No. 5

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR THE WATER SUPPLIES TO URBAN AND SEMI—URBAN CENTERS IN THE KINGDOM OF NEPAL

SEPTEMBER 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of His Majesty's Government of Nepal, the Government of Japan has decided to conduct a Basic Design Study on the Project for the Water Supplies to Urban and Semi-urban Centers and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Nepal a Basic Design Study Team headed by Mr. Shigeru Hataya, Keiyo-South Construction Office, Water Works Bureau, Chiba Prefecture from 20 March to 19 May, 1988.

The team had discussions on the Project with the officials concerned of His Majesty's Government of Nepal and conducted a field survey in 9 project areas. After the team returned to Japan, further studies were made and a draft report was prepared, and for the explanation and discussion of it, a mission headed by Mr. Haruo Suzuki, Deputy Director, Grant Aid Planning and Survey Department, JICA was sent to Nepal from 21 to 30 August, 1988. As a result, the present report has been prepared.

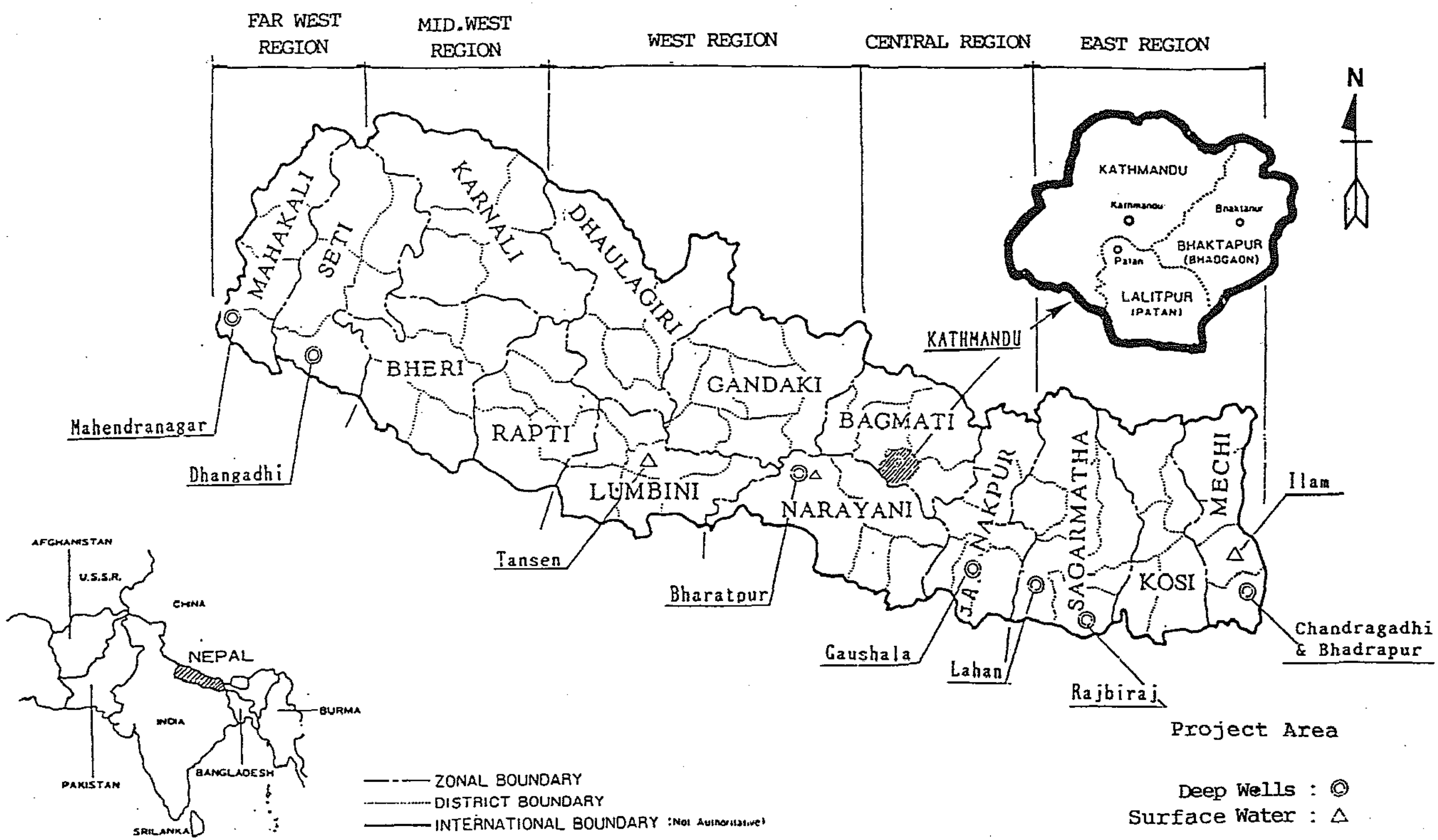
I hope that this report will serve for the development of the Project and will contribute to the promotion of friendly relations between the two countries.

I wish to express my deep appreciation to the officials concerned of His Majesty's Government of Nepal for their close cooperation extended to the team.

September, 1988

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency



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Abbreviations

HMG of Nepal	:	His Majesty's Government of Nepal
DWSS	:	Department of Water Supply and Sewerage
WSSC	:	Water Supply and Sewerage Corporation
MPLD	:	Ministry of Panchayat and Local Development
MHPP	:	Ministry of Housing and Physical Planning
MSTP	:	Management Support for Town Panchayat
UNDP	:	United Nations Development Programme
WHO	:	World Health Organization
JICA	:	Japan International Cooperation Agency
GWRDB	:	Groundwater Resources Development Board
IDA	:	International Development Association
ADB	:	Asian Development Bank

SUMMARY

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In Nepal the First Five Year Development Plan was inaugurated in 1956/57, and this year is the Fourth year of the Seventh Five Year Plan which commenced in 1985. During the First and Second Five Year Plans, development of basic infrastructures was emphasized. This made possible the development of various projects for the subsequent Five Year Development Plans. Based on this preparatory development, the Third Five Year Plan was formulated consisting of a comprehensive development plan involving the private sector as well.

In the Fourth and Fifth Five Year Development Plans, emphasis was given to the development of irrigation and agricultural sectors in addition to the transportation and communications sectors.
Since the Fourth Five Year Plan, development of water supply projects is being promoted as a necessary requirement for the provision of basic needs of the people, and thus the socioeconomic development and national welfare of the people. Since this Fourth Five Year Plan, about 3 to 4% of the total development budget has been allocated for water supply projects, and especially the "urban water supply project" including all 33 cities in Nepal has been given high priority.

A large scale water supply renovation project for big cities such as Kathmandu and others was commenced in 1974. Then with the financial assistance of international and bilateral agencies, such as IDA, ADB, the Government of the United Kingdom, and others, the water supply projects in 23 of the 33 towns of the "urban water supply project" have been undertaken by the DWSS. On these towns' water suppy, twelve(12) projects have been completed

and additional four(4) projects are under construction. Projects for the remaining towns are either under investigation or at detail design stage.

Based on the above mentioned background, a request for grant aid cooperation was made for eight of the remaining towns of this "urban water supply project" and for one village, Gaushala, which is considered to be one of the high priority rural areas.

Project Areas	Requests
Mahendranagar, Dhangadhi, Bharatpur, Lahan, Bhadrapur & Chandragadhi, Ilam (Seven Urban Centers)	Renovation and Augmentation of existing water treatment facilities
Gaushala (One Semi-urban Centre)	New water supply facilities
Tansen (One Urban Centre)	Provision of spare-parts for existing water supply facilities

Among these eight towns, the Tansen project area is to be provided only with spare parts for the existing water supply facilities, while the rest are scheduled for renovation and augmentation of their respective existing schemes. However, for Gaushala village a new water supply scheme will be provided.

Of these project areas, Tansen and Ilam are towns in the hilly region, while the other six towns and Gaushala village are in the Terai region. This Terai region is a plain area with an elevation about 100 m above MSL (Mean sea level), and the area is important for its agricultural farmlands.

Therefore the government has provided considerable budgetary allocations for the development of irrigation facilities.

Due to this, population moving from the northern hilly region where only limited arable lands are available is very prominent, and as a result, the population growth rate of the Terai region is 4.2% against the national average of 2.6%. Also, at present 43.6% of the total national population inhabit this Terai region. Hence the population concentration in the towns of the Terai is very high, and in the project areas concerned, the annual average population growth rate is in the range of 4 to 7%.

The existing condition of the water supply in these project areas is very poor due to aging of the facilities and the increase in water demand caused by the increase in population. Therefore a restricted water supply ranging from only 2 to 9 hours per day is provided. In addition, although many existing groundwater sources contain a high content of iron beyond the allowable concentration, still the necessary iron removal facilities are either not provided or out of order.

This project is aimed at improving the water supply situation in the project areas concerned, thereby contributing to the overall development of the water supply facilities in the whole country. In order to achieve this objective, this basic design study was carried out.

The target design period of this project is 15 years, until the year 2003. The population projection is done based on the available population data and other related data in each project area.

Then the water service areas are demarcated and the corresponding water served population are estimated. The percapita water demand adopted is as recommended by the DWSS design criteria. The water demand of hospitals, schools, and other public insitutions are also taken into consideration. As the basic requirement a 24 hours water supply service is adopted for the estimation of the design water demand.

Design Population : 251,000 (Tansen excluded)

Maximum Daily Water Demand : 32,700 m^3/day (Tansen excluded)

Percapita Maximum Daily Water Demand : 130 l/cap/day (Tansen excluded)

The design facilities for each project areas are shown in Table 1.

The total design requirement of water source wells for the design period of 15 years is 19 numbers. However, by considering the uncertainity inherent to future water demand and the pre-investiment involved, it is very realistic and also economical to adopt a staged implementation of source wells. This would enhance the overall investment efficiency. Accordingly, only 10 number wells to meet a 10 year water source demand is decided to be installed, initially.

The total project cost is estimated at about ¥4,470 million, with a Government of Japan contribution (foreign exchange component) of ¥4,400 million and a Government of Nepal contribution (local cost component) of ¥70 million.

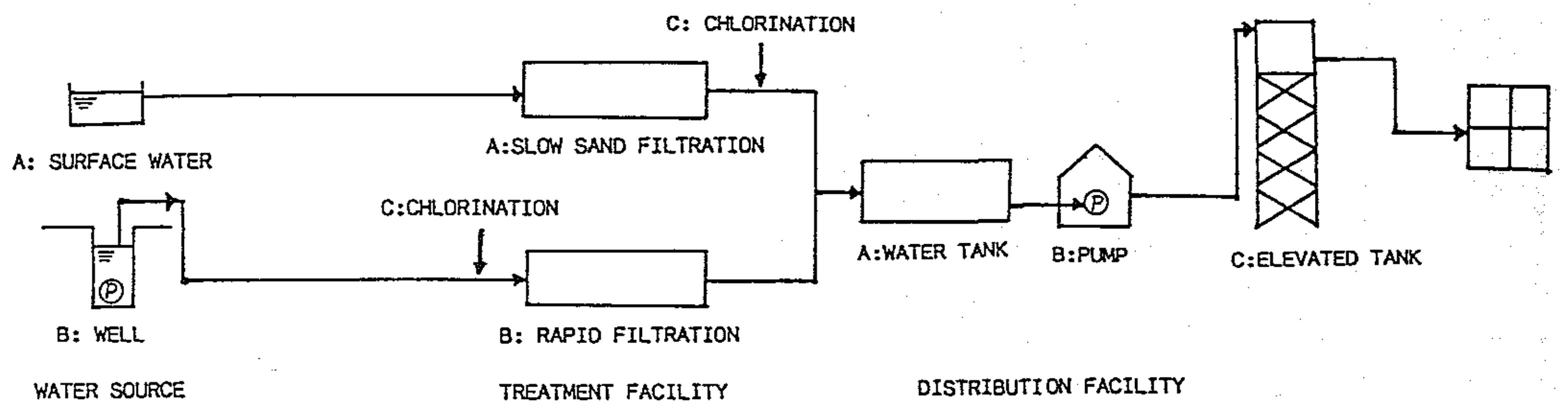


Table 1 Outline of Water Supply Facilities

Site	Water Source		Transmission Main	Treatment Facility			Distribution Facility			Distribution	Design Population
	Surface Water	Well	(ø mm)	Slow Sand Filtration	Rapid Filtration	Chlorination	Water Tank	Pump	Elevated Tank	Pipe Line Total Line	Daily Max Water Rate (m3/day)
Mahendranagar	-	1300 m3/day x 3 (proposed 2)	125,150 mm	-	2700 m3/day	2700 m3/day	*1)900 m3 -	1.4 m3/min X3(standby1)	- 200 m3	ø250 - 50 mm 12,406 m	16,000 2,700
Dhangadhi	-	1700 m3/day X 2 (proposed 1)	125,150 mm	-	-	2600 m3/day	- 500 m3	1.4 m3/min X3(standby1)	- 200 m3	ø250 - 50 mm 20,834 m	14,000 2,600
Bharatpur	2000 m3/day	1700 m3/day X 4 (proposed 4)	125,150 mm	2000 m3/day	-	2000 m3/day 6400 m3/day	900 m3 1200 m3	3.2 m3/min X3(standby1)	- 400 m3	ø400 - 50 mm 23,826 m	65,000 8,400
Gaushala	-	1300 m3/day x 2 (proposed 2)	125,150 mm	-	-	1100 m3/day	- 100 m3	0.5 m3/min X3(standby1)	- 200 m3	ø200 - 50 mm 10,439 m	15,000 1,100
Lahan	-	1300 m3/day x 4 (proposed 3)	125,150 mm	-	4000 m3/day	4000 m3/day	- 550 m3	1.9 m3/min X3(standby1)	450 m3 -	ø350 - 50 mm 24,706 m	31,000 4,000
Rajbiraj	-	1300 m3/day x 5 (proposed 4)	125,150 mm	-	6200 m3/day	6200 m3/day	*1)900 m3 -	2.82 m3/min X3(standby1)	450 m3 -	ø350 - 50 mm 18,216 m	49,000 6,200
Bhadrapur & Chandragadhi	-	1300 m3/day x 5 (proposed 3)	125,150 mm	-	3050 m3/day X 2	3050 m3/day X 2	- 300 m3 X 2	1.4 m3/min X6(standby2)	450 m3 X2 -	ø350 - 50 mm 30,393 m	48,000 6,100
Ilam	1600 m3/day		150 mm	-	-	1600 m3/day	236 m3	-	- -	ø200 - 75 mm 7,689 m	13,000 1,600
Tansen	Pumps and other Equipment would be provided.										
							upper:existing lower:proposed		upper:existing lower:proposed	(TOTAL)	251,000 32,700

*1) Existing one to be improved and used

The estimated cost of operation and maintenance of the Project is NRp6.74 million (¥39.0 million), while the estimated revenue based on existing water tariffs of WSSC is NRp7.06 million (¥40.8 million), hence the Project is economically feasible.

The period of construction including procuring and transporting of materials is estimated to be 47 months after the exchange of notes, while the period including the detailed design and tendering is estimated at 53 months.

In case the project is carried out by the Grant Aid Program of Japan, the project implementation will be carried out in 4 stages, as follows:

The First Stage	:	Gaushala, Tansen
The Second Stage	:	Lahan, Rajbiraj
The Third Stage	:	Bhadrapur, Chandragadhi, Ilam
The Fourth Stage	:	Mahendranagar, Dhangadhi, Bharatpur

With the implementation of this water supply project, an estimated 250 thousand people in the nine (9) project areas consisting of eight (8) towns and one (1) village would reap the benefit of being availed with 24 hours potable water.
This provision of safe water supply would lead to a drastic reduction in water borne disease, thereby immensely improving the general public health of the people with a sound sanitary environment. Furthermore a significant secondary benefit is the contribution of the project to the enhancement of socioeconomic activities. A comparison between water service levels with and without the project is summarized in Table 2.

Table 2 Comparison of Water Supply Levels with and without Project

Project Area	Without Project			With Project		
	Water consumption	Design population	Service duration	Water consumption	Design population	Service duration
	(m^3/day)	(Person)	(hr)	(m^3/day)	(Person)	(hr)
Mahendranagar	300	7,200	5.5	2,700	16,000	24
Dhangadhi	640	6,500	9	2,600	14,000	24
Bharatpur	350	21,900	4	8,400	65,000	24
Gaushala	-	8,000	-	1,100	15,000	24
Lahan	110	14,200	2	4,000	31,000	24
Rajbiraj	160	19,300	3	6,200	49,000	24
Bhadrapur & Chandragadhi	430	21,900	4	6,100	48,000	24
Ilam	200	9,300	6	1,600	13,000	24
Total	2,190	86,400		32,700	251,000	

The provision of water meters for this project ensures the adoption of a rational water tariff system, a necessary condition for instituting a self supporting operation and maintenance system of water supply. This will contribute favorably to the financial condition of water supply projects in the country, including the economic and financial viability of future water supply development projects.

With the implementation of this project, in an overall sense, the provision of potable water supply services in this project is to be increased about 20% of implementation ratio of the "urban water supply project" for 33 cities and contribute to the improvement of the quality of life of people.
Based on this consideration, this project is considered to be very much suitable for the Japanese Grant Aid Program.

It is recommended to institute a rational water tariff system based on water consumption which is measured using water meters. This will facilitate in maintaining a sound financial basis for operation and maintenance of the water supply facilities and also in future augmentation works.

CHAPTER 1. INTRODUCTION

Chapter 1
INTRODUCTION

The Kingdom of Nepal follows the administrative system of a constitutional monarchy.

The country is situated on the southern slopes of the mighty Himalayas. Nepal shares common frontiers with China and India.

Nepal is principally an agricultural country with about 40% cultivated land. The agricultural sector contributes about 62% of the gross domestic product (GDP).

At present, the national infrastructure has not been developed much except in some large cities.

The Government of Nepal has endeavoured to fulfil the basic needs of the people and to improve the services of national welfare, since the first five year plan was commenced in 1956.

In regard of water supply services, the situation even in urban areas is considered rather unsatisfactory. The average daily water consumption is still lower than the planned figures in 1974, and potable water supply facilities are available only limited urban areas and in restricted levels of service.

The reasons for the above situation are mainly 1) increased water demand due to rapid population growth increase, 2) limited operation hours of existing facilities due to limited power supply, and 3) the lack of a sense of environmental sanitation.
Though the Government of Nepal has been making an effort to overcome these problems based on successive five year development programs from the First which

commenced in 1956 to the Seventh at present, however, the implementation of the planned programs has not proceeded on schedule due to financial constraints and technical problems.

Under such background conditions, the Government of Nepal requested the Government of Japan for the provision of technical and financial assistance for potable water supply facilities through its grant aid program.

The proposed project areas for water supply are Mahendranagar, Dhangadhi, Tansen, Bharatpur, Gaushala, Lahan, Rajbiraj, Bhadrapur & Chandragadhi and Ilam.

In response to the request, the Government of Japan, through the Japan International Cooperation Agency (JICA), dispatched a preliminary study team headed by Mr. Tadanori SUZUKI, an official of the First Basic Design Study Division, Grant Aid Cooperation Planning and Study Department, JICA, to Nepal from November 30 to January 8, 1987.

The preliminary study team confirmed the contents, background and appropriateness of the request for Grant Aid Cooperation by the Government of Nepal. The Government of Japan then dispatched a basic design study team headed by Mr. Sigeru HATAYA, Water Supply Bureau, Chiba Prefecture Government, from March 20 to May 19, 1988. The study team confirmed the contents and scope of the Project.

The results of the field surveys and the discussions held with the concerned officials of the Government of Nepal were adopted as the Minutes of Discussions and were signed by both parties (see Appendix A).

The Government of Japan dispached a mission headed by Mr. Haruo SUZUKI, Deputy Director of the Grant Aid Planning and Survey Department, JICA, to Nepal for the explanation of Draft Final Report from August 21 to August 30, 1988. The mission held discussions with the Nepalese officials concerned. The results of the discussions were adopted as the Minutes of Discussions (See Appendix F).

Upon returning to Japan, further studies were made relevant to the Project. As a result, this report (BASIC DESIGN STUDY REPORT ON THE PROJECT FOR THE WATER SUPPLIES TO URBAN AND SEMI-URBAN CENTERS IN THE KINGDOM OF NEPAL) was prepared.

CHAPTER 2. BASIC CONCEPT OF PLANNING

CHAPTER 2

BASIC CONCEPT OF PLANNING

2-1 Principal Natural Characteristics and National Development Programs of Nepal

2-1-1 Natural Conditions

<u>Location and Geography</u>

The Kingdom of Nepal is situated on the southern slopes of the mighty Himalayas. Nepal shares common frontiers with China in the north, and India in the south, east and west, and is landlocked. The country is rectangular in shape and lies between latitude 26°22'- 30°27'N, and longitude 80°04'- 88°12'E.

The total area of the country is about 147, 181 sq. km.

Geographically Nepal can be classified into the following three (3) subdivisions stretching parallel to the Himalayas from the eastern to the western corner of the country:

(1)	High Mountainous zone	:	EL	4,000 m and above
(2)	Midland hilly zone	:	EL	610 m - 4,900 m
(3)	Terai plain zone	:	EL	100 m - 610 m

<u>High Mountainous zone</u>

This zone is located in the northern part of the country and the altitude ranges from 5,000 m to 8,800 m above MSL.

The total area of this zone is approximately 1/3 of the whole country, however the population of this zone is only about 8.7% of the total population of the country, according to the 1981 census.

Midland hilly zone

This zone stretches from the eastern to the western part of the country and is composed of low-lying basins of the hills and river valleys.

The total area of this zone is about 42% (61,708 km^2) of the whole country and 10% of this area is under cultivation. The population of this zone is about 47.7% of the total population (year 1981 census).

Terai plain zone

This zone is situated in the northern edge of the Indo-Gangetic plain. This belt is about 25 km to 40 km wide with an area of 34,000 sq. km. About 40% of this area is under cultivation and the main agricultural products are rice, sugarcane, maize, and wheat. In this area about 43.6% of the total Nepalese population live, however recently the population has increased rapidly due to migration from the hilly region. The population concentration is rather high in the urban areas of this Terai zone. In addition, the movement of population from rural areas to urban areas is also prominent.

Climate and Hydrology

Nepal is located just outside the northern limits of the tropics, hence it principally falls within the subtropical zone. The climate is influenced by the south-east monsoon. The monsoon period is from June to September, during which period about 80% of the total precipitation occurs. The climate varies from mountainous to plain regions due to the change in topography of the country caused by the variation in elevation.

The average annual precipitation varies widely from 250 mm to 2,500 mm depending on the locality. There are four (4) major rivers and a large number of minor rivers (about 6,000) in the country. The four major rivers are the Kosi, Gandaki, Karnali and Mahakali. These rivers derive their water mostly from rain and snow melts in the mountainous regions.

In the Terai area, the rainfall is abundant with subsequent groundwater recharge, hence the area is rich in both groundwater and surface water resources.

2-1-2 Socioeconomic Conditions

Nepal is principally an agricultural country. The agricultural sector contributes about 62% of the gross domestic product (GDP), and 90% of the population is engaged in agriculture.(Table 2.1)

Recently, the rate of contribution of the agricultural sector to the GDP and its rank in exported commodities has decreased, however the corresponding population engaged in agriculture remained virtually unchanged.

Generally agricultural products are much affected by the variation in climate, therefore the GDP is likely to be rather unstable with respect to the preceding GDP.

In the fiscal years of 1980 and 1982, agricultural production declined because of inadequate rainfall due to failure of the monsoons. In order to stabilize and increase the agricultural productivity, the government has expanded the provision of irrigation facilities.

The area cultivated with irrigation facilities was 198,481 ha at the end of the Fifth Plan in 1979 and this area had been extended to 271,693 ha by the beginning of the Sixth Plan in 1984.

The nonagricultural sector contributes about 40% of the GDP and its growth rate ranges from 0.4 to 5.5%. The major industries of this nonagricultural sector are construction, transport and communications, finance (banking) and social services.

Table 2.1 Economic Growth Rate by Main Industries and their Portions in GDP

Unit (%)

Year	Agriculture	Mining Industry	Cottage Industry	Construction Industry	Transport and Communication	Trade, Hotel and Restaurant	Banking	Service Industry etc
1980/81	60.9	3.0	1.3	8.0	7.4	3.7	8.2	7.4
1981/82	59.4	3.1	1.3	9.3	7.0	3.8	8.3	7.7
1982/83	58.0	3.4	1.3	7.8	7.9	3.9	8.7	9.0
1983/84	62.0	3.5	1.4	7.0	6.6	3.8	7.9	7.8

Source : Economic Survey FY 1984-87, Ministry of Finance

UNIT (%)

ACTUAL GROWTH RATE	80/81	81/82	82/83	83/84 estimate	84/85 estimate	(80/81-84/85) Mean Annual Growth Rate
GDP	8.3	3.8	-1.4	7.4	2.8	3.2
Agriculture Sector	10.4	3.5	-2.5	8.7	1.7	2.8
Non-Agriculture Sector	5.5	4.2	0.4	5.5	4.5	3.6

Source : The 2th plan of development

2-1-3 Administrative System

The country is divided into five (5) development regions constituting two or three zones per region. These regional divisions have no relation to the political administrative structure of the country, thus they have no Panchayats.

2-1-4 Infrastructure

Electric power

The capacity of electric power supply to Kathmandu, the capital city of the country, has increased substantially due to the completion of the Kulekhani Hydro-Electric Project.

However it has to be admitted that the power supply to most of the rural areas is much behind the power supply targets.

Recently some hydro-electric projects and installation of transmission lines are being carried out with the assistance of foreign aid and the areas provided with electricity are expanding steadily.

The areas that are yet to be provided with electricity from local transmission lines are supplied with electricity from generators or with power supply bought from neighboring India. In these areas, the power supply is very erratic and unreliable.

Road transport

Most parts of the country are now interlinked internally without the necessity to use foreign (Indian) transportation facilities.

Most roads in big cities, the East-West Highway linking the urban centers of Terai, and the North-South trunk road connected to the East-West Highway are paved.

In the urban areas of the countryside, the paved roads are fewer, hence most roads are unpaved.

The route of North-South road is very intricated due to topographic conditions and its quality of pavement is rather substandard. Therefore this road is not suitable for high speed driving.

The conditions of roads in the Far West region and the Mid West region are extremely poor and breakdowns in transport at river crossings are frequent, caused by flooding during the rainy season. Hence overland transport via Indian roads and air transport are the reliable means of approach to these regions.

Air transport

Five big cities, Kathmandu, Biratnagar, Janakpur, Nepalgunj and Bhairahawa have airports with paved runways, however most of the airports in other urban centers have grass runways.

The number of flight services interlinking the cities is dependent on the size, economic importance etc. of the city and varies accordingly from a single (1) flight to seven (7) flights per week. However the flight services linking the urban centers are rather unreliable, especially during the monsoon season.

2-1-5 Population Movement

Population growth and its distribution

Though a population census has been carried out once every 10 years since 1911, a census conforming to international standards was first accomplished only in 1952. Accordingly, in 1952 the population was only 8,473,478 (about 8.5 million) and it increased to 15,022,839 (about 15 million) in 1981. The population census data obtained since 1952 is given in Table 2.2.

Table-2.2 POPULATION CENSUS (1952-1981)

Year	Total Population	Growth Rate in Precentage	Annual Growth Rate in Percentage
1952/54	8,473,478	-	-
1961	9,412,996	11.10	1.32
1971	11,555,986	22.80	2.07
1981	15,022,839	30.00	2.66

The population growth rate is increasing since 1961, as evident from the available population census data of Table 2.2. The average annual population growth rate during 1971-1981 reached 2.66%.

The main reason for the rapid increase in population growth rate in recent years is that while the birth rate still remains high, the death rate has been declining steadily.

The population distribution according to the respective development regions and geographical regions, as estimated from the census of the year 1981 is given in Table 2.3.

Table-2.3 Population and Family Number-1981 Cencus
(According to Development Region)

Development Region	Population	Family Number
Eastern Region	3,708,923	651,795
Center Region	4,909,357	854,545
Western Region	3,128,859	544,283
MId-western Region	1,955,611	322,334
Far-western Region	1,320,089	212,197
TOTAL	15,022,839	2,585,154

(According to Geographical Region)

Geographical Region	Population	Family Number
Himalaya	1,302,896	226,294
Hilly	7,163,115	1,240,434
Terai	6,556,828	1,108,426
TOTAL	15,022,839	2,585,154

Accordingly, in the year 1981, 8.7% of the total population lived in the High Mountainous Himalaya region, 47.7% in the Midland hilly region, and 43.6% in the Terai plain region.

The average number of family members per household is 6 persons based on the 1981 census.

Among the geopolitical regions, the Terai zone has the highest regional population density, with 192.7 persons per ha. As for the development regions, the population density increases towards the eastern region. The topographical distribution of population density based on the 1981 census is given in Table 2.4.

Table-2.4 Topographical Distribution and Density of Population (1981)

	Population	Population density per sq.km.
Nepal	15,022,839	102.20
Himali Region	1,302,896	25.10
Eastern	638,439	32.40
Central	413,143	65.80
Western	19,951	3.40
Mid-western	242,786	11.40
Far-western		
Hilly Region	7,163,115	116.08
Eastern	1,250,042	116.90
Central	2,108,433	178.60
Western	2,150,939	117.50
Mid-western	1,042,365	76.00
Far-western	604,336	89.40
Terai Region	6,556,828	192.70
Eastern	2,113,442	290.70
Central	2,387,781	256.00
Western	957,969	182.00
Mid-western	670,760	91.70
Far-western	426,876	88.10

Excerpt : Nepal Population Census-1981

The regional average annual population growth rates during 1971-1981 are, 1.6% for the High Mountainous zone, 1.5% for the Midland Hilly zone and 4.2% for Terai plain zone.

The high population density in the Terai region is mainly due to migration from the High Mountainous and Midland hilly regions, as evident from Table 2.5.

Table-2.5 Internal Migration between 1978-1981

Region	Internal	External	Net Migration
Himali Region	35,619	297,086	-61,467
Hilly Region	169,923	594,634	-424,711
Terai Region	724,043	37,865	686,178
Total	929,585	929,585	0

Note:- Net external migration from the concerned region
- Net internal migration to the concerned region

Source: Central Bureau of Statistics Population Census 1981

This phenomenon of migration is mainly due to the high agricultural potential of Terai land and the availability of substantial infrastructure in the Terai region.

Concentration of population towards urban areas

The population of urban areas in 1961 was 336,000, i.e. 3.6% of the total population. This figure increased to 462,000, i.e. 4.0% by 1971, and again to 957,000, i.e. 6.38% by 1981. Based on the population survey conducted exclusively for the whole of 29 town Panchayats in 1985/86, the total town Panchayat population was of 1,360,000 (1.36 million), which corresponds to 8.2% of the total population of the country.

The above mentioned high concentration of population towards urban and semi-urban areas has become a typical feature of Nepal today. Table 2.6 and Table 2.7 illustrate the population pattern and other relevant information of town Panchayats.

Table-2.6 Shape of the Population of Town Panchayats of the Country 1951-1981

Population pattern of Town Panchayats of Nepal

Population range	Number of Town Panchayat	
	1951	1981
5,000 - 9,999	4	2
10,000 - 19,999	5	6
20,000 - 29,999	3	3
30,000 - 39,999	-	4
40,000 - 49,999	2	5
50,000 - 99,999	1	2
100,000 - and above	1	1
Total	16	23

Source : National Census in 1981

Table-2.7 Centralization of the Population Descending Order of the Town Panchayats Arccoding to Population in 1981

Town Panchayat	Geographical region	Population		Annual growth rate
		1971	1981	
Kathmandu	Hilly	150,402	235,160	6.40
Biratnagar	Terai	45,100	93,544	7.60
Lalitpure	Hilly	59,049	79,875	3.10
Bhaktapur	Hilly	40,112	48,472	1.90
Pokhara	Hilly	20,611	46,642	8.50
Mahendranagar	Terai	-	43,834	-
Birgunj	Terai	12,999	43,642	12.87
Dharan	Terai	20,603	42,146	7.40
Janakapur	Terai	14,294	34,840	9.30
Hetauda	Inner Terai	16,194	34,792	7.90
Nepalgunj	Terai	23,523	34,015	3.70
Siddharthanagar (Bhairawa)	Terai	17,272	31,119	6.10
Bharatpur	Terai	-	27,602	-
Dhangadhi	Terai	-	27,274	-
Butwal	Terai	12,815	22,583	5.80
Tribhuvannagar (Ghorahi)	Inner Terai	-	20,608	-
Rajbiraj	Terai	7,832	16,444	7.70
Birendranagar	Inner Terai	-	13,859	-
Dhankuta	Hilly	-	13,836	-
Lahan	Terai	-	13,775	-
Tansen	Hilly	6,434	13,125	7.40
Ilam	Hilly	7,299	9,773	3.00
Bhadrapur	Terai	7,499	9,761	2.70
Total		461,938	956,721	

Source : Central Bureau of Statistics, " National Census Reports "

Based on the 1971 and 1981 population census, the average annual population growth rate for this decade was estimated as 2.66% for the whole country, whereas it was 7.0% in the whole of the town Panchayats only. Accordingly, the extremely high tendency of population concentration towards the Terai region compared to the other areas could be easily understood. A comparison of the ratio of town population according to geopolitical region is given in Table-2.4 and 2.7.

2-1-6 Outline of National Development Programs

The year of 1988 is the fourth year of the Seventh Five Year Plan that was inaugurated in 1985. In the first and second 5 year plans, projects related to the infrastructural development were emphasized in order to set out the basic conditions for the proceeding comprehensive development projects. In the Third Five year plan a comprehensive development program with high priority on private sector development was established. In the Fourth Five Year Plan, development of transportation and communication facilities was given the first priority. In addition to that, agricultural and irrigation projects, and agricultural land reforms were also incorporated.

In the following Fifth and Sixth Five Year Plan mining and electric power industries were added as the important sectors of development.(Table-2.8)

The targets of expenditures for these First to Seventh Five Year Plans were not achieved due to shortage of finances. In all these five year development plans more than 50% of the financing was planned to be derived from foreign financial sources as grants and loans, which was not acquired.

Table-2.8 Outline of Five Year Development Plan

	1st	2nd	3rd	4th	5th	6th	7th
Period	56/57 60/61	62/63 64/65	65/66 69/70	70/71 74/75	75/76 79/80	80/81 84/85	85/86 89/90
Budget (NRp million)	330 private sector not included	600 private sector not included	2,500 public:1740 panchayat:240 private:520	3,540 public:2550 panchayat:120 private:170	9,197-11,404 public:6170-7545 panchayat:930-1187 private:2096-2672	33,940 public:20490 panchayat:1800 private:11650	50,410 public:27000 panchayat:2000 private:21410
Public Sector Foreign Assistance Amount (NRp million) Percentage	170 (52%)	N.A	1250 (63%)	1490 (56%)	N.A	13000 (58%)	20480 (71%)
Expenditure (NRp million) Percentage	215 (65.0%)	597 (99.5%)	1639 (65.6%)	N.A	8871 (96.5%)	N.A	-
Public Sector Priority	Construction Transportation Communication	Transportation Communication Electric Power Industry Tourism	Transportation Communication Electric Power	Transportation Communication Agriculture Irrigation Forestry	Agriculture Forestry Transportation Communication	Agriculture Forestry Mining Electric Power	Agriculture Forestry Mining Electric Power

Due to this fact GDP reached only 2 to 3% against the targeted figure of 4%.

The Seventh Five Year Plan, inaugurated from July, 1985, is now being implemented. The principal feature of this present five year plan is the reduction of central government financed projects and revitalization of private sector financed projects.

A cursory of the Seventh Five Year Plan is as follows;

1. Target and strategy

1) Target

(1) To increase productivity

(2) To increase opportunities for productive employment

(3) To fulfil the minimum basic needs of the people

2) Basic development strategies

(1) To accord overall priority to the development of the agricultural sector

(2) To put more emphasis on the development of forest resources and soil conservation

(3) To put emphasis on the development of water resources

(4) To emphasize industrial development

(5) To emphasize the promotion of export trades

(6) To emphasize tourism development

(7) To control the population growth rate

(8) To consolidate the foundation of national economic integration

(9) To improve management of the economy by decentralizing the decision-making and execution processes

(10) To strengthen and consolidate development administration

2. Investment targets and savings plan
The Seventh Five Year Plan aims at raising the GDP by 4.5% per annual. In order to achieve the above growth rate it is estimated that the production of the agricultural sector should be increased by 3.5 percent and the production of the nonagricultural sector by 5.7%, annually.

An investment outlay of NRs 50,410 million is to be allocated so as to achieve this GDP increase. Out of this total outlay, NRs 27,000 million is estimated to be expended by the government sector and NRs 21,410 million by the nongovernmental private sector, as illustrated in Table-2.9.

Table-2.9 Development Plan of Industrial Sector in Nepal

(Unit : million Rupee, %)

	Public Department	Panchayat&Private Department	Total
Agriculture & Irrigation	8380 (31.0%)	8900 (38.0%)	17280 (34.3%)
Mining & Electric Power	7040 (26.1%)	3800 (16.2%)	10840 (21.5%)
Transportation & Communication	5130 (19.0%)	2130 (9.1%)	7260 (14.4%)
Social Service	6450 (23.9%)	8580 (36.7%)	15030 (29.8%)
Total	27000(100%)	23410 (100%)	50410 (100%)

Decentralization

One of the remarkable features of the Seventh Five Year Plan is the administrative decentralization policy. Until recently the district development programs were under the direct control of the central government. With this decentralization policy these powers are to be delegated to the district Panchayats. The main objectives of the district development programs are as follows:

(1) To increase the productivity of agricultural and non-agricultural sectors,
(2) To increase employment opportunities,
(3) To increase social services, and
(4) To promote environmental conservation by arresting environmental destruction

The financial sources of this district development program are the assistance fund and the budget for district development, both from the central government, and the local fund of the Panchayat. However the local fund is very limited, and hence not very significant. The central government fund for the district development program is given in Table 2.10.

Table-2.10 Development Expenditure
(Target according to Economic Sector)

	Expenditure (million Rupees)	Distribution (%)
Agriculture & Irrigation	1608.3	25.3%
Mining & Electric Power	713.8	11.3%
Transportation & Communication	588.7	9.3%
Social Service	3434.7	54.1%
Total	6345.5	100.0%

Source : the Seventh Plan

3. Fund procurement

The fund requirement for the public sector outlay of this Seventh Five Year Plan is estimated as 27 billion Nepalese Rupees. Of this requirement it is projected to procure NRs.20.48 billion (70.6%) from foreign aid and the remaining NRs.8.52 billion (29.4%) from local sources.

The development fund outlay of the Panchayat sector is NRs.2 billion which is less than 10% of the public sector (central government) development budget, and is only about 4% of the total development outlay. A half of the outlay, NRs.1 billion, is from the central government, thus only NRs.1 billion is to be procured by the Panchayat.

The planned outlay for private sectors is NRs.21.4 billion which represents 42.6% of total outlay of which about NRs.1 billion is to be funded by the central government.

The allocation of fund for various industrial sectors are as follows;

NRs.250 million for the mining industry

NRs.250 million for cottage and small scale industries

NRs.500 million for agricultural development

The necessary fund to be procured by the private sector is NRs.20.41 billion.

2-2 Drinking Water Supply Project

2-2-1 Executing Agency

In Nepal two (2) agencies are responsible for the planning and implementation of potable drinking water supply projects. They are as follows:

- Water Supply and Sewerage Corporation (WSSC)
- Department of Water Supply and Sewerage (DWSS)

The WSSC is actively involved in the drinking water supply project for 13 city areas (Nagar Panchayat).

This agency was established in 1973 with the assistance of the World Bank and was initially named as WSSB. In 1984 the name was altered to the present name, the WSSC. The WSSC is a public service corporation with an "independent" self-supporting accounting system.

The WSSC aims at completely independent functioning, including finance, by charging for the water it supplies to the public. However this aim has hardly been achieved, hence its budget for functioning is being subsidized by the central government.

The DWSS is an organ of the Ministry of Housing and Physical Planning and its activity covers the potable water supply projects of urban areas, which is not under the jurisdiction of the WSSC, and that of village areas with more than a service population of 1,500 people. Furthermore DWSS also engages in small scale water supply projects for small rural communities, such as tube wells. These projects are under the jurisdiction of DWSS.

The organizational chart of DWSS at the period of the study is shown in Fig. 2.2.

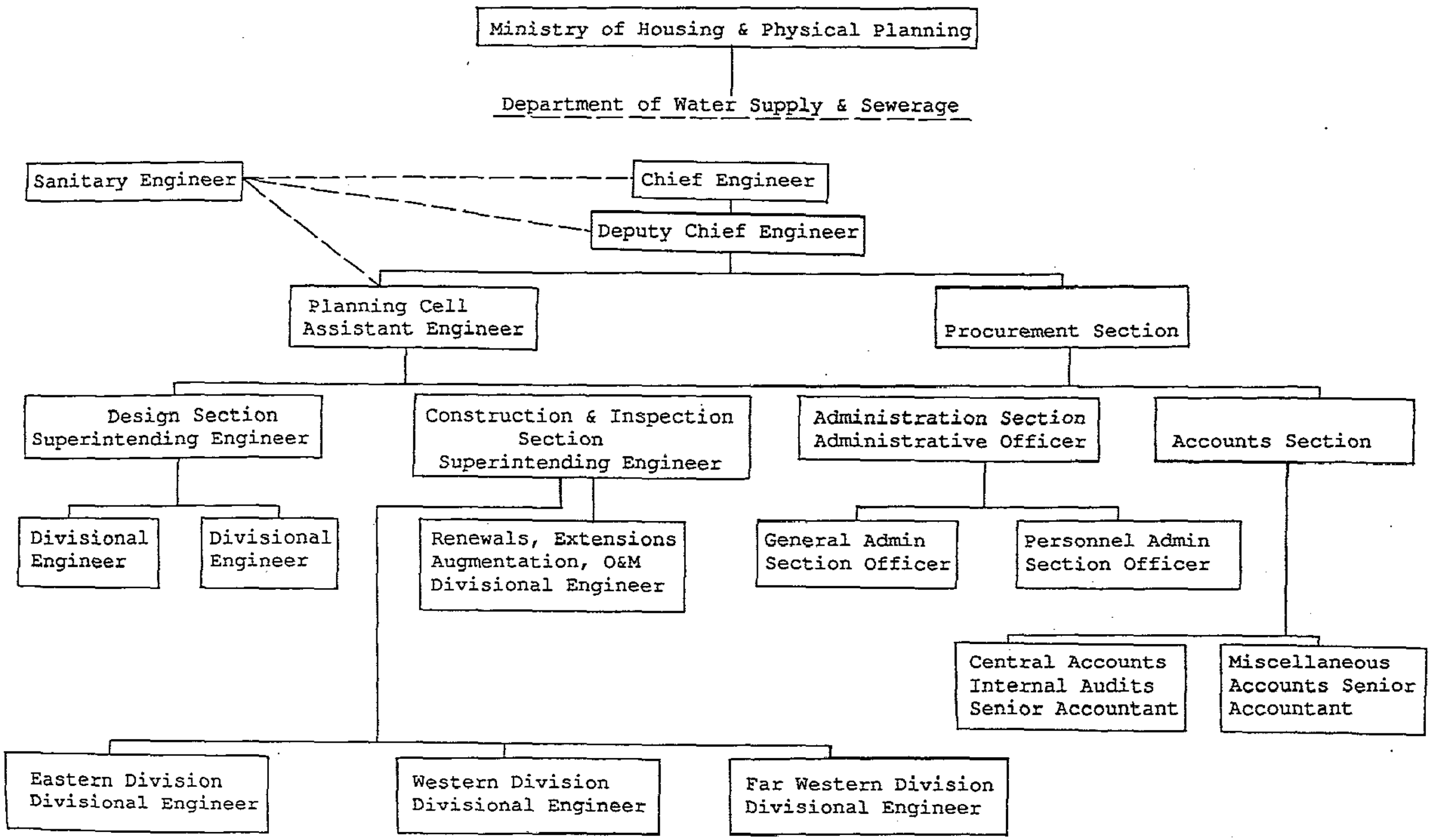


Fig.-2.1 Organizational Chart of DWSS

The MPLD handles the water supply projects of small rural communities with a service population less than 1,500 people. A proposal for such a water supply project should be submitted to the DWSS through the Panchayat concerned.

Then the agency (DWSS) will select the project area and submit its study report to the national planning commission. This commission will make the decision on the project implementation and would request the project budget to the Ministry of Finance. After the approval of the DWSS, the project could be implemented.

2-2-2 Budget of Drinking Water Supply Projects

The development budget for water supply projects has been steadily increasing since the Fourth Five Year Plan as shown below.

Unit : Million NRp

5 Year Plan / Budget	The Fourth Plan (1970-75)	The Fifth Plan (1975-80)	The Sixth Plan (1980-85)	The Seventh Plan (1988-)
Budget of Water Supply Project (NRp mil.)	93	389	1,011	989
Water Supply budget ratio to whole development project ratio (%)	1.1	3.3	4.6	4.1

The Budget for FY1987/88 is NRp.278.2 million, of which about 35% is derived from foreign assistance by ADB and the Government of the United Kingdom (UK).

A) Development Budget (1987 - 88)

(Unit : Million NRp)

	Total	Development Budget	Regular Budget
1. Central level project (9)	31.113	26.020	5.093
2. Projects ADB funded (44)	67.885	61.888	5.997
3. Projects U.K. funded (9)	21.132	19.390	1.742
4. Destrict level project (207)	132.045	115.615	16.430
5. DWSS current expenses	2.496	-	2.496
Sub-Total	254.681	222.913	31.758

B) Budget for operation and maintenance

(Unit : Million NRp)

	Total	Development Budget	Regular Budged
O/M Budget for project office (207)	23,509	1,630	21,879
Sub-Total	23,509	1,630	21,879
Grand Total	278,190	224,543	53,637

The budget for the water supply projects in the seventh 5 year plan of 1985 is as follows:

Budget for water supply development project concerned (1985-90):

Description	Budget (NRp million)
1. On going project from the sixth 5 year plan	180
2. Shallow tube wells and deep tube wells	120
3. New projects	400
4. Renovation feasibility study, sanitation administrative expenses, etc.	65
5. Urban drinking water supply	225
Total	990

From the above information it is clear that new water supply projects and water supply projects of urban areas are given priority.

2-3 Development Plan of Water Supply Projects

2-3-1 Water Supply Development Plan for Urban Areas

Drinking water supply development is given high priority by the HMG of Nepal in view of the prime importance of providing the basic needs of the people and for creating a healthy manpower pool.

The water supply development projects in large cities under WSSC had been implemented since 1974 and were completed in 1984. This was called "the First Project" which involved Kathmandu and two other cities.

After the first project, the second project had been implemented since 1977 and was completed in 1984. This included the renovation of existing water supply facilities in the cities of "the First Projects" plan, extension work of sewerage facilities in Kathmandu and Lalitpur and preparation of the master plan for extension of the First Project plan and for 6 other cities. The "Second Project" was completed in 1984. The rehabilitation of the water supply facilities based on the master plan was carried out in 1980 during the "Third Project" plan. The necessary finance for the implementation of the First to Third Projects was contributed by IDA.

The rehabilitation projects based on the above plan were urgent but still deficient to meet the water demand. At the same time, the feasibility for water supply including the drainage and sewerage for the 22 urban cities of the whole country has been completed by the World Bank and the UNDP since 1984. This is called as "the Fourth Project" and it is aimed at implementation with the assistance of international agencies and bilateral aid programs. The main contents of all these four (4) projects are illustrated in Table 2.11.

Table 2.11 Water supply development projects

1. First Project (1974-1984)
    a) Rehabilitation of water supply facilities of Kathmandu, Lalitpur and Pokhara.
    b) Study for sewerage system in Kathmandu and Lalitpur.

2. Second Project (1977-1984)
    a) Rehabilitaion of water supply facilities
    b) Extension of sewerage system

c) Preparation of master plan
d) Preparation of feasibility study

3. Third Project (1980-1987)
   a) Rehabilitation of water supply facilities
   b) Extension of sewerage system

4. Fourth Project (1983-future)
   a) Feasibility study

2-3-2 Water Supply Project for Rural Areas

The water supply project for rural areas is under the jurisdiction of the DWSS.

As separate projects, there are shallow well water supply projects being executed by the nongovernmental sector and by the volunteer activities of Panchayats.

2-3-3 Existing Status of Population Served with Potable Water

The target of the water supply sectoral development of the Sixth Five Year Plan was to provide with potable water a population of 4.13 million (Rural population: 3.87 million, Urban population: 0.26 million). However the increase in level of water supply services achieved was for 1,191,000 people by the DWSS project and for 736,000 people by the MPLD project, with a total of 1.927 million rural population. This has added and increased by an amount of 357,000 m^3/d in rural water supply.

On the other hand, in regard to the water supply project for urban areas, the aimed increase in population of 263,000 was achieved. Nevertheless the increase in amount of supply achieved was limited to only 103,807 m^3/d, which is 74% of the target supply rate.

Thus the level of potable water supply in Nepal by the end of the Sixth Five Year Plan in June 1985 stood as follows:

Area	Population with water supply	Percentage of population with water supply	Total Population
Rural areas	2,788,000	17.9	15,600,000
Urban areas	950,000	79.9	1,190,000
Country average	3,738,000	22.4	16,790,000

Source: Seventh Five Year Plan

2-3-4 Target of Water Development

As per the Seventh Five Year Plan, the targets of the water supply sector are:

1) to provide with a potable water supply 94% of the urban population and 67% of the rural population
2) to establish basic sanitation.

The estimated increase in population to be provided with potable water supply, as estimated by MSTP is given below;

Organization	Population
1. DWSS	4,508,000
2. WSSC	300,000
3. MPLD*	4,464,000
4. From Sixth Five Year Plan	90,000
Total	9,362,000

* Water supply project of MPLD has been handed to DWSS since the beginning of 1988.

Of the above total population of 9,362,000, the population of urban areas is 338,000 and that of rural areas is 9,024,000.

The major projects included in the Seventh Five Year Plan are as follows:

(1) Piped drinking water project
These are small scale water supply projects of district areas. 89 projects that have been implemented since the Sixth Five Year Plan are to be completed in the Seventh Five Year Plan period. As a result, the population served with potable water is expected to increase by 261,000 people. In addition, 17 new projects will also be executed to increase the population served by an additional 63,000.

(2) Tube well projects
In the Terai zone where the level of the ground water table is high, shallow tube well projects are planned to be undertaken for providing a population of 2,600,000 with a potable water supply. In addition, in some densely populated rural areas and in some semi-urban areas, some deep tube well water supply projects are also planned.

(3) New Rural pipe drinking water
These are small scale water supply projects for the rural areas. The project organization is undertaken by the respective local governments and the intended beneficiaries in cooperation with DWSS. In the current Seventh Five Year Plan 13 projects are planned to provide 1,325,000 people with drinking water.

(4) Reforms, renovation and extension

This project involves the rehabilitation of existing traditional water supply facilities and to extend the population supplied. In the Seventh Five Year Plan, 130,000 people are estimated to get drinking water by these rehabilitation measures.

(5) Feasibility study

Five hundred feasibility studies for the water supply projects are to be prepared in the Seventh Plan. In the study, establishment of some 25,000 number of simple toilet facilities are also planned to attain a good sanitary condition. Also from the extension plan of the sewerage system in the Kathmandu valley, 164,000 people are estimated to benefit. In addition improvement of the sewerage system in other major cities is also planned in this feasibility study.

(6) Drinking water supply program in urban areas

The Third Project which involve the cities of Kathmandu, Bhaktapu, Dharan, Bratnagar, Janakpur, Birgunj, Hetuda, Pokara, Butanl, Bharrahawa and Nepalganj was completed in 1986 and accordingly an increase of 109,000 m^3/d of water supply is expected to be realized. Nevertheless, in the Kathmandu valley the problem of inadequate water supply will not be resolved even after the implementation of this Third Project. As such, another long-term plan is to be carried out during the current Seventh Five Year Plan.

It is also planned that the water supply project for the semi-urban centers as listed in Table 2-12 is to be carried out during the Seventh Plan. By this program renovation and extention of existing water supply facilities are to be made at 31 cities out of the total 33 cities in Nepal. It is estimated that this project implementation would benefit a population of 338,000 people.

(7) District level projects

In accordance with the decentralization policy pursued in the Seventh Plan, water supply projects on a district level sponsored by the respective local governments and the intended beneficiaries are also to be undertaken. These projects are to be planned by the local governments and the beneficiaries themselves and to be implemented with guidance and subsidy from the central government. For this purpose, NRp 11.94 million has been allocated in the current 5 year term.

Table-2.12 Rehabilitation Study of Town Water Supply

Towns	Operating Agency	Studying Agency	Remarks
A.Urban Towns:			
1.Kathmandu	WSSC	WSSC/IDA	
2.Lalitpur	WSSC	WSSC/IDA	
3.Bhaktapur	WSSC	WSSC/IDA	
4.Pokhara	WSSC	WSSC/IDA	
5.Birat Nagar	WSSC	WSSC/IDA	
6.Janakapur	WSSC	WSSC/IDA	
7.Birgunj	WSSC	WSSC/IDA	
8.Hetauda	WSSC	WSSC/IDA	
9.Butwal	WSSC	WSSC/IDA	
10.Bhairahawa	WSSC	WSSC/IDA	
11.Nepalgunj	WSSC	WSSC/IDA	
12.Dharan	WSSC	WSSC/IDA	
13.Banepa	WSSC	T.P./GTZ	
14.Dhulikhel	WSSC	DWSS/GTZ	New Constn.work being executed
15.Mahendranagar	DWSS	DWSS/JICA	
16.Dhangadhi	DWSS	DWSS/JICA	
17.Bharatpur	DWSS	DWSS/JICA	
18.Tansen	DWSS	DWSS/JICA	
19.Lahan	DWSS	DWSS/JICA	
20.Rajbiraj	DWSS	DWSS/JICA	
21.Ilam	DWSS	DWSS/JICA	
22.Bhadrapur (and Chandragadhi)	DWSS	DWSS/JICA	
23.Birendra Nagar	DWSS	DWSS/Korean Govt.	
24.Tribhuvan Nagar	DWSS	DWSS/Korean Govt.	
25.Damak	DWSS	DWSS/British Govt.	
26.Dhankuta	DWSS	DWSS/British Govt.	
27.Taulihawa Nagar	DWSS	DWSS/ADB	Cowi Consult
28.Bidur	DWSS	DWSS/ADB	is enagaged
29.Kalaiya	DWSS	DWSS/ADB	in ADB Projects
30.Jaleshwar	DWSS	DWSS/ADB	
31.Dipayal	DWSS	DWSS/ADB	
32.Malangawa	DWSS		
33.Inaruwa	DWSS		
B.Rural Towns:			
1.Gaushala	DWSS	DWSS/JICA	

2-3-5 Foreign Assistance for Water Supply Projects

In the Sixth Five Year Plan, out of the total funding of NRp 22 billion, about 51% was supplied by foreign aid.

However, out of the total funding allocations for water supply development of NRp.1,056.8 million, only 3% (NRp 35.1 million) was contributed by the foreign aid component. This is due to the premature conditions of water supply development plans.

But in the current Seventh Plan most of the water supply development projects are planned to be implemented, hence it is decided to extend foreign aid funding provisions to the water supply projects of 31 cities.

In Birendranagar and Tribhuvannagar, a detailed design of the water supply project is being carried out.

Also the water supply projects for Damak and Dankuta have been carried out with the assistance of the Government of the United Kingdom (U.K.) since 1983 (NRp 24.5 million).

The budget of DWSS in 1987/88 includes a foreign aid component of NRp 67.9 million from ADB and NRp 21.1 million from the Government of the U.K. In consideration of the aforementioned situation the foreign aid component for such water supply projects is expected to increase in the future.

2-3-6 Contents of the Request for Grant Aid Cooperation

The contents of the request made by the Government of Nepal are as follows;

A) Construction and rehabilitation of the water supply facilities for 8 areas in urban and semi-urban centers

B) Provision of the necessary materials and spare parts for the facilities of Tansen town (1 area)

A detailed description with respect to the above request is given below;

1) Mahendranagar
   (1) Rehabilitation of existing water supply facilities
   (2) Construction of deep well and installation of high lift pumps;
   2 sets
   (3) Construction of water pipeline;
   0.2 km
   (4) Installation of iron removal facility;
   1 set
   (5) Installation of chlorination facility;
   1 set
   (6) Construction of water tank;
   1 unit
   (7) Installation of high head pumps;
   2 sets
   (8) Extensions of distribution system;
   14.3 km
   (9) Installation of water meters;
   3,680 No.
   (10) Installation of public standposts;
   10 sites

2) Dhangadhi

(1) Rehabilitation of existing water supply facilities

(2) Construction of deep well and installation of high lift pumps;
2 sets

(3) Construction of water pipeline;
0.3 km

(4) Installation of chlorination facility;
1 set

(5) Construction of water tank;
1 set

(6) Installation of high head pumps;
4 sets

(7) Extensions of distribution line;
17.6 km

(8) Installation of water meters;
5,100 No.

(9) Installation of public standposts;
30 sites

3) Tansen

(1) Rehabilitation of existing water supply facilities

(2) Construction of intake for surface water;
1 set

(3) Spare parts of existing facility (pumps)

4) Bharatpur

(1) Rehabilitation of existing water supply facilities

(2) Construction of deep well and installation of high lift pumps;
5 sets

(3) Construction of water pipeline;
2.0 km

(4) Installation of chlorination facility;
2 sets

(5) Construction of water tank;
1 unit

(6) Installation of high head pumps;
3 sets

(7) Extensions of distribution line;
25.5 km

(8) Installation of water meters;
7,500 No.

(9) Installation of public standposts;
10 sites

5) Gaushala

(1) Construction of deep well and installation of high lift pumps;
2 sets

(2) Construction of water pipeline;
0.2 km

(3) Installation of chlorination facility;
1 set

(4) Construction of elevated water tank;
1 unit

(5) Extensions of distribution line;
8.0 km

(6) Installation of water meters;
730 No.

(7) Installation of public standposts;
80 sites

(8) Construction of pumping stations;
2 units

(9) Construction of watchman shed;
1 unit

6) Lahan

(1) Rehabilitation of existing water supply facilities

(2) Construction of deep well and installation of high lift pumps;
5 sets
(3) Construction of water pipeline;
0.4 km
(4) Installation of chlorination facility;
1 set
(5) Construction of water tank;
2 units
(6) Installation of high head pumps;
4 sets
(7) Extensions of distribution line;
12.4 km
(8) Installation of water meters;
8,900 No.
(9) Installation of public standposts;
30 sites

7) Rajbiraj

(1) Rehabilitation of existing water supply facilities
(2) Construction of deep well and installation of high lift pumps;
2 sets
(3) Construction of water pipeline;
1.0 km
(4) Installation of water treatment facility;
2 sets
(5) Installation of chlorination facility;
1 set
(6) Construction of water tank;
1 unit
(7) Installation of high head pumps;
4 sets
(8) Extension of distribution line;
8.9 km

(9) Installation of water meters;
5,670 No.

(10) Installation of public standposts;
10 sites

10) Bhadrapur and Chandragadhi

(1) Rehabilitation of existing water supply facilities

(2) Construction of deep well and installation of high lift pumps;
3 sets

(3) Construction of water pipeline;
0.8 km

(4) Installation of chlorination facility;
2 sets

(5) Construction of water tank;
2 sets

(6) Installation of high head pumps;
2 sets

(7) Extensions of distribution line;
10.2 km

(8) Installation of water meters;
8,340 No.

(9) Installation of public standposts;
20 sites

9) Ilam

(1) Rehabilitation of existing water supply facilities

(2) Construction of surface water intake;
1 unit

(3) Construction of water pipeline;
19.0 km

(4) Installation of water treatment facility;
2 sets

(5) Installation of chlorination facility;
1 set

(6) Construction of water tank;
2 units

(7) Extensions of distribution line;
7.7 km

(8) Installation of water meters;
1,320 No.

(9) Installation of public standposts;
30 sites

CHAPTER 3. OUTLINE OF THE PROJECT AREA

CHAPTER 3
OUTLINE OF THE PROJECT AREA

3-1 General

3-1-1 Location and Geography

Nepal is divided into five development regions.

The total land area is about 147, 181 sq. km.

The study areas of this project covering eight towns and one village belong to the following regions.

Far-Western Region	:	Mahendranagar, Dhangadhi
Mid-Western Region	:	-
Western Region	:	Tansen
Central Region	:	Bharatpur, Gaushala*
Eastern Region	:	Ilam, Bhadrapur-Chandragadhi*, Rajbiraj, Lahan

Note: * Villages

Topographically Nepal can be classified into the Terai plains, Churia Hills, Mahabharat Range(Midland hilly zone) and Higher Himalayan zone, from the south to the north of the country.

Of the project areas, Ilam and Tansen belong to the Midland hilly zone, Bharatpur to the Churia range and the rest to the Terai plain.

The geographical features in the above regions are described below.

The Terai plain is located in the southern portion of the country with an average altitude of 100 m. The area is a developed alluvial plain along the

Ganges river, the major river. There are many fan deltas in the vicinity of the rivers. Many medium and small rivers originate from the Midland zone. However many of them become subsoil groundwater flow and disappear at some points downstream due to their low discharges.

The Churia hills ranges from EL 200 m to EL 1,500 m with a relatively gentle slope and stretches from west to east.

The soil is generally composed of unconsolidated shale, mud, and gravel strata and these layers are relatively thin. The vegetation in the area is generally classified as barren land type consisting of grass and shrub. There are some basins surrounded by mountains. Within these basins the natural features are similar to those of the Terai zone. The town of Bharatpur is situated in one such basin, Chitwan.

In the Midland zone, the altitude ranges from 1,500 m to 2,500 m above MSL with steep hills and narrow valleys. Most of the hilly slopes are under cultivation using upland step farming techniques.

3-1-2 Population and Socioeconomic Condition

As mentioned before, 5 towns and 2 villages except Ilam, Tansen and Bharatpur are situated in the Terai zone. Due to its geographical proximity to India, the culture and economy of the Terai is much influenced by India. This Terai region possesses a high potential for agricultural development due to its geography, abundance of water resources and favorable soil characteristics. Large-scale irrigation schemes are being carried out along the big rivers here. The cities of Mahendranagar and

Rajbiraj are developed with agricultural development schemes.

In the Eastern, Central and Western regions vast investment for the development of infrastructure has been carried out. The major projects are the construction of the East-West Highway, National Grid, etc. From the above mentioned aspects, rapid development could be expected to be realized in these regions.

The Terai region is undergoing a population increase caused by population movement from the hilly area and also from neighboring India. As a result, the population growth rate of this region is much higher than the natural growth rate.
The towns of Tansen and Ilam belong to the midland hilly zone. These towns have typical cultural and economic conditions peculiar to their regions, due to their relatively isolated geographical feature. Ilam is famous for its tea plantations. The population growth rate of these areas is mainly due to natural growth only.

The town of Bharatpur also belongs to the Churia range and is strategically located at the junction of the East-West Highway and North-South Highway to Kathmandu. Thus this town plays important roles, as the major traffic conjunctive point and as a trade center of agricultural products.

This Bharatpur town is in vast plain area that consists of many paddy fields with irrigation facilities from the Narayani River.

The populations of the towns and villages in the study areas as of 1987 are as follows:

1.	Mahendranagar	53,731
2.	Dhangadhi	26,051
3.	Tansen	22,403
4.	Bharatpur	40,319
5.	Gaushala	7,986
6.	Lahan	18,123
7.	Rajbiraj	25,878
8-1	Chandragadhi	10,907
8-2	Bhadrapur	14,169
9.	Ilam	11,692

3-2 Natural Conditions

3-2-1 Climate

Climate in Nepal varies depending on the altitude. The variation in climate is so wide ranging from the eternal snows of the Himalayan Mountains to the subtropical climate of the Terai plain.

Most of the study areas except Tansen and Ilam belong to the subtropical zone, while Tansen and Ilam belong to the temperate zone.

The rainy season (monsoon period) is from June to September with a dry season in the rest of the year. The average annual precipitation depends on the effects of the monsoon, and accordingly ranges from 1,000 mm to 2,200 mm. Also 80% of the total precipitation occurs during the rainy season.

In general, the intensity of rainfall during the monsoon is very high, hence the problem of flooding and soil erosion, especially in the hilly terrains, are very common during this season. Temperature variations are both seasonal and influenced by altitude, and a low temperature "winter season" occurs from December to February, and high temperature "summer season" from June to August, in general. The temperature of the subtropical Terai varies from 15°C to 17°C in winter, and 28°C to 29°C in summer.

In the temperate hilly region the overall temperature decreases with increasing altitude and the daily temperature variation is rather high. The variation of temperature and precipitation in the study areas are shown in Appendix B.1 ~ B.5.

3-2-2 General Geological Characteristics

The Terai area is an alluvial plain composed of deposits of the Quartenary period. Fan shaped alluvial plains have developed in the basins of the big rivers that flow from hilly areas. The soil structure is composed of clayey sand and gravel in the surface layer with densely laid cobblestones underneath.

Downstream of the fan shaped alluvium, clayey silt and gravel layers have been deposited in an alternate manner along the areas of ancient river reaches. Also the gravel layer becomes thinner and the clayey silt layer becomes thicker towards the downstream reaches. The cross sectional view of the Terai Aquifers depicting the clayey silt and gravel layer alluvium as "lens shape" are shown in Appendix B.6.

The Bhabar zone is also shown in Appendix-B.7, the thickness of which depends on the size of the river. The bigger the river, the thicker the Bhabar zone and vice versa. Also in this zone the clayey silt and gravel layer becomes thinner and the fine sand layer becomes thicker.

In the Terai, the clayey surface layer of a few meters depth makes this area extremely suitable for agriculture. However, as the soil becomes muddy once absolved in water its engineering characteristics are very poor.

In general, the midland hills range is rather unsuitable for both agricultural and industrial development mainly due to the harsh topographical conditions of its steep slopes and deep valleys.

The soil is composed of schist and gneiss deposits of the Cambrian to Devonian period. The surface soil texture is made of weathered rocks. In Ilam the soil texture is of quartzite layer in the Northern part, and there exists many springs and other water resources at the dislocation.

3-2-3 Ground Water

Terai

There are about 17,000 shallow wells dug in the Terai area for irrigation purposes as per the data of GWRDB (1987). There is a seasonal variation in the groundwater table of this Terai area from 1.5 m to 5.0 m below ground surface.

Churia

In the Churia hills, the groundwater table during the dry season varies from 4 m to 7 m below the ground surface. The soil composition is identified as the main reason for the lower groundwater table of this area.

Four hundred (400) deep wells that have been dug for study purposes in the early stage are being used for irrigation purposes at present. The total number of deep wells for irrigation at present is about 600 numbers.

The typical depth of a deep well in this area ranges from 100 m to 200 m with a yield around 150 m^3/hr to 300 m^3/hr. It is estimated that the coefficient of permeability of the aquifer in the Bhabar zone ranges from 50 m/day to 200 m/day and from 5 m/day to 40 m/day for the aquifer in the other alluvial zone.

The Bhabar zones possess a high groundwater retaining capacity, and the retaining capacity is estimated as 600 - 700 mm/year.

The fan shaped alluviums of big rivers are located in the Bhabar zone. In these areas, the aquifer is very thick, hence the amount of groundwater retained is very high. However, the existence of cobblestones makes the digging of wells rather difficult.

As per the water quality of these groundwaters, high iron (Fe) content has been noted in some of the existing wells. As such this high content of iron might warrant additional treatment for iron removal to improve the water quality for potable use.

There are many artesian aquifers in this Churia hills area and also there exists many artesian wells. However some artesian aquifers have already lost their discharging capacity due to depletion of the water bearing capacity. This effect of depletion is aggravated because these artesian aquifers are confined aquifers of "lens shape" resulting in virtual elimination of any significant recharge.

Bharatpur

Bharatpur is located in the fan-shaped alluvial plain of the Narayani River, and the geological characteristics are similar to that of the Terai Bharatpur zone.
This Bharatpur area is rich in groundwater resources due to the existence of the Narayani River.
The groundwater table is rather shallow and its level varies depending on the locality in accordance with the geological formation of the overlying stratum of the aquifer.

Tansen and Ilam

Tansen and Ilam are located in the Midland zone.
The soil texture is mainly composed of schist and gneiss, hence the water-bearing capacity is very limited.
However when there exists a dislocation in the soil structure due to a fissure in hilly slope, and also when the groundwater table is above the fissure, then the conditions for a spring are established.
There are many springs of this nature in these areas which are potential sources for potable water supply development.

Also in Ilam, in the northern part, the geological formation is composed of a quartzite layer possessing an excellent water-bearing capacity.
Finally the coefficient of transmissibility of the respective aquifers in the study areas where the transmissibility per 100m is above 1000 m^2/day are illustrated in Appendix B-10. Accordingly the areas of Lahan, Chandragadhi and Bharatpur are excluded due to their low transmissibility.

3-3 Socioeconomic Conditions

3-3-1 Electric Power

The electric power supply in Nepal has improved very much with the construction of Kulikhani and other power plants and the accompanying power transmission and distribution systems.

Among the study areas, Bharatpur is the only town that is supplied with power from the National Grid.

However it is expected that some other towns of the study areas also would be supplied with power from the National Grid in the near future.

At present Mahendranagar, Dhangadhi, Rajbiraj, Chandragadhi, and Bharatpur are supplied with power bought from neighboring India.

In these towns, the power supply is prone to frequent interruptions and wide voltage fluctuations. However the towns Bharatpur and Chandragadhi have diessel generators for use in case of an emergency.

The towns of Tansen, Ilam and Lahan are supplied with power from diesel generators. However the power supply of the former two towns is hour-restricted during the night. In Gaushala, there exist no public power supply facilities.

3-3-2 Telecommunications

All urban centers of the study areas are provided with telecommunications offices, except the village of Gaushala.

Public institutions and government offices are supplied with telephone services. However private telephone connections are very uncommon.

The long distance telephone services are rather poor, especially the services to the cities of the Far Western region.

3-3-3 Transportation

The study areas in the Terai plain are located along the East-West Highway which is paved and the condition of transportation is rather good.

About the Midwest region, road conditions will be improved following the completion of East-West Highway.

Tansen is located in between Butwal and Pokhara, the towns linked with paved roads in good condition.

Ilam is linked to the East-West Highway at Charralli with an all-weather rough road, which is undergoing the improvement work of widening and pavement. Still, at present, most of this road is of very narrow width with poor pavement. Hence high speed driving is rather difficult and dangerous, which is also due to the highly serpentine course of the road.

All the study areas of the Terai except Gaushala have airstrip facilities. There are about one or two flights per week linking Kathmandu, however the flight schedule is rather unreliable due to the poor condition of the airstrip. Also these flight are affected quite often by bad weather conditions.

3-3-4 Education

A unified national education system has been undergoing implementation since 1971.

The education system is divided into five levels, namely, 1) primary education of 5 years, 2) Lower secondary education of 2 years, 3) Secondary education of 3 years, 4) College education of 2 years and 5) University education of 4 years.

The rate of primary and lower secondary school enrollment in 1978 were 77% and 32% respectively and are increasing year by year.

The highest level of educational opportunities available for most of the study areas is up to college education, but up to only secondary schooling in Gaushala.
The content of the curriculum of education is affected by the shortage of the necessary educational materials and teaching staff.

3-3-5 Health and Sanitation

In the Terai area, infectious diseases are prevalent mainly caused by inadequate potable drinking water, and sanitation facilities. However the patient ratio of Malaria has declined dramatically in recent times due to intensive mosquito extermination operations.
Most of the study areas are provided with a general hospital equipped with 20 ~ 50 beds.

However the number of hospitals is rather limited, and hence the level of health services provided is still insufficient.

There is one eye hospital for each of the towns of Bharatpur and Dhangadhi.

There are some health posts (2 to 3) for the provision of minimum out-patient services in the towns of the study areas, however the village of Gaushala is provided with only one health post.
Also there are seasonal health examination facilities conducted for children at temporary health posts.

3-3-6 Potable Water Supply

Potable water supply facilities with individual house connections are available in the urban areas.

However the water supply did not keep pace with the water demand, hence there is an acute shortage of water supply. The increase in water demand is attributed to the increase in population and development of urban areas.

The water supply facilities were originally designed for 24 hour continuous supply. However because of the increase in water demand and water loss due to leakage and wastage, many towns are provided with only 2 to 3 hours of continuous water supply.

There are only a few water supply systems equipped with chlorination facilities. Hence the benefits to be gained by having a potable water supply are considerable from the important public health view point.

Water supply services are provided both by private connections and public connections such as standposts.

Private connections are divided into 2 categories.

a) Direct supply to various usage points of the house.

b) Supply to only a sump, or tank in the house.(Bulk supply)

The system b) is advantageous when the pressure and or amount of supplied water is limited.

The water supply charge is based on the number of service taps or the diameter of pipes.

In case of public standposts, the water supply is free of charge.

The operation and maintenance of the water supply systems in the study areas are the responsibility of DWSS.

The maintenance budget allocation for these water supply services by the DWSS is very insufficient resulting in severe hardship.

The village Gaushala is not provided with any central water supply facilities, and at present individual shallow wells are used as the water source.

The water supply project offices in the country side have management, engineering and accounting sectors. The number of staff of the water supply facilities depends on the scale of such facilities, and ranges from 10 to 23 personnel which is equivalent to 1 - 2 persons per 1000 people served with water.

Number of DWSS Staff (1988)

Project area	Population Supplied	Number of Staff	Rate per 1000 people
1. Mahendranagar	7,000	23	3.3
2. Dhangadhi	10,000	13	1.3
3. Tansen	15,000	-	-
4. Bharatpur	25,000	23	0.9
5. Gaushala	-	-	-
6. Lahan	7,000	10	1.4
7. Rajbiraj	13,000	23	1.8
8. Bhadrapur & Chandragadhi	15,000	23	1.5
9. Ilam	8,000	19	2.4

3-3-7 Drainage & Sewerage

There is no sewerage system in the urban areas of the study areas. The domestic wastewater is discharged directly into storm sewers or small drains at present and no sewerage system is planned in the study areas.
The introduction of a sewerage system is now in the stage of project investigation only.

3-4 General Description of Study Areas

3-4-1 Mahendranagar

Mahendranagar is located in the Far-Western region on the alluvial fan developed along the Mahakali River. It is the headquarters of Kulikhani District and had a population of 53,731 in 1987.
The Town has been developed along with the agricultual development scheme commenced in 1973.
Because the town is the administrative and commercial center of the region, its urban area is very active.
The area in between the East-West Highway and the northern part of the present urban area is set aside for industrial development.
Furthermore there is a potential for tourism development due to the existence of Phat Wildlife Reserve.
The outline of the physical setting of the town is given below:

1.	Population	:	53,731
2.	Town Area	:	188 km^2
3.	Government offices	:	62
4.	Hospitals	:	1, 35 beds
5.	Primary Schools	:	10
6.	Lower Secondary Schools	:	5

7. Secondary Schools : 7
8. Colleges : 1
9. Shops, restaurants, etc : 150
10. Enterprises, cottage industries etc : 9

Present Situation of Water Supply Facilities

An outline of the existing water supply facilities and other relevant conditions is as follows:

1 Water Source:

Deep Well (Constructed in 1973)

Diameter (ø) = 150 ~ 300 ^{mm}, Depth (D) = 34.1^{m}

Present Conditions:

Pumping of water, by an axial flow turbine pump.

Fine sand is also discharged along with water, and ground subsidence around the pump house has also been noted.

The amount of sand discharged is small due to the limited operating hours.

2 Water Transmission Line :

Diameter (ø) = 150^{mm}, length (L) = 50^{m}

3 Elevated Tank

Capacity (V) = 180 m^3 (1)

4 Water Treatment Facilities:

Present condition: Aeration and rapid sand filtration facilities are equipped, and the capacity is 2,200 m^3/day. This treatment system is similar to that of Rajbiraj. At present these facilities are under renovation.

5 Distribution Line:

ø = 25^{mm} ~ 125^{mm}, L = 9,300^{m}

6 Water Supply Hours: 5.5 hr/day

7 Type of Water Supply :

Individual house connections	:	495 taps.
Public standposts	:	14

Water Resources and Quality

This area is rich in both surface water (Mahakali River) and groundwater resources. The Mahakali river is used for irrigation purposes, and the head works for such facilities is constructed in the Indian territory of this river and the water is transported back to the Nepalese territory by means of open channel.

Though the alluvial fan of the Mahakali River is rich in groundwater resources, the extraction of groundwater would be difficult as the composition of the aquifer includes boulder stones as well, thereby affecting the drilling operation. The ADBN utilizes the well point method for the construction of boreholes for irrigation.

There are 277 boreholes of about 15m depth belonging to the ADBN around the study area, and more are expected to be constructed in the near future.

The DWSS has two boreholes, of depths of 32m and 15m, used as drinking water sources.
However the water of shallow boreholes are prone to pollution due to contamination from domestic wastewater.
Hence it is recommended that boreholes for potable water supply shall be of depth of about 100m to 150m in order to be pollution free.

3-4-2 Dhangadhi

Dhangadhi is located in the inner Terai bordering India. It is the headquarters of Kailai District in the Far-West region and has developed on the alluvial fan of the Mohana River.
The main industries are commerce and agriculture and recently the town authorities has been making efforts to introduce the production of agricultual goods.
The outline of the physical setting of the town is given below:

1.	Population	: 26,051
2.	Town Area	: 44 km^2
3.	Government offices	: 80
4.	Hospitals	: 2, 75 beds
5.	Primary Schools	: 19
6.	Lower Secondary Schools	: 2
7.	Secondary Schools	: 5
8.	Colleges	: 1
9.	Enterprises, cottage industries etc	: 10

Present Situation of Water Supply Facilities

An outline of the existing water supply facilities and other relevant conditions is as follows:

1 Water Source:

Deep Well (Constructed in 1974)

Diameter (ø) = 200 ~ 300 ^{mm}, Depth (D) = 122^m

Present Conditions:

Pumping of water by an axial flow turbine pump. Power supply from India is not stable. Thus the operation is only made during the steady supply period. A standby pump with a diesel engine is also installed.

2 Water Transmission Line:
  Diameter (ø) 150^{mm}, length (L) = 50^{m}

3 Elevated Tank:
  Capacity (V) = 150^{m3} (1)

4 Water treatment facilities: No facilities (Direct distribution)

5 Distribution Line:
  ø = 40^{mm} ~ 150^{mm}, L = $10,500^{m}$

6 Water supply hours: 8 hr/day

7 Type of water supply:
  Individual house connection : 278
  Public standposts : 9

Water Resources and Quality

The Mohana River flows along the southern part of the town. The area is rich both in the surface and groundwater resources. The GWRDB constructed 13 boreholes, of which 4 are for drinking water purposes and belong to DWSS, while the other rest 9 are for irrigation purposes. The depths of these wells range from 60m to 150m. The DWSS is using these boreholes for potable water purposes.

There exist some artesian wells as well in this area indicating the existence of artesian aquifers.

3-4-3 Tansen

Tansen is the district headquarters of Palpa and is located along the trunk road between Butwal and Pokhara. This town was once the capital city of a local kingdom and at present is the center of politics, culture and industry for the region.
There is a potable water supply scheme in this town implemented with the assistance of the Government of Japan in 1978.
The design capacity of this water supply scheme is 1,000m^3/d and the source is a natural spring named Bulke Spring located 550m below the storage reservoir level. The water is lifted by means of 4 stage lift pumps. The population served is 15,000 people.
However at present the operating capacity of this system is about 60% of the design capacity. This reduction in capacity is caused by the aging of the facilities and the resulting mechanical problems, and the non availability of spare parts.

Present Situation of Water Supply Facilities

An outline of the water supply facilities and their conditions is as follows:

1 Water Source:
Natural spring located 6.4 km North-West from the town. Water supply system was completed in 1978 with the assistance of the Government of Japan.

2 Water Transmission Line:
length (L) = 3,200^m

3 Reservoir:
Capacity (V) = 400 m^3

4 Pumping Stations

1st station : Volute pump x 3,
$Q = 0.35\ m^3/min\ H = 30^m$

2nd ~ 4th stations : Volute pump x 3 x 3 stations,
$Q = 0.35\ m^3/min\ H = 200^m$

5 Water Treatment Facilities:

Chlorination (At present the chlorination facility is out of order)

6 Water Supply Hours: 6 ~ 8 hr/day

Water Resource and Quality

The water discharge of Bulke Spring has decreased from the previous year.
This declining phenomenon is attributed to the lack of precipitation encountered in recent years.

3-4-4 Bharatpur

This town is situated in the Chitwan basin of the Churia Hills and is the district headquarters.
The economic base of the town is represented by its function as a major trade center due to its strategic location as the important traffic conjunctive point linking the East-West and North-South highways.
The Narayangani area along the Narayani River has been developed as a commercial center and the government enterprises and residential areas are developed along the river terraces.
The hinterland has been developed as an agricultural area with medium size irrigation facilities. Also this town has good geographical and transportation

facilities and hence possesses a high potential for industrial development.
There exists a Coca-Cola plant and cement factory as the major industries.
This area is also known for its Chitawan National Park.
The outline of the physical setting of the town is given below:

1.	Population	: 40,319
2.	Town Area	: 42.3 km^3
3.	Government offices	: 50
4.	Hospitals	: 2
5.	Primary Schools	: 26
6.	Lower Secondary Schools	: 10
7.	Shops, restaurants, etc	: 100
8.	Enterprises, cottage industries etc	: 1

Present Situation of Water Supply Facilities

An outline of the water supply facilities and their conditions is as follows:

1 Water Source:
Surface water of the Jugedi Khola River (a branch river of the Narayani River).
The intake is located 9.5 km north of the town. The flow capacity of this surface water source is very limited, hence it is very difficult to meet the future demand with this source. The existing condition of the transmission main from the intake to the reservoir is very poor due to improper maintenance due to lack of funds. There are many visible exposures of spouts on the transmission pipe line.

2 Water Transmission Line:
Diameter (ø) = 200 ~ 250^{mm}, Length (L) = $9,500^{m}$

3 Ground Reservoir:
Capacity (V) = 900 m^3 (1)

4 Water Treatment Facilities:
Manual chlorination with bleaching powder applied directly into the storage reservoir. However this application has been suspended at present due to a shortage of bleaching powder.

5 Distribution Line:
$\varnothing = 50^{mm} \sim 200^{mm}$, $L = 26,900^{m}$

6 Water Supply Hours: 4 hr/day

7 Type of Water Supply:

Individual house connections	:	920 taps.
Public standposts	:	32

Water Resources and Quality

The area is rich in its surface water resources due to the existence of the Narayani River, which has a high discharge flow rate. This river water is used for irrigation purposes. Also the area is supposed to be rich in its groundwater resources as well because it is located on the alluvial fan of the Narayani River.

However the groundwater extraction is rather difficult due to the existence of cobblestones in the aquifer. Due to this reason there is only one deep well belonging to the Coca-Cola plant.

The water level of shallow wells is dependent on the geological formation of the soil stratum of the locality. It has been established that the water of shallow wells becomes polluted due to contamination by domestic wastewater. Hence such waters are unsuitable for drinking purposes.

Hence deep wells seem to be the only possible water source for potable water supply.

3-4-5 Gaushala

This village is located at 10km south of the East-West Highway in the Mahottari District.
The road condition from the East-West Highway to the village is rather good even though it is a rough type road.
The Mogha River forms the western border of this village.
The village is divided into 9 wards and the main product is only rice.
This village has no drinking water supply scheme or medical facilities at present.
The outline of the physical setting of the town is given below:

1.	Population	: 7,986
2.	Town Area	: 9.0 km^2
3.	Government offices	: 9
4.	Hospitals	: 0
5.	Primary Schools	: 1
6.	Lower Secondary Schools	: 1
7.	Secondary Schools	: 1
8.	Colleges	: 0
9.	Shops, restaurants, etc	: 55
10.	Enterprises, cottage industries etc	: 0

<u>Present Situation of Water Supply Facilities</u>

There are no water supply facilities.

Water Resources and Quality

The Mogha River is the only significant surface water resource of this village. The flow in this river is only seasonal hence it is not suitable as a source of drinking water supply. However the ground water source is abundant and is already being used for domestic consumption and irrigation purposes.
There are some ponds used for irrigation as well.
There is no deep well in this village. But there is an artesian well in the village, indicating the existence of artesian aquifers in this area.
According to the well log of Aurahi, the aquifer is composed of a sand layer and hence the installation of deep well is expected to be rather easy.

3-4-6 Lahan

The town belongs to the Siraha District and is located along the East-West Highway. The town functions as a commercial and trading center of the area because of its good traffic condition.
There is an irrigation project office of SIRDP in the town.
Geographically the town is situated on the alluvial fan of the Bailan River that flows through this town.
The Bailan River has many small basins with highly permeable soil characteristics.
The outline of the physical setting of the town is given below:

1.	Population	: 18,123
2.	Town Area	: 17.4 km^2
3.	Government offices	: 0
4.	Hospitals	: 1
5.	Primary Schools	: 9
6.	Lower Secondary Schools	: 0

7. Secondary Schools : 1
8. Colleges : 1
9. Shops, restaurants, etc : -
10. Enterprises, cottage industries etc : -

Present Situation of Water Supply Facilities

The outline of the water supply facilities and their conditions is as follows:

1 Water Source: Deep Well
Diameter (ø) = 200 ~ 400 ^{mm}, Depth (D) = 110^{m}
There are 2 deep wells belonging to the DWSS for water supply, however one well is not utilized at present due to the intrusion of fine sand. The pumps (2 pumps, one as a standby) of this water scheme are operated by an exclusive generator. However the daily hours of operation are limited to only 2 hours due to financial constraints.

2 Water Transmission Line
Diameter (ø) = 150^{mm}, Length (L) = 150^{m}

3 Elevated Tank
Capacity (V) = 450 ^{m3} (1)

4 Water Treatment Facilities: No treatment facility

5 Distribution Line
ø = 50^{mm} ~ 200^{mm}, L = 9,600^{m}

6 Water Supply Hours: 2 hr/day

7 Type of Water Supply
Individual house connections : 130 taps.
Public standposts : 21

Water Resources and Quality

This area is situated on the alluvial fan of the Bailan River and the alluvial fan is composed of highly permeable soil. As such this area is very rich in groundwater resources.
However the only surface water source of any significance is the Bailan River, which discharge is rather low with seasonal variation. Especially the flow during dry season is very low. Hence this river is not a suitable source for potable water supply.
Development of groundwater for potable water supply with shallow wells is easy, however the water is prone to contamination by domestic wastewater. Therefore deep wells are recommended for potable water supply development.

The aquifer is composed of sand including fine sand, and gravel. Hence construction of deep wells is very convenient.

3-4-7 Rajbiraj

The town belongs to Saptari District and is the district headquarters. The town is situated 12 km south of the East-West Highway and 12 km from the Indian border.
This town was planned and developed along with a large scale agricultural development plan which was executed with elaborate irrigation facilities development by extracting water from the Sapta Koshi river. In addition Khado Khola river also flows through this town.
The town is the center of administrative and commercial activities of the district.
An industrial complex is planned in the northern part of the town.

The outline of the physical setting of the town is shown below:

1.	Population	: 25,878
2.	Town Area	: 15.8 km^2
3.	Government offices	: 61
4.	Hospitals	: 1, 50 beds
5.	Primary Schools	: 6
6.	Lower Secondary Schools	: 4
7.	Secondary Schools	: 3
8.	Colleges	: 1
9.	Shops, restaurants, etc	: 67
10.	Enterprises, cottage industries etc	: 43

Present Situation of Water Supply Facilities

An outline of the existing water supply facilities and other relevant conditions is as follows:

1 Water Source: Deep Well
Diameter (ø) = 200 ^{mm}, Depth (D) = 100^{m}
There are 2 deep wells and one more is under construction. At present only one well is being utilized as a water source and the other is out of order due to the problem of fine sand draw-off (intrusion). Ground subsidence in the vicinity of No.1 well has occurred causing structual damage to the pump house due to differential settlement. Although there are two production wells in the water yard, simultaneous operation is very unlikely due to the distance between the two.

2 Water Transmission Line :
Diameter (ø) = 150^{mm}, Length (L) = 150^{m}

3 Elevated Tank :

Capacity (V) = 450 m^3 (1)

4 Water Treatment Facilities:

The treatment facilities are the same as those of Mahendranagar, however they are not operated at present due to leakage in the facilities and mechanical problems. Though the water contains a high content of iron it is distributed without any treatment.

5 Distribution Line :

$\varnothing = 37^{mm} \sim 300^{mm}$, $L = 18{,}600^{m}$

6 Water Supply Hours: 3 hr/day

7 Type of Water Supply

Individual house connections	:	627 taps.
Public standposts	:	10

Water Resources and Quality

The town is located on the western part of the alluvial fan of the Sapta Koshi River, however the river is not in its close proximity. The Khando Khola River flows along the western border of this town and is the only convenient surface water resource for potable use. However, as this stream is ephemeral it is not suitable as a source of drinking water supply.

The area is rich in groundwater resources. However, shallow wells for potable water supply development are not recommended due to the danger of contamination by domestic wastewater. Thus deep groundwater is the only suitable source for potable water development.

The DWSS has two deep water supply wells in the compound of its project office. However, due to the too close proximity of the wells and the resultant interference, only one well is utilized. There is another well (well no.3) under construction using the percussion drilling method, and the drilling operation is already completed, although this new well is also too close to the existing wells.

Any future demand for potable water has to be met by constructing similar deep wells.

According to the well log of well no.3, which is under construction, there are 3 significant aquifer layers, 2 consisting of gravel and cobblestones and the deepest one consisting of sand and gravel. This deepest aquifer of sand and gravel is recommended for utilization in water supply development.

3-4-8 Bhadrapur and Chandragadhi

The study area consisting of Bhadrapur town and Chandragadhi village is located in the East Region of Nepal, and more precisely in the eastern most part of the country.
Bhadratpur also shares an international border with India along the Mechi River.

The economic base of Bhadrapur is commerce and small scale industries such as rice mills, brick factories, printing industries etc. Chandragadhi is a village Panchayat and is the headquarters of Jhapa District. Its economic base is mainly agriculture with rice being the major product.

The outline of the physical setting of the town is shown below:

		Bhadrapur	Chandragadhi Village
1.	Population:	14,169	10,907
2.	Town Area:	16 km^2	
3.	Government offices:	18	9
4.	Hospitals:	1, 50 beds	0
5.	Primary Schools:	2	3
6.	Lower Secondary Schools:	2	0
7.	Secondary Schools:	1	2
8.	Colleges:	0	1
9.	Shops, restaurants, etc:	-	-
10.	Enterprises, cottage industries etc:	32	-

Present Situation of Water Supply Facilities

An outline of the existing water supply facilities and other relevant conditions is as follows:

1 Water Source:

a) Deep Well of Chandragadhi:
Diameter (ø) = 150 ~ 250 mm, Depth (D) = 113.0m
There are two deep wells belonging to the DWSS, but only one is utilized (yield 25 l/sec) due to their close proximity and the resultant interference.

b) Deep Well of Bhadrapur
Diameter (ø) = 150 ~ 250 ^{mm}, Depth (D) = 113.0^{m}.
The operation is managed by the P.W.D of MPLD, however the maintenance of the scheme in rather poor due to insufficient budget allocation.

2 Water Transmission Line:
Diameter (ø) = 200^{mm}, length (L) = 400^{m}

3 Elevated Tank:
Capacity (V) = 450 m^3 (1) --- Chandragadhi
Capacity (V) = 450 m^3 (1) --- Bhadrapur

4 Water Treatment Facilities: No facilities

5 Distribution Line:
$\phi = 37^{mm} \sim 300^{mm}$, $L = 23{,}300^{m}$

6 Water Supply Hours: 7 hr/day

7 Type of Water Supply:
Individual house connections : 352 taps.
Public standposts : 15

Water Resources and Quality

Chandragadhi and Bhadrapur are situated on the alluvial fan of the Mechi River which originates in the Churia Range. The average flow of the river is rather low due to its small catchment area. Nevertheless, this river is the only surface water resource of this area, but still is not suitable for potable water supply development.
Thus the groundwater resource at considerable depth is recommended as the most suitable source for drinking water supply development, as waters at shallow depths are prone to contamination by domestic waste water.

The existing wells for potable water extraction belonging to the DWSS are of depths ranging from 112 to 113m and draw their waters from deep gravel aquifers.
However these waters contain a lot of iron, thus it is necessary to install treatment systems for iron removal to enhance the water quality for domestic usage.

3-4-9 Ilam

This town has developed on the ridge of hills in the East Region and is located at 75 km north from the East-West Highway.
This ridge is surrounded by the Puwa Khola River on the western side and the Mai Khola River on the eastern side.
The town is divided into 9 wards, and of these wards 1 and 2 are described as urban.
The town is an administrative and commercial center. It also functions as a trade center in the East Region linking the routes from hilly areas to the Terai plain.
The main industry of the town is its tea plantation and the yearly production is around 36 tons.

The outline of the physical setting of the town is shown below:

1.	Population	: 11,692
2.	Town Area	: 29.7 km^2
3.	Government offices	: 60
4.	Hospitals	: 1
5.	Primary Schools	: 10
6.	Lower Secondary Schools	: 4
7.	Secondary Schools	: 2
8.	Colleges	: 1
9.	Shops, restaurants, etc	: 219
10.	Enterprises, cottage industries etc	: 9

<u>Present Situation of Water Supply Facilities</u>

An outline of the existing water supply facilities and other relevant conditions is as follows:

1 Water Source:
The Bandi Khola spring has been utilized as the water source, and the extention scheme was completed in 1974. The total design capacity is 450 m^3/d, serving a population of 8,000 people.

2 Water Transmission Line:
Diameter (ø) = 75^{mm} ~ 100^{m}, Length (L) = $12,600^{m}$

3 Reservoir:
Capacity (V) = 43^{m3}, 24^{m3}, 163^{m3}

4 Water Treatment Facilities: No facility

5 Distribution Line:
ø = 15^{mm} ~ 100^{mm}, L = $24,000^{m}$

6 Water Supply Hours: 6 hr/day

7 Type of Water Supply:

Individual house connections	:	278 taps.
Public standposts	:	69

Water Resources and Quality

The major water resources of this area are surface waters. The presently utilized potable water source of this town is a spring named Bandi Khola located 11 km north of the town and its discharge is about 15 l/s. As other water sources there are some springs which discharge about 2 to 3 l/s and these springs are used as drinking waters in the respective localities of rural areas.
As the other prospective water sources for water supply development there are the rivers Pakha Khola discharging 5 l/s and Pakha Khola discharging 200 l/s. These rivers are far distant from the town

at higher elevations (upstream) but are at closer distances at lower elevations (downstream) with respect to the town. Accordingly, these could be used as water sources for water supply development either by tapping upstream or downstream.

By tapping upstream, a gravity transmission main running a long distance and involving high capital cost but low maintenance cost could be realized.

On the other hand, tapping downstream involves high capital and maintenance costs due to the necessity of lift pumps and lifting mains to make up for the elevation difference.

This area is mountainous terrain and the mountain ranges are virtually uninhabited. Hence the water quality of the rivers and streams are not polluted at present and there exists no immediate threat of water quality deterioration of these water resources.

The mean monthly discharge of the rivers in the vicinity of Ilam is shown in Appendix B-11.

CHAPTER 4. CONTENTS OF THE PROJECT

CHAPTER 4
CONTENTS OF THE PROJECT

4-1 Purpose of the Project

The purpose of the Project is to implement the water supply project for the 8 urban and 1 semi-urban centers in compliance with the principal policy of the five year national development plan.
By the implementation of this project, the establishment of water supply facilities for 31 out of the 33 urban centers in the whole country is to be achieved.

4-2 Executing Agency

DWSS is responsible for project implementation in all the project areas.
Provision of the necessary services for basic human needs including that of a safe drinking water supply is one of the 3 principal policies of the national development plan.
Under the circumstances, radical measures for the implementation of the development programs of urban water supply have been commenced recently.

The water supply systems in the Terai area, where most of project areas of this project are located, have not been developed yet. One reason for this condition is that this Terai area is rich in ground water sources at shallow depths, hence water for domestic purposes could be easily extracted from shallow wells, even though the water quality is rather poor. As a result, water is not considered as an economic asset, hence even by providing a water supply service, a water consumption charge system for such a service could not be implemented.

In order to improve the present conditions under the urban water supply project, many urban and semi-urban areas are to be served with an improved piped water supply.
DWSS is responsible for all aspects of operation and maintenance of these facilities. Since the existing water change is low compared to production costs and its collection is incomplete, the required operation and maintenance costs are expected to be a severe financial burden for DWSS, under the present water tariff system.

Recently "decentralization" has been pursued by the central government. Based on this principal policy, in order to alleviate the financial burden the jurisdiction of the operation and maintenance work of water supply schemes are to be delegated from DWSS to the respective town Panchayats.

4-3 Evaluation of contents of the project request

4-3-1 Project Evaluation

As mentioned earlier in the previous section, provision of a safe drinking water supply service is one of the principal policies of the national development plan. However, due to inadequate finances, the water supply development projects have been carried out with the assistance of foreign governments and international agencies.

At present the water supply projects for 23 towns out of 33 towns have been undertaken by the DWSS, of these towns' water supply, twelve projects have been completed and additional four projects are under construction. Projects for the remaining towns are either under study or detail design stage. Those for 8 of the other towns and Gaushala village, have been selected for implementation under this grant aid cooperation of the Government of Japan.

There are already existing water supply facilities in all project areas, except in Gaushala. However, existing facilities are 10 to 15 years old since their completion and the capacities of these systems are very inadequate to meet the present water demand and are practically superannuated.

The ratio of implementation of the "33 city project" without the implementation of this project is 70%. With the implementation of this project the completion ratio is enhanced to 94%. Hence this project contributes to the implementation of 24% of this "33 city project".

Hence the provision of grant aid assistance for upgrading these water supply systems through this project is highly appraised.

4-3-2 Important points of project implementation

(1) The prices charged for potable water supply services by the DWSS and WSSC are extremely low. In most of the project areas, only hourly restricted water supply services are provided because of the inadequate system capacity and the collection of water charges is not carried out properly. This shortfall in revenue is, at present, subsidized by the central government.

In order to cope with this problem and to institute a rational water pricing system, a 24 hour water supply service is necessary, and the DWSS is also aimed at providing such a level of service.

(2) The central government, as mentioned earlier, is considering the delegation of responsibility related to water supply services from the DWSS to the town Panchayats in order to institute an independent self-supporting water supply service system.

In order to achieve this objective, it is necessary to devise a rational water supply service pricing system, for which determination of the actual level of water consumption is a prerequisite.

Therefore the request for the provision of water meters in this project is very positively appraised.
Therefore, practical water meter shall be selected in the Project.

(3) The installation of distribution branch pipes including the work on house connections is not included in the scope of work of this project, due to the limitation of total project costs and the period of construction. However, in order to realize early benefits from the Project such installation of distribution pipes is essential.

Hence if the necessary pipes, locally made HDPE pipes, are procured and provided it will ensure that such installation work is carried out as agreed upon by the DWSS. As such the provision of these branch pipes is very positively appraised.

4-4 General description of the project areas

4-4-1 Project area

A general description of the project areas is summarized below,

Table-4.1 General Description of the Project Area

Site	Political Division	Geographical Location	Administrative Feature	Design Population in 2003
Mahendranagar	Far West Region	Terai	District Headquarters	15,730
Dhangadhi	Far West Region	Terai	District Headquarters	14,169
Tansen	West Region	Pahar	Urban Center	18,120
Bharatpur	Central Region	Terai	District Headquarters	64,531
Gaushala	Central Region	Terai	Semi-urban Center (Village)	14,958
Lahan	East Region	Terai	Urban	30,988
Rajbiraj	East Region	Terai	Zonal Headquarters	49,014
Bhadrapur& Chandragadhi	East Region	Terai	Urban Center	47,757
Ilam	East Region	Pahar	Zonal Headquarters	12,825

Among the project areas Chandragadhi and Gaushala are villages. Gaushala is 1 of the 7 villages for which the water supply project is proposed by DWSS, while Chandragadhi is a neighboring village of Bhadratpur with many administrative offices. The other 8 project areas are towns.
A general breakdown of the project components of this project according to the facilities planned for each of the project areas is as follows:

For Tansen: To be provided with spare parts for the existing water supply facilities.

For Gaushala: A new water supply facility is to be implemented.

All other areas: Renovation and extension of existing water supply facilities are to be implemented.

The project area is to be an urbanized area in the administrative town Panchayat areas. A land use plan for the urban areas was established by DHPP according to the town planning act of 1973, however this plan is now being revised by the MSTP.
Therefore in this study, the map prepared by the DHPP is referred to only for limited purposes.
The proposed water service area is confirmed by the interpretation of aerial photographs taken in 1986 and other information collected during the field survey of this project.

CHAPTER 5. DESIGN OF WATER SUPPLY SCHEMES

Chapter 5

DESIGN OF WATER SUPPLY SCHEMES

5-1 Basic Considerations

The following basic considerations shall be taken into account for the design of water supply schemes.

1) The project areas of this project are included in the implementation schedule of 33 urban area water supply systems as a national project.
   Considering this project background, the basic design criteria for the water supply facilities of this project shall be adopted to be consistent with the already implemented projects of this 33 urban area water supply project.

   Accordingly the design criteria adopted are in accordance with the guidelines of DWSS, unless it is necessary to consider specific conditions of the Project.

2) The existing water supply facilities which are still operable shall be fully utilized by incorporating them into the proposed design.

3) In accordance with the basic policy of DWSS, a 24 hour water supply shall be provided with a water supply service charge system.

4) Economics in construction and ease of operation and maintenance shall be given due consideration in the design.

5) All project areas, except Bharatpur, will have their respective single water source system and distribution system.

The Bharatpur water supply system shall be divided into two interlinked systems consisting of two separate source systems. The highland area will be served by the existing surface water source and the lowland areas with a groundwater source, from deep wells.

6) The existing water supply schemes of Bhadrapur and Chandragadhi, which are independent schemes are planned to be interconnected.

7) All water supply schemes will be equipped with chlorination disinfection facilities using bleaching powder, in due consideration of maintenance, cost, and safety.

8) Slow sand filtration will be utilized for the surface water supply source at Bharatpur.

9) Iron removal facilities shall be incorporated in the treatment system depending on the source water quality.

10) Safe yields for proposed water sources of deep wells shall be determined by referring to existing well data so as to avoid sand draw-off.

5-2 Design Period

The design period adopted is 15 years, as per the guidelines of DWSS, until the year of 2003 from the year of 1988.

5-3 Proposed Service Area

The scheme of Management Support for Town Panchayat (MSTP) is being carried out by MHPP for smooth implementation of the decentralization policy.

The task of this MSTP Project is planning the scale of future land use and infrastructural developments, and the corresponding investments for the town Panchayats. Accordingly town and infrastructural development plans are being prepared. However, such plans have yet to be completed. Hence the relevant town planning maps and other data of the MSTP Project have not been made available for use in this study.

Consequently, the proposed water supply service areas are determined by judicious judgement based on the present conditions of the towns, and the data on town planning of Town Panchayat and MHPP of 1974.

The concept for the formulation of the service area is that, when there exists an interlocked undeveloped area among developed residential areas, and also when all the areas fall within the urban area, then such an undeveloped area is also assumed to be an area of potential future development, hence it is considered as a design service area. The proposed service area of each project site is shown in Fig A-1~A-9.

5-4 Population Projection

The proposed population served is the design population expected to be served at the end of the design period in the project area.

The population survey conducted by the town Panchayat is made available on a ward-wide basis only, and not on the basis of rural and urban areas.

As such it is necessary to modify the population data on a rural and urban basis since the service areas of the Project are urbanized areas.

(1) Present population

The population data is made available from two sources, namely the Central Bureau of Statistics (CBS) and the Management Support for Town Panchayat (MSTP).

The CBS conducts a general population census once every 10 years, and the latest one was in 1981.
The MSTP has also conducted a population survey in 1987, as the basic data of town planning.
The MSTP has also carried out a population forecast up to the year 2002 based on the population census of 1981 and its own population survey of 1987.
A population survey exclusively in the project areas was also conducted by this study team in 1988.

However the population figures obtained by the MSTP and the survey team are inconsistent in five (5) of the project areas. For the purpose of future estimation of population growth rate, the population growth rates of past records were referred to.

The present populations in the project areas as determined by both the surveys of 1987 and the data of 1981 census, along with the population figures adopted for this study are given in Table 5.1.

Table-5.1 Present Population in Town/Village (1987)

Site	Population in 1981	Population in 1987			Administration
		Estimate by MSTP	Town Panchayat	Population adopted	
Mahendranagar*	43,834	53,731	71,196	53,731	Town
Dhangadhi *	20,542	26,051	22,236	26,051	Town
Tansen	17,100	22,403	-	22,403	Town
Bharatpur	27,602	40,320	40,319	40,319	Town
Gaushala	-	-	7,986	7,986	Village
Lahan *	13,775	26,115	18,123	18,123	Town
Rajbiraj *	16,440	25,878	45,379	25,878	Town
Bhadrapur & Chandragadhi	9,761 -	14,169 -	14,169 10,907	14,169 10,907	Town Village
Ilam	9,773	10,215	11,692	11,692	Town

1) Population in 1981 : by the census of the Kingdom of Nepal
2) - : No data and/or out of objects
3) * : No coincidence between MSTP value and value by Town Panchayat

5-5 Proposed Water Served Population

5-5-1 Present population in the proposed water served area

In order to estimate the present population in each of the project areas in 1987, the following methodology is adopted.

1) Determine the ward-wide population density of the Panchayat that encompasses the whole project area concerned, using the ward-wide population data.

2) Identify a representative rural and urban ward in the Panchayat.

3) Divide the project area into urban and rural ward segments, judiciously.

4) Use the selected representative rural and urban ward population densities, respectively to the rural and urban segments of the project area to compute the present (1987) population in the project area.

The project population from the service areas along with the design populations are given in Table 5.2.

Table-5.2 Design Population (1987)

Site	Town/Village Population (A)	Population in Urban Area (B)	Population Density		Remarks (B/A)
			Project Area	Average Population Density	
			ha	person/ha	%
Mahendranagar	53,731	7,206	439	16.4	13
Dhangadhi	26,051	6,491	747	8.7	25
Tansen	22,403	-	-	-	-
Bharatpur	40,319	21,859	1,497	14.6	54
Gaushala	7,986	7,986	903	8.8	100
Lahan	18,123	14,196	848	16.7	78
Rajbiraj	25,878	19,294	430	44.8	75
Bhadrapur & Chandragadhi	25,076	21,878	588	37.2	87
Ilam	11,692	9,342 (5,385)	213	43.8	80 (46)

1 : Tansen : MSTP estimated Value
2 : Bhadra&Chan : Project Population = 18,435 (Bhadra) + 3,443 (Chan)
3 : Gaushala : Administrative area of the village
4 : Ilam : ( ) indicates project population out of the urban area

5-5-2 Population movement in the country

A national population census was first carried out in 1961, and since then it has been carried out once every 10 years. Based on these census data of 1961, 1971, and 1981, the following population tendencies are observed.

1) The average annual population growth rates for the recent two decades were 2.07% and 2.66%, and have increased year by year.

2) Population movement from hilly areas to the Terai area has been 700,000 people during the decade of 1971-1981, which is equivalent to 4% of the total population (16 million people) of the country

Based on the above data it is clear that the population movement from the hilly areas to the Terai, in effect, results in the progressing of decentralization of the population in hilly areas and centralization of the population in the Terai area.

5-5-3 Population movement in the project areas

Of the project areas, as per the geographical classification, Tansen and Ilam belong to the hilly region while all the rest belong to the Terai region.
An outline of population movement in the project areas according to these two regional classifications is as follows:

1) Hilly region

The rate of population growth in these areas is only due to natural means. Then population increase due to population movement is virtually nonexistent.

2) Terai region

Population movement due to internal migration from hilly regions and also due to the influx from neighboring Indian territories is very high.
Also the potential for agricultural and industrial development is very high in this region.
Therefore the rate of population increase in this region in very high compared to the hilly region.
The population change due to population movement in each of the project areas is given in Table 5.3.

5-5-4 Expected population growth rate

Population growth in an area is influenced by many social and economic factors as well. Hence estimation of population growth for a future date is a very complex matter.

In this study, the population growth rates were estimated by considering the following:

1) Latest available data on the population growth rate of the project areas

2) Commercial and urban development potential envisaged in the project areas

3) Geographical administrative features of the project areas

4) Existing indicators such as population growth rate in the DWSS guideline and other estimates made by MSTP.

The estimated population growth rates under the above mentioned conditions are given in Table 5.4.

Table-5.3 Population Movement by the Site

Site	Population by the year (Annual Growth Rate)					Population in 1987
Mahendranagar			43,834 in 1981	[3.5 %]	53,731 in 1987	53,731
Dhangadhi	14,528 in 1978	[12.2 %]	20,542 in 1981	[4.0 %]	26,051 in 1987	26,051
Tansen			17,100 in 1981	[4.6 %]	22,403 in 1987	22,403
Bharatpur			27,602 in 1981	[6.5 %]	40,319 in 1987	40,319
Gaushala			7,986 in 1987			7,986
Lahan	12,923 in 1977	[1.6 %]	13,775 in 1981	[4.7 %]	18,123 in 1987	18,123
Rajbiraj	7,832 in 1971	[7.7 %]	16,440 in 1981	[7.9 %]	25,878 in 1987	25,878
Bhadrapur 1)	7,499 in 1971	[2.7 %]	9,761 in 1981	[6.4 %]	14,169 in 1987	14,169
Ilam	7,299 in 1971	[3.0 %]	9,773 in 1981	[3.0 %]	11,692 in 1987	11,692

1) Not including the population in Chandragadhi
2) All the sites are in the Terai Region except Tansen and Ilam

Table-5.4 PROPOSED POPULATION GROWTH RATE

Site	Total Town Panchayat		Urban	Characteristics of the Site
	Population Growth Rate by Census (1971-1981)	Population Growth Rate by MSTP (1981-2002)	Expected Population Growth Rate	
Mahendranagar	3.5%	3.5%	5.0%	Far-west region in Terai Trading center of agricultural products District zone & Headquarters
Dhangadhi	4.0%	6.0%	5.0%	Far-west region in Terai Trading center of agricultural products District Headquarters
Tansen	4.6%	5.2%	- *	West Hilly region Trading center of agricultural products District Headquarters
Bharatpur	6.5%	5.7%	7.0%	West region in Terai Important traffic point District & Zonal Headquarters
Gaushala	-	-	4.0%	Central region in Terai Village Panchayat
Lahan	4.7%	4.5%	5.0%	Central region in Terai Trading center with India
Rajbiraj	7.9%	6.0%	6.0%	East region in Terai Social increase in population District & Zonal Headquarters
Bhadrapur (Chandragadhi)	6.4%	4.0%	5.0%	East region in Terai Trading center of agricultural products Many goverment offices in Chandragadhi
Ilam	3.0%	1.0%	2.0%	East Hilly region Famous for tea products District & Zonal Headquarters

* Growth rate is not considered because of the rehabilitation of facilities in Tansen.

5-5-5 Proposed design population

The population projection for every 5 years from 1988 to 2008 in the project area is calculated by using the present population (1987) and proposed population growth rates.
The results are shown in Table 5.5.

5-6 Proposed Water Demand

1) Per capita water demand

In this project, the water demand recommended by DWSS in its guideline for design of a water supply project is used.
The percapita water demand of DWSS design standards for various categories of users is given in Table 5.6. As seen from this table the type of domestic usage is divided into 3 categories depending on the level of service.

Table 5.6 Water Demand per Capita for Domestic Use

	Residential Consumption	Recommended Water Demand lit./cap/day	Classification Residence
1	Private Connection-Full plumbing including cistern flushing toilet	150	High water demand residence
2	Private Connection: Yard tap type, hand flush toilet, dry pit toilet, no toilet	65	Middle water demand residence
3	Public standpost	45	Low water demand residence

Table-5.5 PROPOSED POPULATION FOR WATER SUPPLY PROJECTS

SITE	Population in 1987	Growth Rate of Population	Design Population				Remarks
			1993	1998	2003	2008	
Mahendranagar	7,206	5.0%	9,657	12,325	15,730	20,076	
Dhangadhi	6,491	5.0%	8,699	11,102	14,169	18,084	
Tansen	13,200	-	-	-	-	-	
Bharatpur	21,859	7.0%	32,804	46,010	64,531	90,509	
Gaushala	7,986	4.0%	10,105	12,294	14,958	18,198	
Lahan	14,196	5.0%	19,024	24,280	30,988	39,550	
Rajbiraj	19,294	6.0%	27,369	36,626	49,014	65,591	
Bhadrapur-Chandragadi	21,878	5.0%	29,319	37,419	47,757	60,951	
Ilam	9,342	2.0%	10,521	11,616	12,825	14,159	
TOTAL	121,452	-	147,497	191,671	249,971	327,117	

2) *Population distribution according to per capita water demand*

A survey of the type of water consumption utilized by the classified water users, on which the per capita water demand is dependent, has been carried out in the past in the Kathmandu Valley by the DWSS, and in the urban centers by the National Bank.

The results of these surveys are summarized in Table 5.7

In Nepal, even in urban areas, all users do not fall into the "high water demand residence" classification of Table-5.6. Hence it becomes necessary to divide the users into the 3 categories of Type 1, Type 2 and Type 3 users.

Table-5.7 SHARE AND TYPES OF HOUSE CONNECTION OF WATER SUPPLY

	Full plumbing (type 1)	Yard Tap (type 2)	Share	Public Tap (type 3)	Other
Kathmandu ('88 DWSS)	31%	46%	-	23%	-
Kathmandu ('74 National Bank)	10%	61%	-	26%	3%
Biratnagar ('74 DHPP)	8%	34%	-	27%	31%
Hetauda ('74 DHPP)	11%	15%	17%	14%	43%
Birganj ('74 DHPP)	22%	-	15%	52%	11%
Design Value	30%	40%	-	30%	-

Note : 1) Share : Depending on Others' Taps
2) Other : River,Pond, Shallow Wells, etc.

Also, as evident from Table 5.7, in 1974 the Type 1 users (private connections with full plumbing) of Kathmandu city were 10% of the total population served with water. This Type 1 service population increased to 30% in 1988. This change was caused by the change over of Type 2 users to Type 1 users. It is presumed that similar changes in the usage pattern of water would have occurred in other urban areas as well. However no such recent data are available to confirm this supposition, though some datas are available for 3 cities for the year 1974.

Finally, for an overall consideration of the available data, the user categories of this project were planned in a "universal" manner, and are given in Table 5.7,.under the title "Share and Types of House Connection of Water Supply", and accordingly Type 1 use, Type 2 use, and Type 3 use are determined to be 30%, 40%, and 30% respectively, for all the project areas except Gaushala, a village Panchayat.

In case of Gaushala, though it is a village, the central part of the village, ward 1, is urbanized. This tendency toward urbanization is expected to accelerate further in the future.
Hence for ward 1 the same types of user categories as for the Town Panchayats of Table 5.7 are to be used. For the rest of the areas only Type 2 (Yard tap) and Type 3 (Public tap) uses, of 40% and 60% respectively will be adopted.

(2) Hospitals

Water demand per bed is assumed to be 500 l/day, as per the guidelines of DWSS. The number of hospital beds in the future for any one of the project areas is not provided by the authority concerned. Under the existing conditions, in most project areas, the medical facilities are located in the central area of the respective towns and serve the inhabitants of the urban area and also some rural areas in its proximity.

In this study, the number of beds in the target year 2003 is estimated by taking into consideration the features of the existing hospitals and the characteristics of the project areas.

The criteria used for the estimation of the number of beds are given below, and the corresponding bed numbers determined are given in Table-5.8.

Criteria of bed numbers

Characteristics of locality	Bed number/1000 persons
1. Center of zone	4
2. Center of district	3
3. Others	2

The number of beds proposed above, however, is rather conservative. Nevertheless it is reasonable considering the fact that hospitals in urban areas serve the people of the rural areas in the immediate proximity as well. This is evident from Table-5.8 which shows future bed numbers and the population of zones/districts.

Table-5.8 Proposed Water Consumption of Hospitals

Site	Site Population		Number of Hospitals in 1987	Estimate Number of Beds in 2003	Water Demand in 2003 (liter/day)
	Population in 1987	Projected Population in 2003			
Mahendranagar	53,731	117,288	1	350	175,000
Dhangadhi	26,051	56,866	3	250	125,000
Bharatpur	40,319	119,028	1	357	178,500
Gaushala	7,986	14,958	0	0	0
Lahan	18,213	39,757	1	80	40,000
Rajbiraj	25,878	65,739	1	142	71,000
Bhadrapur (Chandragadhi)	25,076	54,738	1	110	55,000
Ilam	11,692	16,051	2	64	32,000

Project area	No. of beds (1)	Population (1981) (2)		(1)/(2)x1000
Mahendranagar	350	Mahakali Zone	530,000	0.7
Dhangadhi	250	Sebi Zone	790,000	0.3
Bharatpur	357	Navayani Zone	1,440,000	0.2
Lahan	80	Shiraha district	380,000	0.2
Rajbiraj	142	Sagaramatha zone	1,350,000	0.1
Bhadrapur and Chandragadhi	110	Mechi Zone	430,000	0.1
Ilam	64	Ilam district		0.01

3) Schools

Water demand per student is assumed to be 10 l/day, as per the guidelines of DWSS.

The existing conditions in relation to the number of students in each of the project area is summarized in Table-5.9.

As evident from Table-5.9, most students of primary schools are from the vicinity of the respective urban areas, whereas the students of middle schools and colleges are from both urban and rural areas.

By taking into consideration the above existing conditions, the number of students in the target year (2003) is estimated based on the following assumptions.

The increase in the number of students in the Terai area is proportional to the general population increase.

Table-5.9 Projected Number of the Students in Urban Area

Site Name	Population of Urban Area in 1987	Number of People in 1987	Proposed Number of People in 2003
Mahendranagar	7,206	P : 530 M : 1600 H : 830 Total 2960	P : 1000 M : 3000 H : 1550 Total : 5550
Dhangadhi	6,491	P : 240 M : 530 H : 1070 Total : 1840	P : 450 M : 1000 H : 2000 Total : 3450
Bharatpur	21,859	P : 530 M : 640 H : 530 C : 530 Total : 2230	P : 1000 M : 1200 H : 1000 C : 1000 Total : 4200
Gaushala	7,986	P : 60 M : 270 H : 530 Total : 860	P :100 M : 500 H : 1000 Total : 1600
Lahan	14,196	P : 400 M : 1340 H : 1600 C : 350 Total : 3690	P : 750 M : 2500 H : 3000 C : 650 Total : 6900
Rajbiraj	19,294	P : 700 M : 820 H : 1340 Total : 2860	P : 1300 M : 1540 H : 2500 Total : 5340
Bhadrapur Chandragadhi	21,878	P : 350 M : 350 H : 850 C : 1000 Total : 2550 P : 210 H : 210 Total : 420	P :650 M : 650 H : 1600 C : 3000 Total : 5900 P : 400 H : 400 Total : 800
Ilam	9,342	P : 510 M : 130 H : 280 C ; 950 Total : 1870	P : 650 M : 170 H : 350 C : 1200 Total : 2370

Note:
1) P : Primary School
2) M : Middle School
3) H : High School
4) C : College

Thus, a 4 % increase in the number of students as per that perceived with respect to the entire population is expected.
However for Ilam, a hilly area, an increase of 1.5 % in the number of students is expected.

4) Public facilities

Water demand for public facilities such as parks, sports fields, hotels etc. is to be 750 lit./day, as per the guidelines of DWSS.

For airports, the water demand of Bharatpur Airport is to be 3,000 lit./day, and that of Bhadrapur Airport is to be 750 lit./day, figures arrived at based on the frequency of flights and number of passengers.

5) Public offices

Water demand for public offices is to be 10 lit./staff number/day, as per the guidelines of DWSS.

The number of staff in the target year is determined by assuming an annual growth rate of 2% with respect to the existing staff number.

The public staff population density in the target year is predicted to be about 100 persons/ha, as per the present land use pattern. A Mahendranagar, however the public plot occupies a rather wide area in the town so that density of public staff is estimated to be about 10 persons/ha.

6) Other facilities

As other facilities worthy of mention, there are lumber mills, rice mills, brick factories, etc., that are establishments of small and medium scale. The water demand of such establishments is assumed to be 750 lit./day in this project.

However it is presumed that industries with high water consumption, like soft drink bottling plants, will have their own private water supply facilities, and hence are not considered for public water supply services.

5-6-2 Expected Water Demand

Based on the conditions stated above, the mean and the maximum daily water demands are determined, and the corresponding results are shown in Table-5.10.

Table-5.10 Proposed Water Demand

Site	HOUSING AREA		OFFICE AREA		HOSPITALS		SCHOOLS		PUBLIC FACILITY		OTHER FACILITY		AVERAGE WATER DEMAND (m3/day)	DAILY MAX WATER DEMAND (m3/day)	HOURLY MAX WATER DEMAND (m3/day)
	Population in 2003	Water Demand (m3/day)	Number of Officers	Water Demand (m3/day)	Number of Beds	Water Demand (m3/day)	Number of Students	Water Demand (m3/day)	Number of Facilities	Water Demand (m3/day)	Number of Facilities	Water Demand (m3/day)			
Mahendranagar	15,730	1,353.0	2,420	222.4	350	175.0	17,250	172.5	3	2.3	0	0.0	1930	2,700	3,600
Dhangadhi	14,169	1,245.0	681	27.3	250	125.0	10,700	107.0	3	2.3	0	0.0	1810	2,600	3,300
Bharatpur	64,531	5,478.0	8,410	84.1	357	178.5	19,600	196.0	8	6.0	2	1.5	5950	8,400	11,000
Gaushala	14,958	748.7	40	0.4	0	0.0	1,600	16.0	0	0.0	0	0.0	770	1,100	1,400
Lahan	30,988	2,652.8	850	8.5	80	40.0	12,900	129.0	0	0.0	7	5.3	2840	4,000	5,200
Rajbiraj	49,014	4,163.5	1,175	11.8	142	71.0	17,320	173.2	0	0.0	2	1.5	4430	6,200	8,100
Bhadrapur (Chandragadhi)	47,757	3,988.1	4,600	103.5	110	55.0	13,650	136.5	4	3.0	11	8.3	4300	6,100	7,900
Ilam	12,825	266.1	917	9.2	64	32.0	4,680	46.8	4	3.0	2	1.5	1190	1,600	2,100
TOTAL	249,972	19,895	19,093	467.2	1,353	676.5	97,700	977.0	22	16.6	24	18.1	22051	32,700	42,600

5-7 Plan of Water Supply Facilities

5-7-1 Design Capacity

The design capacity of water supply facilities is determined according to the required functions of the facility. The average daily demand is determined using the design population and their per capita demand. The daily average demand, however, varies according to the characteristics of the town, local customs and the seasonal variation in water consumption. Thus, in consideration of these variations the daily demand adopted is the maximum daily demand.

According to the guidelines of DWSS, the seasonal water demand variation is to be 1.25 and 1.12 times the average daily demand, respectively, in Terai and Hilly areas.

In generally the maximum daily demand is considered as 1.5 times the average daily demand. Hence, factor values of 1.4 and 1.3 are proposed for the maximum daily demand in the Terai and Hilly areas, respectively, by providing an allowance of 15% more to the DWSS factor.

For the design of distribution pipelines, the maximum hourly demand is adopted. In general the interrelationship between the maximum hourly demand and the maximum daily demand could be expressed as follows:

Hourly Maximum Demand (m^3/day)
= Daily Max. Demand x (1.3 - 2.0) (m^3/day)

Since most of the project areas are semi-urban areas, the hourly maximum factor proposed is 1.3 to the maximum daily demand. Thus, the peak factor proposed is 1.82 (1.4 x 1.3) which is slightly smaller than that proposed in the guideline of DWSS (2.5). Since 24 hour service is proposed, the peak factor, 1.82, is considered acceptable.

Proposed design capacities are summarized in Table 5.11.

Table-5.11 Proposed Design Capacity

	Topo-graphy	Daily average (m^3/day)	Seasonal Variation	Daily maximum (m^3/day)	Peak factor	Hourly maximum (m^3/day)
Mahendranagar	Terai	1,930	1.40	2,700	1.82	3,600
Dhangadhi	Terai	1,810	1.40	2,600	1.82	3,300
Bharatpur	Terai	5,950	1.40	8,400	1.82	11,000
Gaushala	Terai	770	1.40	1,100	1.82	1,400
Lahan	Terai	2,840	1.40	4,000	1.82	5,200
Rajbairaj	Terai	4,430	1.40	6,200	1.82	8,100
Bhadrapur & Chandragadhi	Terai	4,300	1.40	6,100	1.82	7,900
Ilam	Hilly	1,190	1.30	1,600	1.69	2,100

* Peak factor: 1.40 x 1.30 = 1.82 for Terai area
1.30 x 1.30 = 1.69 for Hilly area

The proposed design capacity for each water supply facility is summarized as below;

<u>Type of Facility</u>	<u>Design Capacity</u>
Water Source	Maximum Daily Demand
Treatment Facility	Maximum Daily Demand
Distribution Tank	Maximum Daily Demand
Distribution Pipeline	Maximum Hourly Demand

5-7-2 Water source

Among the 9 project areas, Tansen is limited to only the provision of spare parts for renovation for the existing water supply system.

For Bharatpur, it is necessary to renovate the existing transmission main for surface water intake from the existing capacity of 1,640 m^3/day to 2,000 m^3/day.

However, even with renovation the capacity of this source is insufficient to meet the future demand of 8,400 m^3/day. Thus additional groundwater source utilizing deep wells are also planned.

In Ilam, the water source for supply is limited to only surface water due to its topographical conditions of hilly slopes in the project area.

The proposed water source in the hilly area is rather distant being 20 km away from the service area with many slopes and valley crossings. Due to these difficult topographical conditions, the construction, and operation and maintenance costs of the transmission main from the proposed water source are anticipated to be very high. Therefore the existing water source (864 m^3/day) would be utilized by increasing its effective capacity (1,600 m^3/day) with the renovation of intake and transmission mains for the prevention of leakages.

Except for the above mentioned two project areas, the water sources for all the other project areas are exclusively groundwater sources, due to their hydro-geographic conditions.

In the western to central part of the Terai zone, the yield of groundwater from the existing deep wells in Dhangadhi and Bharatpur is about 1,700 m^3/day. (For details refer to sections 3.2.4 and 3.4)

In the eastern part of Terai the corresponding ground water yield is about 1,700 m^3/day. However the wells with an yield of 1,700 m^3/day have the unfavorable effects of sand discharge, hence are prone to problems of operational and mechanical nature. Therefore, it is recommended that the design yield of the proposed deep wells to be restricted to a maximum of 1,300 m^3/day, the capacity is observed in Mahendranagar, Chandragadhi and Rajbiraj, in order to avert this problem of sand draw-off.

The existing and the proposed necessary additional water source capacity, and the corresponding number of wells are given in Table-5.12.

The power source for the deep well pumping will be exclusively from private diesel generators due to shortage and unreliability of public power supply services to the project areas.

Two types of diessel power generation systems, independent for each of the project areas, are considered and evaluated. They are respectively, the diversified and centralized power generation systems.

A detailed comparative analysis to indentify the optimum choice between the diversified and centralized systems was performed and accordingly the diversified system was found to be the most economical(Appendix-C.1). Hence it has been decided to install a diesel generator in each pumphouse. Also such a diversified system would facilitate the interchangeability of spare parts, and increased reliability of water supply against generator break-downs.

Table-5.12 Proposed Water Capacity and Required Number of the Wells

Site	Future Water Demand (m3/day)	Existing Source Capacity (m3/ day)	Necessary Source Capacity (m3/ day)	Number of Wells		
				Necessary	Existing	Proposed
Mahendranagar	2,700	1,300	1,400	3	1	2
Dhangadhi **	2,600	1,700	900	2	1	1
Bharatpur **	8,400	2,000*	6,400	4	-	4
Gaushala	1,100	-	1,100	2	-	2
Lahan	4,000	1,300	2,700	4	1	3
Rajbiraj	6,200	1,300	4,900	5	1	4
Bhadrapur (Chandragadhi)	6,100	2,600	3,500	5	2	3
Ilam	1,600	864*	736	-	-	-
TOTAL	32,700	8,200	21,636	25	6	19

* : Surface Water or including Surface Water
** : Exsiting and Design Well Capacity is 1700 m3/day/well
Others are 1300 m3/day/well (cf : 6.1.1.1)

5-7-3 Transmission Facilities

The transmission facilities include the transmission main and the other necessary intake structures.

In Bharatpur the necessary repair and renovation works on the existing transmission main include the following items.

1) Repair of leakage including hill slope protection:
ø200 x 100m x 5

2) Repair of leakage including replacement of pipes:
ø200 x 20m x 5

3) Protection of river crossing pipes:
ø200 x 30m

In Ilam the existing transmission main is composed of two (2) lines i.e. a ø100 mm cast iron pipe installed in 1924 and another ø50 mm HDPE pipe installed in 1974.

These transmission mains are very old and there exist many leakages. Therefore renovation and replacement work on these mains for an additional increase of 9 lit./sec from the present rate are proposed to be carried out as indicated below.

1) Length of the main for renovation and replacement:
ø150 mm x 13.22 km

2) Surge pressure tanks: 5

3) Water transmission main bridge: 15 m x 5

5-7-4 Water Treatment Facilities

The design population to be served with water is more than 10,000 people in most project areas. In order to ensure the safety of the water from the important point of view of public health, disinfection is to be provided for all water treatment facilities, as the final step of treatment prior to distribution. As the disinfection agent, chlorination with bleaching powder is recommended in considering ease of handling, and safe application with relatively unskilled labour.

Among the project areas, for a portion of Bharatpur and Ilam the source is surface water. The source for Ilam is a spring and the water quality could be considered to be good (see Table 5.13).

The water quality of Bharatpur is good, however turbidity due to suspended matter is inherent to the surface water of rivers. Hence slow sand filtration is recommended preceding disinfection for the removal of suspended solids.

The design facilities of Bharatpur are shown below with one slow sand filter unit as a standby.

Project area	Capacity of water source (m^3/day)	Design capacity of filters (m^3/day)	Filtration rate (m/day)	Filter area (m^2)
Bharatpur	2,000	2,000	5.0	200x (2+1)No.

As mentioned before, for all the rest of the 6 project areas the source is groundwater. All these groundwater sources, except that of Gaushala, contain high iron content, as per the WHO standard for potable water.

Table-5.13 Water Quality

		Mahendranagar Raw Water	Dhangadhi Deep Well	Bharatpur Coca Cola	Gaushala Shallow well	Lahan Deep Well	Rajbiraj Raw Water	Bhadrapur Deep Well	Chandragadhi Deep Well	Remarks
Appearance		Clear	Clear	Clear	Clear	Hazy	Clear	Clear	Clear	
PH		6.6	6.6	6.5	6.1	5.8	6.2	5.9	6.0	7.0 ~8.5
Colour	Hazen	5	<5	<5	<5	15	<5	<5	<5	
TTL Alkalinity	CaCO3	515.0	247.2	129.78	109.18	168.92	222.48	103.0	72.1	
P.P.H. 〃	〃	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
PH 4.5 〃	〃	515.0	247.2	129.78	109.13	168.92	222.48	103.0	72.1	
TTL Hardness	〃	534.48	208.08	128.52	97.92	163.2	163.32	73.44	73.44	
Calcium Hardness	〃	326.4	122.4	99.96	51	81.6	87.72	28.56	28.56	
Magnesium Hardness	〃	208.08	85.68	78.56	46.92	81.6	46.48	44.88	44.88	
Calcium	Ca	130.69	49.01	40.02	20.42	32.67	35.12	11.43	11.43	75
Magnesium	Mg	50.54	20.81	6.94	11.39	19.82	11.29	10.9	10.9	50
Iron	Fe	0.575	0.01	0.34	0.01	0.46	0.46	0.575	0.35	0.3
Manganese	Mn	0.05	0.005	0.02	0.01	0.0775	0.0675	0.05	0.005	
Silica	SiO2	50	30	40	30	30	60	50	50	
Chloride	Cl	5.76	3.84	3.84	3.84	4.8	4.8	3.84	5.76	220
Phosphate, ortho	P	0.02	0.02	0.01	0.01	0.02	0.2	0.3	0.25	0.5
Ammonia, TTL	N	0.04	0.04	0.02	0.02	0.20	0.20	0.28	0.04	
Comment		hard water	slightly hard	chemical quality of water sample is satisfactory		water acidic + TTL ammonia is slightly *high*	TTL Ammonia is slightly high	Water acidic + TTL ammonia is slightly *high*	Water is slightly acid	International Standard of WHO

Hence these require iron removal facilities as well in addition to disinfection. Those project areas requiring these iron removal facilities are, Mahendranagar, Lahan, Rajbiraj, and Bhadrapur-Chandragadhi.

The following three methods of iron removal are being evaluated for their suitability.

1) Aeration
2) Oxidation by chlorination
3) Oxidation by chlorination with coagulation/flocculation and sedimentation.

In this project, oxidation by chlorination is adopted as a result of the need for less machinery and electrical equipment, and high efficiency of iron removal in comparison to other methods (see Appendix C.2).

For the rapid filtration method after chlorination, siphone type filtration, which is an automatic filtration method that does not use flow control devices such as valves and pumps, is adopted for ease of maintenance.

Since iron concentration of the groundwater is assumed to be in a range between 0.3 and 0.6 no sedimentation device is provided after oxidation of iron.

The type and capacity of the water treatment facilities are summarized in Table-5.14.

Table-5.14 Types and Capacity of the Treatment Facilities

Site	Slow Sand Filtration (m3/day)	Chlorination (m3/day)	Iron Removal (chlorination & rapid filtration) (m3/day)	Water Demand (m3/day)	Water Source
Mahendranagar	-	-	2,700	2,700	ground water
Dhangadhi	-	2,600	-	2,600	ground water
Bharatpur	2,000	2,000 6,400	- -	2,000 6,400	surface water ground water
Gaushala	-	1,100	-	1,100	ground water
Lahan	-	-	4,000	4,000	ground water
Rajbiraj	-	-	6,200	6,200	ground water
Bhadrapur	-	-	3,050	3,050	ground water
Chandragadhi	-	-	3,050	3,050	ground water
Ilam	-	1,600	-	1,600	surface water

5-7-5 Water distribution tank/reservoir

The function of a water distribution tank reservoir is to provide a storage volume of water for maintaining a balance between the water supplied and water treated. The capacity of a reservoir/tank is determined by considering the following points:

1) To provide the necessary capacity for balancing the hourly variation in water demand.

2) To provide storage for fire fighting.

3) To provide storage in case of interruption of intake or treatment facilities due to maintenance or other mechanical troubles,etc.

According to the guidelines of DWSS, the recommended design capacity of a water distribution tank/reservoir is 50% of the design maximum daily demand by taking into account the unreliability of power supply and inadequate water source capacity and the minimum capacity to be at least 25% of the maximum daily demand.

All the project areas with a groundwater source have at least 2 deep wells with generators in all urban areas.. Hence a stable, reliable water supply is possible. In these project areas, the capacity of the elevated tank/reservoir is decided to be 6 hours of the maximum daily water demand, which includes the balancing and fire fighting requirements.

The capacities of the water distribution tanks recommended for various project areas and the relevant considerations are described below.

In Bharatpur, the existing surface water intake capacity is planned to be increased to 2,000 m^3/day by the renovation of the intake and transmission main.

The existing water distribution reservoir capacity is 900 m^3, which is equivalent to 10.8 hours (45%) of the design maximum daily demand, and is sufficient.

In Ilam, the hilly topographical conditions allow the usage of water transmission by gravity to the ground reservoir for distribution, hence it is free from any electricity requirement. The existing distribution reservoir capacity is 3.5 hours of the maximum daily demand, which is rather small compared to the reservoir tank storage capacity of other project areas. Still as the system is immune to electricity failure this low storage is admissible.

For the 7 project areas in the Terai plain elevated water distribution tanks are necessary, while for Ilam in the hilly area the existing ground reservoir is sufficient due to its topographic condition.

For Mahendranagar and Rajbiraj, the existing sedimentation tanks for iron removal are to be utilized as distribution ground reservoirs.

There is no existing water supply system in Gaushala. An elevated water distribution tank is proposed due to the flat topographical condition. As this is a village Panchayat with few house connections, and also due to economic considerations, an elevated water tank storage capacity of 200 m^3, that is equivalent to 4 hours (16%) of the maximum daily demand, along with a 100 m^3 water reservoir that is equivalent to 2 hours maximum daily demand are proposed.

The design distribution facilities are summarized below.

Site	Water Source	Water Tank Existing	Water Tank Proposed	Elevated Tank Existing	Elevated Tank Proposed	Total	Daily Max Water Demand Time
		(m³)		(m³)		(m³)	(hr)
Mahendranagar	Groundwater	900*	-	-	200	1,100	9.8
Dhangadhi	Groundwater	-	500	-	200	700	6.0
Bharatpur	Surface Water	900	-	-		900	10.8
		-	1,200	-	400	1,600	6.0
Gaushala	Groundwater	-	100	-	200	300	6.0
Lahan	Groundwater	-	550	450	-	1,000	6.0
Rajbiraj	Groundwater	900*		450	-	1,350	5.2
Bhadrapur	Groundwater	-	300	450	-	750	5.9
Chandragadhi	Groundwater	-	300	450	-	750	5.9
Ilam	Surface Water	236	-	-	-	236	3.5

Note * Existing one to be improved and used

However, for Mahendranagar and Dhangadhi, the effective water head of the existing elevated tank is only 13 m of the hight which is insufficient for the newly designed water supply systems. Hence new elevated water tanks are to be provided in these areas.

5-7-6 Power Source

Among the project areas there are some which are served with electricity bought from India. However this power supply is not very reliable. A steady and reliable power supply is scheduled for these areas from the National Grid; however, due to financial constraints the implementation schedule is not very clear. Therefore diesel generators are to be used as the source of electric power for these water supply facilities.

When a steady and reliable power supply is made available the diesel generators could be used for emergencies.

5-7-7 Water Distribution Facilities

The water distribution pipe network is designed based on the maximum hourly water demand in the target year 2003.

A minimum effective head of 20m was selected with the necessary condition of a minimum service head of 5m, the recommendation of the DWSS guidelines, so that most of the existing elevated tanks could be utilized.

The laying of pipes is basically planned along the existing roads only, due to the incomplete state of the town development planning.

For the future water-served areas, water distribution will be effected through the proposed nearby design distribution main.

The hydraulic calculation of the pipe networks is carried out, based on the conditions stated above, by using the Hardy Cross method of the Hazen Williams formula.

The design of piping for distribution system for all the project areas is carried out with a minimum pipe diameter of 50 mm.

The piping of the branch connection and other inhouse connections will be carried out at the expense of the beneficiaries concerned, with the permission and supervision of DWSS.

The new pipes will be connected to the existing pipes, thus the existing household connections will remain unaffected.

In the case of new household connections after the completion of the distribution network, such connections will be made to the new distribution main only.
However any connections for renovation of the existing house connections will be made to the new distribution main, by taking the aging of the existing mains into consideration.

Of the total design distribution pipings, pipe lines representing 20% length of which diameters are 75mm and above, will be provided by the Government of Japan. Those lines will be utilized for the extention of distribution branch lines to be constructed by participation of the local beneficiaries under the supervision of the Town Panchayat and DWSS.

5-7-8 Summary of water supply facilities

The water supply facilities to be provided are summarized in Table-5.15.

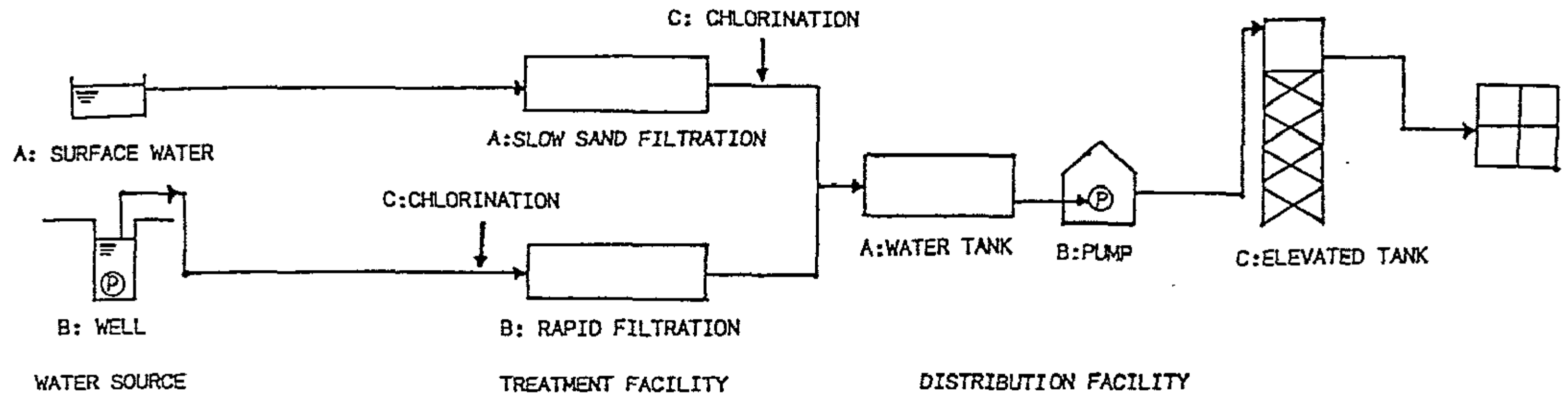


Table-5.15 Outline of Water Supply Facilities

Site	Water Source: Surface Water	Water Source: Well	Transmission Main (ø mm)	Treatment Facility: Slow Sand Filtration	Treatment Facility: Rapid Filtration	Treatment Facility: Chlorination	Distribution Facility: Water Tank	Distribution Facility: Pump	Distribution Facility: Elevated Tank	Distribution Pipe Line Total Line	Design Population Daily Max Water Rate (m3/day)
Mahendranagar	-	1300 m3/day x 3 (proposed 2)	125,150 mm	-	2700 m3/day	2700 m3/day	*1)900 m3 -	1.4 m3/min X3(standby1)	- 200 m3	ø250 - 50 mm 12,406 m	16,000 2,700
Dhangadhi	-	1700 m3/day X 2 (proposed 1)	125,150 mm	-	-	2600 m3/day	- 500 m3	1.4 m3/min X3(standby1)	- 200 m3	ø250 - 50 mm 20,834 m	14,000 2,600
Bharatpur	2000 m3/day	1700 m3/day X 4 (proposed 4)	125,150 mm	2000 m3/day	-	2000 m3/day 6400 m3/day	900 m3 1200 m3	3.2 m3/min X3(standby1)	- 400 m3	ø400 - 50 mm 23,826 m	65,000 8,400
Gaushala	-	1300 m3/day x 2 (proposed 2)	125,150 mm	-	-	1100 m3/day	- 100 m3	0.5 m3/min X3(standby1)	- 200 m3	ø200 - 50 mm 10,439 m	15,000 1,100
Lahan	-	1300 m3/day x 4 (proposed 3)	125,150 mm	-	4000 m3/day	4000 m3/day	- 550 m3	1.9 m3/min X3(standby1)	450 m3 -	ø350 - 50 mm 24,706 m	31,000 4,000
Rajbiraj	-	1300 m3/day x 5 (proposed 4)	125,150 mm	-	6200 m3/day	6200 m3/day	*1)900 m3 -	2.82 m3/min X3(standby1)	450 m3 -	ø350 - 50 mm 18,216 m	49,000 6,200
Bhadrapur & Chandragadhi	-	1300 m3/day x 5 (proposed 3)	125,150 mm	-	3050 m3/day X 2	3050 m3/day X 2	- 300 m3 X 2	1.4 m3/min X6(standby2)	450 m3 X2 -	ø350 - 50 mm 30,393 m	48,000 6,100
Ilam	1600 m3/day		150 mm	-	-	1600 m3/day	236 m3	-	- -	ø200 - 75 mm 7,689 m	13,000 1,600
Tansen	Pumps and other Equipment would be provided.										
							upper:existing lower:proposed		upper:existing lower:proposed	(TOTAL)	251,000 32,700

*1) Existing one to be improved and used

CHAPTER 6. BASIC DESIGN OF WATER SUPPLY

Chapter 6
BASIC DESIGN OF WATER SUPPLY

6-1 Water Source Facilities

The water source facilities of this project are summarized below:

		Mahendranagar	Dhangadhi	Bharatpur	Gaushala	Lahan	Rajbiraj	Bhadrapur & Chandragadhi	Ilam
Water Source	Surface Water	—	—	2000 m3/day	—	—	—	—	1600 m3/day
	Well	1300 m3/day x 3 (proposed 2)	1700 m3/day x 2 (proposed 1)	1700 m3/day x 4 (proposed 4)	1300 m3/day x 2 (proposed 2)	1300 m3/day x 4 (proposed 3)	1300 m3/day x 5 (proposed 4)	1300 m3/day x 5 (proposed 3)	—

The total design requirement of water source wells for the design period of 15 years is 19 numbers. However, by considering the uncertainity inherent to future water demand and the pre-investiment involved, it is very realistic and also economical to adopt a staged implementation of source wells. This would enhance the overall investment efficiency. Accordingly, only 10 number wells to meet a 10 year water source demand is decided to be installed, initially.

6-1-1 Groundwater source

6-1-1-1 Yield of wells

The dimensions of the existing deep wells in various project areas and their well logs are shown in Appendix D.1,.D.2. Based on the yield test results of existing wells in the project areas as shown in Appendix D.1,.D.2, the yield could be considered as a critical yield.

Generally a safe yield is recommended to be 80% to 90% of the critical yield. Except for Dhangadhi and

Bharatpur, sand draw-off (discharge) is observed in all existing wells, especially in the well of Lahan. Due to this reason, a proper safe yield that is free of sand draw-off shall be determined. Hence in this project the design yield is determined to be 80% of the above safe yield. Nevertheless it is also necessary to execute yield tests by considering sand draw-off as the critical limiting factor in the project areas.

An estimate of the proposed well yield at Gaushala, where there is a new water supply scheme, will be determined by referring to nearby irrigation wells.

The depths of the existing wells in all project areas range from 32m to 113m and the yields from 1,200 m^3/day to 2,000 m^3/day.

The existing deep well at Mahendranagar is the most shallow one with a depth of 32m, while all other project area wells are more than 100m deep. Even in the area of Dhangadhi the existence of a good gravel layer aquifer is anticipated, based on the well log diagram. From this favorable geological condition, it is expected to obtain an yield of 2,000 m^3/d with a deeper bore hole.

Based on the well log diagrams of Lahan and Rajbiraj, the alternative layers of clay and gravel are expected to allow further extension of the existing wells. Hence an increased yield, with a critical yield value of 2,000 m^3/day is expected to be obtained with such deeper wells in these areas.

The design well yields including the critical and safe yields determined in the respective project areas are given in Table-6.1.

Table-6.1 Proposed Yields of Wells

Site	critical yields	proper yields	design yields
	(m3/day)	(m3/day)	(m3/day)
Mahendranagar	2,000	1,700	1,300
Dhangadhi *	2,000	1,700	1,700
Bharatpur *	2,000	1,700	1,700
Gaushala	2,000	1,700	1,300
Lahan	2,000	1,700	1,300
Rajbiraj	2,000	1,700	1,300
Bhadrapur	2,000	1,700	1,300
Chandragadhi	2,000	1,700	1,300

Note: * Judging from well logs, less sand draw-off is presumed Dhangadhi and Bharatpur.

6-1-1-2 Design of well casing and borehole

For the case of a design yield of 1,700 m^3/day (1,200 l/min) and 1,300 m^3/day (900 l/min), the necessary calculation procedure for determining the critical velocity of groundwater around the screen and the critical particle grain size (diameter) of sand which shall be moved are given below for illustrative purpose.

Determination of critical velocity (V) is given by the following relationship;

$$Q = 2 \cdot r \cdot m \cdot N \cdot V \cdot P \cdots\cdots\cdots\cdots (1)$$

where

Q = Design well yield (1,700 or 1,300 m^3/day)

r = Radius of well casing (0.125m)

m = Length of screen (35m)

N = Opening ratio of screen (0.16)

V = Critical velocity

P = Void ratio of stratum (0.4)

$$\text{Hence; } V = \frac{Q}{2.r.m.N.P}$$

$$= \frac{Q}{1.758} (m/sec)$$

For $Q = 1,200$ l/min $= 0.02$ m^3/sec

$$V = \frac{0.02}{1.7584} \doteq 0.011 \text{ m/sec} = 1.1 \text{ cm/sec}$$

For $Q = 900$ l/min $= 0.015$ m^3/sec

$$V = \frac{0.015}{1.7584} = 0.0085 \text{ m/sec}$$

$$= 0.85 \text{ cm/sec}$$

Then the critical particle grain size (diameter) corresponding to the above determined critical velocity is read from the diagram (See Appendix D.3), and accordingly the grain diameters are as follows:

For Q = 1,200 l/min particle > 0.045 cm is retained

For Q = 900 l/min particle> 0.035 cm is retained

Generally there are two countermeasures available for the prevention of fine sand draw-off.

They are;

1) Increasing the screen length
2) Using a larger diameter well casing.

The length of the screen is dependent on the available thickness of the effective aquifer. In these project areas the effective thickness of the aquifer is limited to 30 ~ 40 m. The increase in the well diameter will not have any effect on the interstitial velocity of water in the aquifer, while increasing the cost of construction.

The computed critical grain size of 0.035 cm will not interfere with the performance of the submersible pump. Hence some draw-off of fine sand is allowed in the design, and the drawn off sand will be removed by sedimentation in the treatment process. Therefore a casing diameter of 250 mm is adopted.

The relationship between the diameter of the well casing and that of the borehole is generally described by the following formula.

$$2RC = (1.5 \sim 3.0) \cdot D \geqq 140 \text{ mm} + D$$

where

D : Diameter of well casing

RC : Radius of borehole

Hence for a casing diameter (ø) of 250 mm; the minimum diameter of the borehole becomes 390 mm.
Based on the above considerations a design borehole drilling diameter of 450 mm is adopted.

The selected width of the radial gap between the well casing and the borehole, the space to be filled with suitable filling material to prevent the draw-off of sand, is 100 mm.

6-1-1-3 Design depth of wells

The depths of the proposed deep wells are recommended to be in the range of 100 - 150m taking into consideration factors such as possible contamination due to domestic wastewater intrusion at shallow depths, and the hydrogeological conditions as observed from the well logs (See Appendix-D.1).
The depths of wells determined for the project areas are as follows;

<u>Mahendranagar</u>

In order to extract water at a depth greater than 50m, and to ensure the adequate aquifer length that is expected at a depth range of 50 ~ 100m, a well depth of 100m is selected.

Dhangadhi

In order to extract water at a depth greater than 100m, a design well depth of 150m is selected.

Bharatpur

The expected water yield per unit depth is low, hence the required screen length is rather long. Therefore a well depth of 150m is selected with an aquifer at a depth in the range of 110m to 150m.

Gaushala

The draw down observed from the well log is very high. Hence in addition to the aquifer at a depth 60 ~ 85m, aquifers at depth greater than 100m are also to be utilized. Therefore a well depth of 150m was selected.

Lahan

The expected water yield per unit depth is low, hence the required screen length is rather long. Therefore a well depth of 150m is selected with an aquifer at a depth in the range of 110m to 150m.

Rajbiraj

The draw down expected is rather high. Therefore water to be extracted at a depth greater than 100m. Then a design well depth of 150m was selected.

Bhadrapur & Chandragadhi

The expected water yield per unit depth is low and the draw down is high. Hence water is to be extracted at a depth lower than 110m. Therefore a design well depth of 150m was selected.

These design well depths are summarized in Table 6.2.

Table-6.2 Proposed Well Depth

SITE	Design depth of wells(m)
Mahendranagar	100
Dhangadhi	150
Bharatpur	150
Gaushala	150
Lahan	150
Rajbiraj	150
Bhadrapur & Chandragadhi	150

Finally the expected static and dynamic water levels of the design wells are shown in Fig. 6.1. The details of the design wells are shown in Figs.C-1 ~ C-8, E-1.

6-1-1-4 Design screen length

Based on the hydrogeological conditions (see Appendix-D1,D2) and by considering the water yield of existing wells, the design screen length is determined as given below;

Mahendranagar

The depth of an existing well is 35m. The gravel layer is rather thick. However the grain size of the gravel layer is rather large. As such this aquifer is prone to pollution due to contamination from wastewater at shallow depths. Hence the water is to be extracted at a depth greater than 50m with a screen length of 30m.

Dhangadhi

There are two existing wells, A and B, with very different depths and yields. From the well logs, it is seen that there exists a clayey layer at a depth above 100m and also a good aquifer at a depth in the range of 35 ~ 50m. Then the screen length is to be 36m.

Bharatpur

Based on the well log of the existing well, at a depth below 20m there exist sand and gravel layers, and also up to the 100m depth there are no clayey layers. However the yield per unit depth is rather low. Thus a long screen length is necessary. Accordingly, a design screen length of 42m is selected.

Gaushala

There exists a good aquifer in a depth range of 50 ~ 85m. The yield measured at an existing well is 1500 l/min, and the draw down observed in rather high. Hence it is necessary to extract water at a depth greater than 100m with a screen length of 36m.

Lahan

Lahan is located on the alluvial plain of a river. As such the ratio of aquifer depth to the total depth is the highest among the 7 project areas with groundwater sources. However the yield per unit depth is low. Therefore a screen length of 36m is selected.

Rajbiraj

The ratio of aquifer depth against the total depth is rather low. There exists good aquifer at depths in the range of 80 ~ 90m and the yield per unit depth is high. However, the draw down is rather high. Thus the required amount of water is to be extracted at depths in the range of 46 ~ 70m and at depths greater than 100m, with a design screen length of 36m.

Bhadrapur & Chandragadhi

The hydrogeological conditions of both these areas are very similar. The existing well depths are 110m. Also there exist sand and gravel layers below this depth of 110m which could also be used with a design screen length of 36m.

The design screen lengths and Dynamic Water Levels are given as follows;

Design screen length

Project area	Screen length
Mahendranagar	30m
Dhangadhi	36
Bharatpur	42
Gaushala	36
Lahan	36
Rajbiraj	36
Bhad/Chand	36

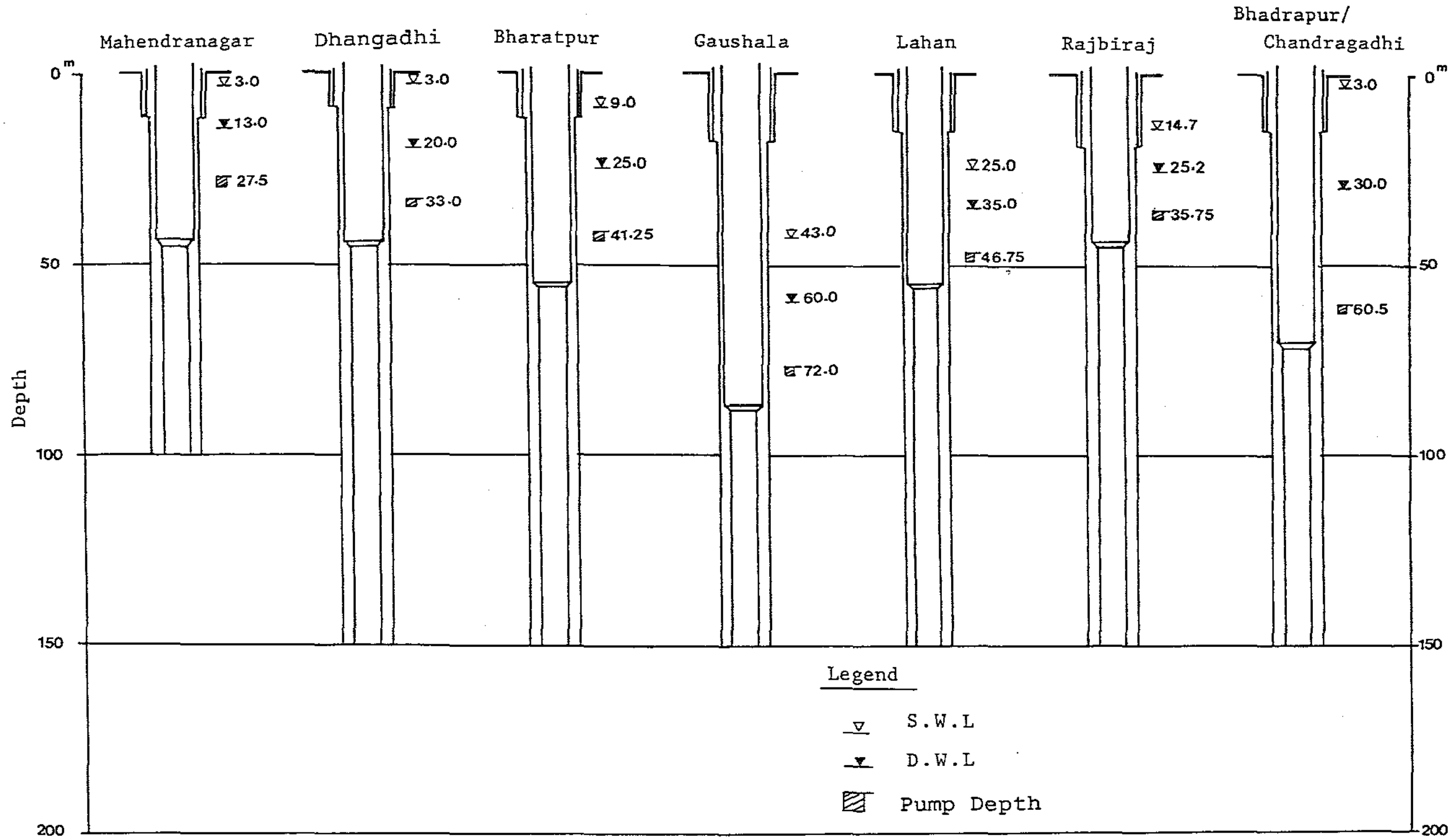


Figure-6.1 Dynamic Water Levels of Wells

6-1-1-5 Submersible pump

The design capacity of the submersible pumps based on the design yield, the total water head, etc., are given below.

Project area	Design discharge	Total head	Power	Pump No
Mahendranagar	900 l/min	56 m	18.5 kw	2
Dhangadhi	1200 l/min	65	22	1
Bharatpur	1200 l/min	65	22	4
Gaushala	900 l/min	114	37	2
Lahan	900 l/min	74	22	3
Rajbiraj	900 l/min	74	22	4
Bhadrapur & Chandragadhi	900 l/min	98	30	3

6-1-2 Surface water sources

Among the project areas, only Bharatpur and Ilam use the surface water sources for this water supply project. Also, only in Ilam is renovation of the existing intake facilities necessary, while the existing intake facilities of Bharatpur will be utilized as is, due to the hydrological condition of the water source.

The existing water source of Ilam, a spring, is located 11 km north of the center of the town. The present capacity of the water source is around 10 lit./sec, which is 9 lit./sec less than the required design capacity of 19 lit./sec (1,600 m^3/day). In order to meet this necessary design capacity, renovation of the existing intake and transmission main, and construction of a new intake facility are required.

6-2 Transmission mains

The transmission mains for the Ilam and Bharatpur water supply schemes are rather elaborate due to their surface water sources and hilly topographic conditions. For Ilam, renovation of all the existing mains from water source to reservoir is necessary while for Bharatpur some improvement work to remedy leakage is sufficient. In all other project areas where the source is groundwater and the topography is rather plain, the transmission mains to the respective elevated tanks are more or less standard types.

For Ilam an additional transmission main of 150 mm ø DI pipe is also designed. The difference in elevation between the intake site and the reservoir at town is about 470 m. Thus 5 pressure reducing devices are also designed along the transmission main. A pressure break tank equipped with a sluice valve is adopted as the pressure reducing device. Bypass and mud drain pipes are also to be installed to facilitate maintenance. The other auxiliary features of this transmission main include 5 truss bridges to cross over depressions, and two of the break pressure tanks in the upper reaches of the main would be installed with strainers to remove suspended matter. The air valves to be installed are accordingly 7 number, based on the topographic conditions (see Fig. C-9).

For Bharatpur the basic requirement is to arrest the prevailing leakages. A brief breakdown of the necessary renovation measures is as follows;

1.	Arresting of leakage	: ø 200 mm x 100 m x 5 No
2.	Renovation of leaking portion	: ø 200 mm x 20 m x 15 No
3.	River crossing	: ø 200 mm x 30 m x 1 No

6-3 Water treatment facilities

The necessary design water treatment facilities for each project area are given below:

Treatment Facility	Mahendranagar	Dhangadhi	Bharatpur	Gaushala	Lahan	Rajbiraj	Bhadrapur & Chandragadhi	Ilam
Slow Sand Filtration	—	—	2000 m3/day	—	—	—	—	—
Rapid Filtration	2700 m3/day	—	—	—	4000 m3/day	6200 m3/day	3050 m3/day X 2	—
Chlorination	2700 m3/day	2600 m3/day	2000 m3/day 6400 m3/day	1100 m3/day	4000 m3/day	6200 m3/day	3050 m3/day X 2	1600 m3/day

6-3-1 Slow sand filter basin

A slow sand filter basin with a design capacity of 2,000 m^3/day is necessary for Bharatpur.

1) Filter area

The area of a filter basin is determined by assuming a standard filtration velocity of 5 m/day.

2,000 m3/day + 5 m/day = 400 m^2

Also one standby basin is to be provided to facilitate maintenance.

18 m x 12 m x 3 basins

2) Depth of filtration tank

The total depth of the filtration tank is to be 3.0 m, composed of an under-drain system of a filter, gravel layer, sand layer, water depth and free board, from bottom to top.

The top level of the tank will be at least 30 cm above the ground in order to prevent fouling due to the intrusion of surface water runoff.

3) Regulating wells

Regulating wells will be provided for every filtration unit in order to regulate the filtrate discharge and to measure the rate of filtration, filter head loss and other parameters.
The regulating well is to be equipped with a device for reverse flow.

4) Duct for water conveyance

The inlet facilities to the filters include a duct for water conveyance. The flow velocity in the inflow duct is determined to be 50 cm/sec. In addition, in order to minimize disturbance of the top sand surface due to turbulence at the inletor on the filter media, the necessary facilities are to be provided.

The details of a slow sand filter basin are shown in Fig.G.2.

5) Chlorination

Chlorination is to be accomplished using bleaching powder (chlorinated lime) with available chlorine of 30%. Generally the concentration of feed ranges from 0.5 mg/l to 2.0 mg/l as available chlorine, and a level of 2 mg/l is to be applied.
The required amount of bleaching powder per day and the design storage tank capacity for Bharatpur are determined as illustrated below:

- Required amount of bleaching powder:
  Maximum daily water demand = 2000 m^3/day.
  Required amount of available Cl_2
  = 2000 x 0.002 kg/day
  = 4 kg/day

Assuming 30% available Cl_2; the bleaching powder requirement

$$= 4.0 \times \frac{100}{30}$$

$$= 13.3 \text{ kg/day}$$

Assuming a solubility of 5%; The maximum daily feed rate

$$= 13.3 \div 0.05$$

$$= 266 \text{ lit./day}$$

Storage tank capacity

A 3 day storage requirement is assumed.

Hence the required effective storage volume

$$= 266 \times 3$$

$$= 798 \text{ lit.}$$

Storage tank capacity is 1.0 m^3.

6-3-2 Rapid sand filter basin

All project areas with a rapid filter use deep wells as their source.

1) Design capacity of filter basin

The iron removal system, for groundwater with a high content of iron consists of chlorination (pre-chlorination) with rapid sand filtration. The rapid filter unit to be used is a constant rate siphon type inorder to minimize the requirement of pumps and other flow control devices (valves), and power.

The necessary water head of filtration will be provided by the static head of the receiving well, which is in-turn provided by the pumping head of submersible deep well water pumps.

A standard filtration velocity of 120 m/d is considered for the design of the filter bed area.

The capacity and dimensions of the designed rapid filter units for the respective project areas are given below:

Project area	Calculated (m^3/d)	Filter units	
		Dimensions (m x m)	Nos.
Mahendranagar	2,700	4.2 x 2.6	2
Lahan	4,000	4.8 x 3.6	2
Rajbiraj	6,200	6.0 x 4.5	2
Bhadrapur	3,050	4.5 x 3.0	2
Chandragadhi	3,050	4.5 x 3.0	2

The following design capacities are used:

Type 1:	6,200 m^2/day	Rajbiraj
Type 2:	4,000 m^2/day	Lahan
Type 3:	3,000 m^2/day	Mahendrangar, Bhadrapur & Chandragadhi

2) Filter area

Filtration velocity is 120 m/day.

$$6,200\ m^3/day \div 120\ m/day = 52\ m^2$$
$$4,000\ m^3/day \div 120\ m/day = 34\ m^2$$
$$3,000\ m^3/day \div 120\ m/day = 25\ m^2$$

3) Number of filter basins

The design total number of filter basins would include of one basin as a standby.

$$52\ m^2 \div 2 = 26\ m^2 \times 2$$
$$34\ m^2 \div 2 = 17\ m^2 \times 2$$
$$25\ m^2 \div 2 = 13\ m^2 \times 2$$

4) Chlorination

The syphon type rapid sand filter basin requires a high water head, about 10 m, in order to wash the filter materials by back washing. Installing the facilities for the feeding of bleaching powder at 10 m high in the receiving reservoir would cause many problems in maintenance. Therefore the feeding of bleaching powder solution is to be accomplished by means of pumping the receiving reservoir.

The available chlorine is to be 30%, and the concentration of feed range is 2 mg/l - 5 mg/l. Thus the required amount of bleaching power per day is determined as given below.

Type 1: 6,200 m^2/day x 0.005 g/l = 31 kg/day
Type 2: 4,000 m^2/day x 0.005 g/l = 20 kg/day
Type 3: 3,000 m^2/day x 0.005 g/l = 15 kg/day

Assuming 30% available Cl_2 and solubility of 5%, the maximum daily feed requirement is as follows.

Type 1: 31 kg/day ÷ 0.3 ÷ 0.05 = 2,067 kg/day
Type 2: 20 kg/day ÷ 0.3 ÷ 0.05 = 1,333 kg/day
Type 2: 15 kg/day ÷ 0.3 ÷ 0.05 = 1,000 kg/day

The capacities of the pumps are as follows.

Type 1: 2,067 lit./day ÷ 24 ÷ 60 = 1.44 lit./min
Type 2: 1,333 lit./day ÷ 24 ÷ 60 = 0.93 lit./min
Type 3: 1,000 lit./day ÷ 24 ÷ 60 = 0.70 lit./min

A 1 day storage requirement is assumed, and the required storage volume is as follows.

Type 1: 2,067 lit./day x 1 day = 2.0 m^3
Type 2: 1,333 lit./day x 1 day = 1.5 m^3
Type 3: 1,000 lit./day x 1 day = 1.0 m^3

6-4 Distribution facilities

The main design distribution facilities to be provided are given below:

		Mahendranagar	Dhangadhi	Bharatpur	Gaushala	Lahan	Rajbiraj	Bhadrapur & Chandragadhi	Ilam	
Distribution Facility	Water Tank	900 m3 —	— 500 m3	900 m3 1200 m3	— 100 m3	— 550 m3	900 m3 —	— 300 m3 X 2	236 m3 —	existing proposed
	Pump	1.4 m3/min X3(standby1)	1.4 m3/min X3(standby1)	3.2 m3/min X3(standby1)	0.5 m3/min X3(standby1)	1.9 m3/min X3(standby1)	2.82 m3/min X3(standby1)	1.4 m3/min X6(standby2)	— —	
	Elevated Tank	— 200 m3	— 200 m3	— 400 m3	— 200 m3	450 m3 —	450 m3 —	450 m3 X2 —	— —	existing proposed

6-4-1 Structures of distribution facilities

The main structural components of the distribution facilities are ground reservoirs/elevated tanks for the storage of water for distribution. The structural materials considered for these facilities are reinforced concrete (RC), steel, and fiberglass reinforced plastic (FRP). A RC structure is recommended for ground reservoirs based on economics of construction costs, and a FRP structure for elevated tanks based on economics of both construction costs and time.

A comparison of the construction costs of these facilities between steel and FRP was made, and the results indicate that FRP is more economical than steel, which also requires periodic maintenance for corrosion proofing measures like painting, etc.

The capacity and other relevant details of the designed distribution reservoirs/elevated tanks in the respective project areas are shown below.

Distribution Reservoir

Project area	Capacity (m^3)	Dimensions LxWxH (m)	No. of basins	Effective depth (m)
Dhangadhi	500	15.9 x 5.35 x 4.0	2	3.0
Bharatpur	1,200	25.2 x 16.05 x 4.0	2	3.0
Lahan	550	16.7 x 6.25 x 4.0	2	3.0
Gaushala	100	7.2 x 5.40 x 4.0	2	2.0
Bhadrapur	300	13.2 x 4.50 x 4.0	2	3.0
Chandragadhi	300	13.2 x 4.50 x 4.0	2	3.0

Elevated Water Tank

Project area	Capacity (m^3)	Dimensions LxWxH (m)	No. of basins	Effective depth (m)
Mahendranagar	200	8 x 8 x 4	1	3.5
Dhangadhi	200	8 x 8 x 4	1	3.5
Bharatpur	400	11 x 11 x 4	1	3.5
Gaushala	200	8 x 8 x 4	1	3.5

Also for Bharatpur, Gaushala and Ilam the chlorination with bleaching power is planned to be accomplished in the distribution reservoir.

6-4-2 High lift pumps

The necessary high lift pump capacities of the distribution reservoirs/pumps for the respective project areas are given below.

High Lift Pumps for Elevated Water Tank

Project area	Capacity (m^3/min)	Water head (m)	Power (kW)	Number of pumps
Mahendranagar	1.4	30.5	11	3 (standby 1)
Dhangadhi	1.4	30.5	11	3 (standby 1)
Bharatpur	3.2	30.5	22	3 (standby 1)
Gaushala	0.5	30.5	5.5	3 (standby 1)
Lahan	1.9	30.0	15	3 (standby 1)
Rajbiraj	2.82	30.0	18.5	3 (standby 1)
Bhadrapur & Chandragadhi	1.4	30.5	11	each 3 (standby 1)

6-5 Power of pumps

Diesel generators are to be used as the source of power for all pumping purposes such as for submersible motor pumps of deep wells, low lift pumps of surface water intake, and the high lift pump of distribution reservoirs/tanks.

The details are shown as follows:

Project area		Capacity	No.	Facilities
Mahendranagar	In	50 KVA	1	P 2
	Out	33 KVA	2	Ps 2
Dhangadhi	In	50 KVA	1	P 2
	Out	33 KVA	1	Ps 1
Bharatpur	In	100 KVA	1	P 2, Ps 1
	Out	33 KVA	3	Ps 3
Gaushala	In	70 KVA	1	P 2, Ps 1
	Out	70 KVA	1	Ps 1
Lahan	In	50 KVA	1	P 2
	Out	33 KVA	3	Ps 3
Rajbiraj	In	70 KVA	1	P 2
	Out	33 KVA	4	Ps 4
Bhadrapur & Chandragadhi	In	50 KVA	2	P 2
	Out	70 KVA	3	Ps 3

Note : "In" means pump inside the compound of the project office
"Out" means pump outside the compound of the project office
"P" means lift pump to the elevated tank.
"Ps" means submersible motor pump.

6-6 Piping for water distribution

1) Route of proposed distribution lines

The proposed route of the distribution pipelines will be along the existing roads and also be interconnected to the existing trunk distribution pipes.

2) Selection of pipe materials

The maximum hydraulic pressure in the distribution system is 20 m, the effective static head of the distribution reservoirs/tanks. The pipe material is to be selected based on durability to pressure requirements and the prevention of leakage at connections.

A comparison of costs between steel and DI (Ductile Iron) pipes for the trunk distribution mains was made, and accordingly, DI pipes were found to be more economical than steel pipes.(Appendix-D.4)

A cost comparison for HDPE (High Density Polyethlene) pipe has not been done, as it has not been considered due to its limited strength against external pressure and the problem of possible leakage.

3) Excavation for pipe laying

The standard cross section of trench excavations for pipe laying is determined based on the diameter of the pipe laid and the design vehicle load on the pipes. There is no guideline set by DWSS concerning this trench excavation for pipe laying, thus the corresponding Japanese standard would be used in this study.

4) Valves

The necessary valves of the distribution system, the sluice valve, air valve, and drain valve, are designed accordingly.

5) Pipe crossings

The structures of pipe crossings are designed accordingly for such places as rivers, canals, and roads. Basic details concerning the distribution pipe system of each project area are shown in Figs.C-1 ~ C-8.

6-7 Public standposts and water meters

About 30% of the design population of water supply are served with public standposts. One standpost is assigned to serve 100 people with water. The necessary numbers of public standposts are decided based on a 10 year design period and the design population of 1998 (see Table-6.3).

The total number of water meters required, in principle, has to be based on the design population of the target year 2003, a 15 year period. However the proposed number of water meters, initially, is for a 5 year design period and the design population of 1993 only (see Table-6.3).

Table-6.3 The Number of Proposed Water Meters and Taps

	water meters	standposts
Mahendranagar	1,167	38
Dhangadhi	1,050	60
Bharatpur	3,959	140
Gaushala	697	37
Lahan	2,296	74
Rajbiraj	3,303	110
Bhadrapur & Chandragadhi	3,538	114
Ilam	1,270	35
Total	17,280	608

6-8 Replacement of pumps at existing boreholes

Since some of the pumps at existing boreholes have been servicing more than 10 years, replacement of these pumps is required.

Site	Service period (years)	Capacity (kw)	No. of unit
Mahendranagar	13	18.5	1
Dhangadi	13	22.0	1
Rajbiraj	17	22.0	1
Bhadrapur	14	30.0	1
Chandragadhi	14	30.0	1

6-9 Extension of power line

In all sites except for Ilam, necessary power supply is provided by diesel generators, which will become emergency power source in the future when electric power will be available from the National Grid. When electric power as the permanent power source is available, extension of power lines is required. Required extension of high power line is approximately estimated as shown below;

Site	Required Extension (m)
Mahendranagar	800
Dhangadhi	1,000
Bharatpur	1,100
Gaushala	2,800
Lahan	1,300
Rajbiraj	1,500
Bhadrapur	800
Chandragadhi	500

6-10 Provision of spare parts for Tansen

Based on the study results, the requirement of spare parts for the water supply scheme in the project area is determined as given below.

1. Pumps and accessories : 1 set
2. Spare parts of pump : 1 set
3. Spare parts of control panel : 1 set
4. Chlorination equipment : 1 set
5. Tools : 1 set

6-11 Tools for operation and maintenance

For operation and maintenance of all facilities at 8 sites the following equipment are required.

Item	No. required
Compressor (20 m^3/min)	1
Chain Block (3 ton)	8
Crane Truck (5 ton)	2
Concrete Mixer	4
Welder	3

6-12 Cost Estimate

The cost estimation is based on the unit cost that prevailed in July 1988 and the exchange rate used is as follows:

1 US$ = ¥ 128
1 US$ = NRp 22.11
1 NRp = ¥ 5.78

The content of the local component by Nepal is ¥ 69.7 million, for the following items:

Item	Quantity	Cost ¥ million
1. Installation of branch pipes	27 km	30.0
2. Office and Stuff Quarter at Gaushala	2 units	12.0
3. Fence at Proposed Facilities	20 places	18.9
4. Extension of High Power Line	9.8 km	8.8
Total		69.7 (NRp.12.1 million)

6-13 Summary of Project Facilities

SITE	MAHENDRANAGAR The maximum daily water consumption 2,700 m3/day				
Facility	Contents	P:proposed E:existing	Specifications	No.	Remarks
Water Source	deep well	E	depth 34.1 m (12" 0-15.8 m) (6" 15.8-32 m)	1	
	deep well	P	1300 m3/day depth 100 m	2	
Intake	deep well	E	borehole pump	1	
	generator	E	electric power engine	1	
	deep well	P	submersible pump 0.9 m3/minx56mx18.5KW	2	
	power source	P	diesel generator 33KVA	2	
	pump house	P	4.6mx3.6mx3.6m	2	
Transmission	transmission main	P	SGPW ø125, 150 mm	440m	
Water Treatment	rapid filtration	E	RC capacity 900 m3	1	
	chlorination equip	P	2700 m3/day injector	1	
	receiving well	P	RC 4.1mx3.3mx9.45m	1	
	rapid filtration	P	1,350 m3/day	2	
Water Distribution	elevated tank	E	Capacity 180m3:H=13 m	1	
	distribution pipe	E	ø 125 - 25	9,290m	
	water tank	P	RC Capacity 900 m3	1	existing one available
	pump	P	1.4m3/minx30.5mx11KW	3	
	elevated tank	P	FRP Q=200 m3 : H=20 m	1	
	power source	P	diesel generator 50KVA	1	
	distribution pipe	P	ø 250 - 50	12,406m	DIP ø 250 - 98 m DIP ø150 - 1,431m DIP ø100 - 4,130m DIP ø 75 - 3,926m
	public tap	P		38	HDPE ø50 - 2,821m
Equipment provided	water meter	P		1,167	
	distribution pipe	P	HDPE ø 50 mm	1,917 m	

SITE	DHANGADHI The maximum daily water consumption 2,600 m3/day				
Facility	Contents	P:proposed E:existing	Specifications	No.	Remarks
Water Source	deep well	E	depth 122m (10" 0 - 53.3 m) (6" 53 -114.6 m)	1	
	deep well	P	depth 150m 1,700 m3/day	1	
Intake	deep well	E	borehole pump	1	
	generator	E	electric power engine	1	
	pump house	E		1	
	deep well	P	submersible pump 1.2m3/minx65mx22KW	1	
	power source	P	diesel generator 33KVA	1	
	pump house	P	4.6mx3.6mx3.6m	1	
Transmission	transmission main	P	SGPW ø 125,150 mm	260 m	
Water Treatment	chlorination equip	P	2,600 m3/day bleach injector	1	
Water Distribution	elevated tank	E	RC Cap 150 m3	1	
	distribution pipe	E	ø150 - 40 mm	10,470m	
	reservior tank	P	250 m3	2	
	pump	P	1.4m3/minx30.5mx11KW	3	
	power source	P	diesel generator 50KVA	1	
	elevated tank	P	FRP Q=200 m3 : H=20 m	1	
	distribution pipe	P	ø 250 - 50 m/m	20,834m	DIP ø250 - 220 m DIP ø200 - 1,089 m DIP ø150 - 2,420 m DIP ø100 - 5,203 m DIP ø 75 - 8,488 m HDPE ø75 - 3,454 m
	public tap	P		60	
Equipment provided	water meter	P		1,050	
	distribution pipe	P	HDPE ø 50 mm	3,476 m	

SITE	BHARATPUR The maximum daily water comsumption 8,400 m3/day				
Facility	Contents	P:proposed E:existing	Specifications	No.	Remarks
Water Source	surface water	E	1,640 m3/day	1	
	surface water	P	2,000 m3/day	1	Improving existing one
	deep well	P	1,700 m/day depth 150 m	4	
Intake	deep well	P	submersible pump 1.2m3/minx65mx22KW	4	
	power source	P	diesel generator 33 KVA	3	
			*100 KVA	1	* concurrently used
	pumphouse	P	4.6mx3.6mx3.6m	4	
Transmission	transmission main	E	DIP ø 200 mm	7,000m	Leaking Protection Required
		P	SGPW ø125,150 mm	800 m	
Water Treatment	receiving well	P	RC 60 m3	1	surface water
	slow sand filtration	P	1,000 m3/day	3	surface water (1 standby)
	chlorination equip	P	2,000 m3/day	1	surface water
	ibid	P	6,400 m3/day (chlorine injector)	1	deep well
Water Distribution system	distribution tank	E	RC 900 m3	1	surface water
	distribution pipe	E	ø 200-50 mm	26,900m	
	water tank	P	RC 600m3 X 2	2	deep well
	water pump	P	3.2m3/minx30.5mx22KW	3	deep well
	power source	P	*100 KVA	1	* concurrently used
	elevated tank	P	FRP 400m3 : H=20m	1	
	distribution pipe	P	ø 400 - 50 mm	23,826m	DIP ø400 - 110m DIP ø250-2,838m DIP ø200-2,860m DIP ø150-5,566m DIP ø100-9,130m DIP ø 75-1,881m HDPE ø50-1,441m
	public tap			140	
Equipment provided	water meter	P		3,959	
	distribution pipe	P	HDPE ø 50 mm	4,476m	

SITE	GAUSHALA	The maximum daily water consumption 1,100 m3/day			
Facility	Contents	P:proposed E:existing	Specifications	No.	Remarks
Water Source	deep well	P	1300 m3/day depth 150m	2	
Intake	deep well power source pumphouse	P P P	submersible pump 0.9m3/minx114mx37KW diesel generator 70KVA ditto *70KVA 4.6mx3.6mx3.6m	2 1 1 2	 concurrently used
Transmission	transmission main	P	SGPW ø125,150 mm	340m	
Water Distribution	water tank water pump power source elevated tank chlorination equip distribution pipe public tap	P P P P P P P	RC 50m3 0.5m /minx35mx5.5KW *70 KVA FRP 200 m3: H=20m 1100 m3/day (bleaching injection) ø200-50mm	2 3 1 1 1 10,439m 37	 concurrently used Steel DIP ø200 -110m DIP ø150-2,508m DIP ø100-4,059m DIP ø75-3,366m HDPE ø 50-396m
Equipment provided	water meter distribution pipe	P P	 HDPE ø 50 mm	697 1,004m	

SITE	LAHAN	The maximum daily water consumption 4,000 m3/day			
Facility	Contents	P:proposed E:existing	Specifications	No.	Remarks
Water Source	deep well	E	depth 110 m (12" 0-40 m) (8" 40-97 m)	1	
	deep well	P	1,300 m3/day depth 150m	3	
Intake	deep well	E	borehole pump	1	
	generator	E	electric power engine	1	
	deep well	P	submersible pump 0.9m3/minx74mx22KW	3	
	power source	P	diesel generator 33KVA	3	
	pumphouse	P	4.6mx3.6mx3.6m	3	
Transmission	transmission main	P	SGPW ø125,150 mm	660 m	
Water Treatment	receiving well	P	RC 57 m3	1	
	chlorination equip	P	4,000 m3/day injection	1	
	rapid filtration	P	2,000m3/day	2	
Water Distribution	elevated tank	E	RC 450 m3:H=20m	1	
	distribution pipe	E	ø 200-50 mm	9,600 m	
	reservior tank	P	RC 275m3	2	
	pump	P	1.9 m3/minx30mx15KW	3	
	power source	P	diesel generator 50KVA	1	
	distribution pipe	P	ø350 - 50 mm	24,706m	DIP ø350 -110m DIP ø250 -891m DIP ø200 -1,441m DIP ø150 -4,840m DIP ø100 -11,660m DIP ø 75 -5,577m HDPE ø 50 -187m
	public taps	P		74	
Equipment provided	water meter	P		2,296	
	distribution pipe	P	HDPE ø 50 mm	4,904m	

SITE	RAJBIRAJ	The maximum daily water consumption 6,200m3/day			
Facility	Contents	P:proposed E:existing	Specifications	No.	Remarks
Water Source	deep well	E	1300 m3/day d=200 mm depth=100m	1	
	deep well	P	1300 m3/day depth 150 m	4	
Intake	deep well	E	submersible pump	1	
	deep well	P	submersible pump 0.9m3/minx74mx22KW	4	
	power source	P	diesel generator 33KVA	4	
	pumphouse	P	4.6mx3.6mx3.6m	4	
Transmission	transmission main	P	SGPW ø125,150mm	840 m	
Water Treatment	rapid filtration	E	RC capacity 900m3	1	
	chlorination equip	P	6200m3/day injector	1	
	receiving well	P	RC 76 m3	1	
	rapid filtration	P	3100m3	2	
water distribution facility	elevated tank	E	RC 450 m3 : H=20m	1	
	distribution pipe	E	ø 300- 37mm	18,600m	
	water tank	P	RC 900 m3	1	Improving existing one
	pump	P	2.82m3/minx30mx18.5KW	3	
	power source		diesel generator 70KVA	1	
	distribution pupe	P	ø 350 - 50 mm	18,216m	DIP ø350 - 110m DIP ø250 - 473m DIP ø200-1,100m DIP ø150-6,281m DIP ø100-4,620m DIP ø 75-5,456m HDPE ø 50- 176m
	public tap			114	
Equipment provided	water meter	P		3,303	
	distribution pipe	P	HDPE ø 50 mm	3,607m	

SITE	The maximum daily water consumption 6,100 m3/day BHADRAPUR and CHANDRAGADHI				
Facility	Contents	P:proposed E:existing	Specifications	No.	Remarks
Water Source	deep well	E	1,300 m3/day	1	Chandragadhi
	deep well	E	1,300 m3/day	1	Bhadrapur
	deep well	P	1,300 m3/day:depth=150m	1	Chandragadhi
	deep well	P	1,300 m3/day:depth=150m	2	Bhadrapur
Intake	deep well	E	borehole pump	2	Chandragadhi
	power source	E	diesel generator	1	Chandragadhi
	deep well	E	borehole pump	1	Bhadrapur
	power source	E	diesel generator	1	Bhadrapur
	deep well	P	submersible pump 0.9m3/minx98mx30KW	1	Chandragadhi
	power source	P	diesel generator 70KVA	1	Chandragadhi
	deep well	P	submersible pump 0.9m3/minx98mx30KW	2	Bhadrapur
	power source	P	diesel generator 70KVA	2	Bhadrapur
Transmission	transmission	P	SGPW ø 125,150mm	160m	Chandragadhi
	main	P	SGPW ø 125,150mm	360m	Bhadrapur
Water Treatment	chlorination equip	P	3,050 m3/day injector	2	
	receiving well	P	RC capacity 38 m3	2	
	rapid filtration	P	1,525m3/day	4	
Water Distribution	elevated tank	E	R.C 450 m3 : H=20m	2	
	distribution pipe	E	ø 300-37 mm	23,000m	
	reservior tank	P	RC 150m3	4	
	pump	P	1.4m3/minx30.5mx11KW	6	
	distribution pipe	P	ø 350 - 50 m/m	30,393m	DIP ø350 - 220m DIP ø300 - 649m DIP ø250-1,826m DIP ø200-4,400m DIPø150-16,005m DIP ø100-2,838m DIP ø 75-2,420m HDPE ø50-2,035m
	power source	p	50KVA diesel generator	2	
	public tap			114	
Equipment provided	water meter	P		3,538	
	distribution pipe	P	HDPE ø 50 mm	5,672m	

SITE	ILAM	The maximum daily water consumption 1,600 m3/day			
Facility	Contents	P:proposed E:existing	Specifications	No.	Remarks
Water Source & Intake	spring	E P P	collection drainage collection pipe(ø450) collection tank	2 55m 1	improvement required
Transmission main	transmission transmission break pressure tank water bridge	E P P P	ø 100 mm DIP ø 150mm	12.6km 13.22km 5 5	
Water Treatment	receiving well chlorination	E P	RC 50m3 1600m3/day (bleach injector)	1 1	
Water Distribution	reservior tank distribution pipe distribution pipe public tap	E E P	RC 236 m3 ø 15 -100mm ø 200 - 75 mm	1 24,000m 7,689m 35	DIP ø 200 - 462m DIP ø100 - 495m DIP ø75 - 6,732m
Equipment provided	water meter distribution pipe	P P	HDPE ø 50 mm	1,270 1,538m	

CHAPTER 7. PROJECT IMPLEMENTATION SCHEDULE

Chapter 7
PROJECT IMPLEMENTATION SCHEDULE

7-1 Implementation Procedure

7-1-1 Responsibility for Project Implementation

DWSS is the agency responsible for the Project's implementation in Nepal.

The Study Team's counterpart in Nepal for the Project's Basic Design Study is the DWSS's Chief Engineer and his Design Section. The implementation of the Project will be undertaken by the DWSS's *Construction & Inspection Section*. For the successful implementation of the Project, close cooperation with the projected town Panchayat is indispensable.

Execution system for the Project is shown in Figure-7.1.

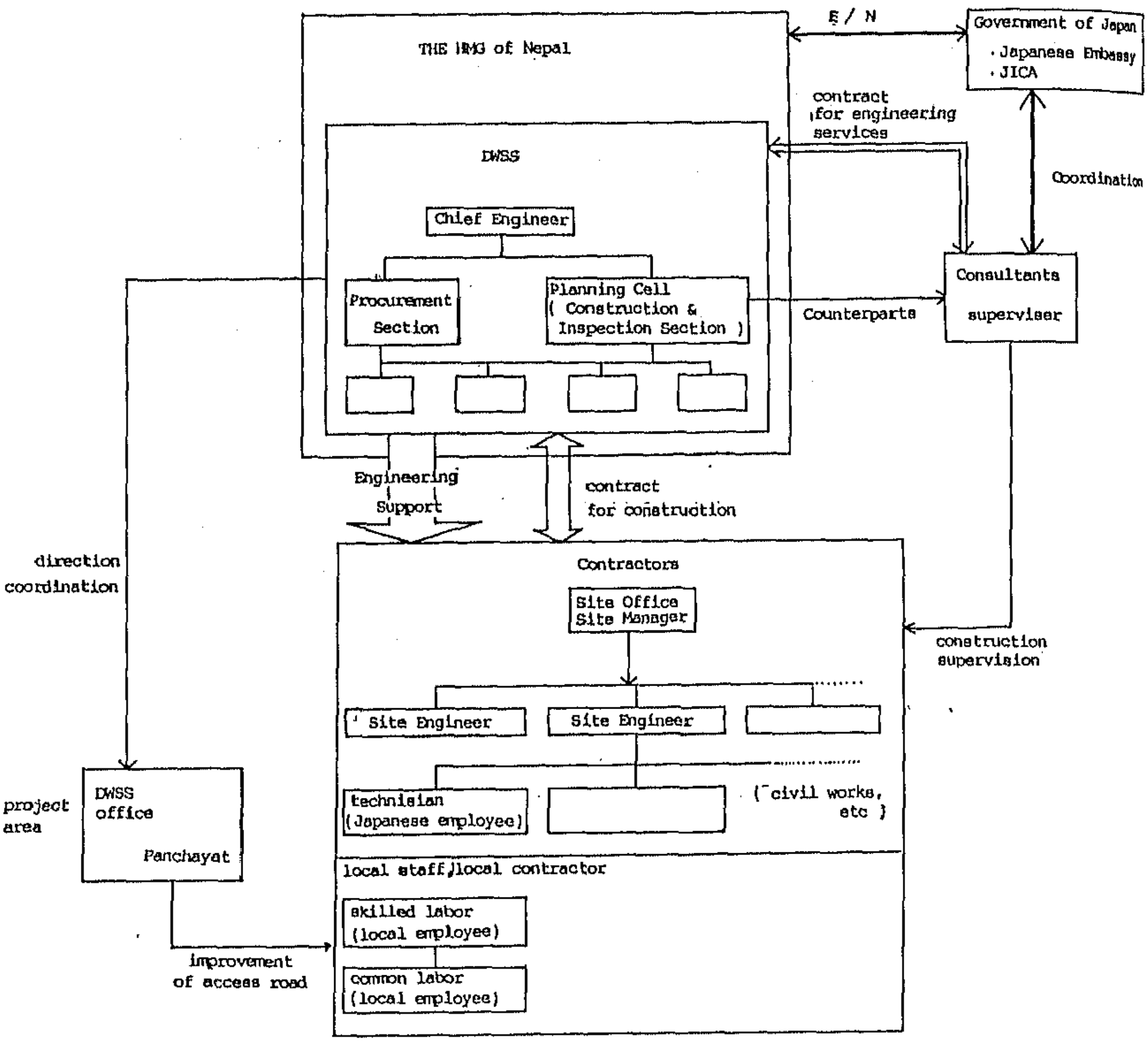


Figure-7.1 Execution System for the Project

7-2 Contribution of the Government of Nepal to the Project

Facilities to be provided by implementing this project are summarized in Section 6.13, "Summary of Project Facilities". Of these the Government of Nepal will undertake responsibility for land acquisition for the intake pumping facilities, transmission, distribution pipeline routes and reservoir/tank. It is also responsible for the installation and other auxiliary pipeline construction work for extension of the branch lines of distribution mains. The necessary pipes are to be provided by the Japanese government.

Further, costs to be incurred by custom duties and clearance will be met by the Government of Nepal.

7-3 Materials and Equipment Procurement Plan

As a result of construction material market research, it was found that sand, gravel, cement, timber, etc., are obtainable in the domestic market.

HDPE pipes used for the distribution branch are also available locally. However the cast iron pipes suitable for the main water supply pipes having greater than 150 mm diameters and machinery of water supply facilities are not manufactured locally, therefore Japanese made pipes and other machinery are to be used in the Project wherever appropriate.(Table-7.1)

The DWSS does not have construction machinery, thus the necessary cost for use of construction machinery is estimated on a hire basis from contractors.

However the four-wheel drive vehicles and trucks used for the purpose of construction are to be donated to the DWSS for operation and maintenance purposes after the construction work.

Table 7.1 Procurement Schedule of Major Materials

	Site	Japan	Remarks
Ductile Iron Pipe		○	Locally unavailable
High Density Polyethylene Pipe	○		Locally available
Cement	○		,,
Gravel	○		,,
Steel Bar	○		,,
Wood	○		,,
FRP Water Tank		○	Locally unavailable
Rapid Filtration Equipment		○	,,
Slow Filtration Equipment		○	,,
Chlorination Equipment		○	,,
Submersible Motor Pump		○	,,
High Lift Pump		○	,,
Diesel Generator		○	,,
Valves		○	,,
Water Meter		○	,,

7-4 Project Implementation Schedule

The Project's implementation is scheduled to be completed within 53 months after the signing of the Exchange of Notes: 47 months for procuring and transporting materials and equipment, and for constructing project facilities.

Judging from road conditions of the project area in the rainy season, the construction schedule is prepared so that the major construction work is to be performed during dry seasons.

The project implementation schedule is shown in Table-7.2.

7-5 Operation and Maintenance

7-5-1 Operation and Maintenance System

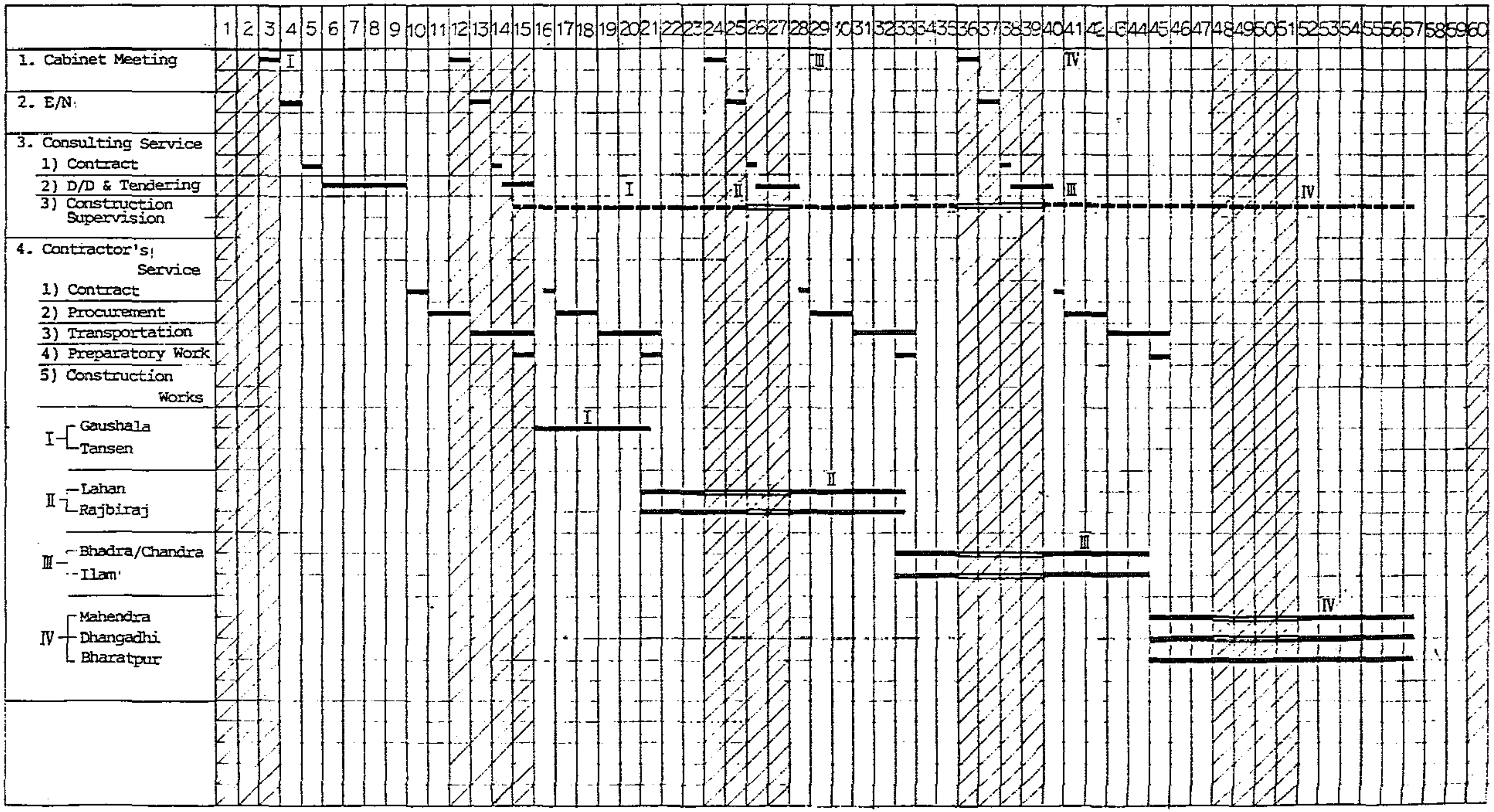
The existing water supply facilities in the project areas are operated and maintained by personnel of the DWSS's Branch Offices.

Presently, the number of employees working in these offices ranges from 10 to 23 people, consisting of an office manager (engineer), and other technical and administrative staff.

For Gaushala, a new scheme, it is necessary to establish the DWSS project office for operation and maintenance.

According to the policy of DWSS, the operation, maintenance, and establishment of a tariff system and tariff collection for the new water supply project are to be carried out by Town Panchayats in the future.
However the permanent establishment of the new system mentioned above may take a certain period of time.

Table-7.2 Implementation Schedule



Therefore in this study it is presumed that DWSS will be responsible for the operation and maintenance work of these water supply schemes at least at the initial stages of implementation.

The number of office staff for the operation and maintenance system is estimated under the following conditions.

1) To install water meters for 17,000 houses and 645 public standposts.
2) Routine operation and maintenance of facilities
3) To collect water charges based on water consumption.

It is proposed to assign one DWSS staffer per 1,000 people of the water served population
The required number of DWSS staff is estimated as shown below.

	Site	Water supply population served	Number of office staff at present (1988)	Required number of staff for the Project
1.	Mahendranagar	15,700	23	16
2.	Dhangadhi	14,200	13	14
3.	Bharatpur	64,500	23	65
4.	Gaushala	15,000	0	15
5.	Lahan	40,000	10	40
6.	Rajbiraj	49,000	23	49
7.	Bhadrapur/ Chandragadhi	47,800	23	48
8.	Ilam	12,800	19	13

7-5-2 Operation and Maintenance Costs

The main items of operation and maintenance costs are described below.

1) Salaries and wages: (See Section 7-5-1)
2) Electric power : (See Appendix E-1)
3) Chemical costs :

Chemical costs for bleach powder are about 1 yen per kg of solution.

Based on the above condition, the operation and maintenance costs are calculated and shown in the table given below.

Estimated Operation and Maintenance Costs

Project Area	Personnel Expenses		Power		Chemical Costs		Total	
	People	NRp/M	kW/M	NRp/M	kg/day	NRp/M	NRp/M	NRp/m3
1. Mahendranager	16	16,000	59	19,139	1,000	5,190	40,329	0.7
2. Dhangadhi	14	14,000	44	15,255	347	1,801	31,056	0.6
3. Bharatpur	65	65,000	132	69,334	1,120	5,813	140,147	0.8
4. Gaushala	15	15,000	48	17,713	147	763	33,476	1.5
5. Lahan	40	40,000	96	33,284	1,333	6,919	80,203	0.9
6. Rajbiraj	49	49,000	125	51,256	2,067	10,728	110,984	0.8
7. Bhadrapur/ Chandragadhi	48	48,000	131	54,190	2,000	10,381	112,571	0.9
8. Ilam	13	13,000	-	-	213	1,106	14,106	0.4
Total	260	260,000	635	260,171	8,227	42,701	562,872	

Project Area	Average daily Water Supply (m3/day)	Operation and maintenance	
		Monthly (NRp/month)	Yearly (NRp Mil/year)
1. Mahendranagar	1,930	40,329	0.48
2. Dhangadhi	1,810	31,056	0.37
3. Bharatpur	5,950	140,147	1.68
4. Gaushala	770	33,476	0.40
5. Lahan	2,840	80,203	0.96
6. Rajbiraj	4,430	110,984	1.33
7. Bhadrapur/ Chandragadhi	4,300	112,571	1.35
8. Ilam	1,190	14,106	0.17
Total	23,220	562,872	6.74

Annual operation and maintenance costs for the Project are estimated at approximately NRp 6.74 million.

CHAPTER 8. PROJECT EVALUATION

Chapter 8
PROJECT EVALUATION

8-1 Effects of the Project

Development, renovation and augmentation of water supply projects is given high priority by the HMG of Nepal, in order to enhance socioeconomic conditions and to elevate the standard of living and quality of life of the people. Accordingly, first priority is given to the enhancement of water supply facilities in 33 urban centers, the "Urban Water Supply Project".

A large-scale water supply project for Kathmandu and two other cities was commenced in 1974 and completed in 1984, the "First Project".

Subsequently the "Second Project", that commenced in 1977 and was completed in 1984, consisted of the following: renovation of the existing water supply facilities in 9 cities which included the "First Project" areas as well, preparation of a master plan for the augmentation of water supply facilities for the above 9 city areas, and the augmentation of sewerage construction work for Kathmandu and Lalitpur.

The "Third Project" consisted of implemention of the augmentation work of the water supply master plan in the 9 city areas of the "Second Project". The construction work of these facilities is in progress.

These First to Third projects were implemented with the financial assistance of IDA. These projects are only urgent undertakings, and hence are not intended to be a long-term solution to the water shortage problem.

In consideration to the above situation, a feasibility study on water supply, drainage and sewerage for 22 urban areas, the "Fourth Project", was carried out with the financial assistance of the World Bank and UNDP, and was completed in 1984. This "Fourth Project" is planned to be implemented with the assistance of international and bilateral agencies (ref. Table 2.11).

At present the water supply projects for 23 towns out of the total 33 towns have been undertaken by the DWSS, of these towns' water supply, twelve projects have been completed and additional four projects are under construction. Projects for the remaining towns are either under study or detail design stage. Of the other 10 areas, the water supply facilities for 8 areas are to be implemented by this project with the financial assistance of Japanese Grant Aid Cooperation. In addition, this project includes the village of Gaushala, an important rural center, as an additional project area that does not fall within the above 33 urban centers.

The existing situation of the water supply facilities in the project areas is very poor mainly due to the aging of the facilities and rapid increase in water demand caused by population concentration in urban centers from rural areas. In all project areas only hourly restricted water supply, for 2-9 hrs per day, is provided, and also in some project areas, even though the sources contain an excessively high content of iron, no iron removal facilities are installed.

In consideration of the above mentioned existing water supply situation, the implementation of this project, which is aimed at providing safe potable water and thereby improving environmental sanitation, will be extremely beneficial to the people of the project areas.

The situation of water supply, before (existing) and after the implementation of this project, is summarized in Table 8.1. From this table it is clear that the proposed water supply service is in accordance with the DWSS guidelines and a 24 hour water supply is possible.

According to the policy of His Majesty's Government of Nepal, the operation and maintenance of water supply schemes in the big cities, like Kathmandu, are carried out by WSSC on the basis of a self-supporting account system due to shortage of funds.
However at present the operation and maintenance of urban center water supply schemes are carried out by DWSS with central government subsidies. Hence as the number of urban water supply projects increases, the amount of central government subsidies would also follow suit. In view of this situation, the DWSS is considering the transfer of operation and maintenance to the respective Town Panchayats.

After the implementation of this project, the operation and maintenance costs of the water supply will be completely covered by the water service charges to be levied based on the present tariff system of WSSC.

8-2 Feasibility of the project

8-2-1 Technical feasibility

One of the important considerations of this basic design is the utilization of the existing facilities to the optimum level. Accordingly the continued utilization of

existing elevated water distribution tanks/ground reservoir, iron removal facilities, etc., is given due consideration in the design.
With respect to the water treatment facilities with rapid gravity filtration, the syphon type filter is adopted for ease of operation and reduction of flow control devices like valves, etc.

Also the water supply facilities designed are in conformity with the existing facilities. Thus the operation and maintenance of these designed facilities would not require any additional skills other than those required at present.
Based on the above mentioned basic design considerations the project would be considered highly suitable to the local conditions, and hence technically feasible from an overall engineering viewpoint.

Table 8.1 Comparison of Water Supply Levels with and without Project

Project Area	Without Project			With Project		
	Water consumption (m^3/day)	Design population (Person)	Service duration (hr)	Water consumption (m^3/day)	Design population (Person)	Service duration (hr)
Mahendranagar	300	7,200	5.5	2,700	16,000	24
Dhangadhi	640	6,500	9	2,600	14,000	24
Bharatpur	350	21,900	4	8,400	65,000	24
Gaushala	-	8,000	-	1,100	15,000	24
Lahan	110	14,200	2	4,000	31,000	24
Rajbiraj	160	19,300	3	6,200	49,000	24
Bhadrapur & Chandragadhi	430	21,900	4	6,100	48,000	24
Ilam	200	9,300	6	1,600	13,000	24
Total	2,190	86,400		32,700	251,000	

8-2-2 Economic feasibility

According to the policy of DWSS the management of water supply schemes of urban centers, which are presently carried out by DWSS with financial assistance from the central government, are to be transferred to the respective Town Panchayats as a means of administrative decentralization.

At present the water supply service charges are levied partly, based on a tariff system that classifies the consumers only on the basis of the size of the pipe (pipe diameter) to the house connection. This is the reason for being unable to establish a self-supporting accounting system. Hence, in order to establish a self-supporting accounting system, it is necessary to modify the water tariff system so that the charges for water consumption could be levied principally based on the quantity of water consumed. Such a modified tariff system is already in use by the WSSC in big cities.

The water tariff system of WSSC is given below.

Pipe Diameter (inch)	Basic Charge (NRp/Month)	Minimum Charge (m^3/Month)	Consumption Charge (NRp/m^3)
1/2	7	10	1.2
3/4	28	27	1.2
1	56	50	1.2
1.1/2	168	140	1.2

For public standposts, NRp 240 per month per tap is paid by the central government, hence it is completely subsidized.

When the water tariff system of WSSC is adopted, the expected total revenue from all of the project areas for DWSS is computed as illustrated below.

1) Full Plumbing

Average number of people per family : 6 people
Mean daily water consumption : 150 l/day/person
Diameter of pipe connection : 1/2 and 3/4 inch
Mean daily water consumption per family :
$0.15 \times 6 \times 30 = 27\ m^3$/month
Water charge for 1/2 inch :
NRp 7 + NRp 1.2 x 17 m^3
= NRp 27.4
Water charge for 3/4 inch (Basic Charge) :
= NRp 28.0

Subtotal revenue of full plumbing :
Number of families with full plumbing
250,000 people x 30% = 75,000 people
Family number = 75,000 ÷ 6 = 12,500 families
Revenue = NRp 27.4 x 6,250 + NRp 28 x 6,250
= NRp 346,250/month
Therefore, annual revenue is:
NRp 346,250 x 12 = NRp 4,155,000/annum

2) Yard Tap

Average number of a family : 6 people
Mean daily water consumption : 65 l/day/person
Diameter of connected pipe : 1/2 inch
Mean daily water consumption per family :
$0.065 \times 6 \times 30 = 11.7\ m^3$/month

Subtotal revenue of yard tap :
Number of families with yard tap
251,000 people x 40% = 100,400 people
Family number = 104,000 ÷ 6 = 16,733

Revenue = (NRp 7 + NRp 1.2 x 1.7) x 16,733
= NRp 151,266/month

Hence, annual revenue is:

NRp 151,266 x 12 = NRp 1,815,192/annum

3) Public Standposts

The water charge per tap is to be NRp 120.
Number of people : 250,000 x 30% = 75,000 people
Number of public standposts : 75,000 ÷ 100 = 750 taps

Subtotal revenue of public standposts :

Revenue = NRp 120 x 750
= NRp 90,000/Month

Hence, annual revenue is:

NRp 90,000 x 12 = NRp 1,080,000/annum

Total annual revenue is as follows:

1) Full Plumbing	:	NRp 4,155,000/annum
2) Yard Tap	:	NRp 1,815,192/annum
3) Public Standpost	:	NRp 1,080,000/annum
Total revenue	:	NRp 7,050,192/annum

From the above computation it is evident that the estimated revenue covers the estimated operation cost, using central power, and maintenance costs of NRp 6.74 million/annum (ref. 7-5-2).

As the power supplies in the project areas are either not available or unreliable, diesel generators are to be used as the power sources, which would become standbys for emergencies in the future, after changing over to a central power supply source.

The use of diessel power generators for energy results in annual operation and maintenance costs of NRp 9.87 million (¥57.0 million). Hence also based on economic efficiency, a change over from diesel power to central power is urged to be carried out at the earliest available opportunity when such a facility is provided (See Appendix E-1).

8-2-3 Feasibility of Management

The management of water supply projects in Town Panchayats is carried out by DWSS.

Presently hourly-restricted water supplies are provided due to the aging of the facilities and inadequate water source capacity.

At present, the number of project staff is incompatible with the existing water supply systems which are rather small-scale facilities with no water charge collection. However, after the implementation of the Project, more project staff will be necessary to undertake the increased workload due to the increase in water supply and modifications in the water tariff system.

The additional staff employed could be easily trained by the project office with the use of existing resources.

By considering the scope of work at present and in the future and the available facilities of the project office, the operation and maintenance work could be effectively carried out under the conditions of a modified water tariff collection system. Therefore the Project is feasible from a managerial viewpoint.

CHAPTER 9. CONCLUSION AND RECOMMENDATIONS

Chapter 9
CONCLUSION AND RECOMMENDATION

9-1 Conclusion

With the implementation of this water supply project, an estimated 250,000 people in the 9 project areas consisting of eight towns and one village would reap the benefits of having potable water supply facilities.
This provision of a safe water supply would lead to a drastic reduction in water-borne disease, thereby immensely improving the general public health of the people with a sound sanitary environment. Furthermore a significant secondary benefit is the contribution of the project to the enhancement of socioeconomic activities.

The provision of water meters for this project ensures the adoption of a rational water tariff system, a necessary condition for instituting a self supporting operation and maintenance system of water supply. This will contribute favorably to the financial condition of water supply projects in the country, including the economic and financial viability of future water supply development projects.

The estimated revenue from water charges, by the implementation of this project completely covers the operation and maintenance costs of the facilities, with an annual revenue of NRp 7.1 million (¥40.8 million) against the corresponding operation and maintenance costs of NRp 6.7 million (¥39.0 million). Based on this consideration, inaddition to the high social benefits, this project is very much suitable for the Japanese Grant Aid Program.

9-2 Recommendations

1. The water supply facilities in big cities are under the WSSC, and these facilities are operated under a self-supporting system. An effort has been made to cover the operation and maintenance costs with the charge levied by the water tariff system based on water consumption. On the other hand, the water supply facilities of urban centers are under DWSS and the water tariff system is based on the size of the pipe (pipe diameter) for in-house connections. As this charging system is not based on water consumption the revenue levied does not cover the operation and maintenance costs, hence necessitating the central government's subsidies. In the near future, with the implementation of the 33 city project, the water supply facilities to these urban centers would be improved, and accordingly the costs of operation and maintenance raised, resulting in increased government subsidies, if the existing tariff system remained unaltered. Apart from the fact that this existing tariff system itself is very irrational, continuation of such a tariff system is very unfavorable for the financially viable existence of DWSS. Therefore, a rationalized tariff system is recommended to be introduced as soon as possible.

2. The water meters necessary for the measurement of water consumption, and hence the adoption of rational, cost effective, and self-supporting water supply services, will be installed. However, in order to evolve such a rational tariff system, data on water yields and consumption patterns have to be collected and analysed. Provision of water meters is made initially, based on a 5 year design period only. The water meters shall be provided to the consumers on a rental basis, and the rent fee be

incorporated in the water tariff structure. The resulting rental revenue shall be utilized for the procurement of required water meters after 5 years.

3. The power sources for this project are diesel generators until central electricity is made available. The cost of this diesel power is 21% more expensive than the central power. Hence an early changeover to central power is recommended when such a service is made available.

4. The infrastructure of the project areas is not yet well developed. With the implementation of this project a 24 hour water supply service will be provided. This may lead to an increase in water supply and hence in wastewater to be disposed of. Thus due consideration must be given to the improvement of drainage and sanitation.