON
THE KOSI RIVER
WATER RESOURCES DEVELOPMENT

FINAL REPORT

Volume 2
APPENDIX I
APPENDIX II
APPENDIX III

MARCH 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

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LIST OF REPORTS

APPENDIX I

SOCIOECONOMY

APPENDIX I

SOCIOECONOMY

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX I
SOCIOECONOMY

1. GENERAL BACKGROUND OF NEPAL

1.1 Location and Natural Features

1.1.1 Location

Nepal is a small landlocked country, the greater part of which lies on the southern slopes of the Himalayan Mountains. Located between northern latitudes of $26^\circ 22'$ and $30^\circ 27'$ and eastern longitudes of $80^\circ 4'$ and $80^\circ 12'$, it is bordered by the Tibetan region of China to the north and India to the south, east and west. Its rectangular shape covers a length of roughly 850km and a width varying from 130-240km, with a total land area of 141,000km^2 (Location Map).

1.1.2 Natural Features

(1) Ecological Zones

The country can be broadly divided into three ecological zones stretching from east to west; namely, i) Mountain Zone, ii) Hill Zone and iii) Terai Zone. The Mountain Zone is situated at an altitude exceeding 3,000m including the Himalayas of Nepal which comprise eight mountains of 8,000m height, about forty mountains of 7,000m and an unknown number of mountains of 6,000m. This Zone accounts for 34% of the total area but only 5% of cultivated land.

The Hill Zone lying between 300-3,000m is a subtropical belt and occupies 43% of cultivated land. This Zone is formed by the Siwalik and Mahabharat mountain ranges. The valleys of various widths and altitudes known as the Inner Terai are enclosed between these two ranges. This Zone is covered by more than 80% of the country's forest.

The Terai Zone, lying below 300m, forms the southern belt extending along the Indian border and accounts for 23% of the total area and 65% of cultivated land. This Zone produces the bulk of the country's food grains. FIG. 1-1 provides the outline of the three ecological zones.

(2)   River Systems

There are three major river systems in the country; namely, i) Karnali; ii) Gandaki or Narayani; and iii) Kosi.   In addition, there are other small systems which do not constitute an integral part of the major systems mentioned above.   Some of the important small systems include; i) Mechi, Kankai and Kamla in Eastern Nepal, ii) Bagmati in Central Nepal, and iii) Rapti, Babai and Mahakali in Far Western Nepal.   Of the major river systems, the Kosi system drains the Eastern Development Region and parts of the Central Development Region.   These three major rivers and their tributaries constitute over 80% of the drainage area in the country.   There are over 6,000 rivers which are the tributaries and sub-tributaries of the three major and seven minor river systems noted above.

1.2   Administrative Divisions and Development Regions

1.2.1   Administrative Divisions

For administrative purposes, the country is divided into 14 zones which are comprised of 75 districts.   Each administrative zone is made up of 4-7 districts comprised of town and village panchayats.   A village panchayat is the smallest administrative unit consisting of wards.   There are a total of 14 zones, 75 districts, 29 town panchayats and 4,023 village panchayats at present in the country (TABLE 1-1).

At the national level, the Government formulates, directs and evaluates all national policies and programs of economic development.   The Zonal Commissioner is responsible for maintaining law and order in the zone while a Chief District Officer (CDO) is similarily responsible at the district level.

1.2.2   Development Regions

From the viewpoint of balanced economic growth and proper attention to regional planning, HMG established in 1973 four Development Regions, each having a primary growth center.   They are: Eastern, Central, Western and Far Western Development Regions.   The Far Western Development Region was divided into the Mid Western and Far Western Development Regions in 1980.

Mechi, Kosi and Sagarmatha zones as the basic development unit have been grouped to form the Eastern Development Region. The Region has 16 districts in all, and Dhankuta is the growth center of the same. Janakpur, Bagmati and Narayani zones have been grouped to form the Central Development Region. The Region has 19 districts in all with Kathmandu as the growth center. Gandaki, Lumbini and Dhaulagiri zones have been grouped to form the Western Development Region composed of 16 districts in all. Pokhara is the growth center of the same.

Karnali, Rapti and Bheri zones have been grouped to form the Mid Western Development Region. The Region has 15 districts, Birendranagar being the growth center of the same. The Far Western Development Region is composed of the Seti and Mahakali zones. The Region has 9 districts with Dipayal as the growth center. TABLE 1-2 presents the names of the districts in each zone, while FIG. 1-1 provides a general picture of the five Regions.

These Regions are responsible for the development activities of their respective area under the guidance of the National Planning Commission.

1.3   Population

1.3.1   Population Statistics

In Nepal before 1951, the only reliable information available came from population counts taken in 1911, 1920, 1930 and 1941. After that, population censuses in Nepal were taken in the years 1952/54, 1961, 1971 and 1981 (TABLE 1-3). According to provisional data of the 1981 census, the total population of Nepal now exceeds 15 million, of which 94% is estimated to live in rural areas. The annual rate of population growth is now estimated at 2.7% and population density is 106/km^2 of surface land and 472/km^2 of cultivable land. Age and sex composition, regional distribution of population and economically active population are presented in TABLE 1-4, 1-5 and 1-6.

1.3.2 Migration

Population has been growing at a much faster rate in the Terai Zone than in the Mountain and Hill Zones which indicates the possibility of migration from the Mountain and Hill Zones to the Terai as shown in TABLE 1-7. The reasons for the relatively high rate of migration to the Terai Zone is mainly economic. The push factors are: increasingly high man-land ratio, declining food availability, steadily deteriorating ecological balance, lesser opportunities for employment, and natural calamities which cause increasing damage because of environmental degradation in the Mountain and Hill Zones.

1.3.3 Population Projections

Population projection for Nepal to the year 2030 was carried out by the Population Commission based on the results of a 1971 census and population statistics in other years. As a result, the population of Nepal is estimated to reach 26.8 million in 2005 and 30.4 million in 2010 according to the medium variant (TABLE 1-8).

1.4 Economic Structure

1.4.1 Agriculture

Agriculture is the mainstay of Nepal's economy; in 1980, this sector accounted for about 60% of GDP, over 90% of employment and nearly 80% of export earnings. In the agricultural sector, food grain production is the most important component, which amounts to about 60% of total agricultural output. The main food grains produced are rice, maize, wheat and millet. Paddy is the most important food grain in Nepal, occupying 62% of total production and 50% of the total cropped area as shown in TABLE 1-9. Except for wheat, the production of food grains has not shown any significant increase in the last five years (TABLE 1-10).

Major cash crops are oilseeds and potatoes in the Hill Zone, and jute, sugar cane and tobacco in the Terai Zone. Major agricultural exports include jute, hides and skins and a number of minor commodities (TABLE 1-11). Rice export declined from a high level of 160,000t in 1975/76 to 36,000t in 1981/82 and no exports were recorded after July 1982 when HMG imposed restrictions on export of the same (TABLE 1-12 & FIG. 1-2).

In spite of the importance of the agricultural sector in Nepal's economy, the national resource base for crop production is severely limited due to topography. Only 22% of the total physical area of the country is used for crop cultivation (TABLE 1-13). Despite an abundance of water, less than 15% of the cultivated area has irrigation facilities, and these are of varying qualities and standards.

As discussed in APPENDIX V, there is a slight increase in total crop production, while the productivity of some of the crops is found to be decreased. Hence, production increase is obviously due to increase in the cultivated area. Now, Nepal has exhausted nearly all virgin land and virtually no additional land is available as new cultivable land. Therefore, Nepal must increase agricultural productivity of the land through intensive cultivation. The productivity of agriculture can be increased only through irrigation facilities, greater application of inputs such as chemical fertilizers and pesticides, and increased knowledge of modern technology among farmers.

1.4.2 Industry

The role which the manufacturing industry plays in the national economy is marginal. The industrial sector (manufacturing and mining) accounts for only 4% of the GDP and provides employment to 1% of the working population. Agro-processing units such as rice husking, wheat milling, oil extracting, jute processing and sugar refining predominate in the industrial sector. Oil and grain mill products occupy more than 80% of the total gross output in the country. Among agro-processing industries, rice mills exist in almost all the important production centers.

TABLE 1-14 indicates the distribution of industrial units, number of personnel employed, the amount of capital invested and the annual value added in all the four Development Regions in the 1976/77 fiscal year. Out of 3,528 industrial units, 745 or 21% were located in the Eastern Development Region, 1,787 or 51% in the Central Region, 665 or 19% in the Western Region and 331 or 9% in the Far Western Region. The Eastern and Central Regions dominated industrialization because of their distinct advantage in transport and communication facilities and access to raw materials from local as well as foreign markets.

1.5   Economic Situation

1.5.1   GDP Growth

GDP growth rate during the Fifth Plan (1975/76-1979/80) showed an annual average rate of only 2.1% against the target of 5%. Compared with the annual population growth rate of 2.66% during the same period, performance of the economy during this period was unfavourable (TABLE 1-15). The cause of the slow GDP growth rate was a decline in total agricultural production by 5.3% during the period.

The performance of the economy in the first two years of the Sixth Plan was favourable. GDP increased by 5.6% in 1980/81 and 3.8% in 1981/82. In the third year of 1982/83, however, production in the agricultural sector declined by 9.7% and this had an adverse effect on prices, foreign trade, balance of payments and foreign exchange reserves. Thus, GDP in 1982/83 registered a decline of 1.3%. Details on GDP and main economic indicators for a five year period are given in TABLE 1-16.

1.5.2   Foreign Trade and Balance of Payments

Since Nepal is landlocked, India has traditionally been the main outlet for Nepal's export of surplus food grains. It has also been the main source of imports of consumer goods. The need for earning convertible currency for importing machinery and other development goods, and reducing its dependence on a single source has led Nepal to embark upon a policy of diversification of trade. This policy has brought a dramatic change in the direction of Nepal's trade as can be seen from TABLE 1-17.

Rice, raw jute and jute products were the most important export items and accounted for about three-fourths of the total export value. Other agricultural exports included maize, potatoes, pulses, oilseeds, tobacco, timber, pigs, cattle, butter, hides and skins as well as ginger and cardamom. Nepal's imports of agricultural products, food and live animals, tobacco and beverage, and oils and fats increased from Rs.269 million in 1975/75 to Rs.633.6 million in 1981/82. Furthermore, Nepal must import all its chemical fertilizers and pesticides as well as a major part of all agricultural equipment.

In spite of the huge trade deficit, Nepal has had a surplus in balance of payments mainly because of a favorable position in the services and transfer account and an expanding flow of foreign assistance (TABLE 1-18).

1.5.3 Energy Situation

The structure of energy consumption for fuel in the country is indicated in TABLE 1-19. In 1978/79 non-commercial sources of energy accounted for about 94.4% of the fuel consumed. Consumption came from firewood (91.8%), vegetable waste (1.9%) and animal dung (0.7%). Commercial energy sources accounted for 5.6% of the total consumption with petroleum products as the main source. In recent years, alternative sources of energy, e.g., biogas plants, hydraulic turbines, etc. have been developed. However, the supply from these sources is minimal.

The main use of fuel is for domestic purposes. Although the overall demand for fuel for agricultural use is very small, the use of energy for agriculture has been steadily increasing in recent years on account of the modernization of the sector. In addition to fuel for running farm equipment and processing, the agriculture sector's need for energy and energy-based products include production inputs such as fertilizer and chemicals. So far locally produced manures still account for the major part of fertilizer inputs, but the use of chemical fertilizers has been increasing rapidly.

Nepal has abundant water resources. If these water resources are properly controlled and developed, theoretically, they could provide for the total irrigation needs of Nepal and generate 20,000-25,000MW of hydroelectricity. Full utilization of the potential requires surface water storage which would substantially increase opportunities for large scale year-round irrigation and flood control as well as hydropower generation for domestic consumption and export.

The Sixth Plan gives high priority to power generation with the objectives of: i) meeting the growing demands of the different sectors, ii) increasing domestic use of electricity to reduce the need for fuelwood and resulting depletion of forest resources, iii) promoting electric transport systems aimed at reducing the use of petroleum, and iv) creating

a surplus for generating foreign exchange earnings via export. The Plan emphasizes multipurpose development of water resources for power and irrigation where possible, and development of small hydropower projects to serve the needs of the Hill areas.

1.6 Economic Development Plans

1.6.1 Development Performance

Nepal launched its initial development plan in the mid-1950s with the inauguration of the First Five-Year Plan in 1956/57. Since then, the country has continued with planned development efforts through the formulation and implementation of four five-year plans and a three-year plan. Data on plan periods and development expenditures and the amount of foreign aid received are given in TABLE 1-20. Despite more than two decades of development efforts, the country has not been able to make any significant progress in raising domestic output. GDP during the last three Five-Year Plans has risen only by an average annual rate of 2.2%, as against a population growth of 2.66% per annum.

1.6.2 Sixth Plan

The objectives of the Sixth Plan, initiated in 1980, are: i) to increase production at a faster rate, ii) to increase productive employment opportunities, and iii) to meet the minimum needs of the people. In order to achieve these objectives, the following development strategies have been laid down: i) according priority to agricultural development, ii) emphasizing the development of cottage and small industries, iii) laying stress on export trade and development of tourism, iv) laying stress on the conservation of natural resources and wealth and development of water resources, v) emphasizing full utilization of infrastructures already created, vi) increasing the absorptive capacity of the economy, and vii) controlling population growth.

To help attain the Plan's objectives, real GDP growth rate has been targeted for an average rate of 4.3%/year, with agricultural GDP growing at 3.2%/year. The allocation of development expenditure in the Fifth and Sixth Plans is presented in TABLE 1-21. It is noteworthy that the irrigation subsector and power subsector showed substantial increases in the Sixth Plan compared to the Fifth Plan.

1.6.3 Development Expenditures and Foreign Aid

Nepal launched its initial development plan in 1956 and foreign aid supported the whole of the government's development expenditure during the First Plan (1956/57-1960/61). Gradually, as the country built up its capacity to raise domestic resources, the ratio declined to 56% during the Third Plan period (1965/66-1969/70) and further to 46% during the Fourth and Fifth Plan periods (1970/71-1979/80). However, as the rate of growth in Government revenue has been slow in comparison to the growth in development expenditure, the ratio is projected to increase to 61% during the Sixth Plan period (1980/81-1984/85) as presented in TABLES 1-20 and 1-22.

2. SOCIOECONOMIC CONDITIONS IN THE STUDY AREA

2.1 Administrative Setup

The Study area is situated in the eastern part of Nepal, occupying about 30% of the total land area and about 40% of the total population in the country. Administratively, the Study area consists of 24 districts, out of which 4 districts belong to the Mechi zone, 6 districts to the Kosi zone, 6 districts to the Sagarmatha zone, 6 districts to the Janakpur zone and 2 districts to the Bagmati zone. The total physical area of 24 districts is 41,674km^2 with a population of 5.94 million in 1981 (TABLE 1-23). FIG. 1-3 presents the administrative divisions within the Study area.

Each district is directed by the Local Development Officer (LDO) who is an official of the Ministry of Panchayat and Local Development. The LDO occupies the position of the Secretary to the district panchayat and is responsible for maintenance of law and order and coordination of development activities of different departments. Each district is divided for administrative and political purposes into about 50-90 village (gaon) panchayats and each of these into nine wards (consisting of between 8 and 150 households).

2.2 Demographic Conditions

2.2.1 Population Distribution by District

Population of 24 districts in the Study area is estimated to be 5.94 million in 1981, with 2.63 million in the Mountain and Hill Areas and 3.31 million in the Terai Area (TABLE 1-24). The population increased from 4.51 million in 1971 to 5.94 million in 1981 with an average growth rate of 2.78% per annum. Population growth rate of the 16 districts in the Mountain and Hill Areas was 1.37%/annum during 1971-81, while that of the 8 districts in the Terai Area was 4.08%/annum during the same period. The higher rate of population growth in the Terai Area is mainly because of migration from the Mountain and Hill Areas (TABLE 1-25).

2.2.2 Population Density

The Study area is divided into three major topographic and ecological areas: Mountain Area in the north, Hill Area in the mid-land and Terai Area in the south. The population density is

143/km^2 of physical area and 441 persons/km^2 of cultivable land in the 24 districts of the Study area. Eight districts in the Terai with 10,864km^2 of physical land occupy 7,281km^2 or 54% of the total cultivable land in the Study area. Details of the Study area including population are shown in TABLE 1-23.

2.2.3 Population Projection

According to the population projection made by APROSC, the population of the Eastern and Central Development Regions is estimated to grow to 6.77 and 8.15 million, respectively (TABLE 1-26). Based on this estimate, the population of the Study area (24 districts) is estimated to grow at an average annual rate of 3.1% to 11 million by 2001 (TABLE 1-27).

2.2.4 Demography in the 8 Terai Districts

The Study area for irrigation and agricultural development planning is the Terai Area between Bagmati and Kankai rivers which consists of the 8 districts of Jhapa, Morang, Sunsari, Saptari, Siraha, Dhanusha, Mahottari and Sarlahi. These 8 districts are divided into two parts; namely, the western area of the Sapt Kosi and the eastern area of the same river.

The 8 districts have a population of 3.3 million (1981), about 22% of the whole country, with a population density of 303/km^2 of physical area and 454/km^2 of cultivable land. About 81% of the families are farm households with a family size of 5.67. The details of demographic conditions in these districts are presented in TABLE 1-28.

2.2.5 Labor and Employment

According to official statistics, about 66% of the population of 10 years and older is considered to be economically active. Based on this estimate, the economically active population in the Study area is estimated to be about 2.7 million in 1981 and is expected to grow to about 5 million by 2001.

Employment patterns at national and regional levels was surveyed by the National Planning Commission in 1976/77. It was found from survey

results that 79% of the economically active population is employed as farm/fish workers followed by 6.9% as production labor workers, 6.9% as clerical workers, 3.5% as sales workers, and 2.4% as service workers and others at the national level. At the regional level, farm/fish workers constituted 85% of the economically active population in rural areas and 35% in urban areas of the Eastern Development Region and 84% and 30% in the Central Development Region (TABLE 1-29).

Persons falling into the economically active population category (age 10 and above) but without participation in any main or subsidiary occupation are defined as unemployed. At the national level, 5.3% of males and 6% of females fall into the unemployed category. For both sexes, unemployed constitute 5.6% of the total labor force. At the regional level rural unemployment for both sexes is higher than the national average percentage (5.6%) of the Central Development Region and lower than the national average in the Eastern Development Region. Urban unemployment for both sexes is higher than the national average (6%) for both the Eastern and Central Development Regions.

Based on the survey report mentioned above, about 85% of the economically active population in the rural areas and about 35% in the urban areas of the Study area are estimated to be employed in the agricultural sector.

2.3 Agriculture and Industry

2.3.1 Agricultural Situation

Out of the gross land area of 41,700km^2 in the Study area, about 13,479km^2 is estimated to be under cultivation. The sixteen districts in the Mountain and Hill Areas which have a gross land area of 30,810km^2 occupy only 6,198km^2 of the cultivable land. The eight districts in the Terai Area on the other hand, which have a physical area of only 10,890km^2, occupy 7,281km^2 or 67% of the cultivable land in the Study area (TABLE 1-23).

The Study area contributes significantly to the national economy in supplying about 36% of total food grains and about 40% of total cash crops in the country. Food grain production in the Study area in 1982/83 was 689,710t paddy, 195,540t wheat, 254,760t maize, 44,110t millet and

3,270t barley which correspond to 37%, 34%, 35%, 36% and 16% of the total production in Nepal, respectively. Major cash crops in the Study area are oilseeds, potatoes, sugar cane, jute and tobacco. Approximately 60% of oilseeds, 72.1% of potatoes, 68.3% of sugar cane, almost 100% of jute and 94.9% of tobacco are produced in the 24 districts of the Study area.

The present situation of agriculture in the Study area is discussed in detail in APPENDIX V.

2.3.2 Industries

The industrial sector in Nepal accounts for about 5% of the GDP and provides employment to only 1% of the working population. About 70% of industrial output comes from formal manufacturing which mainly consists of public enterprises. The other 30% derives from cottage and small industries.

According to the census of manufacturing establishments conducted in 1976/77, there are 1,289 manufacturing establishments in the Study area, of which 1,040 (83% of the total) were oil and grain mills (TABLE 1-30). Activities of other mentionable establishments include baking, sugar refining, tea packing, yarn and textile, carpet and rugs, footwear, sawmills, printing, soaps, jute processing, ice, furniture, cigarette factory and bricks. It is also observed that about 33% of the manufacturing establishments in Nepal are concentrated in the 8 Terai districts of the Study area and that 3 out of 4 large establishments with more than 1,000 working persons are situated in this area, one in Janakpur and two in Biratnagar (TABLE 1-31). Number of manufacturing establishments with and without a power supply are presented in TABLE 1-32.

Major public enterprises in the Study area are Janakpur Cigarette Factory Ltd. (Janakpur), Nepal Tea Development Corporation Ltd. (Illam), Raghupati Jute Mills Ltd. (Biratnagar) and Chandeswari Textile Industry Ltd. (Kavrepalanchok).

2.4 Infrastructure

2.4.1 Roads

Transportation in the Study area depends mainly on road traffic. The East-West Highway runs through the Terai Area, providing all weather

access along the proposed irrigation area. This highway is well maintained and plays a major role in transport of both goods and passengers. There are some other highways connecting major towns in the Terai Area such as the Biratnagar-Dhankuta Road, and Jaleswar-Janakpur Road (FIG. 1-4). However, the transportation system in the Mountain and Hill Areas is very poor. Most of these areas have not been covered by the national transportation network system, except for the Kathmandu-Kodari Road along the upper reaches of the Sun Kosi River. Typical transportation in these areas is by footpath and people spend days in walking, sometimes fording rivers to reach their destination.

In order to improve the present limited transportation system in the Mountain and Hill areas, the HMG intends to construct an east-west highway along the Sun Kosi and Tamur rivers. However, it may take quite some time to complete the road due to the substantially large construction cost.

2.4.2 Airports

Air travel seems to be the only practical way to reach many hilly areas. The number of airfields serving the Hill Area is almost double those serving the Terai Area. However, most of the airfields in hilly areas are seasonal and all airfields in the hill areas are of the STOL and consequently can not accomodate large aircrafts. There are twelve (12) airfields in the Study area as of Aug. 1980, out of which only two airports, namely Biratnagar and Janakpur, can accomodate large aircraft.

2.4.3 Railways

Nepal has, at present, only two railway lines: i) Raxaul (a border town of India) to Birganj and ii) Jayanagar (India) - Janakpur. A major portion of Nepal's imports from overseas are consigned from Calcutta to the railheads nearest the Nepalese border on Indian railways, and from there on trucks to towns on the Nepalese side of the border. The more important of these transit links are: i) Jogbani (India) - Biratnagar, ii) Raxaul (India) - Birganj, iii) Nautanawa (India) - Bhairawa, and iv) Rupaidiyah (India) - Nepalganj.

2.4.4 Ropeways

There is a 42km long ropeway between Kathmandu and Hetauda having a capacity of 22t/h. Until the early 1950s the ropeway played an important role as the only means of transport other than porters in carrying trade between India and the Kathmandu valley. At present, the ropeway is a poorly utilized transport facility in Nepal. It has been the policy of the HMG to develop north-south ropeways operated by electric power. Some feasibility studies have been undertaken for ropeways in the different Regions which include Dhankuta-Bhojpur Ropeway in the Eastern Development Region.

2.4.5 Waterways (Navigation)

Possibilities of navigation on three of the large rivers of Nepal, i.e., Kosi, Narayani and Karnali, to the Bay of Bengal are planned to be further explored and studied as they would greatly reduce costs involved in transportation of goods to and from India. At present, these and other rivers are being used only to a very limited extent for local transportation. Possibilities of navigation on the Kosi River are discussed in detail in APPENDIX VI.

3. ECONOMIC ANALYSIS

3.1 Introduction

Projects or schemes are generally evaluated from various aspects such as technical, institutional, social, financial, economic and others. This chapter primarily deals with the methodology and basic assumptions for the economic evaluation of the schemes identified in the Master Plan.

3.2 Methodology

3.2.1 General

The benefit-cost analysis of projects or schemes is usually based on the economic benefits and costs to identify those projects which would make greater contributions to the overall economy of a country. The project which gives the maximum net return to invested capital is generally given the highest priority. This approach assumes, therefore, that capital is the limiting factor to accelarating economic development and growth. The benefit-cost analysis method was extensively used in the Study for comparing the alternative schemes.

3.2.2 B/C and B-C Criteria

There are three methods commonly used in benefit-cost analysis of development schemes financed by lending agencies. These analyses are the Benefit/Cost Ratio (B/C), the Net Present Value (NPV or B-C) which is sometimes referred to as the Net Present Worth, and the Internal Rate of Return (IRR).

B/C ratio is calculated by summing up the present values of costs over the project's life and comparing these with the sum of the present value of benefits and expressing the comparison as a ratio. A general definition of B/C ratio is:

$$B/C = \frac{\text{Sum of Discounted Tangible Incremental Benefits}}{\text{Sum of Discounted Tangible Incremental Costs}}$$

According to the philosophy of this criterion, any project with the higher discounted sum of benefits than the discounted sum of its cost is profitable and deserves to be carried out. In principle, therefore, all projects having the ratio of greater than 1 may be carried out. Priority given to projects with the highest ratios.

The B-C (NPV) of a project is the sum of all expected benefits over time less the expected costs, discounted at a given discount rate. As with the B/C ratio, a rate is normally chosen which is thought to be close to the opportunity cost of capital. It is normal practice to calculate the B-C at discount rate between 8-15%, 12% being a frequent choice. With the B-C method, no ranking of non-mutually exclusive alternative project is possible, as B-C is an absolute, not a relative measure.

The IRR of a project is the discount rate which when applied to the cost and benefit streams, will make the B/C ratio 1:1 and the B-C equal to zero. It is a measure, expressed in percentage terms, of the return to capital employed on a project.

In the Master Plan Study, economic viability of each project was assessed by calculating B/C ratio. B/C ratio was treated as the main indicator to determine the economic viability of each project.

3.2.3 Basic Parameters for Benefit-Cost Analysis

(1) Appropriate Discount Rate

Before discounting the benefits and costs streams, it is necessary to chose the discount rate or rate to apply. International lending institutions generally favor using a real discount rate of 12% per annum. In view of the fact that numerous other development studies in Nepal have utilized the rate of 12%, the basic economic analysis in the Study utilized the same discount rate.

(2) Economic Life of Proposed Project

The economic life of each project was taken to be equal to the assumed life span of the major works to be constructed, i.e. 50 years after the completion of the construction works.

(3) Exchange Rate and Price Level

The monetary measurement used for the evaluation of benefits and costs is Nepalese Rupees at the end of 1983. A foreign exchange rate of NRs. 15.60 against US$1 was fixed based on the official exchange rate at the end of 1983.

(4)   Economic Prices of Farm Input and Output

Economic prices of farm input (chemical fertilizers) and output (paddy, wheat, jute and maize) were calculated on the basis of world market price projections estimated by the World Bank in 1982. World market price of each item was adjusted to the farm gate price taking account of quality, international shipping and handling, inland transport cost, processing ratio and other related factors (TABLE 1-33).

(5)   Economic Labor Cost

Economic cost of farm labor was estimated to be 50% of actual market wage rate considering the status of employment opportunities in each of the project areas. Economic labor cost of the construction works was assumed to be the same as the actual wage rate.

(6)   Construction Period

All construction periods of hydropower schemes were assumed to be 5 years. The disbursement schedule was assumed to be 10% for the first year, 20% for the second year, 30% for the third and fourth year, and 10% for the fifth year. The construction periods of irrigation schemes were assumed to be 5 years and 9 years depending on project scale.

3.2.4   Economic Costs

Preliminary cost estimates were prepared for all schemes considered in the Master Plan based on 1983 price levels. It was assumed that the schemes would have an economic life of fifty (50) years from the commissioning dates and that at the end of their economic life, they would have no residual value. The components of economic costs are presented below.

Hydropower Schemes

a) the capital cost of construction in constant 1983 prices less duties and taxes; The capital cost consists of direct construction cost, engineering service and government administration costs, compensation cost and physical contingency;

b) the annual cost of operation and maintenance assumed at 1.5% of the capital cost;

c) the cost of replacement of electric and mechanical equipment assumed at 50% of the construction cost, to be disbursed in the 26th year after the completion of the construction works; and

d) no allowance made for price escalation and interest during construction.

Irrigation Schemes

a) the capital cost of construction in constant 1983 prices less duties and taxes;

b) the annual cost of operation, maintenance and replacement assumed at 3% of the direct construction cost;

c) no allowance made for price escalation and interest during construction.

3.2.5 Economic Benefits

Ideally the economic benefits should include both tangible and intangible benefits. However, only direct tangible benefits were identified for calculation of the B/C ratio from the accounting viewpoint. Effects of indirect and intangible benefits are considered in the priority evaluation system.

(1) Economic Power Benefit

Economic benefits to be derived from the hydropower projects were estimated on the basis of the least-costly alternative power cost criterion. The coal-fired thermal plant of 100MW unit capacity was selected as the best alternate source of power (APPENDIX IV). Economic power benefits consist of capacity benefit (kW-value) and energy benefit (kWH-value), which are also estimated in APPENDIX IV.

The total power benefit of each hydropower scheme is calculated by the formula on the following page.

Total annual benefit = (maximum output x kW-value) x

(annual energy output x kWh-value)

(2) Economic Irrigation Benefits

Economic benefits to be derived from the irrigation schemes were estimated by the "with" and "without" comparisons. The costs and benefits that will arise "with" the proposed project are identified and compared with the situation as it would be "without" the project. The difference is the incremental net benefit arising from the project investment. The net incremental benefit is measured by comparing the net production value of agricultural output under future "with" project situation against "without" project situation. Net production values of agricultural output under future "with" and "without" situations are presented in TABLE 1-34.

The net incremental value of production of various crops would arise from the increase in:

a) cropping intensity from 131.7% (west area) and 135.6% (east area) to 216% (both areas with project); and

b) crop yields, resulting from improved seeds, improved farming practices and irrigation.

Net incremental value of production per ha, i.e. net annual benefit per ha, was calculated as follows (see also TABLE 1-35 and 1-36):

- Sapt Kosi east area: NRs 12,445 or US$798.40/ha
- Sapt Kosi west area: NRs 13,046 or US$836.28/ha

The annual benefits of an irrigation scheme are measured multiplying the above figures by the irrigation area.

3.3 Schemes Proposed in the Master Plan

3.3.1 Objective of the Master Plan

As defined in the S/W, the objective of the Study is to prepare a comprehensive water resources development plan for the Kosi River Basin taking into consideration hydroelectric generation, irrigation, flood control navigation and other potentials including inter-basin development schemes. The ultimate objective of the Kosi Master Plan is optimum utilization of water resources in the Kosi River Basin for the purpose of

economic growth and social improvement of the people in Nepal. To achieve this goal, the Study has been carried out to inventory the resources of the Basin, and to ascertain the needs and the possiblities for Basin development in order to meet those needs.

3.3.2 Planning Procedure

For the formulation of the Master Plan, the planning procedure as set in below was adopted.

(1) Clarification of Development Strategy and Needs

The development strategy in the fields of water resources development covering hydroelectric generation, irrigation, flood control, navigation and other potentials was examined and the development needs for each sector were clarified after careful review of the existing data and information.

(2) Identification of Possible Projects

Based on the existing data and information, site identification study was conducted and possible projects for each sector were identified for further detailed field survey.

(3) Field Investigation and Project Formulation

Field investigation was conducted on the identified project sites and alternative schemes covering hydroelectric generation, irrigation and other potentials were formulated.

(4) Master Plan Formulation

The identified alternative schemes were compared and evaluated considering technological and economic aspects. From all the identified schemes, the plans which are consistent with sound engineering and economic principles and the policies of HMG were selected as priority schemes (APPENDIX IV). Among the priority schemes, priority schemes to meet immediate needs in Nepal were finally selected for early construction. The implementation schedule of top priority schemes was examined and formulated taking into consideration balanced and orderly development of the water resources in the Basin.

3.3.3 Sectoral Development Schemes

(1) Hydropower

As mentioned in APPENDIX IV, 52 hydropower schemes were formulated in the Kosi Basin and 2 hydropower project sites were identified in the Kamla basin for possible multipurpose schemes. The 52 hydropower schemes include 5 project sites for possible multipurpose schemes in combination with other components such as irrigation and flood control. Hydropower schemes identified in the Kosi Basin are listed in TABLE 1-37.

All the identified hydropower schemes in the Basin were compared and evaluated based on the project priority system (Priority Evaluation Table in APPENDIX IV). As a result, the following 13 schemes were selected as prospective hydropower schemes for the formulation of the Master Plan.

HYDROPOWER PRIORITY SCHEMES

No.	Scheme	Evaluated Point	Installed Capacity (MW)	Construction Cost Including Access Road (mill. US$)	Remarks
1.	Sapt Kosi	371	3,489	2,721	For Export
2.	Arun No.3	336	240	268	
3.	Arun No.2	331	239	292	
4.	Sun Kosi No.1	315	1,357	1,051	For Export
5.	Sun Kosi No.3	313	536	582	
6.	Sun Kosi No.2	312	1,110	1,027	For Export
7.	Arun No.1	307	146	277	
7.	Bhote No.1	307	64	89	
9.	Tama Kosi No.3	301	123	206	
9.	Tamur No.1	301	696	846	
11.	Tama Kosi No.2	299	196	245	
11.	Khimte No.1	299	49	66	
13.	Dudh Kosi No.1	295	227	449	

(2) Irrigation

As a result of optimization study (APPENDIX V), the following 3 irrigation systems were determined as optimum irrigation development plans in the Master Plan. Considering that the Study is defined in terms of effective development of the Kosi River, irrigation schemes which are not based on diversion from the same were not included in the Master Plan.

Schemes	Command Area (ha)	Water Source
Sun Kosi Diversion	175,100	Sun Kosi River diversion to the Kamla
Sapt Kosi West Irrigation	17,100	Sun Kosi River diversion to the Trijuga
Sapt Kosi East Irrigation	59,350	Tamur River diversion for the Sapt Kosi East Area

As shown in TABLE 1-38, the Sun Kosi Diversion Scheme was given the first priority in terms of irrigation development given its high economic return.

(3) Flood Control, Navigation and Others

No definite schemes were identified in terms of flood control, navigation and other potentials due mainly to the limited data base available. Potential studies, however, were conducted for flood control, navigation, inland fishery and tar irrigation to provide suggestions for further investigations.

3.3.4 Multipurpose Development Schemes

For the integrated use of water resources, the potential for multipurpose schemes was studied (APPENDIX IV and APPENDIX V). As a result, the Sun Kosi Multipurpose Scheme was formulated as one of the priority schemes in the Master Plan. The Scheme consists of the Sun Kosi Diversion Scheme (Phase I) and the Sun Kosi No.3 Scheme (Phase II).

3.3.5 Economic Evaluation of Each Priority Scheme

Priority schemes proposed in the Master Plan consist of 10 hydropower schemes for domestic power supply, 3 hydropower schemes for power export and the Sun Kosi Multipurpose Scheme (Phase I). Economic evaluation of each scheme is summarized in TABLE 1-39 (see also APPENDIX IV and APPENDIX V).

TABLE 1-1   NUMBER OF ZONES, DISTRICTS, VILLAGE
PANCHAYATS AND TOWN PANCHAYATS BY DEVELOPMENT REGIONS

Development Region	Zone	District	Village Panchayat	Town Panchayat
Eastern	3	16	907	8
Central	3	19	1,242	10
Western	3	16	896	5
Mid Western	2	15	581	3
Far Western	2	9	397	3
Total	14	75	4,023	29

Source: Ministry of Panchayat and Local Development

TABLE 1-2   DEVELOPMENT REGIONS, ZONES AND DISTRICTS OF NEPAL

Region	Zone	District	
EASTERN	Mechi	1. Taplejung	3. Ilam
		2. Panchthar	4. Jhapa
	Kosi	5. Sankhuasabha	8. Dhakuta
		6. Bhojpur	9. Sunsari
		7. Tehrathum	10. Morang
	Sagarmatha	11. Solukhumbu	14. Udayapur
		12. Okhaldhunga	15. Saptari
		13. Khotang	16. Siraha
CENTRAL	Janakpur	17. Dolakha	20. Dhanusha
		18. Ramechhap	21. Mahottari
		19. Sindhuli	22. Sarlahi
	Bagmati	23. Rasuwa	27. Lalitpur
		24. Dhading	28. Bhaktapur
		25. Nuwakot	29. Kavre
		26. Kathmandu	30. Sindhupalchok
	Narayani	31. Makwanpur	34. Bara
		32. Chitwan	35. Rautahat
		33. Parsa	
WESTERN	Gandaki	36. Manang	39. Gorakha
		37. Lamjung	40. Kaski
		38. Tanahu	41. Syangja
	Lumbini	42. Gulmi	45. Nawalparasi
		43. Arghakhanchi	46. rupandehi
		44. Palpa	47. Kapilvastu
	Dhawalagiri	48. Mustang	50. Baglung
		49. Myagdi	51. Parbat
MID WESTERN	Karnali	52. Humla	55. Jumla
		53. Mugu	56. Dolpa
		54. Kalikot	
	Rapti	57. Rukum	60. Pyuthan
		58. Salyan	61. Dang
		59. Rolpa	
	Bheri	62. Dailekh	65. Banke
		63. Jajarkot	66. Bardiya
		64. Surkhet	
FAR WESTERN REGION	Seti	67. Bajhang	70. Achcham
		68. Bajura	71. Kailali
		69. Doti	
	Mahakali	72. Darchula	74. Dandeldhura
		73. Baitadi	75. Kanchanpur

Note: The Study area of the Master Plan is included in the Mechi, Kosi, Sagarmatha, Janakpur and Bagmati Zones.

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

TABLE 1-3   POPULATION GROWTH

Census Year	Population	Average Annual Growth (%)
1911	5,638,749	-
1920	5,573,788	-0.14
1930	5,532,574	-0.08
1942	6,283,649	1.16
1952/54 1/	8,256,625	2.51
1961	9,412,996	1.65
1971	11,555,983	2.07
1981	15,020,451	2.66

Source: Central Bureau of Statistics

1/ The population census was conducted in two stages; the eastern
    part of the country was enumerated in 1952 and the western
    part in 1954.

TABLE 1-4

AGE AND SEX COMPOSITION OF POPULATION
(Percentage)

Year / Age Group	1971			1976			1981		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
0-4	13.6	14.7	14.1	15.6	15.4	15.5	15.4	15.2	15.3
5-9	15.2	14.9	15.1	12.9	12.9	12.9	13.2	13.0	13.1
10-14	12.1	10.4	11.2	12.5	12.1	12.3	11.3	11.3	11.3
15-19	9.4	8.7	9.1	10.5	9.7	10.1	11.0	10.7	10.9
20-24	8.0	8.8	8.4	8.3	7.9	8.1	9.2	8.4	8.8
25-29	7.8	8.3	8.1	7.0	7.4	7.2	7.2	6.8	7.0
30-34	6.6	7.4	7.0	6.4	6.9	6.7	6.1	6.4	6.2
35-39	6.6	6.2	6.4	5.8	6.2	6.0	5.5	6.0	5.7
40-44	5.2	5.4	5.3	5.2	5.4	5.3	5.0	5.4	5.2
45-49	4.2	3.8	4.0	4.4	4.4	4.4	4.4	4.6	4.5
50-54	3.5	3.4	3.5	3.5	3.4	3.4	3.6	3.7	3.6
55-59	2.3	2.2	2.2	2.6	2.6	2.6	2.8	2.8	2.8
60-64	2.4	2.7	2.5	2.0	2.0	2.0	2.0	2.1	2.0
65-69	1.2	1.2	1.2	1.6	1.9	1.7	1.4	1.5	1.5
70	1.8	1.9	1.8	1.7	1.8	1.8	1.9	2.1	2.1
All Ages	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
No. of Persons	5,817,203	5,738,780	11,555,983	6,426,280	6,410,738	12,873,018	7,599,046	7,421,405	15,020,451

Source: (1) 1971 Census
(2) 1976 Mid-term Population Sample Survey
(3) 1981 Preliminary Census Results

TABLE 1-5   REGIONAL DISTRIBUTION OF POPULATION

Year	1971		1976		1981	
	Persons	% of Total	Persons	% of Total	Persons	% of Total
Eastern Region	2,797,500	24.21	3,067,086	23.90	3,703,848	24.65
Central Region	3,865,753	33.46	4,319,601	33.65	4,915,907	32.74
Western Region	2,465,540	21.33	2,712,781	21.13	3,135,554	20.88
Mid-Western Region	1,468,896	12.71	1,675,825	13.05	1,953,309	13.00
Far-Western Region	958,294	8.29	1,061,725	8.27	1,311,833	8.73
Total	11,555,983	100.00	12,837,018	100.00	15,020,451	100.00
Mountains	1,138,610	9.85	1,214,494	9.46	1,291,073	8.59
Hills, of which:	6,080,407	52.62	6,698,888	52.18	7,436,100	49.51
Kathmandu Valley	(618,912)	(5.36)	(692,555)	(5.39)	(766,820)	(5.11)
Terai	4,336,966	37.53	4,923,636	38.36	6,293,278	41.90

Note: In November 1981, the old Far-Western Region was divided into the Mid-Western and the Far-
         Western Regions.
         In this table, the 1971 and 1976 populations of the old Far-Western Region were
         disaggregated into Mid-and Far-West using zonal population data.

Source: Central Bureau of Statistics.

TABLE 1-6 ECONOMICALLY ACTIVE POPULATION CLASSIFIED BY INDUSTRY, OCCUPATION, AND EMPLOYMENT STATUS

Year	1971		1976	
	Persons Engaged ('000)	% of Total Engaged	Persons Engaged ('000)	% of Total Engaged
Industry				
Agriculture, Forestry & Fishing	4,579	94.35	5,572	89.90
Manufacturing	52	1.07	42	0.68
Electricity, Gas & Water	2	0.04	2	0.03
Construction	5	0.10	5	0.08
Commerce	64	1.32	283	4.57
Transport & Communications	10	0.21	6	0.10
Financial & Business Services	3	0.06	8	0.13
Personal & Community Services	138	2.84	280	4.52
Occupation				
Professional & Technical	25	0.52	229	3.69
Administrative	1	0.02	4	0.06
Clerical	47	0.97	55	0.89
Sales	60	1.24	70	1.13
Services	34	0.70	21	0.34
Farming & Fishing	4,579	94.37	5,490	88.58
Production & Labor Workers	106	2.18	329	5.31
Employment Status				
Self-employed	4,170	85.93	4,295	59.16
Employee	453	9.33	763	12.31
Unpaid Family Workers	208	4.29	1,083	17.48
Employer	22	0.45	65	1.05

Source: Central Bureau of Statistics.

TABLE 1-7   POPULATION CHANGE BY ECOLOGICAL ZONES

		Population in 1971	Population in 1981	Annual Population Growth Rate (%)
1.	Western Mountains and Hills	1,748,305	2,002,926	1.37
2.	Central Mountains and Hills	2,277,831	2,652,298	1.53
3.	Eastern Mountains and Hills	2,036,240	2,283,687	1.15
	Sub-total:	6,062,376	6,938,911	1.36
4.	Western Terai	697,995	1,262,216	6.10
5.	Central Terai	942,520	1,458,513	4.46
6.	Eastern Terai	3,234,181	4,593,991	3.57
	Sub-total:	4,874,696	7,314,720	4.14
7.	Kathmandu Valley	618,911	766,820	2.17
	Nepal	11,555,983	15,020,451	2.66

Source: 1.   Population census 1971
          2.   Population census 1981 (Preliminary)
          3.   Population Increase in Nepal 1971-1981,
               Dr. Harka Gurung, March 1982

TABLE 1-8   POPULATION PROJECTIONS TO YEAR 2030

Unit: '000

Year	Very High (1)	Medium (2)	Low (3)	Very Low (4)
1975	12,840	12,840	12,840	12,840
1980	16,640	14,640	14,640	14,640
1985	16,710	16,510	16,360	16,240
1990	19,270	18,630	18,110	17,700
1995	22,450	21,010	19,840	18,930
2000	26,410	23,650	21,420	19,710
2005	31,220	26,830	23,320	20,670
2010	36,920	30,410	25,360	21,640
2015	43,700	34,370	27,430	22,490
2020	51,790	38,720	29,440	23,120
2025	61,480	43,530	31,390	23,520
2030	72,950	48,930	33,460	23,930

Source: Population Commission, 1982

TABLE 1-9

PRODUCTION AND CROPPED AREA
FOR MAJOR CROPS IN NEPAL
(1978/79-1982/83 AVERAGE)

Crops	Production ('000 mt)	% of Food Grains	Cropped Area ('000 ha)	% of Cropped Area
Food Grains				
Paddy	2,251.2	62	1,270.8	50.0
Maize	701.9	20	466.0	18.4
Wheat	511.5	14	403.0	15.9
Millet	123.3	3	123.8	4.9
Barley	22.5	1	26.0	1.0
Sub-total:	3,610.0	100	2,289.6	90.2
Cash Crops				
Sugarcane	495.0	–	24.3	1.0
Oilseeds	75.9	–	121.5	4.8
Tobacco	303.2	–	7.7	0.3
Potatoes	303.2	–	42.7	1.6
Sub-total	932.8		248.8	9.8
Total cropped area:			2,538.4	100.0

Source: Economic Survey 1982/83, Ministry of Finance, 1983

TABLE 1-10

PRODUCTION OF PRINCIPAL CROPS
(Percentage over the previous year)

Crops	1978/79 Production	%	1979/80 Production	%	1980/81 Production	%	1981/82 Production	%	1982/83* Production	%
Food Grains										
Paddy	2,339.0	2.5	2,059.9	-11.9	2,464.3	19.6	2,560.1	3.9	1,832.6	-28.4
Maize	743.0	0.3	553.8	-25.5	742.9	34.1	751.5	1.2	718.2	-4.4
Wheat	454.0	10.4	440.0	-3.1	477.2	8.5	525.9	10.2	660.4	25.6
Barley	22.0	-2.2	23.3	5.9	23.0	-1.3	23.3	1.3	20.9	-10.4
Millet	133.0	2.7	119.3	-10.3	121.5	1.8	121.7	0.2	121.1	-0.5
Cash Crops										
Sugarcane	379.0	-2.0	384.4	-3.2	483.4	25.8	590.0	22.1	638.3	8.2
Oil Seeds	92.0	17.2	61.9	-32.7	77.1	24.6	79.1	2.6	69.4	-12.4
Tobacco	5.0	-16.7	5.5	10.0	5.5	0.6	4.8	-12.7	6.7	38.2
Jute	65.6	17.6	67.5	2.9	59.3	-12.1	42.7	-28.0	31.1	-27.1
Potato	268.0	-1.1	278.4	3.9	275.2	-1.1	319.8	16.2	374.6	17.1

* Estimate

Source: Economic Survey 1982-83

TABLE 1-11   EXPORTS OF MAJOR COMMODITIES (QUANTITY)

	Unit	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82
I. Exports to India								
Rice (husked)	MT	157,716	129,216	17,984	5,407	880	40,002	36,503
Maize	MT	-	2,025	4,012	3,952	2,248	17,749	15,988
Mustard & Linseed	MT	13,717	7,990	978	-	-	-	-
Herbs	MT	1,541	1,722	1,586	1,651	1,639	1,759	2,764
Dried Ginger	MT	1,778	1,732	912	1,380	1,121	1,117	1,067
Raw Jute	MT	-	-	-	591	3,425	15,302	13,581
Jute Cuttings	MT	-	-	-	1,230	3,654	12,145	8,388
Jute Goods	MT	-	-	-	865	691	1,392	13,219
Timber	OM	56,940	96,192	123,869	145,207	104,342	135,246	44,516
II. Exports to Third Countries								
Rice (husked)	MT	7,185	6,676	44,931	62,191	11,336	5,451	25,211
Hides & Skins	PCS	649	844	1,056	2,115	2,585	2,120	1,818
Raw Jute	MT	21,814	28,877	27,884	28,481	23,009	24,349	16,300
Jute Cuttings	MT	6,112	5,364	3,729	4,426	191	28	-
Jute Goods	MT	10,624	10,500	9,336	14,956	11,077	3,563	153
Timber	CM	-	-	-	-	20,065	24,349	255
Carpets	Sq.M	19,784	47,473	26,530	53,279	66,775	80,000	99,000

Source: Trade Promotion Center and Nepal Rastra Bank.

TABLE 1-12   RICE EXPORT

Year	Quantity (MT)	Average Unit Price (Rs/kg)	Export Value (Mln. Rs)	Quantity To India (%)
1975/76	164,901	3.14	518.1	96
1976/77	135,892	2.66	361.1	95
1977/78	62,915	2.68	168.8	29
1978/79	67,598	3.08	208.4	8
1979/80	12,216	2.94	35.9	7
1980/81	45,453	3.12	141.7	88
1981/82	61.714	4.24	261.9	59

Source: Trade Promotion Center and Nepal Rastra Bank.

TABLE 1-13   LAND USE PATTERNS

Type of Land Use	1975		1980	
	Area in Sq. km.	% of the Total	Area in Sq. km.	% of the Total
Forest Area	48,230	34.19	40,997	29.06
Cultivated Area	23,260	16.49	31,268	22.17
Land Under Snow	21,121	14.97	21,121	14.97
Pasture	17,857	12.66	17,857	12.66
Water	4,000	2.84	4,000	2.84
Residential Area and Roads	300	0.21	300	0.21
Others (Waste and Barren Land, etc.)	26,291	18.64	25,516	18.09
Total	141,059	100.00	141,059	100.00

Source: Facts About Nepal, Department of Information.

TABLE 1-14   INDUSTRIAL UNITS BY DEVELOPMENT REGIONS

(1976/77)

	Devlopment Regions				
	Eastern	Central	Western	Far-Western	Total Nepal
1	2	3	4	5	6
Number of Industrial Units	745	1,787	665	331	3,528
Number of Personnel Employed	15,561	22,134	7,864	4,561	50,120
Total Amount of Capital Invested (million Rs.)	339	1,358	694	51	2,442
Annual Value Added (million Rs.)	142	249	82	60	533

Source: Census of Manufacturing Establishments 1976/77,

National Planning Commission, 1981.

TABLE 1-15   ACTUAL PERFORMANCE OF
                    NATIONAL DEVELOPMENT PLANS

	Third Plan 1965-70	Fourth Plan 1970-75	Fifth Plan 1975-80
1. GDP Growth Rate	2.6 (3.8)	2.0 (4.0)	2.1 (5.1)
2. Increase in Food Grain Production (%)	1.0	1.8	-2.8
3. Agricultural Productivity (Ton/ha)	1.92	1.85	1.78
4. Share of Agriculture in GDP (%)	60	68	60

Source: NPC and MOF
Note: Figures in parentheses indicate the target.

TABLE 1-16
(1 of 2)

MAIN ECONOMIC INDICATORS
(Percent change over the previous year)

Unit: %

	1978/79	1979/80	1980/81	1981/82	1982/83*	First Nine Months 1981/82	First Nine Months 1982/83*
1. Gross Domestic Product (1974/75 Prices)	2.4	-2.3	5.6	3.8*	-1.3		
2. Major Agricultural Production	3.4	-12.4	16.6	4.0	-9.7		
a. Food Grain Production	3.1	-13.5	19.0	4.0*	-12.1		
b. Cash Crop Production	5.4	-6.1	3.5	4.0	5.1		
3. Industrial Production	1.3	6.1	-3.1	14.8	18.8		
4. Consumer Price Index	3.5	9.8	13.4	10.4	-	4.6	7.8
5. Money Supply	21.6	13.0	13.3	12.6	-	15.8	17.3
6. Imports	16.8	20.6	27.2	11.3	-	7.0	28.7
7. Exports	24.0	-11.3	39.8	-7.3	-	8.6	-32.9
8. Trade Deficit	11.6	46.7	21.0	22.0	-	6.3	58.5
9. Foreign Exchange Reserves	30.8	-0.9	12.4	25.9	-	23.4	-10.0

* Provisional
Source: Ministry of Finance

TABLE 1-16
(2 of 2)

	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83
Agriculture 1/	10,389	11,616	13,365	13,520	15,510	16,792	
Non-agriculture	5,886	6,810	7,414	8,336	9,956	11,471	
GDP at Factor Cost	16,255	18,426	20,779	21,886	25,466	28,263	
Net Indirect Taxes	1,025	1,306	1,436	1,465	1,986	2,276	
GDP at Market Price (Nominal)	17,280	19,732	22,215	23,351	27,452	30,539	
			(Constant 1974/75 Prices)				
Agriculture	11,141	11,141	11,480	10,933	12,066 (61%)	12,492 (61%)	12,067 (60%)
Non-agriculture	6,681	7,466	7,568	7,673	7,576 (39%)	7,902 (39%)	8,060 (40%)
GDP at Market Price	17,822	18,607	19,048	18,606	19,642	20,394	20,127

1/ Agriculture includes fishing and forestry
Sources: CBS and NPC

TABLE 1-17

DIRECTION OF FOREIGN TRADE

Unit: million NRs

	1977/78	1978/79	1979/80	1980/81	1981/82
1. Total Exports	1046.2	1296.8	1150.5	1608.6	1490.5
a To India	498.1	650.1	520.9	992.4	994.4
b To Other Countries	548.1	646.7	629.6	616.3	496.1
2. Total Imports	2496.6	2884.7	3480.1	4428.2	4930.3
a From India	1534.1	1581.7	1786.4	2179.0	2280.9
b From Other Countries	935.5	1303.0	1693.7	2249.2	2649.4
3. Trade Balance	-1423.4	-1587.9	-2329.6	2819.6	-3439.8
a With India	-1036.0	-931.6	-1265.5	-1186.6	-1286.5
b With Other Countries	-387.4	-656.3	-1064.1	-1632.9	-2153.3

Source: Quarterly Economic Bulletin, Nepal Rastra Bank,
Vol. XVI - XVII

TABLE 1-18

BALANCE OF PAYMENT

Unit: 10⁶ NRs

	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82
1. Trade Balance*	-812.9	-856.4	-1450.6	-1608.8	-2416.6	-2830.2	-3452.0
a Exports, f.o.b.	1208.7	1189.0	1965.2	1303.6	1152.7	1612.7	1496.0
b Imports, c.i.f.	2021.6	2045.4	2515.8	2912.4	3569.3	4442.9	4948.0
2. Services: Net	284.3	493.2	571.6	778.6	873.2	1117.0	1378.0
a Receipts	(774.6)	(932.2)	(1121.6)	(1439.1)	(1719.0)	(2070.1)	(2292.5)
b Payments	(463.3)	(839.0)	(550.0)	(660.5)	(845.8)	(953.1)	(914.5)
3. Transfers: Net	588.6	617.9	587.5	869.5	1188.2	1417.3	1681.7
a Private	(213.4)	(245.7)	(203.4)	(290.3)	(344.2)	(466.0)	(453.4)
b Central Government	(375.2)	(372.2)	(384.1)	(579.2)	(844.0)	(951.3)	(1228.3)
4. Current Account Balance	60.0	254.7	-291.5	39.3	-355.2	-295.9	-392.3
5. Official Capital: Net	145.8	214.8	291.9	428.6	577.2	633.8	774.1
a Foreign loans	(163.7)	(233.4)	(310.7)	(447.7)	(597.9)	(664.9)	(806.5)
b Amortization	(-17.9)	(-18.6)	(-18.8)	(-19.1)	(-20.7)	(31.1)	(-32.4)
6. Miscellaneous Capital Items: Net	152.4	-158.7	10.4	115.5	-195.6	-143.8	123.0
7. Changes in Reserves: Net (Increase)	-358.2	-310.8	-10.8	-583.4	-26.4	-194.1	-504.8

*: Revised on customs data basis (at basic exchange rate)
Source: Nepal Rastra Bank

TABLE 1-19   STRUCTURE OF ENERGY CONSUMPTION AS FUEL a/

(1978/79)

Sector	Fuelwood		Vegetable Waste		Animal Dung		Coal and Cokes		Petroleum Fuels		Electricity		Total	
	TOE	%	TOE	%	TOE	%	TOE	%	TOE	%	TOE	%	TOE	%
Transportation	-	-	-	-	-	-	3000	5.0	56775	94.7	153	0.3	59928	100.0
Domestic	2516700	95.9	52000	2.0	20000	0.8	-	-	28685	1.1	6559	0.2	2623944	100.0
Agricultural	-	-	-	-	-	-	-	-	4403	86.5	688	13.5	5091	100.0
Commercial and Industrial	20300	28.9	-	-	-	-	33078	47.0	10956	15.6	6013	8.5	7034	100.0
Street Lighting	-	-	-	-	-	-	-	-	-	-	175	100.0	175	100.0
Other and Losses	-	-	-	-	-	-	-	-	-	-	5000	100.0	5000	100.0
All Uses	2537000	91.8	52000	1.9	20000	0.7	36078	1.3	100819	3.6	18588	0.7	2764485	100.0

a/ TOE = Tonnes of oil equivalent.

Source: APROSC - Assessment of Ongoing Development Program, 1982.

Table 1-20   FOREIGN AID FINANCING OF PUBLIC SECTOR
               DEVELOPMENT EXPENDITURES DURING DIFFERENT PLANS

(Unit: 10^6 NRs)

Period	Development Expenditure	Foreign Aid (Gross)	%
First Plan (1956-1961)	382.9	382.9	100.0
No-Plan Year (1961-1962)	86.2	70.6	81.9
Second Plan (1962-1965)	614.7	478.3	77.8
Third Plan (1965-1970)	1,639.1	919.8	56.1
Fourth Plan (1970-1975)	3,356.9	1,509.1	45.0
Fifth Plan (1975-1980)	8,832.6	4,240.8	48.0
1975/76	1,238.9	505.6	40.8
1976/77	1,498.3	556.9	37.2
1977/78	1,808.0	848.4	46.9
1978/79	1,978.8	989.4	50.0
1979/80	2,308.6	1,340.5	58.1
Sixth Plan (1980-1985), (Planned)	21,750.0	13,260.0	61.0
1980/81 (actual)	2,731.1	1,562.2	57.2
1981/82 (revised estimate)	4,073.8	2,059.0	50.5

Source: Nepal Agriculture Sector Strategy Study, 1982

Note: Foreign Aid includes grants and loans.

TABLE 1-21   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 1-22   GOVERNMENT BUDGET

	1980/81 Actual	1981/82 Actual	1982/83 Estimate	1983/84 Estimate
1. Expenditure	4092.3	5361.3	6949.1	9522.6
a. Regular	1361.2	1634.4	2140.6	2429.3
b. Development	2731.1	3726.9	4808.5	7093.3
2. Receipts	3288.1	3672.8	4450.3	5972.0
a. Revenue	2419.2	2679.5	3055.6	4306.0
b. Foreign Grants	868.9	993.3	1394.7	1666.0
3. Deficit	-804.2	-1688.5	-2498.8	-3550.6
4. Sources of Financing	943.3	1229.9	2141.1	3550.6
a. Foreign Loan	693.3	729.9	1141.1	2334.6
b. International Loan	250.0	500.0	1000.0	1216.0
C. Cash Balance (Surplus -)	-139.1	458.6	357.7	0

Source: Economic Survey 1982/83, MOF

TABLE 1-23 POPULATION DENSITY PER SQUARE KILOMETER OF PHYSICAL AREA
AND CULTIVABLE LAND IN THE STUDY AREA (1981)

District	Physical Area(km^2)	Cultivable Land (km^2)	Population	Population Density per km^2 (Physical Area)	Persons per km^2 (Cultivable Land)
Mountains					
1. Taplejung	3,020	150	116,884	39	779
2. Sankhuwa Sabha	2,510	135	129,513	52	959
3. Solukhumbu	2,930	80	87,444	30	1,093
4. Dolakha	1,980	90	150,494	76	1,672
	(10,440)	(455)	(484,335)	(46)	(1,064)
Hills					
1. Illam	1,370	930	177,442	130	191
2. Panchthar	1,370	505	153,342	112	304
3. Terhathum	820	591	93,305	114	158
4. Dhankhuta	1,680	852	128,568	77	151
5. Bhojpur	1,840	243	192,789	105	793
6. Khotang	1,720	141	212,108	123	150
7. Udaypur	2,470	700	159,313	64	228
8. Okhaldhunga	1,270	129	137,920	109	107
9. Ramechap	1,370	674	163,470	119	243
10. Sindhu-palchok	2,600	130	232,804	90	1,790
11. Kavre	1,270	579	307,604	242	531
12. Sindhuli	2,590	269	188,232	73	700
	(20,370)	(5,743)	(2,146,897)	(105)	(374)
Terai					
1. Jhapa	1,480	1,191	480,056	324	403
2. Morang	1,814	1,092	534,490	290	489
3. Sunsari	1,360	813	343,007	252	422
4. Saptari	1,250	1,086	381,277	305	351
5. Siraha	1,140	957	376,390	330	393
6. Dhanusha	1,190	798	432,511	363	542
7. Mahottari	1,250	815	363,975	291	447
8. Sarlahi	1,380	529	398,397	89	753
	(10,864)	(7,281)	(3,310,103)	(305)	(455)
Total	41,674	13,479	5,941,335	143	441

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

TABLE 1-24   DISTRICT POPULATION CHANGE
             IN THE STUDY AREA FOR 1971-81

Districts	Population 1971	Population 1981	Annual Growth Rate (%)
A. Mountains and Hills			
1. Taplejung	84,719	116,884	
2. Sankhuwa Sabha	114,313	129,513	
3. Solukhumbu	105,324	87,444	
4. Dolakha	130,022	150,494	
5. Ilam	139,538	177,442	
6. Panchthar	145,809	153,342	
7. Terhathum	119,307	93,305	
8. Dhankuta	107,649	128,568	
9. Bhojpur	194,506	192,789	
10. Khotang	163,297	212,108	
11. Udaypur	112,622	159,313	
12. Okhaldhunga	122,862	137,920	
13. Ramechhap	157,349	163,470	
14. Sindhu Palchok	206,384	232,804	
15. Karve Palanchok	245,165	307,604	
16. Sindhuli	147,409	188,232	
Mountains and Hills Total	(2,296,271)	(2,631,232)	(1.37)
B. Terai			
1. Jhapa	247,698	480,056	
2. Morang	301,557	534,490	
3. Sunsari	223,434	343,007	
4. Saptari	312,565	381,277	
5. Siraha	302,304	376,390	
6. Dhanusha	330,601	432,511	
7. Mahotari	324,831	363,975	
8. Sarlahi	175,543	398,397	
Terai Total	(2,218,533)	(3,310,103)	(4.08)
Study Area Total:	4,514,804	5,941,335	(2.78)

Source: Population Census data in 1971 and 1981. The boundaries for
          Districts in 1981 do not accord with those in 1971 because of
          shifts of some village panchayats in 1975.

TABLE 1-25　　　　POPULATION INCREASE 1971-81

Area	Population in Thousands		Average Growth Rate per Annum (%)
	1971	1981	
1. Nepal	11,555.9	15,020.4	2.66
2. Study Area	4,514.8	5,941.3	2.78
a. Mountain and Hill	(2,296.3)	(2,631.2)	(1.37)
b. Terai Area	(2,218.5)	(3,310.1)	(4.08)

Source: CBS

TABLE 1-26

POPULATION PROJECTIONS OF NEPAL BY DEVELOPMENT REGION

Development Region	Ecological Zone	1981 Population	Ratio (%)	1986 Population	P.G.R. (%)	1991 Population	P.G.R. (%)	1996 Population	P.G.R. (%)	2001 Population	P.G.R. (%)	2006 Population	P.G.R. (%)
Eastern	Mountain	398,405	11.04	430,231	1.51	573,744	1.94	534,260	2.43	618,982	2.99	733,004	3.44
	Hill	1,453,113	40.27	1,588,519	1.80	1,771,078	2.20	2,019,459	2.66	2,358,989	3.16	2,808,150	3.55
	Terai	1,756,965	48.67	2,169,803	5.31	2,637,802	3.98	3,173,274	3.76	3,790,918	3.62	4,503,375	3.50
	Total	3,608,483	100.00	4,188,553	3.02	4,882,624	3.11	5,726,993	3.24	6,768,889	3.40	8,044,529	3.51
Central	Mountain	435,861	9.22	478,471	1.88	531,675	2.13	599,268	2.42	685,493	2.72	792,845	2.95
	Hill	2,176,705	46.06	2,429,279	2.22	2,739,510	2.43	3,125,002	2.67	3,606,310	2.91	4,198,101	3.08
	Terai	2,113,632	44.72	2,465,102	3.12	2,868,804	3.08	3,330,065	3.03	3,854,864	2.97	4,450,220	2.92
	Total	4,726,398	100.00	5,372,852	2.60	6,139,989	2.70	7,054,335	2.81	8,146,667	2.92	9,441,716	2.99
Western	Mountain	44,398	1.44	37,411	-3.37	31,319	-3.49	27,032	-2.90	25,395	-1.24	26,691	1.00
	Hill	2,310,282	74.83	2,540,837	1.92	2,814,782	2.07	3,148,003	2.26	3,558,357	2.48	4,050,651	2.62
	Terai	732,536	23.73	933,641	4.83	1,148,152	4.22	1,398,223	3.87	1,660,405	3.64	1,967,728	3.45
	Total	3,087,216	100.00	3,511,889	2.58	3,994,253	2.61	4,563,258	2.70	5,244,157	2.82	6,045,070	2.88
Middle Western	Mountain	281,782	13.97	301,959	1.39	330,739	1.82	376,188	2.61	443,424	3.34	534,084	3.79
	Hill	1,218,060	60.37	1,336,334	1.87	1,498,572	2.32	1,732,262	2.94	2,062,168	3.55	2,502,335	3.94
	Terai	517,761	25.66	670,710	5.31	841,067	4.63	1,034,911	4.23	1,257,680	3.98	1,513,441	3.72
	Total	2,017,603	100.00	2,309,003	2.73	2,670,378	2.95	3,143,361	3.31	3,763,272	3.66	4,549,860	3.87
Far Western	Mountain	303,076	25.00	329,576	1.69	360,146	1.79	397,790	2.01	444,396	2.24	499,766	2.38
	Hill	663,375	54.68	719,144	1.62	792,203	1.95	891,687	2.39	1,025,604	2.84	1,198,080	3.16
	Terai	246,683	20.32	365,550	8.18	490,975	6.08	623,966	4.91	765,562	4.17	916,933	3.67
	Total	1,213,134	100.00	1,414,270	3.11	1,643,324	3.05	1,913,443	3.09	2,235,562	3.16	2,614,779	3.18
All Nepal		14,652,834		16,796,567	2.76	19,330,568	2.85	22,401,390	2.99	26,158,547	3.15	30,695,954	3.25

Source: Agricultural Project Services Center (APROSC), Kathmandu
Note: P.G.R. = projected population growth rate per annum

TABLE 1-27   1981 - 2001 PROJECTED POPULATION OF THE STUDY AREA

| Year | Compounded Annual Growth Rate (%) | | Projected Population | | |
	Mountain/Hill	Terai	Mountain/Hill	Terai	Study Area
1981	-	-	2,631,232	3,310,103	5,941,335
1986	2.0	4.0	2,905,093	4,027,246	6,932,339
1991	2.3	3.8	3,239,027	4,852,828	8,091,885
1996	2.6	3.6	3,682,573	5,791,535	9,474,108
2001	2.8	3.4	4,227,824	6,845,361	11,073,185

TABLE 1-28 DEMOGRAPHIC CONDITIONS OF 8 TERAI DISTRICTS (1981)

	Western Zone of the Sapt Kosi				Eastern Zone of the Sapt Kosi				Total
	Sarlahi	Mahottari	Dhanusha	Siraha	Saptari	Sunsari	Morang	Jhapa	
Total Population (in thousands)	398.7	361.0	432.5	375.4	378.9	344.5	534.6	979.7	3,305.8
Men 0-14 yrs.	88.7	79.6	92.0	79.4	80.2	76.3	119.8	108.5	724.6
15-59 yrs.	105.9	96.4	121.8	104.9	104.1	92.8	145.8	132.3	904.2
60 over	11.4	11.1	11.1	10.6	10.0	9.2	12.7	11.2	87.2
Total:	206.0	187.1	224.9	194.9	194.3	178.3	278.3	252.0	1,716.0
Women 0-14 yrs.	79.7	69.0	81.9	70.4	64.5	70.0	113.1	103.6	664.5
15-59 yrs.	102.0	93.7	114.7	99.8	100.9	87.9	132.7	114.7	844.5
60 over	11.0	11.2	11.0	10.1	9.2	8.3	10.5	9.4	80.8
Total:	192.7	173.9	207.6	180.3	184.6	166.2	256.3	227.7	1,589.8
Density per km2									
Physical Area	289	289	363	329	303	253	290	662	303
Cultivable Land	754	443	542	392	349	424	490	822	454
Number of Families (in thousands)	71.7	64.3	79.8	68.6	68.6	58.2	91.0	81.1	563.3
Farm Families	61.6	57.7	63.8	60.3	53.1	41.5	74.7	63.9	476.7
(Family Size)	5.56	5.56	5.42	5.47	5.52	5.92	5.87	5.91	5.67

TABLE 1-29   EMPLOYMENT PATTERN OF ECONOMICALLY ACTIVE POPULATION (AGE 10 YEARS AND ABOVE)
DEVELOPMENT REGION LEVEL

Development Region	Farm/Fish Workers		Production Labour Workers		Service Workers		Sales Workers		Clerical Workers		Administrative Workers		Proff./Tech Workers		Total Employed
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Both
Eastern	85.35	34.57	7.87	19.34	1.03	4.10	0.83	16.02	4.04	22.46	0.03	0.20	0.50	3.32	100.0
Central	83.99	29.73	6.06	18.81	3.77	4.57	1.90	19.44	3.89	23.76	-	-	0.44	6.68	100.0
Western	84.94	60.53	4.32	11.54	1.03	2.96	0.97	10.92	8.01	11.54	0.09	-	0.64	2.50	100.0
Far-Western	90.98	18.96	2.39	17.59	1.51	10.19	0.57	34.72	0.93	13.89	0.04	-	0.23	4.63	100.0
Nepal	85.89	38.96	5.32	16.65	2.03	4.55	1.25	7.63	5.02	18.83	0.04	0.04	0.46	3.34	100.0
Nepal (Rural Plus Urban)	79.45		6.88		2.37		3.50		6.91		0.04		0.85		100.0

Source: A Survey of Employment, Income Distribution and Consumption Pattern in Nepal, 1976/77

TABLE 1-30   NUMBER OF MANUFACTURING ESTABLISHMENTS
IN THE STUDY AREA (1976/1977)

Districts	Total No. of Establishments	Oil & Grain Mill Prod.	Others	Gross Output RS. 1000
Mountains				
Solukhumbu	4	0	4	1,146
Dolakha	7	0	7	1,108
Hills				
Illam	3	1	2	1,866
Terhathum	2	0	2	-
Dhankhuta	4	3	1	324
Bhojpur	17	1	16	1,021
Udayapur	12	12	0	6,085
Okhaldhunga	3	0	3	202
Sindhupalchok	18	17	1	2,441
Kavre	50	43	7	19,626
Sindhuli	7	6	1	2,485
Terai				
Jhapa	207	159	48	227,859
Morang	154	115	39	621,841
Sunsari	86	74	12	68,462
Saptari	124	115	9	356,267
Siraha	129	121	8	82,482
Dhanusha	160	131	29	145,845
Mahottari	137	123	14	40,395
Sarlahi	165	145	20	82,065
TOTAL	1,289	1,066	223	1,661,520
Nepal	3,528	2,637	891	3,939,955

Source: Census of Manufacturing Etablishments 1976/77, CBS, 1981

TABLE 1-31
(1 of 2)

NUMBER OF ESTABLISHMENTS BY SIZE BASED ON THE NUMBER OF PERSONS ENGAGED

Districts	Total No. of Estabs.	Size Based on the Number of Persons Engaged						
		1 - 9	10 - 19	20 - 49	50 - 99	100 - 499	500 - 999	1,000 - & Over
Mountains								
Solukhumbu	4		2	1		1		
Dolakha	7		3	4				
Hills								
Illam	3	1	2					
Terhathum	2		2					
Dhankhuta	4	3		1				
Bhojpur	17	4	13					
Udayapur	12	12						
Okhaldhunga	3		2	1				
Sindhupalchok	18	18						
Kavre	50	48	1		1			
Sindhuli	7	6	1					

Districts	Total No. of Estabs.	Size Based on the Number of Persons Engaged						
		1 - 9	10 - 49	20 - 49	50 - 99	100 - 499	500 - 999	1,000 - & Over
Terai								
Jhapa	207	144	19	16	17	10	1	
Morang	154	102	23	10	6	11		2
Sunsari	86	75	5	2	3	1		
Saptari	124	104	7	4	4	5		
Siraha	129	114	6	2	5	2		
Dhanusha	160	138	14	3	2	2		
Mahottari	137	123	5	4	2	3		1
Sarlahi	165	148	9	5	2	1		
Total	1,289	1,040	114	53	42	36	1	3
Nepal	3,528	2,795	364	177	103	77	8	4

TABLE 1-32   CAPACITY OF POWER EQUIPMENT IN THE MANUFACTURING
ESTABLISHMENTS IN THE STUDY AREA

| District | No. of Establishments | | | Capacity of Power Equipment | | |
	Total	Without Power Equipment	With Power Equipment	Prime Movers Except Generators H.P.	Electric Motors H.P.	Generators K.W.
Mountains						
Solukhumbu	4	4	-	-	-	-
Dolakha	7	7	-	-	-	-
Hills						
Illam	3		3	72	53	71
Terhathum	2	2	-	-	-	-
Dhankhuta	4	1	3	-	60	-
Bhojpur	17	16	1	14	-	-
Udayapur	12	-	12	184	-	-
Okhaldhunga	3	3	-	-	-	-
Sindhupalchok	18	1	17	69	33	
Kavre	50	6	44	55	686	10
Sindhuli	7	1	6	97	-	-
Terai						
Jhapa	207	15	192	4,067	405	2,554
Morang	154	11	143	5,040	7,042	6,327
Sunsari	86	5	81	1,225	1,287	375
Saptari	124	6	118	1,652	291	1,112
Siraha	129	7	122	1,464	264	6
Dhanusha	160	14	146	1,561	1,641	1,106
Mahottari	137	10	127	1,524	325	-
Sarlahi	165	17	148	3,057	1,609	50
Total	1,289	126	1,163	20,081	13,606	11,611
Nepal	3,528	388	3,140	41,996	33,499	16,249

Source: Census of Manufacturing Establishments 1976/1977, CBS, 1981

TABLE 1-33   UNIT PRICES OF AGRICULTURAL INPUT AND OUTPUT
(1 of 2)

Unit: NRs

Items	Unit	Economic Price
1. Inputs		
Seed		
Paddy, Improved	kg	2.50
Paddy, Local	"	2.30
Wheat	"	3.00
Jute	"	15.30
Sugarcane	"	0.30
Maize	"	3.00
Pulses	"	7.00
Oilseeds	"	8.00
Tobacco	"	80.00
Potato	"	2.50
Fertilizer		
Urea	kg	5.50
TSP	"	4.10
Manure	"	0.05
Farm Labor		
Human Labour	man/day	4.00
Animal Labour	head/day	6.00
2. Outputs		
Paddy Improved	kg	3.30
Paddy, Local	"	3.00
Wheat	"	3.70
Jute	"	4.60
Sugarcane	"	0.28
maize	"	2.40
Pulse	"	7.00
Oilseeds	"	8.00
Tobacco	"	80.00
Potato	"	2.00

Source: (1) Price Projections by World Bank, 1982
       (2) MOA

I - 59

TABLE 1-33
(2 of 2)

ECONOMIC PRICES OF FARM INPUTS AND OUTPUTS

Item	Paddy	Wheat	Maize	Jute	Urea	TSP
Project 1995 World Market Price (US$ ton)	418	190	142	465	275	195
Quality Adjustment (%)	70	100	100	70	100	100
Adjusted Price (US$/ton)	293	190	142	326	275	195
International Shipping and Handling (US$/ton)	50	60	40	40	60	50
Border Price (US$/ton)	343	250	182	366	335	245
(NRs/ton)	5,351	3,900	2,839	5,710	5,226	3,822
Inland Transport and Handling (NRs/ton)	-270	-200	-400	-300	+300	+300
Farm-gate Price (NRs/ton)	5,081	3,700	2,439	5,410	5,526	4,122
Processing Ratio (%)	65	100	100	85	100	100
Adjusted Farm Prices (rounded)	3,300	3,700	2,400	4,600	5,500	4,100

Source: Price Prospects for major Primary Commodities, World Bank, 1982

Note: (1) Nepal is a net exporter of foodgrain and jute, and net importer of fertilizer

(2) Projected 1995 world market prices are expressed in 1981 constant U.S. dollars

TABLE 1-34
(1 of 2)

NET PRODUCTION VALUE OF AGRICULTURAL OUTPUT
UNDER FUTURE WITH AND WITHOUT PROJECT CONDITIONS

	Crop Yield (ton/ha)		Unit Prices (NRs/ton) (Economic Prices)	Gross Prod. Value (NRs/ha)		Production Cost (NRs/ha)		Net Prod. Value (NRs/ha)	
	With	Without		With	Without	With	Without	With	Without
Paddy									
- Improved Wet	4.0	2.876	3,300	13,200	9,491	2,792	2,132	10,408	7,359
- Improved Summer	3.5	2.876	3,300	11,550	9,491	2,730	2,132	8,820	7,359
- Local Wet	-	1.479	3,000	-	4,881	-	1,490	-	3,391
Wheat	3.0	1.443	3,700	11,100	5,339	2,657	1,867	8,443	3,472
Jute	2.5	1.673	4,600	11,500	7,696	2,936	2,036	8,564	5,660
Sugarcane	30.0	22.046	280	8,400	6,173	6,784	5,345	1,616	828
Maize	2.0	1.411	2,400	4,800	3,386	2,284	1,004	2,516	2,382
Pulses	0.8	0.35	7,000	5,600	2,450	1,539	979	4,061	1,471
Oilseeds	1.0	0.646	8,000	8,000	5,168	1,482	755	6,518	4,413
Tobacco	1.0	0.754	80,000	80,000	60,320	2,566	2,035	77,434	58,285
Potato	15.0	-	2,000	30,000	-	5,729	-	24,271	-

Note: (1) Crop Yields as per TABLE 1-35

      (2) Unit Prices as per TABLE 1-33

TABLE 1-34
(2 of 2)

SUMMARY OF PRODUCTION COST PER HA

Unit : NRs

Crop	Labour Cost	Iput Cost	Others	Total
(1) Future With Project				
Paddy				
- Improved (Wet)	1,088	1,450	254	2,792
- Improved (Summer)	1,032	1,450	248	2,730
- Local	-	-	-	-
Wheat	980	1,435	242	2,657
Jute	1,604	1,065	267	2,936
Sugarcane	1,692	4,475	617	6,784
Maize	956	675	140	1,539
Pulse	724	675	140	1,539
Oilseeds	568	779	135	1,482
Tobacco	808	1,524	233	2,566
Potato	1,508	3,700	521	5,729
(2) Future Without Project				
Paddy				
- Improved (Wet)	836	1,175	121	2,132
- Improved (Summer)	836	1,175	121	2,132
- Local	828	578	84	1,490
Wheat	716	1,045	106	1,876
Jute	1,356	565	115	2,036
Sugarcane	1,492	3,550	303	5,345
Maize	872	75	57	1,004
Pulse	504	420	55	979
Oilseeds	544	168	43	755
Tobacco	760	1,160	115	2,035
Potato	-	-	-	-

TABLE 1-35   NET PRODUCTION VALUE PER HA

AT FULL DEVELOPMENT STAGE (SAPT KOSI EAST AREA)

	Future With Project			Future Without Project		
	Net Prod.Value (NRs/ha)	Cropping Ratio (%)	Weighted Value (NRs/ha)	Net Prod.Value (NRs/ha)	Cropping Ratio (%)	Weighted Value (NRs/ha)
Paddy						
- Improved Wet	10,408	94	9,784	7,359	17.9	1,317
- Improved Summer	8,820	25	-	7,359	4.5	331
- Local Wet	-	-	-	3,391	56.1	1,902
Wheat	8,443	35	2,955	3,472	13.7	476
Jute	8,564	5	428	5,660	6.2	351
Sugarcane	1,616	1	16	828	1.1	9
Maize	2,516	15	377	2,382	12.4	295
Pulses	4,061	25	1,015	1,471	6.3	93
Oilseeds	6,518	15	978	4,413	17.5	772
Potato	24,271	1	243	-	-	-
Total		216	18,001 (1)		135.6	5,546 (2)

Note: Incremental Net Benefit/ha: 18,001 - 5,546 = 12,455 (US$798.40/ha)

TABLE 1-36

NET PRODUCTION VALUE PER HA
AT FULL DEVELOPMENT STAGE (SAPT KOSI WEST AREA)

	Future With Project			Future Without Project		
	Net Prod.Value (NRs/ha)	Cropping Ratio (%)	Weighted Value (NRs/ha)	Net Prod.Value (NRs/ha)	Cropping Ratio (%)	Weighted Value (NRs/ha)
Paddy						
- Improved Wet	10,408	97	10,096	7,359	17.9	1,317
- Improved Summer	8,820	25	2,205	7,359	4.5	331
- Local Wet	-	-	--	3,391	56.1	1,902
Wheat	8,443	35	2,955	3,472	13.7	476
Sugarcane	1,616	1	16	828	1.1	8
Maize	2,516	15	377	2,382	12.4	295
Pulses	4,061	27	1,096	1,471	6.3	93
Oilseeds	6,518	14	1,760	4,413	17.5	772
Tobacco	77,434	1	774	58,285	2.2	1,282
Potato	24,271	1	243	--	--	-
Total		216	19,522 (1)		131.7	6,476 (2)

Note: Incremental Net Benefit/ha: 19,522 - 6,476 = 13,046 (US$836.28)

TABLE 1-37
(1 of 2)

HYDROPOWER SCHEMES IDENTIFIED
IN THE KOSI BASIN

Main Stream	Scheme	Type of Generation	Installed Capacity (MW)	For Nepal or Power Export	Priority Mark (more than 295)
Tamur	TM-1*	PRR	696	N	301
	-3	"	186	"	301
	-4	SRR	51	"	
	-5	"	70	"	
	-6	"	76	"	
	-7	"	101	"	
	KB-1	"	15	"	
	-2	"	15	"	
	-3	"	12	"	
			(1,222)		
Arun	AR-1	SRR	146	"	307
	-2	"	239	"	331
	-3	"	246	"	336
	-4	"	120		
	-5	"	202		
	-6	"	238		
			(1,185)		
Sun Kosi	SU-1*	R	1,357	Export	315
	-2*	"	1,110	"	312
	-3*	"	536	N	313
	-4*	SRR	26	"	
	DD-1	PRR	228	"	295
	-2	"	87	"	
	-3	"	48	"	
	-4	"	46	"	
	-5	"	73	"	
	-6	"	36	"	
	-7	"	89	"	
	-8	"	93	"	
	-9	"	63	"	
	-10	"	49	"	
	MA	"	13	"	
	LK-1	"	21	"	
	-2	"	17	"	
	-3	"	31	"	
	-4	"	25	"	
	KM-1	"	49	"	299
	-2	"	22	"	
	TA-2	"	196	"	299
	-3	"	123	"	301
	-4	"	126	"	
	-5	"	102	"	
	-6	"	113	"	

TABLE 1-37
(2 of 2)

HYDROPOWER SCHEMES IDENTIFIED
IN THE KOSI BASIN

Main Stream	Scheme	Type of Generation	Installed Capacity (MW)	For Nepal or Power Export	Priority Mark (more than 295)
Sun Kosi	RS-1	SRR	10	N	
	-2	"	13	"	
	-3	"	12	"	
	-4	"	10	"	
	BH-1	"	64	"	
	-2	"	69	"	
	BA		58	"	
	ID-1	PRR	58	"	
	-2	SRR	33	"	
	-3	"	25	"	
			(5,013)		
Sapt Kosi	SAPT*	R	3,489	Export	371

Note: 1/ TM: Tamur, KB: Kabeli Nadi, AR: Arun, SU: Sun Kosi, DD: Dudh
Kosi, MA: Maulung Khola, LK: LIkhu Khola, KH: Khimte Khola, TA:
Tama Kosi, TA: Tama Kosi, RS: Rosi Khola, BH: Bhote Kosi, BA:
Belephi, ID: Indrawati

2/ Schemes with * mark are suitable for multipurpose projects

3/ R signifies Reservoir

4/ Two (2) hydropower project sites in the Kamla basin are not
included in the table.

TABLE 1-38   IRRIGATION DEVELOPMENT SCHEMES
                    IDENTIFIED IN THE MASTER PLAN

Scheme	Construction Cost (10^6 US$)	Construction Cost per ha (US$)	B/C Ratio (12%)
Sun Kosi Diversion			
a. Irrigation sector only (without hydropower)	470.9	2,689	1.33
b. Irrigation and hydropower	550.7	2,368	1.54
Sapt Kosi West Irrigation	60.4	3,532	1.10
Sapt Kosi East Irrigation	232.5	4,711	0.76

Note: (1) No allowance for interest, duties and price escalation was made in the construction cost estimate.

(2) Allocated cost of irrigation in Sun Kosi Multipurpose Scheme is US$414.6 million.

(3) Sun Kosi Diversion corresponds to phase I of Sun Kosi Multi-purpose Scheme.

TABLE 1-39   ECONOMIC EVALUATION OF EACH PRIORITY SCHEME

	Capital Cost (10^6 US$)	Cost per kW or per ha (US$)	Energy Cost (¢/KWh)	B/C Ratio
Hydropower Schemes for Domestic Use				
1. Arun No. 3	268	1,119	2.29	2.91
2. Arun No. 2	292	1,222	2.65	2.49
3. Arun No. 1	277	1,897	4.03	1.66
4. Tama Kosi No. 3	206	1,675	5.77	1.42
5. Tama Kosi No. 2	244	1,250	4.05	1.98
6. Sun Kosi No. 3	582	1,086	4.75	1.95
7. Khimte Khola No. 1	66	1,347	3.26	2.14
8. Bhote Kosi No. 1	89	1,388	3.38	2.09
9. Tamur No. 1	846	1,216	5.20	1.76
10. Dudh Kosi No. 1	449	1,969	7.76	1.13
Hydropower Schemes for Power Export				
1. Sapt Kosi High Dam	2,721	780	2.74	3.03
2. Sun Kosi No. 1	1,051	775	3.83	2.59
3. Sun Kosi No. 2	1,027	925	3.65	2.41
Multipurpose Scheme				
1. Sun Kosi Diversion (Phase I)	551	2,368/ha	-	1.54
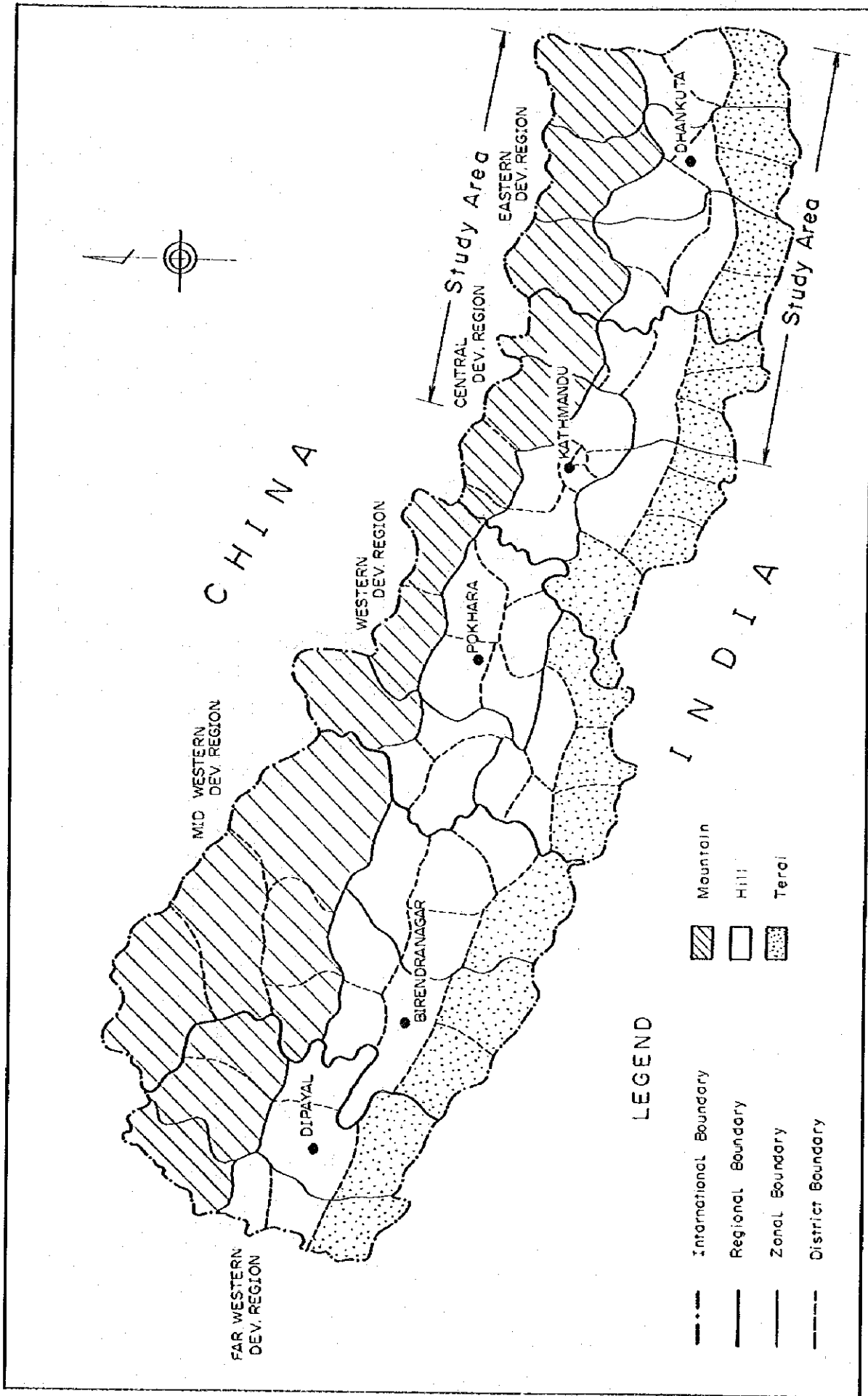
FIG. 1-1   ECOLOGICAL ZONES AND DEVELOPMENT REGIONS

LEGEND

Mountain
Hill
Terai

International Boundary
Regional Boundary
Zonal Boundary
District Boundary

CHINA

INDIA

FAR WESTERN DEV. REGION
MID WESTERN DEV. REGION
WESTERN DEV. REGION
CENTRAL DEV. REGION
EASTERN DEV. REGION

Study Area

DIPAYAL
BIRENDRANAGAR
POKHARA
KATHMANDU
DHANKUTA
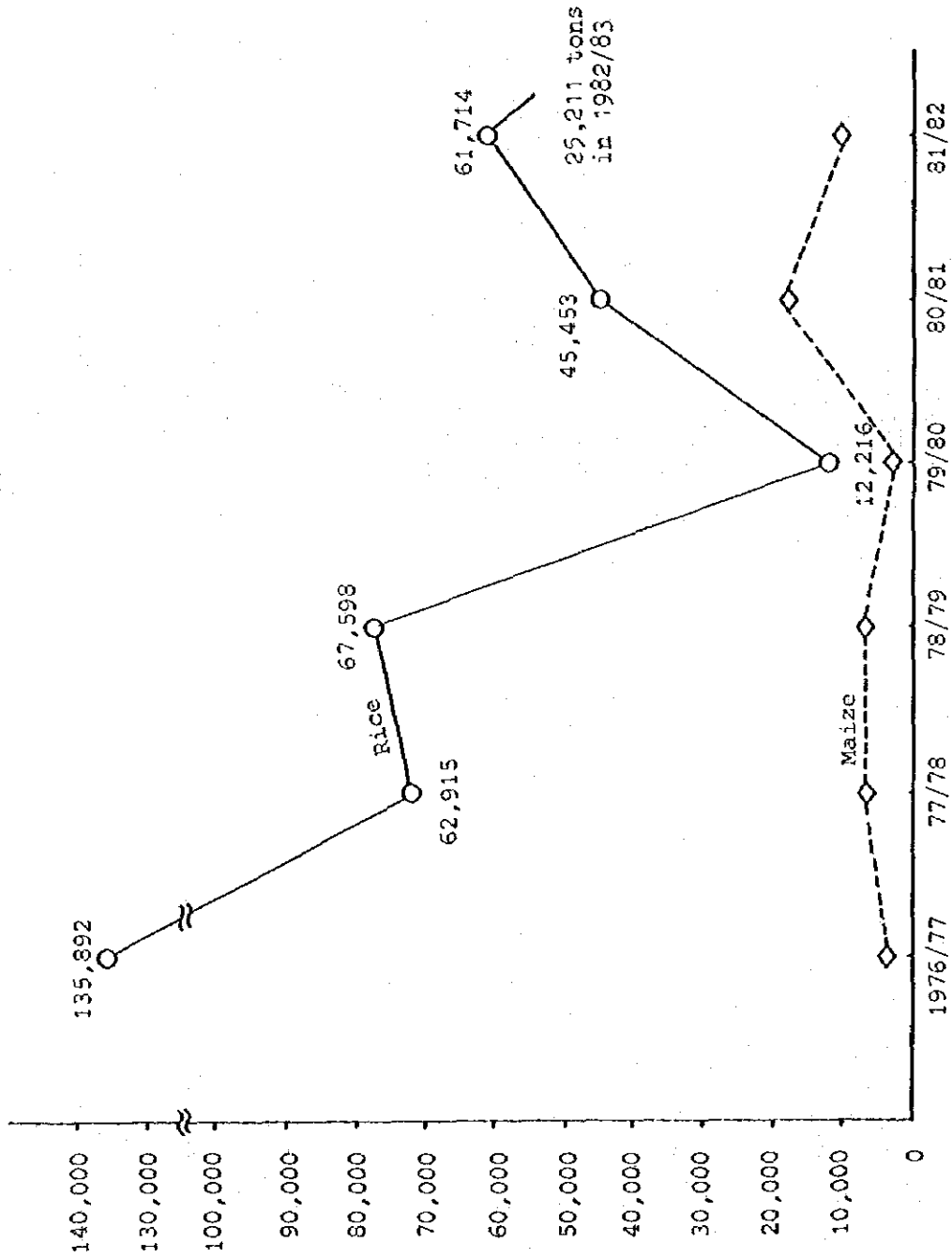
EXPORT TREND OF RICE AND MAIZE

FIG. 1-2

ADMINISTRATIVE DIVISION IN THE STUDY AREA

FIG. 1-3

TRANSPORTATION IN THE STUDY AREA

FIG. 1—4

APPENDIX II

METEOROLOGY & HYDROLOGY

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX II

METEOROLOGY & HYDROLOGY

1. METEOROLOGY

1.1 General

The Kosi Basin is located in the Mountain and Hill Areas of eastern Nepal. The area has two distinct seasons: dry season from Nov-May and rainy season from Jun-Oct. Prevailing winds during the dry season are westerly while those in the rainy season are easterly. Rainfall during the rainy season has a cycle of about 10-15 days; however, rainfall does not occur in every part of the Kosi Basin at the same time. Rainfall conditions also differ according to elevation. Areas over 3,000m have a high percentage of drizzle while those lower than 2,000m are subject to heavy downpours.

The Study area has a difference in annual average temperature ranging from about 5 to 25°C (FIG. 2-1). Daily temperature change during the rainy season is comparatively slight. With the end of the rainy season and the coming of strong westerly winds in November, temperature drops rapidly reaching minimum temperatures in January. As temperatures during the dry season rise with sunshine hours and decrease quite suddenly with nightfall, daily fluctuation in temperature averages about 15-20°C.

Humidity during the rainy season has a monthly average of 90%, with little daily variation in humidity. Dry season humidity, on the other hand, varies widely during a one day period and is much lower than that of the rainy season totaling only about 20% of the same. Water content near the soil surface is likewise high during rainy season at 10%, dropping in the dry season.

The Team collected meteorological data at 107 meteorological stations in the Kosi Basin, and on the basis of the same, carried out among others the following analyses:

- Annual rainfall
- Annual Isohyet
- Probable rainfall
- Evaporation

To understand the meteorological conditions in the Kosi Basin, the Team selected some representative meteorological stations presented in the table below to illustrate the climatic characteristics of each area for reference in this report.

TABLE 2-1   REPRESENTATIVE METEOROLOGICAL STATIONS

Area	Average Annual Rainfall (1971-80) (mm)	Average Annual Temperature (1971-80) (°C)	Referenced Meteorological Station (Nos.)	Elevation (m)
Sun Kosi & Tama Kosi	2,189	19.2	1103	2,003
Dudh Kosi	1,898	14.2	1120	2,770
Arun	1,464	25.2	1303	1,329
Tamur	1,147	21.7	1318	158
Terai (near Janakpur)	1,263	29.8	1114	93

About 80% of the above-mentioned annual rainfall takes place in the monsoon season (Jun to Sep).

The Team derived the relation formula between evaporation and elevation from collected meteorological data. Data compiled from 15 observation stations in various parts of Nepal show that the range of average annual evaporation loss differs with altitude. The correlations between heights above sea level where evaporation reaches 960mm to 1,980mm yearly and the average annual evaporation loss is as follows:

$y = -0.25774 x + 1611.9$

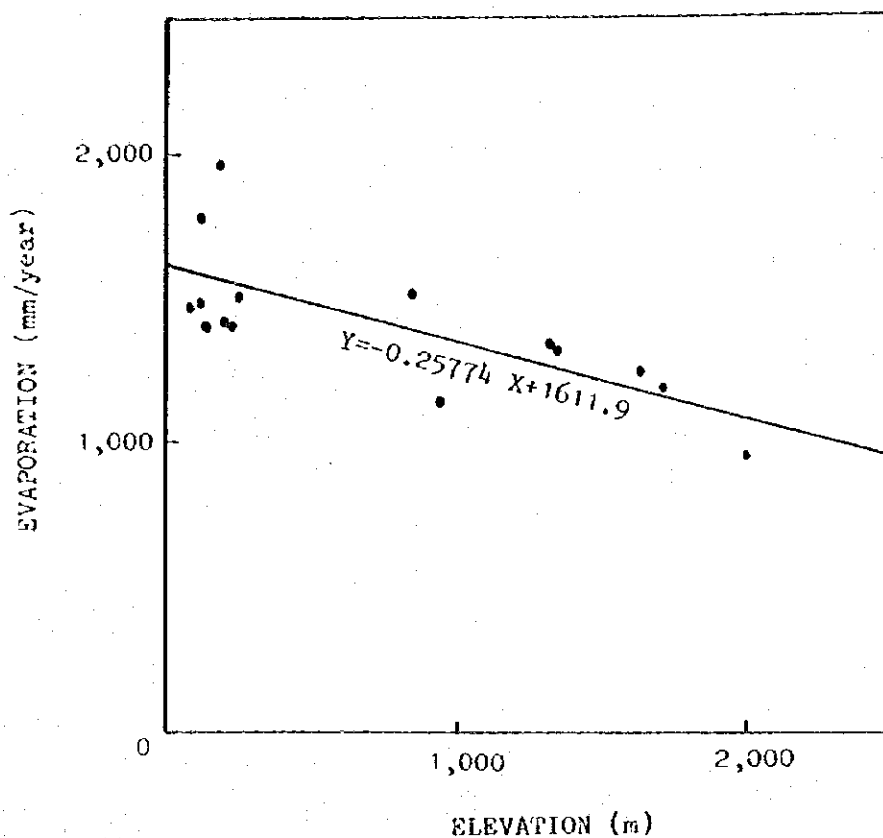y: Average annual evaporation loss (mm)

x: Height above sea level (m)

FIG. 2-2   ELEVATION - EVAPORATION CORRELATION

The equation shown on the graph:

$$Y = -0.25774\,X + 1611.9$$

1.2   Meteorological Stations in the Study Area

Location of meteorological stations in the Study area are as shown in FIG. 2-3. There are 107 stations scattered over the area: 20 stations in the Terai Area and 87 stations in the Mountain and Hill Areas (TABLE 2-2). There are two categories of meteorological station: climatological stations which observe air temperature, relative humidity and precipitation, and precipitation stations which observe rainfall only.

As the majority of meteorological stations in the Study area were established before 1970, sufficient rainfall data are available for study. However, irrigation planning requires not only rainfall data but also data on temperature, humidity, wind, evaporation and sunshine. The latter data are insufficient as only a few stations have been collecting the same.

1.3 Isohyet Map

From the monthly rainfall data collected in the Study area, annual rainfall was analysed for the period from 1971 to 1980 to obtain mean annual rainfall for preparation of the annual isohyet map as shown in FIG. 2-4.

The majority of precipitation in the Kosi Basin is borne by airflows from Bengal Bay during the rainy season. These airflows cross the Terai to the Mahabharat Range and the Himalayan Mountains with heavier rainfall in the Terai plain and the area between the 2 mountain ranges.

The Terai Area has an annual rainfall of only 1,000-1,500mm. From the isohyetal map, it can be seen that there are some particular areas in the Kosi Basin where rainfall is distributed in a concentric circular pattern including the Sun Kosi and Arun River basins. Maximum annual rainfall in the Sun Kosi is 3,500mm with a minimum of 2,000mm and rainfall is particularly heavy in the upper reaches of the Sun Kosi, the Bhote Kosi basin where rainfall exceeds 3,500mm.

Maximum rainfall in the Arun River basin is 4,000mm and the minimum is 2,000mm. However, Rain gauge stations in those areas where rainfall reaches levels close to 4,000mm are scarce, therefore further study by installation of the stations would be required. The Tamur River basin is located in the east part of the Arun River basin and the maximum rainfall is estimated to be reached about 2,500mm.

2. HYDROLOGY

2.1 General

The Study area is topographically and climatically divided into two major areas; the Kosi Basin and the Terai Area. The catchment area of the Kosi River is approximately 61,000km^2, with 55% in Nepal and 45% in Tibet. About 10% of the catchment area is covered by glacier, ice and snow throughout a year.

The Kosi River is composed of 7 rivers, of which the main affluents are from east to west, the Tamur River, the Arun River and the Sun Kosi River. The tributaries of the latter include the Indrawati, Tama Kosi, Likhu Khola and Dudh Kosi rivers. The relative proportions of each catchment area and annual discharges of the 3 main rivers and the Sapt Kosi River are presented in the following table.

TABLE 2-3   CATCHMENT AREA & ANNUAL DISCHARGE IN THE KOSI BASIN

River	Catchment Area		Annual Discharge		Annual Average Discharge (m^3/s)
	km^2	(%)	$10^6 m^3$	(%)	
Sapt Kosi	61,000	(100)	50,900	(100)	1,630
Sun Kosi	19,000	(31)	22,400	(44)	770
Arun	36,000	(59)	18,300	(36)	600
Tamur	6,000	(10)	10,200	(20)	350

In the Terai Area, there are innumerable medium and small rivers originating from the Mahabharat Range and Siwalik Hills. These rivers change their courses every rainy season due to lack of embankment and river protection works. Almost all of these rivers except major rivers dry up in the dry season. Major rivers among them are the Bagmati, Kamla and Kankai from west to east.

TABLE 2-4   FEATURES OF MAJOR RIVERS IN THE TERAI AREA

River	Catchment Area (km^2)	Annual Discharge $(10^6 m^3)$	Recorded Year
Bagmati	2,720	5,052	1965-68
Kamla	1,470	1,409	1956-69
Kankai	1,150	1,643	1964-69

Note: Catchment areas are estimated at the outlet of rivers from the Mountain Area to the Terai Area.

2.2 Gauging Stations

There are 14 gauging stations in which 13 are still active in the Kosi Basin, the Sun Kosi, Arun, Tamur and Sapt Kosi. On the Arun River, a new gauging station at Legwa Ghat was established in 1979 and stopped in 1983, and the recorded water level was processed by the Team to obtain discharge data. Another gauging Station was established at Turki Ghat upstream of Legwa Ghat in 1975 and the water level has been recorded. These data were also processed by the Team to convert the same to discharge data. On the Sapt Kosi, the Barahkshetra gauging station existed since 1949. The Team was only successful in collecting monthly mean discharge data as this gauging station is controlled by the Government of India.

In the Terai Area, there are altogether 4 gauging stations; two on the Bagmati and one each on the Kamla and Kankai. These gauging stations were established in connection with the on-going irrigation projects on each river. The data obtained at these three gauging stations contain monthly but not daily discharge.

During the Study, the Team conducted field survey of the existing gauging station, particularly, on the Arun River, to prepare a new rating curve from gauging water levels, discharges measured by DIHM since 1975 and actual measurement of discharge by the Team in the middle of August 1984 at Turik Ghat gauging station. The rating curve prepared by the Team is shown in FIG. 2-5.

For the clarification of the hydrological characteristics of the Basin, average unit discharge per 100km^2 recorded in the Kosi Basin and 4 gauging stations in the Terai Area are tablulated in TABLE 2-5.

TABLE 2-5   DISCHARGE PER 100km^2

Gauging Station No. & Name of River	Catchment Area (Km^2)	90% Dependable Discharge (m^3/s/100km^2)	Annual Average (m^3/s/100km^2)	Period of Record
Kosi Basin				
610 (Bhote Kosi)	2,410	0.60	3.07	1965-78 [1]
620 (Balephi Khola)	629	1.84	9.06	1964-78 [1]
630 (Sun Kosi)	4,920	0.85	4.80	1964-75
640 (Rosi Khola)	87	0.21	3.44	1964-78
647 (Tama Kosi)*	2,753	0.74	5.94	1971-78
650 (Khimte Khola)	313	1.46	8.85	1965-78
652 (Sun Kosi)	10,000	0.79	5.58	1968-78
660 (Likhu Khola)	823	1.35	6.52	1964-78
670 (Dudh Kosi)*	4,100	1.05	5.44	1964-75
680 (Sun Kosi)*	17,600	0.75	4.17	1966-77
690 (Tamur)*	5,640	0.89	6.05	1970-78
695 (Sapt Kosi)	57,000	-	2.70	1949-78
604 (Arun)[2]	34,904	0.40	1.53	1979-1982
604.5 (Arun)*	33,766	0.38	1.30	1976-83
Terai				
550 (Bagmati)	585	-	0.69	1962-74
590 (Bagmati)	2,720	-	5.89	1965-68
Kamala (Kamla)	1,470	-	3.04	1956-69
770 (Kankai)	1,150	-	4.53	1964-69

1/ no data in 1968
2/ presently not active

* Gauging Station with automatic recorder

     The locations of the above active gauging stations are shown in FIG. 2-6 and 2-7.

2.3   Reliability of Gauging Data

2.3.1   General

     Studies on the correlation between annual rainfall and corresponding discharge at all the gauging stations were made utilizing the collected hydrological data. At some gauging stations analysis results show over-discharge, indicating more discharge than rainfall, which can not be properly explained from an ordinary theory of water balance.

Possible reasons for such discrepancy may be; (i) simple errors in measurements reflecting inadequate measurement practice and facilities, and (ii) actual discharge from glacier and snow. It is suggested that further studies, especially field survey, should be conducted to raise the accurancy of the data which are a major factor for planning of water resource development.

Far that additional data should be provided in future by way of: (i) installation of automatic recorders on the Sun Kosi and Arun rivers, (ii) measurement of flood hydrograph during the rainy season, and (iii) periodic measurement of river flow and cross-sectio twice a month and after floods. Such data would be useful for studies in the future including pre-feasibility and feasibility studies.

2.3.2 Discharge Balance Among Gauging Stations in the Sun Kosi Basin

There are 10 gauging stations in the Sun Kosi Basin. To check the reliability of discharge data recorded, the Team carried out discharge balance study among the gauging stations as shown in FIG. 2-8. Average annual discharges, average August discharge (maximum discharge) and average March discharge (minimum discharge) from 1971-75 which have common records were used for checking and are tabulated in the table below.

TABLE 2-6   DISCHARGES AT GAUGING STATIONS IN THE SUN KOSI BASIN

No. of G.S.	C.A. (km^2)	Annual Discharge (m3/s)	August Discharge (m3/s)	March Discharge (m3/s)
610	2,410	76.6	216.5	15.8
620	629	55.6	174.4	9.5
630	4,920	249.5	772.1	46.5
640	87.2	3.0	7.6	1.0
647	2,753	153.9	464.9	23.6
650	313	27.1	81.6	4.3
652	10,000	526.1	1,677.4	84.5
660	823	55.0	161.4	10.6
670	4,100	227.4	678.5	37.2
680	17,600	706.5	2,253.0	147.9

From review of the discharge balance study, it is concluded that some discrepancies occur in the figures for No.680 G.S and upstream gauging stations on the Sun Kosi River as described below.

(1)   Annual average discharge of No.680 G.S is 101.7m^3/s lower than the total discharge of No.652, No.660 and No.670, despite remaining catchment area (2,657km^2) between upstream gauging stations and No.680 G.S.

(2)   August average discharge shows greater inbalance 264.3m^3/s between upstream gauging stations and No.680 G.S.   This indicates that high water level discharge records are less than actual discharge at No.680 G.S.   The rating curve should be checked by periodic gauging of discharge particularly in rainy season and several measurements of cross-section.

(3)   The March average discharge shows a normal balance or slightly lower in No.680 G.S than in upstream G.S.

2.3.3   Runoff Coefficient Against Rainfall

The runoff coefficient is also examined to review collected discharge data by the Thiessen method. All collected rainfall data in the Basin was adopted to estimate the runoff coefficients at the discharge gauging stations while annual rainfall in the Tibet area was assumed at 500mm/yr. The results are tabulated in the table below.

TABLE 2-7   RUNOFF COEFFICIENT

River	G.S.	Runoff Coefficient	Range of Coefficient	Period
Bhote Kosi	610	0.62	0.49 - 0.72	1971-78
Indrawati	620	0.79	0.60 - 0.98	1971-78
Sun Kosi	630	0.78	0.67 - 0.89	1971-75
Rosi Khola	640	0.77	0.61 - 0.95	1971-78
Tama Kosi	647	0.98	0.81 - 1.20	1971-78
Khimte Khola	650	0.83	0.67 - 0.92	1971-78
Sun Kosi	652	0.82	0.72 - 0.94	1971-78
Likhu Khola	660	1.31	1.19 - 1.42	1971-78
Dudh Kosi	670	1.30	1.13 - 1.38	1971-75
Sun Kosi	680	0.72	0.66 - 0.81	1971-76
Tamur	690	1.01	0.80 - 1.22	1971-78

Differential distribution of coefficient is shown in FIG. 2-9. Review of the results includes the following items.

(1) Generally the normal coefficient of discharge is considered to have a range of 0.6-0.8. From this perspective, the discharge coefficient of No.680 G.S. is reasonable.

(2) The discharge obtained for gauging stations No.647 (Tama Kosi), No.660 (Likhu Khola), No.670 (Dudh Kosi) and No.690 (Tamur), are greater than 1.0 of the coefficient. Two possible reasons are:

      a) Discharge data were measured higher than actual discharge.

      b) Rainfall data in the Basin are incorrect due to large glacier areas for which there is no rainfall data. Actual rainfall may be greater than adopted rainfall data.

Consequently further study is required particularly on rainfall in the glacier areas.

2.3.4 Rating Curve

Rating curves at each gauging station were prepared by using measured water levels and discharges collected. Number of measurements was not confirmed but measurements of discharge and cross section of gauging station are thought to be made only 2 or 3 times a year at each station. Measurements for high discharge in particular were not conducted.

Based on Study results, the rating curve equation formula at each gauging station was calculated as shown in TABLE 2-8.

2.3.5 Hydrological Data

Collected discharge data in the Study area are shown in TABLE 2-9.

3. FLOOD DISCHARGE

3.1 Statistical Analysis

For estimation of flood discharge by the statistical method, daily discharge on the Sun Kosi, Tamur and Arun rivers were extended to 15 years (1964-78), supplementing unrecorded data by the correlation study. The

correlations of discharge at the upper reaches near the Sun Kosi No. 3 site, the middle reaches near the Sun Kosi No. 2 site and the lower reaches near the Sun Kosi No. 1 site were analysed and the correlations between the Sun Kosi, Tamur and Arun rivers are also analysed. These correlations are shown in FIG. 2-11.

Daily discharge data were processed by the Hazen Method to estimate the probable mean daily discharge corresponding to the various occurrences. The probable mean daily discharge must be extended to obtain the peak discharge. The flood hydrograph (FIG. 2-12) shown in the Feasibility Report on Sapt Kosi High Dam was used. The rate of peak and mean discharges depends on the continuing hours and shape of flood and start/end time of measurement for mean daily discharge. The rate varies from 1.74 to 1.32.

Probability curves of flood discharge on the main rivers were obtained as shown in FIG 2-13. The probable peak discharges (43,000m^3/s) which coincide with the probable maximum discharge for a 10,000-year return period, were obtained and are tabulated below.

TABLE 2-10   PROBABLE FLOOD DISCHARGE

Return Period	Sapt Kosi (CA=61,000km^2)	Sun Kosi (CA=19,000km^2)	Arun (CA=36,000km^2)	Tamur (CA=6,000km^2)
5	20,300	8,200	8,200	4,300
10	22,700	9,200	9,200	4,700
20	25,100	10,300	10,100	5,100
200	32,100	13,100	12,900	6,300
1,000	36,700	15,100	15,000	7,100
10,000	43,000	17,800	17,600	8,200

Further study for each site is required to accurately estimate flood by measurement of flood and analyses. In the Master Plan Study, the Team adopted the highest level of design flood of existing and planned dams in Nepal as data in the Kosi Basin was not available.

3.2 Existing Data

3.2.1 General

Gauging stations equipped with automatic recorders are listed below:

- No.647, Busti G.S., Tama Kosi River
- No.670, Rabuwa Bazar G.S., Dudh Kosi River
- No.680, Kampu Ghat G.S., Sun Kosi River
- No.690, Mulghat G.S., Tamur River
- No.604.5, Turik Ghat G.S., Arun River

At other gauging stations, measurements are recorded manually without automatic equipment.

Hydrographs of floods on the Sun Kosi, Arun, Tamur and Sapt Kosi rivers at Tribeni were available as described in the "Feasibility Study Report on Kosi High Dam". However, these data were collected in 1948 and 1954 with no recently recorded data.

3.2.2 Recorded Data

The Team utilized flood data provided by ED. The recorded gauging stations and recorded period are shown in TABLE 2-11 and TABLE 2-12. Flood probability curve derived based on the said data is as shown in FIG. 2-14.

TABLE 2-11   FLOOD RECORD

No.	Gauging Station	River	Available Recorded Period
630	Panchuwar Ghat	Sun Kosi	1964 - 1974
652	Khurkot	Sun Kosi	1967 - 1974
670	Rabuwa Bazar	Dudh Kosi	1964 - 1974
680	Kampu Ghat	Sun Kosi	1965 - 1977
690	Mulghat	Tamur	1970 - 1978
695	Barakshetra	Sapt Kosi	1984 - 1978