His Majesty's Government of Nepal
Ministry of Water Resources
Department of Irrigation

FEASIBILITY STUDY
ON
EXPANDING GROUNDWATER DEVELOPMENT
FOR
IRRIGATION IN THE BIRGANJ AREA OF THE TERAI

VOLUME I

MAIN REPORT

November, 1993

Nippon Koei Co., Ltd.
in association with
Binnie & Partners
and
Nepalconsult (P) Ltd.

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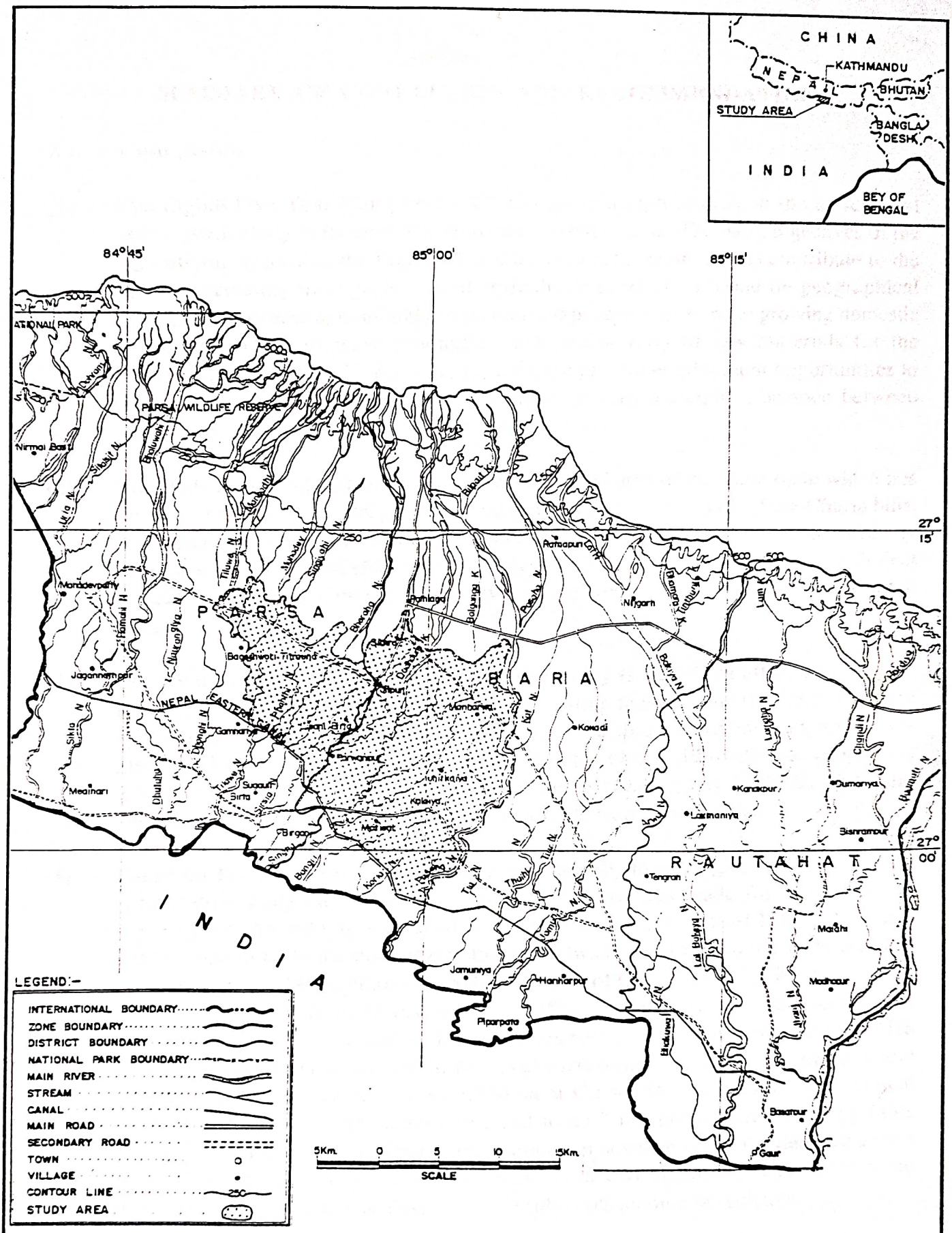

Location Map

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY
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INTERNATIONAL DEVELOPMENT ASSOCIATION

SUMMARY OF CONCLUSION AND RECOMMENDATION

A. Conclusion

(1) The Eighth Five Year Plan (1992 - 97) has given a high priority to the agricultural sector, particularly to its intensification and diversification. The basic objectives of the agricultural sector that the Eighth Plan intends to achieve are to: (a) contribute to the national economy through increased agricultural production based on geographical features; (b) increase agricultural production and productivity to meet growing domestic food demand; (c) increase production and productivity of raw materials for the expansion of agro-based industries; (d) increase gainful employment opportunities to the majority of small and marginal farmers; and (e) maintain a balance between agricultural development and the environment.

(2) The study area of 32,900 ha is located in the Birganj area of the Terai plain which lies on the northern edge of Ganges plain and immediately to the south of the Churia hills. The area extends over the alluvial plain bounded by the fringe of forest in the north, by the Nepal Eastern Canal (NEC) of the Narayani Zone Irrigation Development Project (NZIDP) in the south, by the Tilawe river in the west and by the Pasaha river in the east.

(3) The net irrigable area measured in the present study is 13,840 ha after deducting the unsuitable lands, the lands being irrigated by existing facilities and the lands occupied by villages, rivers, roads, irrigation facilities and other facilities from the above-mentioned study area. The net irrigable area thus obtained broadly consists of: (a) 2,540 ha of farmers-managed irrigation scheme (FMIS); (b) 1,000 ha of Sirsia-Dudhaura Irrigation scheme (SDIS); and (c) 10,300 ha of rain-fed area.

(4) Based on the above-obtained irrigable area and hydrogeological parameters, the optimization study on the groundwater development was made for three kinds of cropping patterns with the conceivable cropping intensities (C.I) of 195%, 185% and 175%. According to the study result, the groundwater resources in the study area can be developed for the irrigation of 6,810 ha in case of C.I = 195%, 7,250 ha in case of C.I = 185% and 7,540 ha in case of C.I = 175% without any adverse effects to the existing shallow tubewells and spring-fed rivers being used for the irrigation in FMIS area. These obtained results are further evaluated from the economic viewpoint and concluded that the development of 7,250 ha at C.I = 185% is the most economical option for the project (hereinafter referred to as " the project area"), though this development area cannot be rigidly programmed in advance under the demand driven approach. For this development plan, about 78 MCM of groundwater needs to be abstracted in a year, which is about 52% of exploitable amount of recharge.

(5) Based on the above-studied result, the future cropping intensity for the project is proposed to be 185% which is 38% higher than the present cropping intensity of 147%. By introducing this cropping pattern to the project area and adopting the improved agricultural technologies supported by irrigation water supply, the unit yields

of crops would be increased from the present level to a great extent: from 2.8 tons/ha to 4.2 tons/ha for monsoon paddy, from 45.0 tons/ha to 65.0 tons/ha for sugarcane, from 2.2 tons/ha to 3.5 tons/ha for wheat, 2.2 tons/ha to 4.0 tons/ha for maize and 7.7 tons/ha to 18 tons/ha for vegetables. As a result, the production of crops would be increased by 7,860 tons for paddy, 2,060 tons for sugarcane, 9.190 tons for wheat, 6,950 tons for maize and 8,100 tons for vegetables as compared to the present productions.

(6) For the irrigation development in the above 7,250 ha, it is planned that the FMIS and SDIS areas will be irrigated through conjunctive use of surface water and groundwater, while the rain-fed area will be irrigated totally by groundwater, because it is sole water source in the area. Based on the hydrogeological parameters obtained through the field survey and study, the required number and well-to-well distance of both shallow tubewell (STW) and deep tubewell (DTW) are obtained as follows, though these number and distance will be changed based on the farmers' demand.

Scheme	Irrigation Area (ha)	Number of Tubewells		Well-to-Well Distance (m)	
		STW	DTW	STW	DTW
FMIS Area	1,200	30	8	430	1,100
SDIS Area	970	0	10	-	1,100
Rain-fed Area	5,080	170	52	350	910
Total	7,250	200	70	-	-

(7) In addition to the above irrigation works, the upgrading of existing road network for about 90-km length and building work including the renovation of existing GWRDP buildings in the Parwanipur compound will be included in the project works.

(8) The time to be required for the implementation of the project is estimated to be 8 years including the time necessary for the survey, design, tender calling, construction, procurement of construction materials and mechanical and electrical works, procurement of construction and O&M equipment and technical supports.

(9) The total project cost is estimated at NRs.1,587 million (US$ 31.7 million) consisting of NRs.760 million (US$ 15.2 million) of local currency portion and NRs.827 million (US$ 16.5 million) of foreign currency portion including the physical contingency of 10 % and price contingencies of 10% per annum for local currency portion and 3.5% per annum for foreign currency portion.

(10) For the implementation of the project, the Ground Water Development Board (GWDB) would be responsible for central level inter-sectoral coordination and procurement decisions of goods and services. As the executive body for the project implementation, the Project Executing Organization (PEO) is proposed to be established in Birganj for the project period. The PEO would consist of one Unit and six Sections: (i) Monitoring and Evaluation Unit; (ii) Administration Section; (iii) Planning and Institutional Development Section; (iv) Drilling Section; (v) Civil Construction Section; (vi) Commissioning and Servicing Section; and (vii) Account Section. In order to review

and facilitate implementation operation and to provide direct coordination among WUAs/WUGs, farmers, PEO and field level line agencies, the Representative Committee would be formed in the project area. The Committee would comprise the PEO project manager as the member secretary, PEO officers and a representative of ADBN, AIC, DADO, DIO and DDC. WUA would send representatives to the committee. One of them would be the chairperson of the Committee.

(11) When the project is in full operation, the total net return with project would amount to NRs.311.5 million, more than double of that without project which is estimated at NRs.117.2 million. Thus, the difference of NRs.194.3 million is regarded as the benefit accrued from the project in terms of financial price.

(12) According to the economic evaluation on the project, the economic rate of return (EIRR) is estimated to be 20.5% and the net present value (NPV) of the project would be NRs.928.7 million at the discount rate of 10%. The sensitivity analysis are also worked out and indicates that the project viability would be rather insensitive to adverse changes. From these results of evaluation, it can be said that the project is economically feasible.

(13) According to the result of groundwater simulation and optimization study, the exploitation of groundwater for the irrigation of 7,250 ha will not cause any land subsidence, adverse effects of spring discharge and interference with the prior water right. As the other possible environmental impacts to be caused by the agricultural development, change of soil fertility, water pollution and biological change are predictable due to increase of fertilizer use. To ensure the proposed project to be environmentally more sound and to increase the environmental quality, the environmental management and monitoring plan would need to be formulated in the detailed design stage and to be executed throughout the construction and post-construction stages.

B. Recommendation

(1) The project is technically sound and economically feasible. Furthermore, the project will provide substantial and sustainable socio-economic benefit not only in the project area but also in region and nation as a whole. Thus, it is recommended that the project be implemented as early as possible.

(2) The project should be implemented based on the realization of a need to let the farmers participate in the irrigation project development, operation and maintenance and management process. The proposed project would be visualized under the basic principle that the WUAs/WUGs formed in the project will get proper information about the project right from its inception. Users should get full information on project concept, objectives, procedures of implementation and roles and responsibilities of parties involved in the project and generate self service support capabilities. Therefore, the proposed project should be implemented on the users' demand and their capability.

The WUA along with PEO officials would develop a capability, by which operation and maintenance system would be done.

(3) The groundwater simulation and optimization study made under this feasibility study shows that the area of 7,250 ha out of total irrigable area of 13,840 ha can be developed without giving any adverse effects to the existing shallow tubewells and spring-fed rivers running in the project area, and it is recommended, for the moment, that the remaining area of 6,590 ha be excluded from the development area dealt with in the present feasibility study. Through the above-mentioned simulation and optimization study, however, it is understood that the possibility of development for the remaining area should be confirmed based on another optimization study to be made based on the further detailed hydrogeological data which will be collected from the tubewells to be constructed for the development of the above-mentioned 7,250 ha. Based on this understanding, it is recommended that another groundwater simulation and optimization study be conducted to clarify the possibility for the inclusion of this area in the project area as the second phase development.

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LIST OF ABBREVIATIONS

ADBN	:	Agricultural Development Bank of Nepal
ADO	:	Agriculture Development Office
AEO	:	Agriculture Extension Officer
AIC	:	Agricultural Inputs Corporation
AO	:	Association Organization
ASC	:	Agriculture Service Center
BLGWP	:	Bhairawa Lumbini Groundwater Project
CATC	:	Central Agriculture Training Center
CDADO	:	Chief District Agriculture Development Officer
CDO	:	Chief District Office
CIDA	:	Canadian International Development Agency
DAD	:	Department of Agricultural Development
DADO	:	District Agriculture Development Office
DDC	:	District Development Committee
DIO	:	District Irrigation Office
DOI	:	Department of Irrigation
DTW	:	Deep Tubewell
EIRR	:	Economic Internal Rate of Return
FAO	:	Food and Agriculture Organization of the United Nation
FMIS	:	Farmers Managed Irrigation Scheme
GDP	:	Gross Domestic Product
GWDB	:	Groundwater Development Board
GWRDP	:	Groundwater Resources Development Project
HMGN	:	His Majesty's Government of Nepal
IBRD	:	International Bank for Reconstruction and Development
ICB	:	International Competitive Bidding
IDA	:	International Development Association
ILC	:	Irrigation "Line of Credit" (Pilot Project)
INGO	:	International Non-government Organization
JT	:	Junior Technician
JTA	:	Junior Technical Assistant
LCB	:	Local Competitive Bidding
NARC	:	Nepal Agriculture Research Council
NBL	:	Nepal Bank Limited
NEA	:	Nepal Electricity Authority
NEC	:	Nepal Eastern Canal of NZIDP
NFC	:	Nepal Food Corporation
NPC	:	National Planning Commission
NPV	:	Net Present Value
NRB	:	Nepal Rastra Bank
NZIDP	:	Narayani Zone Irrigation Development Project
O & M	:	Operation and Maintenance
PEO	:	Project Executing Organization

RATC	:	Regional Agriculture Training Center
RCRP	:	Rice Crop Research Program
SCF	:	Standard Conversion Factor
SDIS	:	Sirsia Dudhoura Irrigation System
SFDP	:	Small Farmers Development Project
STW	:	Shallow Tubewell
T & V	:	Training and Visit System of Agricultural Extension
UNDP	:	United Nations Development Programme
USAID	:	United States Agency for International Development
VDC	:	Village Development Committee
WUA	:	Water Users' Association
WUG	:	Water Users Group

ABBREVIATIONS OF MEASUREMENTS

Length

mm	=	Millimeter
cm	=	Centimeter
m	=	Meter
km	=	Kilometer

Time

sec	=	Second
min	=	Minute
h	=	Hour
d	=	Day
yr	=	Year

Area

mm^2	=	sq. mm	=	Square millimeter
cm^2	=	sq. cm	=	Square centimeter
m2	=	sq. m	=	Square meter
km2	=	sq. km	=	Square Kilometer
Ropani	=		=	509 sq. m
Bigha	=		=	0.66 ha

Electrical Measures

kW	=	Kilowatt
MW	=	Megawatt

Volume

lit	=	Liter		
m^3	=	cu.m	=	Cubic meter
MCM	=	10^6 m^3	=	Million cubic meter

Other Measures

%	=	Percent
°	=	Degree
'	=	Minute
"	=	Second
°C	=	Degree Celsius

Weight

mg	=	Milligram
g	=	Gram
kg	=	Kilogram
ton	=	Metric ton

Derived Measures

lit/sec	=	liter per second
m^3/sec	=	Cubic meter per second

Money

NRs.	=	Nepalese Currency Rupee
US$	=	US Dollar
¥	=	Japanese Yen

Exchange Rate

US$	=	NRs. 50.0
	=	¥ 110

1. INTRODUCTION

1.1 General

This report is prepared as per the Terms of Reference (TOR) attached to the Contract between the Department of Irrigation (DOI), Ministry of Water Resources, His Majesty's Government of Nepal (HMGN) and Nippon Koei Co., Ltd. in association with Binnie & Partners and Nepalconsult (P) Ltd. signed on December 11, 1992 to provide the Consulting Services for Feasibility Study on Expanding Groundwater Development for Irrigation in the Birganj Area of the Terai.

This report presents the finding on the present conditions of the study area, project development plan, the results of feasibility level design of the project facilities, estimate of project costs and benefits and the project evaluation from economic and financial view points.

1.2 Background of the Project

The project "Expanding Groundwater Development for Irrigation in the Birganj Area of the Terai" having a gross irrigation area of some 20,000 ha in the follow-up of the Master Plan Project of Central and Eastern Terai Plain which was first formulated as the priority project by UNDP/FAO in the period from 1967 to 1972. Within the framework of the Master Plan Project, a sub-project under the FAO/IBRD Cooperative Program was identified in March 1970. Subsequently, the feasibility report on the project as a part of the Birganj Irrigation Project was prepared under UNDP/FAO NEP 7 study project .

Based on the result of the above feasibility study, IDA appraised the Birganj Irrigation Project and decided to finance the project for its implementation as the Narayani Zone Irrigation Development Project (NZIDP) in 1972. Under the NZIDP Stage-I (1973 - 1980), a part of the project area, 2,730 ha mainly in Bara district centering Kalaiya, had been developed by re-drilling 3 tubewells of 17 Indian-aided existing wells and by constructing 14 new deep tubewells.

Under the NZIDP Stage-II (1981 - 1985), the investigation and study for the development of shallow tubewells were made in both Kalaiya area (12,000 ha) and Simra area (8,000 ha) to formulate the Community Shallow Tubewell Scheme and the development of 63 shallow tubewells in total had been completed in the areas by the end of 1986. For the electrical and mechanical works, however, no work has been done so far, and most of the

tubewells except 26 wells, on which farmers have installed pumps by themselves, are not being used. This scheme would explore and develop the farmers' capacity to finance and operate irrigation tubewells themselves with some assistance from ADBN and NZIDP, if the scheme is successful.

In order to explore the groundwater potential particularly of the deep aquifer in the Terai, DOI is collecting hydrogeological data through exploratory boring under the Groundwater Resources Development Program as one of the activities of Bhairawa-Lumbini Groundwater Project Stage III (BLGWP - III). This program covers both Bara and Parsa districts. The exploratory boring has been completed at 4 sites last year and 6 more will be completed by the end of this year in the study area.

1.3 Study Area

According to the Terms of Reference attached to the Contract for the Consulting Services, the north boundary of the study area is not clearly defined mentioning that the main area of investigation would be the 20,000 ha gross area covered by the Nippon Koei study of 1971 plus a possible extension to the north to around the latitude of Simra. According to the results of field reconnaissance and the interpretation of 1 : 25,000-scaled aerial photographs shot in 1989, the forest has been opened up to the north from the latitude of Simra in some parts for more than 5 km for agricultural purpose. Since these newly opened area can be categorized in the Land Capability Class I and farmers in these areas are demanding a perennial water supply for irrigation, the north boundary of the study area is decided to be the fringe of the forest including the newly opened area. As for the south, west and east boundaries of the study area, the same boundaries as defined in the 1971 feasibility study, i.e. NEC in the south, the Tilawe river in the west and the Pasaha river in the east, are taken as the boundaries of the study area which covers 32,900 ha as shown in Location Map (hereinafter referred to as "study area").

1.4 Scope of Consulting Services

1.4.1 Objectives

There are two objectives for the Consulting Services (the Services). One is to provide a suitable irrigation strategy and scheme for exploitation of the groundwater resources in the study area located in the north of Nepal Eastern Canal (NEC), which would command the maximum possible extension of 32,900 ha. The other is to establish an optimum development plan for conjunctive use of groundwater and the surface water in the command area of NEC, through the study of various development alternatives.

1.4.2 Scope of Services

In order to meet the objectives mentioned above, the Consultants would make a feasibility study of the study area. The major study and work items contained are summarized below.

(a) To collect and review the existing data and reports.

(b) To clarify existing constraints on the groundwater irrigation scheme as well as the surface irrigation scheme in the study area, which are being faced now.

(c) To study the groundwater development method planned under BLGWP-III.

(d) To review the soil and land capability aspects.

(e) To review existing geological and hydrogeological data.

(f) To review and update the agricultural and agro-economic data such as crop yields, cropping intensity, cropping pattern, irrigation water requirements and agricultural supporting services.

(g) To investigate the existing road infrastructures and to prepare their extension and upgrading plans.

(h) To investigate the existing power transmission and to prepare its extension plan for energization of tubewell pumps.

(i) To carry out a digital modelling study on groundwater potential development.

(j) To formulate the basic groundwater development plan in the study area and both sides of NEC, taking into account the conjunctive use with surface water, through various alternatives.

(k) To establish a definite groundwater development plan.

(l) To make a project evaluation.

(m) To prepare necessary reports such as Interim Report, Draft Final Report and Final Report.

1.5 Work Performed in the Study Period

1.5.1 Mobilization

"Notice to Proceed" was issued by Ground Water Resources Development Project (GWRDP) to the Consultants on December 11, 1992. Upon the receipt of the Notice to Proceed, the Consultants dispatched the Study Coordinator/Irrigation Engineer to Nepal on December 15, 1992 to initiate the Consulting Services.

1.5.2 Field Survey

After collecting the data for meteo-hydrology, topography, hydrogeology, soils, agriculture, agro-economy, irrigation and power transmission infrastructure in Kathmandu, the experts made the following field surveys:

(a) Investigation of present conditions of irrigation practices and water management in the BLGWP area, Narayani Zone Irrigation Development Project (NZIDP) area and the study area.

(b) Investigation of present conditions of existing shallow tubewells and deep tubewells in the NZIDP area and the study area and measurement of water levels of the tubewells in these areas.

(c) Socio/institutional survey in the BLGWP area, NZIDP area and the study area.

(d) Additional agricultural data collection in the field from the authorities concerned and through farm household survey in the study area.

(e) Additional agro-economic data collection in the field from the authorities concerned and through farm household survey in the study area.

(f) Topographic survey at the Jamuni diversion weir site and along its headrace channel.

(g) Investigation on the present conditions of power supply in the study area.

1.5.3 Analysis and Study

In the present study period, the following analysis and study have been made by the respective experts:

(a) Review of feasibility study made by UNDP/FAO in 1971.

(b) Meteo-hydrological study.

(c) Hydrogeological study and aquifer potential determination.

(d) Land use and agricultural study including the analysis of data collected from the authorities concerned and through farm interview survey.

(e) Agro-economic study including the analysis of data collected from the authorities concerned and through farm interview survey.

(f) Demarcation of irrigation areas of different water sources.

(g) Study on conjunctive use of groundwater with surface water.

(h) Planning and alternative study on irrigation facilities including irrigation canal system, types of pump and motors and road network.

(i) Institutional study particularly for the project office and farmers' organization.

(j) Establishment of definite development plan including the determination of optimum scale of groundwater development area, recommendation on improved farming practices, preparation of plan and preliminary design for irrigation

system, drainage system, power transmission infrastructures and road network and establishment of efficient O&M system and preparation of project implementation schedule.

(k) Project evaluation from economic and financial viewpoints.

2. GENERAL ECONOMIC AND AGRICULTURAL BACKGROUND

2.1 Land and Population

The Kingdom of Nepal is a land-locked country with an area of 147,181 km^2. Major portion of the country is of high mountains and rolling hills. Nepal is broadly divided into three parallel ecological belts, namely, Terai, Hills and Mountains, which are distinctive in topography, climate, vegetation and agricultural productivity. Hills and Mountains each covers 43% of the land area and the remaining 14% lies in flat Terai plain.

According to the 1991 Census, the total population in 1991 was about 18.5 million, of which 90% were living in rural areas. The annual growth rate of the population was 2.1% during 1981 to 1991, slightly decelerated from 2.6% during the previous decade. The population density as of 1991 was 125 persons/km^2 and 6.2 persons per ha of cultivated land. The continuing population pressure on already intensively used land resources causes depletion and erosion of soils and migration from Hills to Terai. Once scarcely populated Terai has now the highest population density at 408 persons/km^2, as well as population per cultivated land at 7.0 persons/ha.

2.2 National Economy

2.2.1 General

Nepal is grouped into one of the lowest income countries in the world with per capita gross domestic product (GDP) at US$ 116[1/]. GDP of Nepal was estimated at NRs. 130.7 billion or equivalent to US$ 3.1 billion in 1991/92. Nepal is by nature a high cost economy because of its land-locked geographical position and extremely mountainous terrain. These conditions combined with a rapid population growth produce the dominant source of mass poverty which is the most distinguishable feature of the economy and a long-standing problem in national planning. It is estimated that about 9.2 million or 49% of the total population live in below the "poverty line"(National Planing Commission, *Eighth Plan*).

The dynamics of the economy is characterized by sharp fluctuations depending on the performance of agricultural sector which on its turn heavily depends on erratic monsoon. The average growth rate of GDP in the real term was 5.2% during last five years. The growth of agriculture sector fluctuated from 8.1% between 1986/87 and 1987/88 to 0.5% between 1990/91 and 1991/92. Non-agriculture sector recorded more steady growth at more than 6% except for the years affected by India's border blockade.

The national economy is dominated by agriculture. Although contribution of the agriculture sector has been declining, this sector still produced 51% of value added in 1991/92. The industry sector is on a very low base accounting for only 9% of GDP, but has recorded accelerated growth. The dominance of agriculture is more distinguishable in the distribution of

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1/ Based on the preliminary result of the 1991 population census and the official exchange rate as of July 1991 at US$ 1=NRs. 42.70. GDP in US$ is lower by about 10%, if evaluated with an exchange rate at commercial banks.

labour force which indicates more than 80% of population still rely on agriculture. The economic structure and its change during the last decade are as shown below.

Sector	Share in GDP		Share in Employment	
	1981/82	1991/92	July 1981	July 1991
Agriculture, Forestry & Fishery	57.2%	50.8%	91.1%	80.5%
Manufacturing	4.0%	9.0%	2.3%	3.4%
Other Industries	8.0%	7.9%	0.1%	0.9%
Services	24.5%	26.0%	6.5%	15.2%
Indirect Taxes	6.3%	6.3%	-	-

Sources: Calculated from data in Ministry of Finance. *Economic Survey 1991-92*, Central Bureau of Statistics. *Statistical Yearbook 1991* and *Population Census-1991 (Advance Tables).*

2.2.2 Foreign Trade

Nepal's foreign trade has long been suffering from chronic and expanding trade deficit. The export earnings only cover about 30% of the foreign currency expense for imports. The trade deficit in 1990/91 was NRs. 16.6 billion which is equivalent to 16% of GDP. The growing trade deficit is offset in the balance of payment by a flow of foreign loans and grants. The foreign aid disbursement plays a vital role in Napalese economy accounting for 31% of the government expenditure or 46% of the development expenditure in 1990/91.

During 1970s and 1980s, the trade structure had been changed remarkably. Declining share of India in both export and import is the most notable change in trade destination and increasing export of manufactured products is that in commodity composition. Agriculture and forestry based products had lost their dominance in export share from 82.3% in 1974/75 to 21.9% in 1990/91.

Along with the recent political reform of liberalization, Nepalese Rupee was made convertible to foreign currency recently. All export taxes are waived and custom duty levied on the imports are reduced. Export has consequently increased drastically, which is expected to decrease the trade deficit, if the tendency continues.

2.2.3 National Development Plans

Since 1956, the Government of Nepal has made continuous endeavor to develop national economy through seven consecutive five-year plans[1/]. The economic indicators during the three decades, however, explicitly show that the results were not of satisfactory. The average annual growth rate in real GDP was 3.4% during the period from 1964/65[2/] to 1989/90. The growth in per capita income during the period was marginal at 0.8% per annum due to high rate of population increase.

After the establishment of the multi-party political system in 1990, the government has adopted a development philosophy and approaches to transform the economy into an open,

1/ The second plan period was exceptionally of three years.

2/ GDP estimates are available on a regular basis only from this year.

liberal, transparent and competitive market oriented economy. The Eighth Plan (1992-1997) was formulated in conformity with this policy. Equity and sustainability aspects in economic development are also important concerns of the plan. The plan seeks to achieve the following three principal objectives:

(a) Sustainable economic growth;
(b) Alleviation of poverty; and
(c) Reduction of regional imbalances.

Programs given special priority in the Plan are:

(a) Agricultural Intensification and diversification;
(b) Energy development;
(c) Development of rural infrastructure;
(d) Employment generation and human resources development;
(e) Reduction in population growth;
(f) Industry and tourism development;
(g) Export promotion and diversification;
(h) Macro-economic stabilization;
(i) Administrative reform; and
(j) Monitoring and evaluation.

The target annual growth rate of the Eighth Plan is set at 5.1%, which is to be achieved by 3.7% growth of the agriculture sector and 6.1% growth of the non-agriculture sectors. The per capita GDP is planned to be increased at an annual rate of 3.0% during the period.

2.3 Agriculture in Nepal

Agriculture is the backbone of Nepal's economy employing 81% of labour forces, producing 51% of value added and earning 15% of export in 1991/92. The sector also provides growing agro-industrial sector with raw materials. About 90% of national population live in rural areas and thus the socioeconomic life of the people is under pervading influence of agriculture. The growth in this sector is the key to national development, as well as to alleviation of prevailing poverty.

Agriculture in Nepal is practiced utilizing only about 20% of total land area. Paddy, maize, wheat and millet are the major cereal crops cultivated together in nearly 85% of the gross cropped area. Potato, pulses, sugarcane and oilseeds are the main cash crops grown in about 10% of cropped area. Most cultivations are mainly made by small scale subsistence farmers using manual labor and bullock power. Crop yields are generally at low level, much lower than those in other Asian countries. The average yields of major crops during the past five years were 2.3 tons/ha, 1.5 tons/ha, 1.4 tons/ha, 0.6 ton/ha and 31.5 tons/ha, respectively for paddy, maize, wheat, oilseed and sugarcane. Production fluctuates largely by years depending on irregular and uncertain monsoon rains due to lack of sufficient irrigation.

The long term production statistics reveal that the agricultural development in Nepal has been dependent highly on area expansion rather than on unit yield increase. The yields of major crops except for potato and sugarcane have mostly stagnated or even declined sometimes during the last decade. This implies that cultivated land has already been extended to marginal and unproductive lands. Further agricultural development, therefore, must be derived from raising land productivity and cropping intensity. The following table shows the indices of food crop production.

Item	1974/75	1979/80	1984/85	1989/90	1990/91	1991/92
Cereal Crops Total (Index: 1974/75 = 100)						
Area	100.0	102.8	120.0	140.6	141.7	138.5
Yield	100.0	82.9	92.9	107.3	108.9	104.2
Production	100.0	85.2	111.5	150.8	154.3	144.3

Source: Ministry of Finance. *Economic Survey 1991-92.*

The increase rate of population has been exceeding that of food production during 1970s and 1980s. The declined per capita production forced the traditional rice exporter to virtually terminate its export by the middle of 1980s as shown in the table below. On the other hand, rice import combined with food aid has become constant though the amounts fluctuate by years. Annual rice import and food aid averaged at about 20,770 tons during 1985/86 to 1989/90.

(Unit : tons)

Item	1975/76	1980/81	1985/86	1986/87	1987/88	188/89	1989/90
Export	157,716	45,453	20,209	2,152	41	216	244
Import	1,493	55,156	6,608	35,012	21,669	9,169	13,529
Food Aid	0	8,115	0	27,887	871	0	0
Balance	156,223	-17,818	1,3601	-60,747	-22,499	-8,953	-13,285

Source: Agricultural Projects Services Center *Essential Food Commodities Supply Management Data Base Study*, 1990., Department of Customs *Foreign Trade Statistics.*, and unpublished data from Nepal Food Corporation

Although the production level is less than the nation's consumption requirements at present, import of foodstuffs is not enough to make up this deficit because of lack in foreign exchange and high costs of both inter- and intra- national transportation. The regions suffering from food shortages are mostly in Hills and Mountains where there is little source of cash incomes and transportation is extremely poor. In addition to this regional imbalance, seasonal variation also threatens the country's food security. Every four or five years there are sharp declines in agricultural production due to the absence of reliable water supplies. The decreasing food availability and its inconsistency cause serious nutrition problem, in particular for the poor people.

2.4 Agricultural Supporting System

(1) Agricultural Extension System

The Department of Agriculture Development (DAD) under the Ministry of Agriculture has an overall responsibility of agriculture related services in the country. Under the Director General (DG) of DAD, the Deputy Director General of Crop Science is in charge of the implementation of agriculture extension activities in the country as a whole. At district level, Chief District Agriculture Development Officer (CDADO) of District Agriculture Development Office (DADO) is responsible for agricultural extension activities. Each DADO operates seven Agriculture Service Centers (ASC) which provide all the agricultural and livestock extension services to farmers. Three Junior Technicians (JT) and three Junior Technical Assistants (JTA) are stationed at one ASC and carry out field visit, farmer training, demonstration, advisory services and others.

The World Bank promoted Training and Visit (T&V) system has been adopted in 19 Terai districts and 3 Hill districts. Training of extension workers and their regular contact with farmers are emphasized in the system. Extension workers are working as agricultural extension agents as well as a bridge or traffic between research and farmers. Along with recent policy reform, the government intends to make extension services more practical, simple and cost effective, with due attention to small holding farmers. Unification of service structure and coordination with research agencies are also in the main concerns of the policy.

Agricultural training channels have recently been centralized under the Central Agriculture Training Center (CATC) which belongs to DAD and is directed by the Deputy Director General of Planning, Monitoring and Evaluation. CATC controls Regional Agriculture Training Centers (RATC) located in all of five Regions and coordinates all the agriculture related training programs. CATC conducts workshops and training seminars for the gazetted officers of DAD staff, while RATC organizes regular training courses for farmers and in-service training to JT/JTA and officers on various aspects of agriculture, livestock, horticulture and fishery. DADO also conducts agriculture training to farmers and refresher training to the officers and JT/JTAs.

(2) Agricultural Research

Agricultural research works in Nepal are under the umbrella of the Nepal Agriculture Research Council (NARC), an autonomous research body of which executive committee is chaired by the Minister of Agriculture. NARC is headed by the Executive Director and there are five directors representing crops and horticulture research, animal and fisheries research, planning and coordination, personnel administration and financial administration. The directors manage 12 Central Divisions, 14 Commodity Programs (ten for crop and horticulture research and four for animal and fisheries research) and four Regional Agriculture Research Directorate Offices that control in total 16 Agriculture Research Centers.

NARC is mandated with all the powers and responsibilities for the development of plan, programs and policies on any issues regarding agricultural research in the country. It has

been entrusted with the task of achieving national goal of increasing agricultural production and productivity by implementing coordinated research programs. Research activities are carried out in order to develop appropriate technology in different components of Nepalese agriculture for increasing the productivity of cereal crops, grain legumes, cash crops, potato, vegetables, horticulture, spices, livestock and fishery.

(3) Agricultural Credit System

Farmers in Nepal utilize both institutional and non-institutional credits. Institutional loans are used for production investment, while non-institutional loans are mainly used for consumption purposes. The Agricultural Development Bank (ADBN) and several commercial banks collectively disbursed NRs 2,946 million of institutional credit in 1990/91. Non-institutional credit is provided mostly by landlords and traders and a tiny part by relatives or friends. No statistics are available for these informal credit sources.

ADBN is a public organization that plays an dominant role in agricultural finance in Nepal. Established in 1968, it presently operates seven Supervision and Control Offices, five Regional Training Centers, 18 Banking Offices, 162 branch and sub branch offices, 393 Small Farmer Development Project offices and two Appropriate Technology Unit/Private Enterprise Development Centers, located throughout the country. ADBN provides loans to farmers through cooperative society or directly to the farmers for the purpose of agriculture and agriculture related enterprises. ADBN credit consists of four major classes of loans; short-term production loan; short-term marketing loans; medium-term loans for purchase of tubewell irrigation pump sets, animals and farm equipment; and long-term loans for horticulture, agro-processing equipment installation, land development and agro-industry. ADBN offers subsidized credit programs for some specific purposes including tubewell installation.

In addition to ADBN, commercial banks have been actively participating in financing in agriculture sector since 1974/75, under the direction of the Nepal Rastra Bank (NRB), the central bank, to finance a certain proportion of their total deposit to the "priority sector." At present the priority sector financing should not be less than 8% of the total loan outstanding. The amount allocated for agricultural loan is at most 15% of the budget depending on the collection of outstanding loans. Nepal Bank Limited (NBL) and Rastriya Banijya Bank (RBB) are the main banks which provide agricultural loans. The share of commercial banks in total agricultural credit disbursement has been increasing rapidly, and since 1988/89 exceeding that of ADBN. Commercial banks disbursed 63% of agricultural loan amount in 1990/91, while ADBN disbursed the remaining 37%.

(4) Agricultural Input Distribution System

The Agricultural Input Corporation (AIC) is a public corporation which deals with fertilizers, agro-chemicals, improved seeds and agricultural tools. AIC had been the only agency responsible for importing and distributing input supply until private sector has recently allowed to enter the business. AIC still remains as the sole distributor of fertilizer in many regions, because the activities of private sector in importing and marketing have not started yet. The situation would be changed after private dealers start to be involved in the business.

AIC operates a branch office in each district which supplies inputs to farmers mainly through cooperative societies and registered private dealers. AIC has adopted a free dealership policy to cooperatives and private dealers, yet in practice cooperatives are given priority in dealership license and marketing zone.

(5) Cooperative Society (Sajha Sanstha)

Cooperative societies or *Sajha Sanstha* were founded on the strength of the Cooperative Bank in 1964. The main role of cooperative societies is to distribute agricultural inputs to the farmers and provide farmers with agricultural credit. Cooperatives used to be the only dealers of AIC for the sales of agricultural inputs, mainly fertilizer in the past. They also enjoyed monopoly as the sole dealer of Nepal Food Corporation (NFC) for the purchase of grains in Terai and the sales of them in the food deficit areas in Hills. Cooperative formation used to be directed by the government on a compulsory base, which resulted in managerial failure of many cooperatives.

Along with the government policy of liberalization, the principles of self-reliance, voluntary, autonomy and democracy are stressed for the organization and management of cooperatives. As a result, cooperatives were forced to face a competition with private dealers. The role of the cooperatives, however, has not been diminished so far, due to an advantage as well-organized institutions. The government regards them as an indispensable medium for the overall development of rural areas. Individual customers, AIC and NFC prefer to use their services, because cooperatives seem to be more reliable and less chances of misutilizing the commodity and cheating the customers.

2.5 Agricultural Development Policy and Strategy

The Eighth Plan (1992-97) has given a high priority to the agricultural sector, particularly to its intensification and diversification. The targeted annual growth rate of the sector of 3.7% per annum is planned to be achieved by attaining annual growth rate of 5.4 % in food grains, 9.1% in cash crops, 5.4% in horticulture and 3.8% in livestock. The basic objectives of the agricultural sector that the Eighth Plan intends to achieve are to:

(a) Contribute to the national economy through increased agricultural production based on geographical features.

(b) Increase agricultural production and productivity to meet growing domestic food demand.

(c) Increase production and productivity of raw materials for the expansion of agro-based industries.

(d) Increase gainful employment opportunities to the majority of small and marginal farmers.

(e) Maintain a balance between agricultural development and the environment.

To attain the above mentioned objectives, a comprehensive agricultural development policy has been set by the National Planning Commission. Privatization, self-reliance and autonomy are the main concerns in the policy on the basis of the principle of economics. However, the equity issue is stressed as well, paying attention to the impoverished classes such as landless/small farmers and women. The agricultural policies intend to:

(a) Accord priority to the appropriateness of agro-ecological zones in the development of agricultural production program.

(b) Commercialize and diversify agricultural production on the basis of comparative advantage and export potential.

(c) Encourage the production of industrial crops to meet the requirements of raw materials for the agro-industries.

(d) Bring the management of agricultural extension services under a unified structure in order to bring about a more efficient and effective delivery of extension services.

(e) Carry out the agricultural extension services through farmers groups at the village level.

(f) Encourage the private sector to become involved in the production, import and distribution of agricultural inputs to accelerate the process of marketed agricultural development.

(g) Expand the use of improved seeds and technology by involving the private sector in the production and distribution of such inputs.

(h) Give emphasis on agricultural research on rainfed and hill agriculture.

(i) Simplify the disbursement of agricultural credit.

(j) Revitalize the cooperatives on democratic principles, along with full transparency in their operations to contribute to overall development of rural areas.

2.6 Irrigation Development and Services

2.6.1 Past Achievement of Irrigation Development

Nepal has rich water resources for irrigation development, not only for surface water but also for groundwater development. From the mid 1960's, government agencies have been actively involved in constructing and managing new irrigation schemes, and assisting farmer groups to construct or rehabilitate Farmers Managed Irrigation Schemes (FMIS). The Department of Irrigation (DOI) has played an important role in the development of new irrigation schemes.

Agriculture in Nepal is largely carried out under the rainfed conditions. It is estimated that only about 1,091,000 ha or 41% of the total agricultural land have some kind of irrigation facilities. Farmers have developed 823,000 ha or 75% of total irrigated area, and DOI has constructed and managed 268,000 ha or 25%.

DOI placed most of its efforts on the development of medium and large scale irrigation schemes over the past two decades in the Terai plain, and the DOI-managed projects in particular are concentrated in this area. The Master Plan Study prepared by the Ministry of Water Resources in 1990 presents that the DOI Extensive Irrigation Development Schemes in Terai benefit from monsoon irrigation, of which only 40 - 60% of the net command area is effectively irrigated in the spring and monsoon season, and only 10 - 20% in the winter season.

2.6.2 Possibility of Irrigation Development in Nepal

Nepal has an estimated total cultivation area of 2.64 million ha which is unlikely to increase due to existing intense pressure upon the cultivation areas and the awareness of need to protect watersheds of rivers with forest cover. According to Master Plan for Irrigation Development plan in Nepal (Cycle 2) prepared under United Development Programme in 1990, the upper limit of irrigation development is approximately 1.76 million ha, of which some 1.30 million ha is located in the Terai and 0.46 million ha in the Hill and Mountain Areas. Of this area, approximately 1.09 million ha is currently irrigated in various ways. About 820,000 ha is in FMISs and the rest is in the government schemes. The estimated upper limit on irrigation area in groundwater schemes alone is 360,000 ha, while the present irrigation area by ground water is estimated at about 110,000 ha. Thus, the remaining potential is about 250,000 ha consisting of 200,000 ha by shallow tubewells and 50,000 ha by deep tubewells.

2.6.3 Government Policy and Plan for Irrigation Development

The basic objectives of irrigation development set out in Eighth Plan are to:

(a) increase agricultural production through the application of irrigation technologies appropriate to diverse climate and soil conditions and with the minimum detrimental effects to the environment,

(b) enhance the credibility of irrigation system through improvement in the management of existing irrigation system, and

(c) provide irrigation facilities for the maximum area of land by implementing economically, technically and environmentally sustainable projects with the participation of farmers.

To achieve the above objectives, the Irrigation Policy was promulgated by Ministry of Water Resources in 1992. This Irrigation Policy emphasizes:

(a) to develop irrigation services through cost-effective investment in the irrigation development and extension programs which should ensure that they are sustainable from the technical, financial, institutional and environmental perspectives and also ensure greater returns in the short run by meeting the water requirements of the farmers' fields with an objective of increasing agriculture production,

(b) to decrease the government's involvement in construction, maintenance and operation of irrigation schemes by gradually increasing the participation of organized users without having adverse impact on effectiveness of the different stages of implementation of irrigation development, and

(c) to continue the Nepalese farmers' tradition of construction and management of irrigation systems as autonomous entities in private sector by making it more stable and extensive.

Under the present Irrigation Policy, the groundwater development program will be implemented under the collective ownership of the users. The program will be introduced only on the basis of demand from the majority of farmers. In the implementation of such program, there should be a full participation of organized farmers (users) from the very beginning to the implementation and the full responsibilities of operation, maintenance and management of the system by users after its completion. For a new tubewell development scheme, the users have to contribute 10% of construction cost in case of deep tubewell system and 15% in case of shallow tubewell system respectively, and the balance cost of construction will be borne by the government. The users will have to provide all land required for the construction purpose free of cost.

3. THE STUDY AREA

3.1 Location and Administration

The study area of 32,900 ha in gross is located in the Birganj area of the Terai plain which lies on the northern edge of Ganges plain and immediately to the south of the Churia hills. The area extends over the alluvial plain immediately to the north of the Nepal Eastern Canal (NEC) of the Narayani Zone Irrigation Development Project (NZIDP). The area is bounded by the fringe of forest in the north, by NEC in the south, by the Tilawe river in the west and by the Pasaha river in the east. The Birganj - Hetauda Road passes through the study area in south - north direction bisecting the area almost equally (Location Map).

Administratively the western half of the study area, i.e. between the Tilawe river to the Birganj - Hetauda Road, is included mostly in Parsa district and the remaining area up to the Pasaha is located within the jurisdiction of Bara district. These areas are further managed by 14 village development committees (VDC) in Parsa district and by 31 VDCs in Bara district. The district office of Parsa is located at Birganj and that of Bara is located at Kalaiya.

3.2 Population and Labour Force

The present population and the number of households in the study area were estimated at 225,330 persons in 36,214 households based on the preliminary findings of the Population Census 1991. The population as of 1993 was forecast from that as of 1991 assuming the same population increase rates as during 1981-1991 at 2.62% and 2.71% in Bara and Parsa districts, respectively. The average family size is estimated at 6.22. Population density in the study area is 685 persons/km^2, which is much higher than the average of Bara and Parsa districts at 310 persons/km^2.

Study Area	Total No. of Household	Population			Family Size
		Total	Male	Female	
Area in Bara	25,430	158,683	81,789	76,894	6.24
Area in Parsa	10,784	66,647	34,328	32,319	6.18
Total	36,214	225,330	116,117	108,207	6.22

Source: Estimated from the preliminary results of the National Population Census 1991.

The study area is characterized by abundant labour resources and thus labour availability is not supposed to constrain agriculture sector. Available labour force for farming activities was estimated at about 113,000 based on above population, rate of economically active population at 67%, and rate of economically active population mainly engaged in agriculture at 75%. A preliminary estimation shows that the annual and peak month labour requirements are only at only 16% and 42% of annual and monthly available labour force.

3.3 Natural Conditions

3.3.1 Topography

The study area lies on a flat and fertile land with the elevation ranging from 140 m to 70 m sloping down from north to south at the gradients of 1:350 in the northern half of the area

and 1:1,000 in the southern half of the area. The area is intersected by north to south natural streams and rivers. These rivers form the boundaries of irrigation blocks. The topography of the area is suitable for irrigation farming.

In the study area, the following maps and aerial photographs are available:

(a) Topographic maps on a scale of 1:5,000 prepared by UNDP/FAO in 1971, which cover the southern two-thirds of the study area.

(b) Topographic maps on a scale of 1:50,000 prepared by the Government of India in 1957, which cover the whole study area.

(c) Contact print of aerial photographs on a scale of 1:50,000 prepared by the Survey Department of HMGN in 1978, which cover the whole study area.

(d) Contact print of aerial photographs on a scale of 1:25,000 prepared by the Survey Department of HMGN in 1989, which cover the northern half of the study area.

(e) Contact print of aerial photographs on a scale of 1:40,000 prepared by the Survey Department of HMGN in 1987, which cover the southern half of the study area.

3.3.2 Climate

Favorable climatic factors in the study area permit growth of a wide range of sub-tropical arable crops. However, some limitations exist; lower sunshine in the monsoon season, uncertain distribution of rainfall and low temperature in winter. Those climatic limitations naturally govern the cropping patterns to great extent: paddy maturation is hindered between November and February, onset of monsoon in June hinders harvest of early matured paddy, maize, soybeans, groundnuts and almost all vegetables have very poor yields when cultivated during the monsoon.

The following summary table gives the main features of climatic conditions observed at Parwanipur (Ref. Annex B).

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total or Average
Rainfall (mm/month)	12.0	17.0	15.0	41.0	105.0	256.0	457.0	299.0	255.0	75.0	5.0	13.0	1,550.0
Evaporation (mm/day)	1.8	2.9	4.7	6.8	7.0	6.3	5.5	4.9	4.2	3.4	2.5	2.0	4.3
Sunshine (hr/day)	7.5	8.2	9.0	9.1	9.6	6.2	4.8	6.5	7.0	8.1	8.6	7.9	7.7
Air Temperature (°C)	15.7	17.6	22.7	27.4	29.3	30.0	29.2	29.1	28.2	26.2	22.0	17.0	24.5
Wind Speed (km/hr)	2.2	3.3	4.6	6.4	7.1	6.7	6.3	5.7	4.7	2.6	2.0	1.8	4.4
Relative Humidity (%)	85.0	78.0	63.0	56.0	65.0	76.0	79.0	83.0	83.0	78.0	75.0	81.0	75.0

3.3.3 Hydrology

In and around the study area, there flow many number of north - south flowing rivers, among which the predominant ones are the Tilawe, Phanthi, Bheraha, Sirsiya, Bangari, Pasaha, Thalhi, Tiar, Jamuni, Arwa and the Bhakuwa rivers, on which there is no regular

gauging station. The hydrological study on these rivers was made by Multi Disciplinary Consultants (P) Ltd., Nepal in 1988 and its results were presented in the study report on "Local River Use and River Training". According to the study results, the floods of these rivers for respective return periods are as shown below and their estimated mean monthly discharges are as shown in Annex B.

Name of River	Catchment Area (km^2)	Flood in Return Period of 100 yrs (m^3/sec)	50 yrs (m^3/sec)	10 yrs (m^3/sec)
Tilawe	264	1,351	1,196	828
Phanthi	53	339	298	205
Bheraha	78	592	526	366
Sirsiya	96	633	560	388
Bangari	204	1,152	1,022	710
Pasaha	228	1,341	1,191	829
Thalhi	69	540	478	333
Tiar	43	329	290	200
Jamuni	107	731	648	451
Arwa	141	882	783	544
Bhakuwa	21	138	121	83

Among the above-mentioned rivers, the Tilawe, Sirsia, Pasaha, Thalhi, Tiar, Jamuni, and the Arwa rivers give some perennial flow at the crossing points with NEC and sporadic discharge measurements have been made by the NZIDP office and this study team at the said crossing points as shown in Annex B. According to these measured results, the discharges of these rivers in the dry season particularly in March to May, which can be used for augmentation of NEC discharge in the dry season through diversion, are in the order mentioned below.

Name of River	Discharge in Dry Season (m^3/sec)
Tilawe	0.40 - 0.50
Pasaha	0.20 - 0.30
Tiar	0.30 - 0.60
Jamuni	1.00 - 3.00

3.3.4 Geology

Within the regional geotectonic frame, the Terai, northern extension of Indo-Gangetic Plain, is included in the sub-Himalaya geotectonic unit, unconformably overlying the Siwalik Formation. The Terai plain lies on the northern edge of the Indo-Gangetic Plain immediately south of the Siwalik Hill. It is formed of unconsolidated alluvial deposits comprising coarse fan deposits, clay, silt, sand and gravel in variable proportions. In general, coarse sediments are confined to northern foot-hills and popularly known as "Bhabar Series". These coarse sediments gradually pass on to relatively finer sediments known as Terrain Plain Deposits through a narrow Transitional Zone. The geological succession can be generalized as given below.

Formation	Age	Lithology
Terai Alluvium	Holocene to Recent	Coarse Fan deposits, Silt, Sand, Gravel and Clay
Upper Siwalik	Plio-Pleistocene	Conglomerate, clays, sands, pebbles
Middle Siwalik	Upper Pliocene	Pebbles, sandstones, minor state and clays
Lower Siwalik	Late Miocene	Nodular shales and clay, sandstones and pseudo-conglomerates
Lower Gondwana	Upper Carboniferous to Permian	dolomite, State, shale, meta-sandstone
Metamorphic Series	Pre-Cambrian to Lower Paleozoic	State, Phylise, Schist, Gneiss, Granite-gneise

In the present context, the metamorphic series and Lower Gondwana formations are collectively grouped as "Basement". The "Basement" rocks are exposed along the Mahabharat Hills (Lower Himalaya); a mountain range between the Siwalik Hills and the Midland basin (e.g. Kathmandu Basin).

Broadly speaking, the Terai Alluvium is a wedge-shaped deposit which pinches out of the foot-hills and thickens southward on to the plain. The alluvial deposits have so far not been penetrated and hence the actual thickness is not known. However, drilling for petroleum exploration upto a depth of 450 m in Rauxal area did not hit bed rock. A generalized north - south schematic profile is illustrated in Fig. 3.1.

3.3.5 Hydrogeology

Abundant groundwater resources were identified in the study area through the extensive hydrogeological investigation made under the UNDP/FAO Programme in 1971 and the Groundwater Investigation in Bara and Parsa made by UNDP Programme in 1992. According to the results of hydrogeological investigation made under the said UNDP/FAO Programme, there found that three zones of aquifers; layer 1 phreatic aquifer, layer 2 artesian aquifer and layer 3 artesian aquifer. Among these aquifers, the Birganj deep tubewell scheme under NZIDP intended to develop the layer 3 aquifer, while the community tubewell scheme depended on the layer 1 aquifer for its water source.

3.3.6 Soil and Irrigation Suitability of Land

According to the Land System Maps prepared in 1986 under Land Resource Mapping Project (LRMP) financed by the Canadian International Development Agency (CIDA), about 26,460 ha (80%) out of 32,900 ha of the total study area is occupied by the recent alluvial plain having fine to loamy soils and about 2,850 ha (9%) is occupied by the alluvial fan apron complex with loamy soils mainly extending over the area immediately south of the forest. The remaining area of 3,590 ha (11%) lies on the active alluvial plain extending along both banks of the rivers as mentioned in Annex-A.

The land capability map also prepared by CIDA in 1986 shows that almost all the study area, except a few patches of lands along the Dudhoura river (150 ha), Bangari river (50 ha) and the Pasaha (60 ha) which are frequently flooded and categorized in Class.V, belongs to Class I, in which the lands are nearly flat (less than 1° slope). The soils are deep and they have few limitations for arable agriculture as mentioned in Annex-A.

As for the irrigation classification of the land in the study area, the said land capability map also shows that about 29,880 ha (91%) is categorized as Class 1 (27,530 ha) or Class 2 (2,600 ha) of the irrigation classification. The rests are categorized in Class 5 (2,510 ha) and the frequently flooded area (260 ha) for which no irrigation classification is given. In this classification, the land categorized in Class 1 is suitable for the diversified crop cultivation and the Class 2 land is moderately suitable for the diversified crop cultivation. The lands categorized in Class 5 are not arable at present.

3.4 Infrastructures

3.4.1 Transportation and Communication

In the study area, there exist two asphalt-paved roads: one is Birganj-Hetauda Road and the other is the road connecting Birganj to Kalaiya which is the market center in the Bara district, so-called Birganj-Kalaiya Road. The Birganj-Hetauda Road runs in south-north direction dividing the study area into two almost equally and meets the East-West Highway at Pathalaiya located 25-km north of Birganj. Both roads are well-maintained and playing an important role for the transportation and communication in this region.

Other than the above-mentioned roads, the important roads in the study area are NEC operation road and the so-called Janta Road, both of which run almost in east-west direction forming the south and north boundaries of the study area respectively. The NEC operation road with gravel pavement is provided on the right bank of the canal and of all-weather type. The Janta Road runs almost along the fringe of the forest in both Parsa and Bara districts. The road in the part of the study area is gravel-paved and passable even in the rainy season.

In addition to the above main roads, there are many roads which run in north-south direction connecting the Janta Road to the NEC operation road or Birganj-Kalaiya Road at the interval of 3.5 km on an average. All these roads, except two roads, are bumpy without any pavement and bridges.

The area is served by scheduled air flight two times in a day between Kathmandu and Simra located 20-km north of Birganj.

General public communication system in the study area is postal system. The telegraphic and telephone services are also available in Birganj and Kalaiya.

3.4.2 Power Supply

The section of the system of interest in the study area includes the East-West 132 kV grid line, and the 66 kV double circuit line in the Hetauda-Birganj corridor. The present NEA

system in the study area includes the use of 66 and 33 kV lines for power transmission with distribution at 11 kV. NEA plan for expansion in the study area is to extend these same arrangement rather than changing to 33 kV.

3.4.3 Irrigation System

(1) Existing Irrigation Schemes in the Study Area

(a) Farmers Managed Irrigation Scheme (FMIS)

According to the inventory survey made in this study period, there are 59 FMISs in the study area; 45 in Parsa district and 14 in Bara district, and their gross command area is 6,330 ha (5,040 ha in net) in total, 3,990 ha (3,190 ha in net) in Parsa district and 2,340 ha (1,870 ha in net) in Bara district as shown in the following table and their locations are as shown in Fig.3.2.

Parsa District

River	No. of FMIS	Gross Command Area (ha)
Amadai	4	170
Bougi	4	660
Phanti	13	1,620
Phokaha	3	310
Manbodhi	4	160
Mahabeva	3	140
Lotaha	1	20
Singhya	2	220
Dodawa	1	150
Kiyosot	1	250
Nasiya	1	10
Jhingai	1	10
Sukhi	1	30
Megha	4	130
Aurahi	1	80
Chegraha	1	30
Total	45	3,990

Bara District

River	No. of FMIS	Gross Command Area (ha)
Bangri	1	150
Dudhaura	2	170
Katoh	2	300
Sirsia	1	60
Bhaluhi	2	250
Tenlahar	1	250
Emiriti	1	560
Balganga	1	90
Bengahi	1	80
Kirkichaha	1	330
Doodwa	1	100
Total	14	2,340

These areas are mainly located along small seasonal streams originating from the Churia hills. These streams generally provide sufficient water for monsoon paddy cultivation in the normal monsoon year, but according to the results of farm interview and the discharge measurement conducted in March 1993 (Ref. Annex B), it is judged that the river discharge in the dry season is sufficient only for the irrigation of 2,500 ha and remaining 2,540 ha is fallow in the dry season.

(b) Sirsia-Dudhaura Irrigation Scheme (SDIS)

In the study area, there runs the SDIS irrigation system constructed in 1957, which covers a gross irrigation area of 2,050 ha (1,620 ha in net). The system is composed of two overlapping irrigation systems, namely, Sirsia Irrigation System (SIS) fed by the Sirsia river and Dudhaura Irrigation System (DIS) fed by the Dudhaura river as

shown in Fig. 3.2. These two systems have altogether 13 km of main canal; 6 km of Sirsia Main Canal having 3 branch canals and 7 km of Dudhaura Main Canal having 4 branch canals. Out of net command area of 1,620 ha, 1,100 ha comes under SIS and 520 ha under DIS. Some part of this irrigation area, about 150 ha is getting supplemental water supply in the dry season from three deep tubewells; No.2, No.6 and N-14 of NZIDP.

All the canal systems in this area have been improved under the Irrigation Management Project of USAID and the improvement of essential structures and necessary earth works have been made also. After the above improvement of the canal system, the irrigation management and water distribution in the area have been successfully practiced by establishing water users associations (WUA) at the branch canal level and water users groups (WUG) at the tertiary canal level. The maintenance of the main canal is being done under the responsibility of DOI, whereas the maintenance of branch and tertiary canals are being made under the responsibilities of WUAs and WUGs.

Even after the above improvement and water management of the canal systems, however, SDIS is facing a shortage of water supply. The combined discharge of Sirsia and Dudhaura rivers in the dry season is estimated at 0.40 - 0.50 m^3/sec, which can irrigate about 400 - 500 ha at the maximum. Since the net irrigation area of SDIS is about 1,470 ha in the dry season, which excludes 150 ha being irrigated by said three tubewells, about 1,000 ha of the area is in a shortage of irrigation water in the dry season.

(c) Shallow Tubewells

A large number of shallow tubewells have been recently drilled by farmers in Bara and Parsa districts for irrigation purpose. According to ADBN of Bara district, only in the last fiscal year, about 500 shallow tubewells have been drilled north of NEC covering about 2,000 ha in net. Drilling of the wells in the study area is still continuing and likely to increase in number in future. Similarly, some areas north of NEC in Parsa district in the study area is being irrigated by STWs. The lists of wells in respective VDCs of Bara and Parsa districts in the study area are as shown in Table 3.1. According to this table, about 1,700 shallow tubewells in Bara district including 26 NZIDP community tubewells mentioned in Sub-Section 3.4.3 (2) (c) hereof and 140 in Parsa district had been drilled by January 1993 and their command areas were about 4,490 ha and 420 ha respectively.

(d) Deep Tubewells

There are five deep tubewells working for the irrigation of 175 ha in the study area, of which two covering 40 ha each are being operated by DIO of Bara district, one (35 ha) by farmers' organization, one (30 ha) by the Parwanipur Agricultural Station and other one (30 ha) by sugar cane farm of Birganj Sugar Factory.

(2) Narayani Zone Irrigation Development Project

(a) Nepal Eastern Canal

The surface water supply of NEC is being diverted from the left (east) bank intake of the Gandak Barrage on the Narayani River through India's Main Eastern Canal (MEC) and Don Branch Canal. NEC is directly supplied with water from the Don Branch Canal near Indo-Nepal border and extends eastward for about 75 km to the Bagmati river. The canal was planned and constructed to serve the project area of 37,980 ha to the south of NEC up to the Indo-Nepal border. The command area is divided into following 15 blocks, the boundaries of which are defined largely by the rivers which flow in a north-south direction.

Stage I command area	Block 1 to 6	17,400 ha
Stage II command area	Block 7 to 12	12,280 ha
Stage III command area	Block 13 to 15	8,300 ha
		37,980 ha

The NEC system including main secondary canals and distributaries up to 20 cusec (0.75 m^3/sec) capacity was originally constructed by the Bihar Government. The Stage I and II of the project area (29,680 ha) have been recently developed including provision of additional secondaries and tertiary systems with improvement to original main canal and distributaries up to 20 cusec.

Under the Stage III of NZIDP, the original main canal and distributaries were upgraded and some of distributaries were extended to cover their respective command areas. Tertiary canal development is being implemented and scheduled to be completed by June 1994 up to the Stage II command area. Flood control and river training works in major rivers were also done to protect the project area against floods from the rivers crossing NEC.

The Indo-Nepal agreement for the water supply of Gandak Barrage specifies that 24.1 m^3/sec of water would be delivered to NEC on perennial basis from the Don Branch Canal except two scheduled closure periods for the repair and maintenance of the Don Branch Canal. These closure periods are in November /December (45 days) and in March/April (30 days).

The discharge measurement records at the head of NEC are available for the period from 1980 to 1992 except 1990, though they are sporadic, as shown Annex B and summarized in Table 3.2. These records reveal that the discharge of 24.1m^3/sec has never been available on perennial basis. The discharge is highly erratic and unreliable. Judging from the historical records of NEC and the physical condition of the Don Branch Canal, it is difficult to assure that the agreed supply of 24.1m^3/sec will be made available in foreseeable future on continuous basis.

In order to overcome such inferior water supply condition of NEC, NZIDP constructed 7 inlet structures on the left bank of NEC to lead irrigation water from the Uria, Sikta,

Bangari, Pasaha, Thalhi, Jamuni and Arwa rivers for the augmentation of the NE(water supply. Farmers also constructed a temporary type of earthen brush-wood dar on the Jamuni river to irrigate about 2,500 ha in the NEC command area between th Tiar and Arwa rivers. In addition, the farmers have also constructed more than 1,20(shallow tubewells in the NEC command area from Block 1 to Block 12 as shown i the following table to irrigate some 3,000 ha.

Block Area	Number of Shallow Tubewells	Block Area	Number of Shallow Tubewells
1	17	9	127
2	18	10	183
3	19	11	231
4	7	12	260
5	59	13	188
6	21	14	60
7	31	15	196
8	248	Total	1,665

(b) Deep Tubewells

Under the NZIDP financed by IDA, 14 existing deep tubewells, which were constructed under Minor Irrigation Program funded by India, were rehabilitated and 14 deep tubewells were newly developed. There was also one observation well drilled in 1971, which was converted into production well in 1985. Thus, 29 deep tubewells are available in the NZIDP area and the total irrigation area of these tubewells was planned to be 2,730 ha. However, out of 29 tubewells, 19 tubewells were reported operational and 3 tubewells were non-operative due to non availability of spare parts for pumps and motors. According to the result of field survey made by the study team in March 1993, however, only 15 deep tubewells are being operated at present to irrigate 900 ha and the remaining 14 wells are not operative because of tubewell failure (7 Nos.) and damage of pump and motor (7 Nos.).

According to the data provided by the NZIDP office, the annual operation hours and the total irrigated area of the above mentioned tubewells for past 10 years from 1980/81 to 1989/90 except 1989/90 are as follows:

Year	Pump Nos. Operated	Irrigated Area ha	%	Average Operation Hour Per Pump
1980/81	20	911	33	662
1981/82	19	776	28	680
1982/83	25	1,535	55	1,140
1983/84	18	1,760	63	1,040
1984/85	21	12,130	41	824
1985/86	22	1,037	37	620
1986/87	21	1,106	40	520
1987/88	21	1,094	39	747
1988/89	16	1,019	37	-
1990/91	21	2,001	73	629

(c) Community Tubewells

Towards reducing the investment burden on HMGN for groundwater development, the community shallow tubewell development scheme was implemented in the study area under NZIDP Stage - II as the pilot scheme. The scheme aimed to explore and develop the farmers' capability of finance and to operate shallow tubewells themselves with some assistance from ADBN and the NZIDP staff. For this purpose, 63 community shallow tubewells were drilled, out of which, however, only 26 tubewells have been installed with pumps and diesel engines by farmers and the rest have been capped and not in use. Neither NZIDP nor ADBN Bara and Parsa were found to encourage farmers to install pumps and diesel engines taking subsided loan from ADBN. Many farmers are willing to use these tubewells for irrigation purpose, if the government restores the drilled tubewells and persuade farmers to install their pumps.

3.5 Agriculture

3.5.1 Land Holding and Land Tenure

The average size of operational land holding in the study area is estimated at 1.11 ha, according to the farm household survey. Land holding shows a skewed distribution in favor of larger farms. The lowest 68% class in farm size farms own only 28% of land, while the highest 11% own 39% of land. Land distribution and average sizes among different farm size classes are shown below.

Farm Size		% of Household	% of Area	Average Size of Holding (ha)
Marginal	(- 1.02ha)	68%	28%	0.46
Small	(1.02 - 2.71ha)	22%	33%	1.66
Medium	(2.71 - 5.42ha)	9%	29%	3.63
Large	(5.42ha -)	2%	10%	7.14
Overall		100%	100%	1.11

Source: Farm household survey

Land ownership of households is estimated as follows:

Ownership Status	percent in total
1. Owner operator	51%
2. Owner cum rented out operator	3%
3. Owner cum rented in operator	32%
4. Exclusive tenant	13%
5. Mixed operator (owner, rented out and rented in)	1%

Source: Farm household survey

About 35% of cultivated land is under tenant contracts, of which two-thirds are of crop sharing and the rests are of fixed rent. Prevailing rents are half of gross products in share cropping and about 540 kg/ha of paddy in fixed in kind rent.

3.5.2 Land Use

Present land use in the study area is estimated based on the result of the Land Resources Mapping Project (LRMP). Gross farm land occupies 29,060 ha or 88.3% of the total study area and 3,840 ha or 11.7% is non-farm land. The farm land is sub-divided into three categories, i.e., wet land, upper wet land and dry land. Wet land and the most part of upper wet land are cultivated for paddy during monsoon season. The non-farm land is comprised of mix land, urban land, grazing land and forest land. The following table shows the land use in the study area.

Item	Land Use Area (ha)	(%)
Farm Land	29,060	88.3
1. Wet Land	17,130	52.2
2. Upper Wet Land	11,740	35.7
3. Dry Land	190	0.6
Non-farm land	3,840	11.7
1. Mix Land	1,400	4.2
2. Urban Land	100	0.3
3. Grazing Land	1,730	5.3
4. Forest Land	610	1.9
Total	32,900	100.0

Source: Estimated from LRMP Land Use Map

Out of the gross farm land of 29,060 ha, 23,890 ha is estimated to be net farm land after subtracting land occupied by river bed, irrigation facilities, road, houses and others. In terms of irrigation condition, farm land is categorized into fully irrigated land, partially irrigated land and rainfed land. Fully irrigated land occupies 39.4% of net farm area, partially irrigated 14.8% and rainfed 45.8%, as shown below. The existing irrigation systems in the study area consist of Farmers Managed Irrigation Schemes (FMIS), the Sirsia-Dudhaura Irrigation Scheme (SDIS), shallow tubewells (STW) and deep tubewells (DTW).

Scheme	Gross Land Area (ha)	Net Farm Area (ha)	Fully Irrigated Area (ha)	Partially Irrigated Area (ha)	Rainfed Area (ha)
FMIS Area	6,300	5,040	2,500	2,540	0
SDIS Area	1,840	1,470	470	1,000	0
STW Area	6,140	4,910	4,910	0	0
DTW Area	1,910	1,530	1,530	0	0
Rainfed Area	12,870	10,940	0	0	10,940
Total	29,060	23,890	9,410	3,540	10,940
Percent		100.0%	39.4%	14.8%	45.8%

Note : Partially irrigated areas are irrigated in summer season but not in dry season .

3.5.3 Cropping Pattern and Agricultural Production

Crop cultivation in the study area is practiced in total 23,890 ha of farm land. The household survey results indicate that fully irrigated farming has the highest cropping intensity of 185.0% followed by partially irrigated at 149.1% and rainfed at 146.2%. The cropped areas under fully irrigated, partially irrigated and rainfed conditions are estimated to be 17,410 ha, 5,280 ha and 16,000 ha respectively. The total cropped area in a year is thus estimated at 38,690 ha. The area under different crops and cropping intensity, by irrigation status of the study area is presented below.

Crop	Fully Irrigated		Partially Irrigated		Rainfed		Total	
	C.I.(%)	Area (ha)	C.I.(%)	Area (ha)	C.I.(%)	Area (ha)	C.I.(%)	Area (ha)
Early Paddy	1.2	2,287	1.2	42	1.2	131	10.3	2,460
Monsoon Paddy	95.0	8,940	95.1	3,367	93.2	10,196	94.2	24,963
Summer Maize	-	-	-	-	1.5	164	0.7	459
Sugarcane	4.8	452	4.8	170	2.4	263	3.7	884
Summer Pulse	0.1	9	0.1	4	0.1	11	0.1	24
Summer Vegetables	0.1	9	0.1	4	0.1	11	0.1	24
Wheat	41.1	3,868	20.5	726	20.5	2,243	28.6	6,836
Lentil	12.3	1,157	19.3	683	19.3	2,111	16.5	3,952
Oil Crops	3.0	282	4.2	149	4.2	459	3.7	890
Winter Maize	1.9	179	0.8	28	0.8	88	1.2	295
Potato	1.0	94	0.6	21	0.6	66	0.8	181
Winter Vegetables	0.9	85	0.3	11	0.3	33	0.5	152
Other	0.5	47	2.1	74	2.1	230	1.5	375
Total	185.0	17,410	149.1	5,280	146.3	16,000	162.0	38,690
(Land Area)		9,410		3,540		10,940		23,890

Note: Totals may not sum due to rounding.

Various cropping patterns are adopted by farmers, depending on availability and sources of irrigation water. The main crops grown in the study area are paddy, wheat, oil crops, lentil, sugarcane and maize. In some of the irrigated area, farmers are cultivating summer vegetables and winter vegetables which are high value crops in terms of return on investment. The graphic cropping calendar and cropping pattern under the present condition are presented in Fig. 3.3. Farming practices presently observed in the study area are described in detail in Annex-D.

Crop yields vary widely depending on the availability of irrigation water, use of agricultural inputs levels and crop management. The average crop yields at present are estimated as shown below referring to the results of the household survey. The crop yields under irrigated condition are about 16% to 76% higher than the rainfed condition depending upon the nature of crops.

Crop	Irrigated Condition (ton/ha)	Rainfed Condition (ton/ha)
Early Paddy	3.0	1.7
Monsoon Paddy	2.8	2.1
Summer Maize	-	2.2
Sugarcane	45.0	38.0
Winter Maize	3.2	2.0
Wheat	2.2	1.6
Lentil	0.7	0.6
Potato	13.0	10.6
Oil Crops	1.0	0.7
Vegetables	7.7	5.5

The total crop production in the study area is estimated based on the above crop yields and cultivated area. The estimated total crop production in the study area amounts to 121,970 tons, of which 64,370 tons are from the fully irrigated area of 9,410 ha, 19,220 tons from the partially irrigated area of 3,540 ha and 38,380 tons from from the rainfed area of 10,940 ha.

(Unit : tons)

Crop	Fully Irrigated Area	Partially Irrigated Area	Rainfed Area	Total
Paddy	31,891	9,498	21,635	63,024
Maize	572	57	536	1,165
Sugarcane	20,326	7,646	9,977	37,949
Wheat	8,509	1,161	3,588	13,258
Lentil	810	410	1,267	2,487
Oil Crops	282	104	322	708
Potato	1,223	225	696	804
Vegetables	724	77	241	1,043
Pulses	33	39	120	192
Total	64,370	19,219	38,382	121,971

3.5.4 Farm Inputs and Labor Use

The present level of farm inputs used in the study area is estimated using the average farm input amount obtained by the farm household survey. Estimated total input use per hectare in the study area is presented below in the table. The present amount of per hectare use of chemical fertilizer is almost one-third of the recommended dose. At present, in total 6,820 tons of seeds, 2,580 tons of complex, 2,690 tons of urea, 24 tons of potash, 44,690 tons of farm yard manure (FYM) and NRs 1,390,000 value of pesticides are estimated to be used in the study area. Total labor use in the study area is estimated at about 4,560 thousand man-days of human labor and 1,220 thousand animal-days of draft labor. Most of farm operations are carried out manually by draft labors and farm labors.

Crop	Seed (kg)	Fertilizer Use				Pesticide (NRs)	Labor use	
		Complex (kg)	Urea (kg)	Potash (kg)	FYM (kg)		Human (days)	Draft (days)
Early Paddy	69	50	60	0	1,087	22	141	32
Monsoon Paddy	60	70	81	0	1,697	52	141	32
Summer Maize	15	6	20	3	644	0	101	27
Sugarcane	4,394	135	110	9	521	77	267	50
Wheat	139	82	82	1	267	2	64	32
Lentil	53	24	2	0	27	0	52	25
Oil Crops	17	33	6	0	209	0	83	28
Winter Maize	23	102	95	6	2,529	29	101	27
Potato	1,152	118	43	33	1,500	218	220	45
Vegetables	0.2	130	87	0	855	236	236	34

3.6 Agricultural Support Service

(1) Agricultural Extension Services

The District Agriculture Development Office (DADO), headed by the Chief District Agriculture Development Officer (CDADO), is responsible for implementing agricultural extension activities at district level. CDADO is supported by agriculture extension officers and subject matter specialists (SMS) stationed in the headquarters. There are seven technical sections and one administrative cum account section in one DADO. Each DADO operates seven Agriculture Service Centers (ASC) within a district. ASC is staffed with an assistant production officer as office-in-charge and three Junior Technicians (JT), three Junior Technical Assistants (JTA). The staff are responsible for implementing agricultural extension activities and provide agricultural advice to the farmer in its command area. The extension activities include agriculture training, method demonstration, production demonstration, block demonstration and farmers' visit program to demonstration or research station.

There are six ASCs located in the study area. The location of DADOs and ASCs are shown in the map in Fig. 3.4. The World Bank promoted T&V system has been adopted in agricultural extension works in the area. The major activities undertaken in T&V system are as follows;

(a) Visit the contact farmer periodically.
(b) Collect farmers' problems and carry them to SMS and feed back to farmers about its solution.
(c) Give impact points according to cropping season.
(d) Organize and attend fortnightly, monthly, bimonthly and biannual meetings and training programs.
(e) Prepare a program for the coming season.
(f) Report his/her work progress to concerned authority.

The existing extension organization and system in the study area seem to be well established. Nevertheless, the extension works practically have not permeated into village farmers well. The results of the farm household survey indicate that the participation of farmers in the extension activities is rather low. The average percentages of farmers who ever

have participated in agriculture training, demonstration conduction, demonstration visit, ASC visit, and DADO office visit are 4%, 4%, 65%, 18%, 25%, respectively. The participation of farmers either in district level visit program or service center level program is almost negligible. These imply that there is a lot of room for improving agricultural extension activities.

(2) Agricultural Training

There are five Regional Agriculture Training Centers (RATC) in the country, which are coordinated by the Central Agriculture Training Center (CATC). Among the five RATCs, one is located in Parwanipur (Bara district) in the center of the study area. CATC and RATC organize training programs on various subjects to farmers, progressive farmers, JTAs, JTs and officers. DADO also organizes training programs to farmers, progressive farmers and JT/JTAs.

(3) Agricultural Research

Out of the 16 Agriculture Research Centers under the umbrella of Nepal Agriculture Research Council (NARC), Sugarcane Research Program Jitpur and Agriculture Rice Research Center Parwanipur are situated in the study area. The research programs in these institutions are basically of varietal investigation, technology generation studies, and breeder and foundation seed multiplication program. The Research Center in Parwanipur extends services for soil test and also deals with solution for agriculture related problems. The Center contains some other research farms such as the horticulture research farm, fishery farm and poultry farm. The technologies generated or developed from the research will be extended and disseminated to farmers through extension agency, publication media and research out-reach activities.

(4) Agricultural Credits

Agricultural Development Bank of Nepal (ADBN) is the major source of agricultural credit in the study area. Nepal Bank Limited (NBL), a commercial bank, also provides some credit to agriculture and agriculture related sectors in the study area, though the loan amount is less than one-tenth of that of ADBN. The location of branches and sub-branches of ADBN and NBL in the study area is as shown in Fig. 3.4.

(a) Agriculture Development Bank of Nepal (ADBN)

ADBN extends agricultural credit either directly to farmers, through cooperative society or through the Small Farmer Development Project (SFDP). ADBN operates branch offices at Kalaiya and Birganj, and these branch offices command three sub-branch offices in Bara district and two in Parsa district. ADBN supplied a total amount of about NRs 46.4 million in Bara district and NRs 48.0 million in Parsa district in the fiscal year 1991/92. The largest part of ADBN loan was financed to crop cultivation followed by agricultural tools and irrigation in Bara district during the last four years. The largest share went for agricultural tools in Parsa district followed by crop cultivation during the same period.

The interest rate of ADBN ranges from 18% to 20% per annum depending upon the objectives of loan. Repayment period varies by nature of loan purpose from 18 months to more than seven years. The government provides subsidies consisting of interest subsidy and capital subsidy for ADBN credit so as to facilitate the farmers to increase their agricultural productivity.

(b) Nepal Bank Limited (NBL)

NBL is only a commercial bank that provides agricultural credit in the study area. One branch office in Kalaiya and three sub-branch offices in Bara and one branch office in Parsa are operated in the study area. These NBL offices together supplied about NRs 2,434 thousand in agriculture sector, NRs 759 thousand in cottage industry sector and NRs 1,082 thousand in service sector in 1991/92. Interest rates charged by NBL are more or less similar to those charged by ADBN, but no subsidy is provided to NBL loans.

(5) Agricultural Inputs Distribution

Agricultural Input Corporation (AIC) operates two branch offices at Kalaiya and Birganj, which supplies inputs to farmers mainly through cooperative societies and registered private dealers. There are 14 cooperative societies, 10 cooperative depots and 34 private dealers in the study area. The two AIC branch offices respectively sold 61 tons and 129 tons of crop seeds and 10,529 tons and 12,339 tons of chemical fertilizers in 1991/92.

Out of 28 and 24 cooperatives (including one cooperative union) existing in Bara and Parsa district respectively, 10 and 4 are either located in the study area or serve the VDCs in the study area. The total amount of crop seeds and chemical fertilizers sold by the cooperatives in the study area in 1991/92 was 35 tons and 5,500 tons respectively. The location of cooperatives is shown in Fig. 3.4.

District AIC offices have a program to grow seed multiplication. In Bara and Parsa districts, about 240 ha of seed multiplication program was carried out in 1990/91 and 355 ha in 1991/92. Multiplied seeds are processed at AIC processing center and distributed through cooperatives or private dealers.

3.7 Water Users Association

3.7.1 General

The Irrigation Policy of 1992, HMGN, has explicitly given an importance to farmers organization. The policy puts an emphasis on the willingful participation of the water users through their organization called Water Users Association (WUA). There are both informal and formal WUAs in the study area. These WUAs have independent style of operation, but they have common objective of distributing water to the users on equity basis. The reason for organizing such WUAs is to make users capable to harness benefit from the project and get

justifiable return to the investment. It would make the irrigated agriculture sustainable and increases the farm production. It would also reduce operation and maintenance cost burden of the government.

The difference between informal and formal WUAs is that the informal WUA is formed among the water users without any legal registration, whereas the formal WUA is formed with the appropriate constitution, recognized and legally registered in Chief District Office (CDO).

3.7.2 Informal Water Users Association

The water users in the study area have traditionally been associated with informal WUAs. The formation of the informal WUA is based on local water source and water need for resource mobilization. The WUA committee members are chosen by voice in a general meeting. The leader of WUA calls general meeting to carry out maintenance work. The records of labor and cash contribution are maintained by the secretary who is elected by the water users.

The WUA mobilizes resources for operation and maintenance of the irrigation system on the basis of size of the irrigated land. Generally the WUA committee is assisted by the secretary and some messengers in preparing description of cash and labor mobilization required from each users. The messengers inform users of the schedule of maintenance work and required labor contribution from each water users. For water distribution, messengers inform users of water distribution schedule. They get a portion of harvest from water users. Rules of water distribution and punishment for irregularities are adopted by the general meeting of the water users.

3.7.3 Formal Water Users Association

There are two types of formal WUAs in the study area: (1) WUAs organized as per DOI recommendation and registered at the concerned project office or District Irrigation Office (DIO) and (2) WUAs organized by the users of FMIS and registered CDO following the Association Registration Act 2034. The WUAs under NZIDP and SDIS belong to the first category and WUAs of FMISs belong to the second category respectively.

In NZIDP, the project office is responsible to collect annual water charge from the users at the rate of NRs. 200 and NRs. 400 per hectare for using surface water and groundwater respectively. The fixed water charge covers only a small portion of the required operation and maintenance costs. Supply of surface water is done in rotation to have equity in water distribution. But demand for tubewell water is honored only when the users produce the last year's paid receipt of water charge to the pump operator.

The formal WUAs in FMIS have written the regulation for O&M, resource mobilization and enforcement of rules and regulations of WUA functioning. Canal cleaning is done 1-3 times in a year. Mobilization of labor for maintenance work is done based on the rates determined by the WUA committee. If some water users do not participate in canal cleaning,

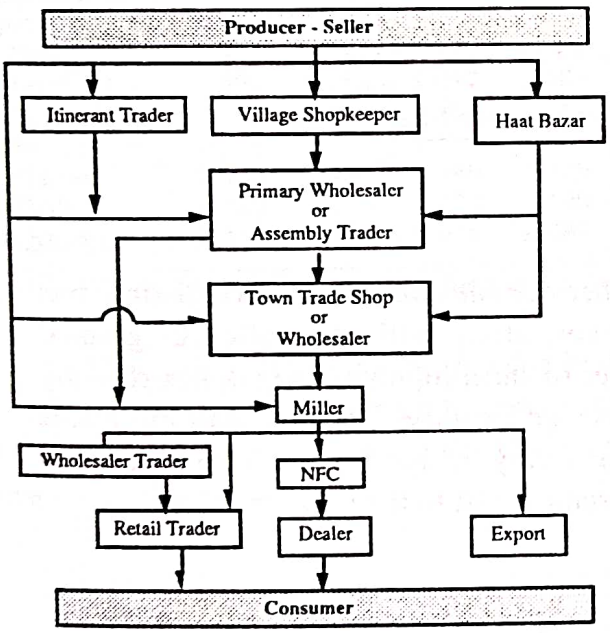
they are fined at the rate defined by the committee. Water distribution is done following a distribution schedule decided by the committee. Water conflicts are put forward to the committee. The messengers inform of water supply dates to the users.

The decisions of WUAs in the study area for using irrigation water are guided by economic and management aspects of the system operation. This is more so in the case of Bara district. They are ready to adopt any system, if it pays back and if it is easily manageable. Three crops cultivation in a year has become a common practice in Bara district.

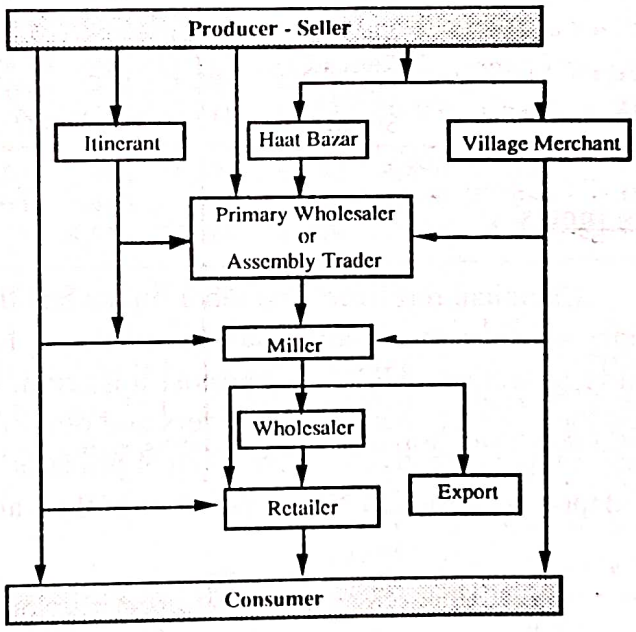
3.8 Market and Prices

3.8.1 Marketing of Crops

Marketable amounts of major food crops from the study area towards other areas are estimated at 21,450 tons of paddy, 2,230 tons of wheat, 1,130 tons of lentil, 210 tons of oil crops and 40 tons of potato. Those products are marketed through various channels including small periodic markets (*haats*), wholesalers, itinerant traders, Nepal Food Corporation (NFC). The marketing channels of the two most important crops, namely rice and wheat, are depicted below:



Marketing Channels for Paddy/Rice in the Study Area



Marketing Channels for Wheat in the Study Area

3.8.2 Processing and Storage Facilities

Rice and wheat consumed within rural areas and those sold at *haat* bazaar are processed at small rice and flour mills located in villages. Cellar and huller mills are located in larger town such as Birganj processing those dealt by large wholesalers/traders. Maize and oil crops are also milled in the same rice/flour mills in separately installed machines. Sugarcane is mostly processed at the Birganj Sugar Factory which is the only one sugar factory in the area.

Foodgrains are stored at farm level in traditional containers called Dehari and Gun Those earthen or bamboo-made bins are not moisture proof which lead to high storage loss if the products are stored for long period. Fumigation or other insect pest control measures farm level are not practiced. Wholesalers and millers have comparatively better stora facilities which are safe in terms of insect and pest infections.

AIC and cooperatives own warehouses with a capacity of 3,250 tons in total in t study area. Those are used for storing mainly farm inputs rather than farm products.

3.8.3 Prices of Crops and Farm Inputs

Crops

The prevailing farmgate prices for major crops in 1991/92 collected through the far survey are as follows:

(Unit: NRs/kg)

Crop	Farmgate	Wholesale	Retail
Paddy Coarse	5.1	5.6	6.9
Paddy Fine	6.5	7.2	7.3
Wheat	5.5	7.0	7.3
Maize	5.0	5.6	6.1
Mustard	14.4	17.3	17.9
Lentil	10.9	n.a.	n.a.
Sugarcane	0.60	(factory price NRs. 0.72/kg)	

Farm Inputs

Chemical fertilizers and other inputs had been heavily subsidized until recently in form of cost subsidy and transportation subsidy. However, along with the policy of gradua subsidy reduction, AIC, the foremost important dealer of farm inputs in Nepal, has recentl raised the price of chemical fertilizers and other inputs significantly. The AIC uniform price of major inputs are given below. Actual prices at villages vary by the distance from the neares AIC depot, being added NRs 10/ton/km of the transportation cost to the uniform prices.

(Unit: NRs)

Input		Unit	Prices at February 1993	Prices Last Year
1. Fertilizer				
Urea	(46: 0: 0)	kg	5.55	5.41
Complex	(20:20: 0)	kg	10.00	5.68
M.Potash	(0: 0:60)	kg	8.50	2.90
A.Sulphate	(21: 0: 0)	kg	6.90	4.20
DAP	(18:46: 0)	kg	12.50	7.52
TSP	(0:46: 0)	kg	8.00	4.64
2. Crop Seed				
Wheat		kg	12.05	9.55
Paddy	(Coarse)	kg	not available yet	8.20
Paddy	(Mansuli)	kg	not available yet	9.05
Maize		kg	14.70	11.00

Source: AIC, Kalaiya and Birganj

Labor Cost

The wage rates obtained through the farm survey average NRs 20/day for female, NRs 25/day for male and NRs 80/day for bullock. Meals, normally breakfast and lunch, are additionally provided by employers. The average wage rate is estimated at NRs 30/day considering the meal benefit. No seasonal variation in wage rate was observed throughout the study area.

3.9 Farm Economy

3.9.1 Crop Budget

The crop budgets of different crops are estimated on the basis of information obtained in the farm household survey and the market survey. The value and prices used are those in the latest crop season. The estimated crop budgets are presented below.

(Unit: NRs /ha)

	Early Paddy	Monsoon Paddy Irrigated	Monsoon Paddy Rainfed	Maize	Wheat	Oil Crops	Potato	Sugarcane Irrigated	Sugarcane Rainfed	Lentil& Pulses	Vege-tables
Gross Return	11,611	19,124	14,343	11,352	9,200	10,080	53,000	27,315	23,066	6,585	35,750
Production Cost	4,124	5,212	4,415	3,285	4,051	1,805	18,832	12,406	10,679	2,295	3,306
Input Cost											
Seed	507	441	441	209	1,327	357	13,824	2,900	2,900	901	200
Fertilizer	699	1,261	1,012	1,183	979	272	1,307	1,518	1,104	215	1,423
Pesticides	22	52	52	17	2	-	218	77	77	-	236
Labor Cost											
Human	1,980	2,490	1,980	1,320	750	690	1,800	6,120	4,890	510	810
Draft	720	720	720	400	800	400	720	1,200	1,200	560	480
Net Return	7,487	13,912	9,928	8,067	5,149	8,275	34,168	14,909	12,387	4,290	32,444

Note : Family labor cost, land tax, irrigation fee are not included in the production cost.

The agricultural production value in the study area is estimated based on the above crop budget and cultivated area of each crop as shown below. In total, farm products valued at NRs 527.3 million is produced and NRs 398.0 million of value added accrues annually in the study area.

(Unit: NRs 1,000)

Crop	Cultivated Area (ha)	Gross Return	Production Cost	Net Return
Irrigated Early Paddy	2,287	46,861	11,095	35,766
Irrigated Monsoon Paddy	12,307	235,359	64,144	171,215
Rainfed Early Paddy	173	2,009	713	1,295
Rainfed Monsoon Paddy	10,196	146,241	45,015	101,227
Maize	459	5,211	1,508	3,703
Wheat	6,836	62,891	27,695	35,196
Oil Crops	890	8,971	1,607	7,365
Potato	181	9,593	3,409	6,184
Irrigated Sugarcane	622	16,990	7,717	9,273
Rainfed Sugarcane	263	6,066	2,809	3,258
Lentil & Pulses	4,327	28,493	9,930	18,563
Vegetables	152	5,434	503	4,931
Total	38,692	527,259	165,048	397,976

3.9.2 Farm Household Budget

The present farm household budget was estimated for five different farm size models which represent marginal, small, medium, large and average farm households. The estimated result shows that the income level of farm households in the study area is absolutely low for marginal and small farmers. Their average incomes are lower than the "poverty line" set by the National Planning Committee (World Bank/UNDP 1990). Larger farmers enjoy higher income and expense in contrast. The farm household budget are summarized below.

(Unit : NRs/year)

Description	Marginal	Small	Medium	Large	Average
In Rainfed Area					
Inflow	19,900	42,490	80,350	152,720	32,310
Farm Revenue	9,620	32,630	69,020	131,420	21,860
Non-farm Income	10,280	9,860	11,330	21,300	10,450
Outflow	19,900	39,400	55,950	118,310	30,440
Farm Costs	2,600	9,080	23,370	48,430	6,720
Living Expense	17,110	29,340	33,960	75,050	23,720
(Household Income)	17,300	33,410	56,980	104,290	25,590
Net Reserve	190	4,070	23,020	29,240	1,870
In Partially Irrigated Area					
Inflow	22,040	50,240	97,300	186,050	37,490
Farm Revenue	11,760	40,380	85,970	164,750	27,040
Non-farm Income	10,280	9,860	11,330	21,300	10,450
Outflow	20,270	40,740	58,890	124,090	31,340
Farm Costs	3,000	10,550	27,230	56,360	7,620
Living Expense	17,110	29,340	33,960	75,050	23,720
(Household Income)	19,040	39,690	70,070	129,690	29,870
Net Reserve	1,930	10,350	36,110	54,640	6,150
Poverty Line Income*	30,611	41,464	45,592	61,639	34,785

Notes: *Estimated by National Planning Commission at US$ 92.76/person
Household income is total inflow less farm costs,

4. THE PROJECT

4.1 Project Concepts

The basic objective set out in the Eighth Plan (1992 - 1997) is to increase agricultural production through the application of irrigation technologies appropriate to: (1) diverse climate and soil conditions and with the minimum detrimental effects to the environment; (2) enhance the credibility of irrigation system through improvement in the management of existing irrigation system; and (3) provide irrigation facilities for the maximum area of land by implementing economically, technically and environmentally sustainable project with the participation of farmers.

In order to achieve these major objectives, the project aims at extension of stabilized irrigated agriculture through conjunctive use of surface water and groundwater. In this view, the particular emphases are laid on the following matters:

(a) Unit yield of rainy season paddy should be increased and stabilized through supplemental irrigation by means of groundwater development, provision of proper drainage and introduction of improved technology of irrigated agriculture.

(b) Diversified cropping pattern including rainy season paddy, wheat, maize, sugar cane, mungbeans, potatoes, vegetables and other cash crops such as mustard and lentil should be introduced to the development area through the provision of year-round irrigation.

(c) Agricultural production should be increased by expanding the irrigation lands through efficient use of the limited groundwater sources.

(d) Agricultural extension services should be strengthened and the linkage with research and training should be improved to attain the high level of crop production.

(e) The project should be so formulated as to bring great impacts on farm economy in the backward areas in the Terai Plain.

4.2 Basic Approach to the Project

4.2.1 Demand Driven as against the Supply Driven

Generally irrigation projects are prepared and implemented by the government without adequate effort in assessing the real need and capability of the intended beneficiaries. As a result, the beneficiaries do not have an adequate knowledge about the project that is going to be developed for them. Thus, they hesitate to participate either in the process of project development or in the operation and management of the project. From this fact, it is judged necessary to inform the users of concept, goals and objectives, and process and procedures of the project implementation. This will provide the beneficiaries with a chance to discuss among themselves and make up their minds with regard to the proposed project.

In addition to the above basic consideration, it is noted that the project should be designed and implemented only after receiving formal applications from users demanding for it. In other words, it should be a demand driven approach as against supply driven approach of the past. The application form should spell out terms and conditions to be followed by both assisting agency as well as beneficiaries. The beneficiaries' commitment for development, O&M and management of irrigation project should be sought in advance to ensure sustainability of the project. The detailed information on processes and procedures of implementation of "demand driven groundwater and/or conjunctive use of surface water and groundwater" need to be developed.

4.2.2 Private Management of Irrigation Facilities

Aiming to reduce the financial burden of operation and maintenance for HMGN, the government has started to hand over deep tubewell systems to farmers. Before handing over the tubewells, however, it is needed for the government to assess the required manpower and workshop facility to be developed in the private sector, to evaluate their capability and to ask the farmers for taking over the tubewells.

The private management is more effective than the public management, if the farmers have an enough capability for O&M and management of the tubewell system. Considering the present less capability of the farmers, therefore, it is advisable to improve the capability of the private sector for the management of irrigation projects.

Public sector should handle only those projects which individual farmers or a group/association of farmers cannot handle owing to huge financial involvement and complicated technology. Even in such a large irrigation system, the scope for joint management should be explored and implemented. For all other small and medium projects, beneficiaries' groups themselves should be made capable for O&M and management of the projects.

Services needed for such projects should also be privatized. Farmers or their associations should be encouraged to provide needed services. They can gradually develop their workshop facilities with some initial training and financial assistance or can have their access to private firms in the local market for repair and maintenance services. The service is supposed to be better from private firms, as they compete for quality.

In case of deep tubewells, the agency people should continue to provide technical support until private capability for such a support system is fully developed. In this case however, care must be taken to encourage private parties to build up their capabilities within a project period.

4.2.3 Water Users Association

Irrigation Regulation Act 2045 B.S. (1988) requires water users to form WUA to actively participate in the development, O&M and management of irrigation projects. The

reason for having WUA is to make users capable of harnessing benefit from the project and get justifiable return to the investment. It makes the irrigated agriculture sustainable and increases the farm production. It also reduces the O&M cost burden of the government. Therefore, it is very necessary to strengthen these organizations such that they can solve all farmer related problems with minimum or no assistance from outside agencies.

4.3 Delineation of the Project Area

The study area was measured on the Land Capability Map prepared by CIDA in 1986 by drawing the fringe line of the forest on the map based on the 1 : 25,000-scaled aerial photographs shot in 1989. The study area thus measured, particularly in the southern two-thirds of the area, was confirmed on the 1 : 5,000-scaled topographic maps prepared in 1971, and obtained to be 32,900 ha in total. Then, after deducting the unsuitable lands for irrigation categorized in Class 2c and 5sd of Irrigation Classification, flooded lands, areas presently irrigated by shallow and deep tubewells and the lands occupied by villages, rivers, roads, irrigation facilities and other facilities from the above-measured study area, the net irrigable area in the study area is obtained to be 13,840 ha as shown below.

(1)	Study area	32,900 ha
(2)	Unsuitable lands	
	(a) Class 2s of Irrigation Classification	670 ha
	(b) Class 2st of Irrigation Classification	290 ha
	(b) Class 5sd of Irrigation Classification	2,620 ha
	(c) Flooded area (Class V of Land Capability)	260 ha
(3)	Gross cultivated land in the study area, (1) - (2)	29,060 ha
(4)	Area perennially irrigated by stream flows in FMIS and SDIS areas	3,710 ha*1
(5)	Existing shallow tubewell areas	6,140 ha
(6)	Existing deep tubewell areas	1,910 ha
(7)	Gross irrigable area in the study area, (3) - {(4) + (5) + (6)}	17,300 ha
(8)	Land occupied by villages, rivers, roads, irrigation facilities and other facilities, 20% of (7)	3,460 ha
(9)	Net irrigable area in the study area, (7) - (8)	13,840 ha

Note *1: This area includes 3,120 ha in FMIS area and 590 ha in SDIS area.

The above obtained net irrigable area in the study area is divided into three different areas according to the existing irrigation schemes and water sources in the area as follows:

(1)	Farmers-managed irrigation schemes (FMISs)	2,540 ha
(2)	Sirsia-Dudhaura Irrigation Scheme (SDIS)	1,000 ha
(3)	Rain-fed area	10,300 ha
	Total	13,840 ha

Based on the above-obtained net irrigable area in the study area and hydrogeological parameters mentioned in Annex C, the optimization study on the groundwater development was made for three kinds of cropping patterns with the conceivable cropping intensities (C.I.) of 195%, 185% and 175% as detailed in Annex C. According to the result of the optimization study, the following areas can be developed for respective cropping intensities without any adverse effects to the existing shallow tubewells and spring-fed rivers being used for irrigation in FMIS and SDIS areas:

Development Area	Possible Irrigable Area (ha)		
	C.I. =195 %	C.I.= 185 %	C.I. = 175 %
(1) FMIS Area			
- Bhabar Zone	617	651	651
- Terai Plain Zone	684	796	872
Total	1,301	1,447	1,532
(2) SDIS Area			
- Bhabar Zone	0	0	0
- Terai Plain Zone	691	799	868
Total	691	799	868
(3) Rain-fed Area			
- Bhabar Zone	2,125	2,193	2,207
- Terai Plain Zone	2,695	2,813	2,942
Total	4,820	5,006	5,149
(4) Total			
- Bhabar Zone	2,742	2,844	2,858
- Terai Plain Zone	4,070	4,408	4,682
Total	**6,812**	**7,252**	**7,540**

Among the above three cases of development plan, the comparative study is made in terms of B/C ratio and net present value (NPV) to seek out the most economical development plan for the project as detailed in Annex E and summarized below.

Cases	B/C Ratio	NPV (NRs.'000)
C.I. = 195 % Case	3.76	2,594,200
C.I. = 185 % Case	3.81	2,648,000
C.I. = 175 % Case	3.47	2,367,300

The above calculated results show that the case of C.I. = 185 % is the most economical option among three from both viewpoints of B/C ratio and NPV followed by the case of C.I. = 195 % and the case of C.I. = 175 %. Therefore, it is concluded that the project be developed for the area of 7,250 ha with the cropping intensity of 185%.

The development area obtained through the optimization study includes some lands where irrigation facilities are rather developed like in the FMIS and SDIS areas and farmers are getting good benefits. On the contrary, some rain-fed lands are excluded from the area of optimized development plan. Considering the equalization of the irrigation benefit, therefore, some adjustment of the development area is made within the limit obtained through the optimization study by cutting some irrigated areas from the optimized development area and by including some outside rain-fed areas in the development area. Thus, the area to be developed under the project (hereinafter referred to as the "project area") is decided to be 7,250 ha as shown below (Fig. 4.1), though this development area needs to be adjusted among the four development areas based on the farmers' demands while implementation.

Development Area		Project Area (ha)	
		Before Adjustment	After Adjustment
(1)	FMIS Area		
	- Bhabar Zone	651	450
	- Terai Plain Zone	796	750
	Total	1,447	1,200
(2)	SDIS Area		
	- Bhabar Zone	0	0
	- Terai Plain Zone	799	970
	Total	799	970
(3)	Rain-fed Area		
	- Bhabar Zone	2,193	1,680
	- Terai Plain Zone	2,813	3,400
	Total	5,006	5,080
(4)	Total		
	- Bhabar Zone	2,844	2,130
	- Terai Plain Zone	4,408	5,120
	Total	**7,252**	**7,250**

As for the remaining area of 6,590 ha of 13,840 ha, its development possibility will be judged based on the further optimization study to be made based on the hydrogeological data which will be collected through the project implementation for the area of 7,250 ha.

4.4 Agricultural Development Plan

4.4.1 Future Land Use

At present 29% of the project area is partially irrigated and the rests are totally rainfed. Under future with project condition, the rainfed area will be gradually changed into suitable land for irrigation agriculture. Most of the project area is classified into suitable land for irrigation, and thus there will no constraints to irrigation development in this aspect. The net farm land of 7,250 ha will be irrigated under the project. Some 320 ha of present farm field will be converted into lands for canals, drains and other irrigation facilities. In discussing agriculture in the project area, hereinafter, without project condition gives agriculture in 7,570 ha and with project condition gives that in 7,250 ha. The change in irrigation condition is presented below.

Land Type	Without Project	With Project
Partially Irrigated Area	2,170 ha	-
Rainfed Area	5,400 ha	-
Fully Irrigated Area	-	7,250 ha
Project Facilities	-	320 ha
Total	7,570 ha	7,570 ha

4.4.2 Proposed Cropping Patterns

In forecasting the future situation under without project condition, it is assumed that the cultivated area, cropping pattern and cropping intensity will remain at present situation. There would not be much change in both cultivated area and cropping pattern in the project area, if

irrigation water is not provided. A drastic change in cropping intensity and cropping pattern will take place only when irrigation water becomes available.

On the other hand, after implementation of the project, farmers will be encouraged to intensify their cultivation. Farmers will choose most profitable crops and they will intend to use improved agricultural inputs to higher level to increase the crop productivity. The cropping intensity as well as crop productivity will certainly increase upto great extent. The project plans to increase the cropping intensity by 38% from present 147% to 185%.

The proposed cropping pattern is framed, taking the following into considerations: 1) climatic condition; 2) sources of irrigation water; 3) socio-economic conditions; and 4) marketing situation. Paddy, wheat, maize and oil crops are the main crops in the frame work of the proposed cropping pattern. Vegetable cultivation is also recommended due to higher benefit expectation. Early paddy is not included in proposed cropping pattern in tubewell areas, because its water requirement is very high and irrigation cost will be thereby increased. The proposed cropping patterns in the project area are graphically presented in Fig. 4.2.

4.4.3 Proposed Farming Practices

In order to realize the benefit of full exploitation of the agricultural potential, a package of improved agricultural technologies needs to be introduced to the project area. The target yields and cropping intensity will be attained through the change in farming practices in addition to stable irrigation water supply. The improved agricultural technology includes the use of improved high yielding varieties, use of recommended dose of nutrient with timely top dressing, use of recommended seed rate or plant density, provision of timely irrigation, good land preparation, timely crop protection and timely crop husbandry.

The present low crop yield is attributed to low dose and erratic use of inputs without any proper technical knowledge. The recommended farming practices and input doses will lead to proper crop density, proper nourishment of crops and proper care of crops, which finally will result in good production. The agricultural input requirements per hectare proposed for future farming practice are shown below.

Crop	Seed (kg)	Fertilizer Requirement			Pesticide (NRs)	Labor Requirement	
		Urea (kg)	TSP (kg)	Potash (kg)		Human (days)	Draft (days)
Monsoon Paddy	50	174	87	33	200	180	40
Summer Maize	30	174	87	33	300	140	36
Sugarcane	4,500	217	130	67	400	320	50
Summer Vegetables	0.5	217	130	167	400	260	45
Wheat	100	174	87	33	-	140	36
Lentil	40	43	43	0	-	80	30
Oil Crops	10	130	87	33	200	120	30
Winter Maize	30	174	87	33	300	140	36
Potato	1,500	152	109	67	400	260	45
Winter Vegetables	0.5	217	130	167	400	260	45
Spring Maize	30	174	87	33	300	140	36
Mungbean	30	43	87	0	-	90	35

4.4.4 Crop Yields and Production

Crop yields in the project area can not be expected to increase from present level under without project condition. The past trend indicates that there has been no statistically significant yield increase during the last 10 years in Bara and Parsa districts. There would not be a drastic technical improvement under the condition of poor or non availability of irrigation water. The crop yields under without project condition is thus estimated to be the same as those under present condition.

Once improved agricultural technologies are adopted and agricultural inputs are used at optimum level, a significant increase in crop yield is expected being supported by timely irrigation water supply. Unit yields of crops in future with project condition are estimated on the basis of the present technology level among farmers and research outcomes about yield potential. The anticipated unit yields of different crops under the project condition are given in the following table.

Crop	Present (Irrigated) (ton/ha)	Potential Yield * (ton/ha)	Anticipated Yield * (ton/ha)
Early Paddy	3.0	2.8-4.3	3.5
Monsoon Paddy	2.8	3.5-8.7	4.2
Sugarcane	45.0	65.0-70.0	65.0
Wheat	2.2	4.0-5.2	3.5
Lentil	0.7	1.5-3.5	1.2
Oil Crops	1.0	1.0	1.0
Maize	2.2	3.5-4.0	4.0
Potato	13.0	15.0-20.0	20.0
Vegetables	7.7	12.0-20.0	18.0
Mungbean	-	1.0-1.5	1.2

Note : * Information compiled from office record, Central Seed Technology Division, NARC, Lalitpur.

Future crop production is estimated from the anticipated yields and the proposed cropping pattern. The anticipated productions of different crops in the project area are given below. As compared to the without project condition, crop production will increase to a large extent except some crops of which cultivated area will be decreased.

Crop	Cropping Intensity (%)	Cultivated Area (ha)	Anticipated Yield Rate (ton/ha)	Production With Project (ton)	Production Without Project (ton)	Increment (ton)
Paddy	80.0	5,800	4.2	24,360	(16,501)	7,859
Summer Maize	10.0	725	4.0	2,900	(178)	2,722
Sugarcane	10.0	725	65.0	47,125	(9,612)	2,061
Summer Vegetable	3.0	218	18.0	3,915	(42)	3,873
Wheat	46.0	3,335	3.5	11,673	(2,483)	9,190
Lentil	5.0	363	1.2	435	(877)	-442
Oil Crops	5.0	363	1.0	363	(223)	140
Winter Maize	8.0	580	4.0	2,320	(121)	2,199
Potato	3.0	218	20.0	4,350	(481)	3,869
Winter Vegetable	3.0	218	20.0	4,350	(125)	4,225
Spring Maize	7.0	508	4.0	2,030	(-)	2,030
Mungbean	5.0	363	1.2	435	(-)	435
Total	185.0	13,413				

4.4.5 Marketing and Price Prospect

The increased agricultural products after the implementation of the project will be either consumed by farmers themselves or marketed. Marketable amounts of major crops at full development stage are estimated at 8,840 tons of paddy, 6,740 tons of wheat, 6,020 tons of maize, 2,850 tons of potato. If the project is not implemented, a large part of presently marketable amount would be depleted due to a rapid population increase.

(Unit : ton)

Crop	Without Project		With Project	
	Production	Marketable	Production	Marketable
Paddy	16,501	2,156	24,360	8,836
Maize	299	-	7,250	6,022
Wheat	2,483	-	11,673	6,740
Lentil	877	388	435	12
Oil Seeds	223	43	363	169
Potato	481	-	4,350	2,851

Note: Estimation method and assumptions are given in Annex D.

In estimating future crop budget in financial prices, all the prices are given at 1993 price level assuming that there will be no relative price increase in future. The newly announced prices presented in Sub-section 3.8.3 are used for input prices. Output prices in 1993 are still not available and then estimated from the 1991/92 average prices using 10% inflation rate. For economic evaluation, international market fluctuation in future is considered for tradable goods referring to the World Bank's price forecast as discussed in Chapter 7.

4.4.6 Crop Budget and Irrigation Benefit

Future crop budget is estimated for both future without and with project conditions on the basis of proposed farming practice, input requirements and price estimation. The crop budgets are given in Tables 4.1 and 4.2 and summarized below. The net return under with project condition will be much higher than that under without project condition. The expected increase in return will sufficiently exceed the increased cost of higher level input use.

(Unit: NRs./ha)

	Early Paddy	Monsoon Paddy Irrigated	Monsoon Paddy Rainfed	Maize	Wheat	Oil Crops	Potato	Sugarcane Irrigated	Sugarcane Rainfed	Lentil	Vege-tables
Without Project											
Gross Return	12,716	20,944	15,708	12,452	10,080	11,088	58,300	30,024	25,354	7,239	39,325
Product Cost	4,201	5,291	4,488	3,415	44,65	1,808	19,055	12,509	10,743	2,294	3,355
Net Return	8,515	15,653	11,220	9,037	5,615	9,280	39,245	17,515	14,611	4,945	35,970
With Project									(Mungbean)		
Gross Return		31,416		22,640	22,050	15,840	110,000	43,355	15,840	14,490	135,850
Product Costs		8,710		7,185	7,632	5,401	27,190	17,116	4,805	4,259	9,176
Net Return		22,706		15,455	14,378	10,439	82,810	26,239	11,035	10,231	126,674

Note : Family labor cost, land tax, irrigation fee are not included in the production cost.

The agricultural production value in the project area is estimated based on the above crop budget and proposed cultivated areas as shown below. The total net return with project will be NRs. 311.5 million, more than double of NRs. 117.2 million estimated for without project condition. The difference of NRs. 194.3 million is regarded as the benefit accrued from the project in terms of financial price.

(Unit: NRs 1,000)

Crop	Without Project			With Project			Increment of Return
	Gross Return	Production Cost	Net Return	Gross Return	Production Cost	Net Return	
Rainfed Early Paddy	1,157	382	775	-	-	-	-775
Irrigated Monsoon Paddy	43,328	10,921	32,308	182,213	50,521	131,692	99,384
Rainfed Monsoon Paddy	79,058	22,586	56,472	-	-	-	-56,472
Maize	1,768	485	1,283	41,046	13,026	28,020	26,737
Wheat	15,644	6,929	8,715	73,537	25,586	47,951	39,236
Oil Crops	3,526	575	2,951	5,750	1,961	3,789	1,961
Potato	2,624	857	1,766	23,980	5,928	18,052	16,286
Irrigated Sugarcane	3,122	1,301	1,822	31,432	12,409	19,023	17,201
Rainfed Sugarcane	3,296	1,397	1,899	-	-	-	-1,899
Lentil	11,785	3,735	8,050	5,260	1,546	3,714	-4,336
Vegetables	1,219	104	1,115	59,231	4,001	55,230	54,115
Mungbean	-	-	-	5,750	1,744	4,006	4,006
Total	166,428	49,272	117,156	245,986	66,200	311,477	194,321

4.4.7 Future Farm Household Budget

Future household budgets for five representative farm models are estimated in the same manner as in Sub-section 3.9.2. For any size of model, farm income will increase more than 170% due to an increase of crop production. As a result, the marginal model farm can earn more than the "poverty line" estimated by the National Planning Commission. Although in absolute term larger farms get larger incremental income, the relative increase in net reserve is significantly larger for smaller farms. The change in farm household budget is further discussed in the farm budget analysis in Chapter 7. The results of estimation for household budget under without and with project conditions are shown below.

(Unit : NRs/year)

	Marginal	Small	Medium	Large	Average
Without Project					
Rainfed Area					
Total Revenue	20,700	45,400	86,710	165,210	34,250
Household Income	18,020	36,060	62,760	115,650	27,350
Living Expense	17,620	31,140	36,700	82,770	24,950
Net Reserve	370	4,920	26,060	32,880	2,400
Partially Irrigated Area					
Total Revenue	23,050	53,890	105,270	201,730	39,930
Household Income	19,970	43,060	77,440	144,190	32,040
Living Expense	17,740	31,260	36,800	82,980	61,210
Net Reserve	2,230	11,800	40,640	61,210	7,100
With Project					
Total revenue	39,450	110,750	228,510	443,770	78,250
Household Income	32,490	85,600	170,420	320,800	61,010
Living Expense	26,200	55,390	72,500	180,150	42,260
Net Reserve	6,290	30,210	97,920	140,650	18,750
Poverty Line Income*	30,611	41,464	45,592	61,639	34,785

Note: *Estimated by National Planning Commission at US$ 92.76/person (WB/UNDP 1990).
Household income is total revenue less farm costs.

4.4.8 Strengthening of Agricultural Support Services

Agricultural supporting services in the project area are generally well established in term of organizational system as discussed in Section 3.6. However, the performance of each service is not at fully satisfactory level. The existing constraints can be mainly attributed to shortage of budget, well trained staff and transportation facilities. Recognizing that the reinforcement of present support system is essential to achieve the anticipated agricultural production, the followings are recommended for each service sector.

Extension Service
- Improve the working environment of extension workers.
- Give extension workers incentives to good performance.

Credit System
- Increase the number of sub-branch office of ADBN.
- Simplify the process of appraising loan application.
- Ease the access of small holders to institutional credit.

Input Distribution System
- Improve AIC's supply and distribution through well prepared annual plan.
- Encourage farmers to use credit for using more farm input.

Agricultural Research
- Strengthen the linkage between research and extension agencies.

Marketing
- Develop the agricultural marketing information system.

4.5 Irrigation Plan

4.5.1 Irrigation Water Requirements

The irrigation water requirements are estimated by analyzing such factors as consumptive use of water by crops, percolation of cultivated soils, effective rainfall and irrigation efficiency. In this project, however, no data are available on these factors, so that the experimental results obtained at the Hardinath Pilot Farm, particularly for paddy cultivation, and for other crops, empirical data shown in "FAO Irrigation and Drainage Paper No 24" are referred to in the estimation of the irrigation water requirements. The calculation procedure and results are detailed in Annex E and summarized below.

(a) Reference crop evapotranspiration

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
69	94	155	209	233	178	176	165	140	126	86	75	1,706

(b) Percolation rate in paddy field : 2.0 mm /day

(c) Puddling water requirement : 150 mm

(d) Irrigation efficiency

Water Delivery System	Paddy Irrigation			Upland Irrigation		
	Delivery Efficiency	Field Efficiency	Overall Efficiency	Delivery Efficiency	Field Efficiency	Overall Efficiency
DTW Buried Pipe System	95	80	76	95	65	62
DTW Lined Open Channel	85	80	68	85	65	55
DTW Earth Open Channel	65	80	52	65	65	42
STW Buried Pipe System	97	80	78	97	65	63
STW Lined Open Channel	90	80	72	90	65	59
STW Earth Open Channel	75	80	60	75	65	49

Note : DTW : Deep Tubewell STW : Shallow Tubewell

(e) Unit design discharge

(Unit: lit /sec/ha)

Water Delivery System	Unit Design Discharge	
	24-hour Irrigation	18-hour Irrigation
DTW Buried Pipe System	0.90	1.20
DTW Lined Open Channel	1.01	1.34
DTW Earth Open Channel	1.32	1.76
STW Buried Pipe System	0.88	1.12
STW Lined Open Channel	0.95	1.27
STW Earth Open Channel	1.14	1.52

4.5.2 Water Resources Development

(1) Surface Water Resources

There are six major rivers running through the project area southwards. These are the Tilawe, Phanti, Beraha, Sirsia, Bangari and Pasaha from west to east, all of which originate from the Churia Hills.

All the above-mentioned rivers have not been guaged except some sporadic measurements on the Tilawe and Pasaha rivers as shown in Annex B, but the estimated results are available in the report on "Local River Use and River Training" prepared by Multi Disciplinary Consultants (P) Ltd. in 1988, which deals with the major rivers not only in the project area but also in its surrounding areas also as shown in Annex B. All these rivers can be taken into consideration as the water sources when the study on the augmentation of NEC water is made, if these rivers provide good perennial flows. The discharges were estimated for the mean monthly flow at their crossing points with NEC by applying the regression analysis.

Among the above-mentioned rivers including those in the surrounding areas, the Uria, Sikta, Bangari, Pasaha, Thalhi, Jamuni and Arwa have been used as the emergency water sources for NEC, when NEC was in shortage of water due to breaches of the Don Branch Canal, from which irrigation water is released to NEC. For the diversion of water from these rivers to NEC, NZIDP has constructed intake structures on NEC at the crossing points with these rivers. On the other hand, the Tilawe river has been used as the source of augmentation of water for NEC since start of NZIDP.

The above-mentioned rivers and their tributaries are also used as the irrigation water sources for FMISs mainly located immediately south of the forest boundary. Particularly in the project area, there are four to five FMISs getting the water of the same river in succession. In order to divert water from these rivers to their fields, the farmers generally construct brush-wood dams in the upper reaches, earthen brush-wood dams in the middle reaches and earthen dams in the lower reaches. In general pattern, the leakage of water through the upper dam and the flow generated by groundwater discharge between the upper and lower dams are picked up by the lower dam till there is very little water left for further use. In such a way, the FMISs along the middle and lower reaches always suffer from the water shortage especially in dry monsoon and in winter season.

In order to know the availability of surface water from the above mentioned rivers and streams for the use of irrigation purpose, discharge measurements were carried out at the crossing points with NEC and at all the intake points of the FMISs in February and March 1993 by the study team. According to the results of these measurements and the previous measurements, the Jamuni river can be expected as a water source for the augmentation of the NEC supply, having a dry season flow of 1.0 - 3.0 m^3/ sec, while the other major rivers have less dry season flows ranging 0.2 - 0.6 m^3/sec. As for the tributaries of these major rivers and streams, they are giving dry season flows of more than 2.0 m^3/sec in total to the FMIS areas of some 2,500 ha even in the dry season. In the water balance study between the irrigation demand and water supply, therefore, these river flows, particularly of the Jamuni river and the tributaries of the major rivers and streams, are taken into account for the augmentation of NEC supply and the irrigation water supply to FMIS areas respectively.

(2) Groundwater Resources

In the project area the phreatic shallow aquifer (Layer 1 aquifer) and the confined deep aquifers (Layer 2 and Layer 3 aquifers) are expected as the potential groundwater resources. It is believed that these two aquifers compose a combined one hydrological unit which is recharged by percolation of rainfall and also by lateral groundwater inflow from the northern boundary through coarse material deposited in the foothills of the Siwalik range, and discharged as subsurface lateral flow through extension of the these aquifers over the southern boundary and also as springs and seeps which feed perennial streams in the project area.

Groundwater is presently abstracted for the amount of 32.2 MCM/year from the phreatic shallow aquifer and 7.4 MCM/year from the confined deep aquifers. Preliminary water balance was carried out in the present study and resulted that the groundwater recharge would be 173.8 MCM/year, of which 23.9 MCM/year is discharged through the shallow and the deep aquifers to the south across the India-Nepal border. The remaining 149.9 MCM/year is considered as an excess of groundwater recharge which could be in some extent abstracted for groundwater irrigation development.

This consideration was further examined by the groundwater simulation and optimization study concluding that the optimum groundwater development plan in the project area would abstract 78 MCM/year of groundwater for irrigation, covering the area of 7,250 ha for cropping intensity (C.I.) of 185%. Effects to spring discharge by the optimized plan is estimated to be

very small : about 9% of decrease in spring discharge is predicted. Effects to the existing shallow tubewells was also evaluated that the regional groundwater level in the shallow aquifer under the optimized plan will be at about GL.- 4 m in the whole study area.

For the above optimized plan of groundwater irrigation development, two types of tubewell, the shallow tubewell with diesel driven centrifugal pump and the deep tubewell with electric motor driven shaft turbine pump are proposed.

Shallow tubewell would be suitable for the Bhabar Zone, northern half of the project area, where the shallow aquifer has high transmissivity and also high groundwater table as 2 - 3 m below ground surface. Well yield of 12 lit/sec could be generally expected in this zone for the typical shallow tubewell constructed with ND 100 mm steel liner to a depth of 50 m drilled in the minimum spacing at around 300 m.

Deep tubewell would be suitable for the Terai Plain Zone, southern half of the project area, where the shallow aquifer is thinner and less productive, but the deep aquifer becomes thicker and increasingly productive toward the south. In this zone, well yield of 80 lit/sec is generally expected for the typical deep tubewell with ND 250 mm steel liner to a depth of 150 m drilled in the minimum spacing at around 700 m.

4.5.3 Irrigation Development Plan in the Project Area

(1) General

The area to be irrigated under the project is broadly divided into following three different types of the areas according to the existing irrigation conditions and water sources:

(a) Farmers Managed Irrigation Scheme (FMIS) area of 1,200 ha is fully irrigated in the monsoon season at present by water diverted from rivers and streams originating from the Churia hills, but few water is available in these rivers and streams in the dry season because of withdrawal of water in their upstream. Therefore, this area needs to be irrigated through the conjunctive use of groundwater and surface water particularly in the dry season.

(b) Sirsia-Dudhaura Irrigation Scheme (SDIS) area of 970 ha is only irrigated in the monsoon season by water diverted from the Sirsia and Dudhaura rivers but not in the dry season because of shortage of river flow. Therefore, this area also needs to be irrigated conjunctively with groundwater in the dry season.

(c) Rain-fed area with a total irrigation area of 5,080 ha has no surface water sources for irrigation. For perennial irrigation, therefore, groundwater development is needed in this area.

(2) FMIS Area

According to the study made in the previous Section 4.3, about 450 ha out of total area to be irrigated under the project is included in the Bhabar Zone, where the transmissivity coefficient of the phreatic aquifer ranges from 500 to 1,000 m^2/day, and the rest of 750 ha comes under the Terai Plain Zone, where the transmissivity coefficient of the phreatic aquifer is less than 100 m^2/day. This aquifer is assumed to give an average potential yield of 12 lit/sec/well in the Bhabar Zone and less than 5 lit/sec/well in the Terai Plain Zone in case the well diameter is 10 cm.

According to the past experiences in and around the project area, a shallow tubewell with a potential yield of more than 5 lit /sec can be developed within an economical range for irrigation purpose. Moreover, due to the reason that the shallow tubewell would be more attractive to the farmers than the deep tubewell, because of below mentioned reasons, the irrigation area of 450 ha included in the Bhabar Zone will basically be irrigated by shallow tubewells.

(a) Low construction cost per hectare,
(b) Easy repair of mechanical parts,
(c) Easiness in organizing the water users' group, and
(d) Easiness in distributing water to each water user due to less users in each tubewell command area as compared to the case of deep tubewell.

The result of the hydrogeological study mentioned in Sub-section 4.5.2 (2) shows that the minimum allowable interval between the shallow tubewells would be in the range of 300 m. On the other hand, the result of water requirement calculation made in Annex E shows that the peak water requirement with a 80 % dependability in the dry season is 0.79 lit/sec/ha for a 18 hour pump operation in a day, provided that the buried pipes of distributary system is applied, though the distribution system may partly be of lined or unlined open channel system when they are demanded by farmer groups. Based on these figures and the average potential yield of 12 lit/sec/well for the phreatic aquifer in the Bhabar Zone, the required number of shallow tubewells and the required interval between tubewells are obtained to be 30 Nos. and 430 m respectively as detailed in Annex E.

As for the rest of 750 ha located in the Terai Plain Zone, where the yield of shallow tubewell with ø 100 mm casing pipe is less than 5 lit/sec/well but that of deep tubewell with ø250 mm casing pipe is more than 80 lit/sec/well can be expected, the area needs supplementary water supply by deep tubewells in the dry season. According to the calculated results of water requirements, the peak irrigation water requirement in the dry season is 0.60 m^3/sec with a 80 % dependability as a whole and will be supplemented by 8 deep tubewells to be constructed at the average interval of 1,100 m, provided that each tubewell will be constructed for the capacity of 80 lit/sec, though this capacity would be ranged from some 50 lit/sec to 80 lit/sec depending on farmers' demands, and the pumps are operated for 18 hours per day in the peak period of irrigation water supply in the dry season. The locations of deep tubewells are as shown in Fig. 4.3.

(3) Sirsia-Dudhaura Irrigation Scheme Area (SDIS)

According to the result of study made in the foregoing Section 4.3, the area of 970 ha in net can be irrigated in this scheme area through the development of groundwater without giving any harm to its nearby area. This development area is totally included in the Terai Plain Zone with low transmissivity coefficient in the phreatic aquifer (less than 500 m^2/day), while the high transmissivity is expected in the deep aquifer (more than 2,500 m^2/day) which would give 80 lit/sec/well with a ø 250 mm casing pipe. Judging from this hydrogeological conditions, it is proposed to supplement the shortage of irrigation water in the dry season by constructing deep tubewells. The required number of deep tubewells would be 10 Nos. to supplement the shortage of 0.58 m^3/sec at the peak irrigation period in the dry season, assuming that each tubewell will be provided with a capacity of 80 lit/sec and the pump will be operated for 18 hours per day and pumped water is distributed to the fields through a buried pipe system.

(4) Rainfed Areas

According to the result of study made in the foregoing Section 4.3, the net area to be irrigated by developing groundwater would be 5,080 ha, of which about 1,680 ha is in the Bhabar Zone and the rest of 3,400 ha lies in the Terai Plain Zone. As mentioned in Sub-section 4.5.2 (2), the potential yield of the phreatic aquifer in the the Bhabar Zone is about 12 lit/sec on an average in case the well diameter is 10 cm, and the groundwater of this zone can be economically developed, while the development of the groundwater in the phreatic aquifer of the Terai Plain Zone is not so economical because of its less potential yield. For the irrigation development in these areas, therefore, it is recommended that the area in the Bhabar Zone be developed by the shallow tubewells and the area in the Terai Plain Zone, where the potential yield of the deep aquifer is in the order of 80 lit/sec with the well diameter of 25 cm, be developed by the deep tubewells. The minimum allowable spacing of tubewells would be 300 m for the shallow tubewell and 700 m for the deep tubewell according to the result of hydrogeological study mentioned in Sub-section 4.5.2 (2).

Based on the above-mentioned hydrogeological parameters and the unit peak water requirement of 0.88 lit/sec/ha with a 80 % dependability in case of buried pipes of the distribution system, the number of tubewells and their spatial distribution are calculated as follows:

Tubewell	Number of Tubewells	Interval between Tubewells (m)
- Shallow	170	350
- Deep	52	910

4.5.4 Augmentation of NEC Water Supply

In order to assess the irrigation area to be covered by NEC under the present supply condition, "Study on Re-Formulation of Narayani Zone Irrigation Development Project" was made by Nippon Koei in 1992. In this study, the water balance calculation was carried out

between the NEC water supply and irrigation water demand for the past 8 years and concluded that the NEC water supply even including the supplemental water supply from the Tilawe could not serve the total command area of NEC; hardly 24,500 ha of the total area of 29,700 ha with an 80 % dependability in June and August. The rest of 5,400 ha, which would require the irrigation water supply of 4.10 m3/sec in the peak time, would need to be irrigated by other water sources. In this study, however, the below-mentioned supplemental water supplies of the Jamuni river flow and existing 1,200 shallow tubewells were neglected for the sake of conservative estimate of irrigated area.

According to the results of sporadic discharge measurements made by the NZIDP office, inquiries to the local people and the discharge measurements made in this study period on the said rivers, the Jamuni river gives average discharge of 9.0 m^3/sec in the rainy season and 1.0 - 3.0 m^3/sec in the dry season, while the other rivers give discharge of only 0.2 - 0.6 m^3/sec in the dry season, though their discharges in the rainy season are ample. Actually the farmers are taking water from the Jamuni river by constructing an earthen brush-wood diversion dam 6.0-km upstream of the crossing point with NEC to irrigate about 2,500 ha in the NEC command area between the Tiar and Arwa river, mainly Blocks-10 and Block-11 even in the dry season, though the actually irrigated area varies year to year because of temporary nature of the diversion dam.

In addition to the above surface water source, more than 1,200 shallow tubewells have been drilled by farmers themselves in the area from Block 1 to Block 12 of the NEC command area as mentioned in Sub-section 3.4.3 (2). These tubewells can be used as the supplemental water sources to the NEC water supply. According to the field observation, these shallow tubewells give the pumped discharge of 5 lit/sec/well on an average. Since these tubewells are generally operated for 4 - 5 hours a day in the peak time, the contribution of these tubewells to the NEC water supply would be 2 - 3 m^3/sec, which cover some 3,000 - 4,000 ha under the present cropping pattern prevailing in the area.

From the above result of study, it can be concluded that any development of new water sources need not to be developed for the purpose of augmentation of NEC water supply.

4.6 Project Works

4.6.1 Irrigation Works

(1) Tubewell Irrigation System

The project area is hydrogeologically divided into two zones ; Bhabar Zone in the northern part of the project area and Terai Plain Zone in the central and southern part of the project area. Out of the total net irrigable area of 7,250 ha for the project, 2,130 ha is included in the Bhabar Zone and will be irrigated by shallow tubewells, while the rest of 5,120 ha is in the Terai Plain Zone and will be irrigated by deep tubewells.

For the distribution of irrigation water, the buried pipe system will basically be employed for both shallow and deep tubewell areas following the result of economic

comparison made in Annex E, though some areas will be provided with lined or unlined open channel systems depending on the farmer groups' perceptions and requirements.

(a) Shallow Tubewell Irrigation System

For the irrigation of 2,130 ha included in the Bhabar Zone, some 200 shallow tubewells will be drilled keeping well-to-well distance of 350 - 450 meters. The well depth would be 40 - 50 meters depending on locality. In the drilled holes, black mild steel pipes with a diameter of 100 mm will be installed and gravel packing will be provided in annular spaces between the pipes and the walls of holes. Each well will be equipped with a horizontal mounted self priming end suction centrifugal pump with a 10 - 15 lit/sec of discharge capacity. The pump will be driven by 5 HP diesel engine.

The water pumped from the well will be led to a buried pipe distribution system with a one pipeline loop through a 1.5-high control chamber provided near the pump house. The pipeline will be of uPVC pipe with a diameter of 90 mm and pressure rating of 2.5 kg/cm^2. The pipeline loop with 7 distribution outlets (alfalfa valves) will serve about 15 ha for the FMIS area and 10 ha for the rain-fed area, and each outlet will serve approximately 2.0 ha for the FMIS area and 1.5 ha for the rain-fed area. Approximately 100 m of buried uPVC pipe will be required per hectare for both areas. A pump house with a floor area of 2.20 m x 2.0 m will be constructed at each tubewell site.

(b) Deep Tubewell Irrigation System

In order to irrigate 5,120 ha in the Terai Plain Zone, about 70 deep tubewells will be constructed at the interval of 900 - 1,100 m between the tubewells. Most of the tubewells will yield 80 lit/sec, which will serve 95 ha of farmlands for the FMIS and SDIS areas and 65 ha for the rain-fed area. The depths of tubewells will be 150 m on an average which vary from place to place depending on the depth of confined deep aquifers below the ground surface. The wells will be equipped with vertical shaft multi-stage turbine pumps driven by electric motors rated 40 kW and pump motor protection equipment.

The pumped water will be once stored in a 6.0-m high control chamber and led to a buried pipe distribution system with three pipeline loops for the FMIS and SDIS areas and two loops for the rain-fed area. The pipeline loops will be of 160 mm diameter uPVC pipe for the FMIS and SDIS areas and 200 mm diameter for the rain-fed area, both of which have a pressure rating of 2.5 kg/m^2. Each loop with 14 outlets (alfalfa valves) could serve about 30 ha, and each outlet will serve 2.0 - 2.5 ha. Approximately 80 m of buried pipe for the FMIS and SDIS areas and 70 m for the rain-fed area will be required per hectare. A pump house with a floor area of 5.7 m x 8.6 m will be constructed at each tubewell site. The pump house will be provided with a pump operator's room with a floor area of 3.5 m x 5.7 m.

4.6.2 Drainage Works

In order to evacuate surplus rainwater from farmlands, three kind of drains; field drains, collector drains and main collector drains, or natural drain will be needed in the project area. A field drain will be constructed by farmers themselves in each irrigation rotation unit of 4 to 5 ha. This field drain will outfall into a collector drain. The collector drain will function as a carrier to a main collector or river. For the design of these drains, a drainage rate is estimated at 4.0 lit/sec/ha as detailed in Annex E.

Based on the result of design made in the sample area in Baghai village, the total lengths of respective drains are estimated as follows:

(a)	Field drains	:	750 km
(b)	Collector drains	:	360 km
(c)	Main collector drains (natural drains)	:	60 km

4.6.3 Road Network

An all-weather road network is required to provide farm-to-market access, to allow the introduction of new farm inputs and other project extension services and to facilitate the operation and maintenance of the tubewells. In order to construct an efficient road network for the above-mentioned purposes, the Janta Road for a length of 1.4 km and 13 existing north-south roads with a total length of 90 km will be gravel-metalled and provided with 5 culverts, 62 irrigation crossing and 8 cross drains. In addition to these roads, 70 service roads with a total length of 41 km will also be required between the tubewells and the above-mentioned trunk roads.

The Janta Road and all the north-south roads will have a total width of 6 m, of which 3.5 m will be gravel-metalled with a thickness of 25 cm, while the service roads will have a total width of 5 m with 25-cm thick gravel metalling for the width of 3.5 m. All these roads will be constructed on embankments raised at least 0.5 m above the nearby farmlands.

4.6.4 Electric Power Supply System

The proposed electrical power supply system will be constructed from a standard 11 kV equipment to designs basically similar to others already in use by NEA. All lines will be single circuit. No requirement for double circuit lines is foreseen and these would not be used due to the operational limitations they impose.

The power required, typically 50 kVA, is sufficient to justify the provision of a dedicated transformer. For the security of supply reasons, domestic connections to this will not be permitted. Domestic loads will be connected to the 11 kV line via separate transformers provided at a later date as a part of of rural electrification project.

Two types of line would be built; heavy weight with 150-mm^2 ACSR conductor for 32 km length and light weight with 70-mm^2 ACSR conductor for 243 km length. The major part

of the system constructed will be of the light weight type , as this has more than adequate current rating for the loads proposed. Heavy weight type will only be constructed on the most heavily loaded sections of the system.

For the benefits of construction, operation, maintenance and fault location, 11 kV lines will be routed alongside roads and tracks as far as possible rather than running across open country side.

4.6.5 Buildings

(1) Office and Quarters

Project Executing Organization (PEO) will utilize the existing office building complex which is being used by the Groundwater Resources Development Project (GWRDP), Parwanipur, with its compound of 2.5 ha. Under the project, however, the following renovation and new construction works will be needed:

(a) Renovation of existing two offices, one gust house, five quarters and one garage.

(b) Construction of fencing wall of 250 m.

(2) Agricultural Training Hall

For the purpose of training to JT/JTA, village level agricultural assistants, officials of agricultural service centers and progressive farmers, mentioned in Section 4.7.2 hereof, two agricultural training halls will be constructed at Dohari and Biruwaguthi. Each training hall will have three rooms with a total floor area of 150 m^2.

(3) Stores

There exist 9 stores with a total storage capacity of 1,700 MT in the project area; two in Parsa district (600 MT) and seven in Bara district (1,100 MT). For the use of fertilizer reserve, however, two additional stores will be needed in the project area. These stores will have a storage capacity of 75 MT each and will be constructed at Belawa and Phatepur.

4.6.7 Equipment

PEO will procure the heavy equipment and vehicles for the use of O&M purpose, mechanical and electrical workshop equipment, aquifer testing equipment, and office equipment. The required number of respective equipment are detailed in Annex H .

4.7 Project Services

4.7.1 Training

(1) Training to Farmers

In order to develop farmers' skill and capacity to manage the irrigation system, training will be organized for target groups of WUA members. Trainees would be recommended by WUAs. Training would be provided in the fields of; (a) operation and mechanic; (b) agriculture extension; (c) cooperative and marketing; and (d) water management. The training would be organized by Planning and Institutional Development Section of PEO. The training period of pump operators and mechanics would be for seven to ten days. Likewise training period for agricultural extension and water management and cooperatives activities would also be for seven to ten days as detailed in Annex G.

Agriculture extension and water management training to farmers would include special short training at agriculture service centers (ASC), organizing meetings with farmers of TWs, farm walks to demonstrate practices on existing TW systems to new TW farmers, field demonstration in farmers land and farmers to farmers training.

There would be two types of training within the period of six years.

(a) First type of training would deal with the orientation. This would also include the training on the attitudinal/behavior change of the farmers.

(b) Second type of training would include the formal in depth training which would provide main theoretical aspect of the tubewell operation and maintenance, water management, agricultural extension and marketing. It would also provide them practical training such as farmers-to-farmers training on the transfer of technical skills and management skills.

The role of trainers in PEO would be to assist WUA in identifying and selecting trainees. Local consultants will organize and conduct the training. The WUA members would be trained by local consultants. Experts from international non-government organization (INGO) specializing in irrigation management and training would help to ensure quality of training. Evaluation of training would be done by the selected INGO. PEO trainers would provide day to day specific problem solving training to WUA members.

There would be following two training packages for 560 target groups of WUA members:

(a) First package training would provide training regarding pumping operation maintenance and management. This type of training would be provided to operators and mechanics. The training period for this type of training would be for seven to ten days. WUA members would be trained intensively by five resource persons (local consultants) provided by PEO. The trainees will have

three-day field trips which would be decided by the Planning and Institutional Development Section of PEO. The WUA members (trainees) would be practically demonstrated during the field trips. This would give opportunity to utilize their practical knowledge and skill that they would gain during trainings.

(b) Second package of training program would deal with the water management aspect, agricultural extension, co-operatives, etc. The resource persons would provide them practical and theoretical training to trainees recommended by WUA for seven to ten days. The theoretical training would be conducted for five to seven days and field trips for two to three days.

In the final year of the training, farmers would be able to give training to their fellow farmers by themselves. Selected INGO would be entrusted for the supervision, quality control, evaluation and documentation of the training program.

(2) Training to PEO Staff

PEO will also organize training/seminar for its staff to develop their project implementation capacity. The staff training/seminar will basically focus on: (a) orienting the staff towards the objectives and process of the project to enable them to efficiently implement the project; (b) building a team approach among the staff to skilfully handle their team relations; and (c) reviewing project outcomes and suggesting improvement measures to collectively promote their project implementation capability. The first year of the project, PEO will concentrate on (a) and (b) types of training/seminar. In the consequent project years, PEO will focus on (c) type of training/seminar. Local consulting firm having expertise and experience in participatory groundwater development and with a multi-disciplinary expertise will provide a consultant facilitator to conduct the training/seminar in close collaboration with the PEO trainers. The PEO trainers will prepare and organize the training/seminar inputs with the help of the consultant facilitator.

4.7.2 Agricultural Strengthening Support

Under the agricultural strengthening program, PEO is proposed to provide the agricultural support fund of NRs. 6.54 million under a technical assistance arrangement. The fund will be utilized by the two District Agricultural Development Offices (DADO) of Bara and Parsa. PEO will be in charge of coordinating and monitoring the agricultural activities of DADOs with an assistance of the project consultants. DADOs will prepare an action plan in collaboration with the project consultants to utilize the agricultural support fund.

The activities planned to be undertaken with the fund include:

(1) Training Program

(a) Village level agriculture assistant program

During the project implementation period, about 580 progressive farmers will be selected from the project area and they will be given agriculture training at ASC. The duration of the training will be about a month and the training program will cover all aspects of improved farming practices of major cereal crops, vegetables and livestock. The participants in the training will be selected on the recommendation of WUA.

(b) Refresher Training Program

The periodical refresher training will also be organized for JT, JTA and some of the farmers who already finished the village level agriculture assistant training to update their technological ability. The program will be a short training (two days) course, in which about 20% to 25% will be for vegetable farming and the rest for cereal crop farming.

(2) Extension Activities

The extension activities are the main tools to disseminate agricultural technologies to the farmers. The main extension activities in the project area will be:

- result demonstration,
- method demonstration,
- farmer's field trial,
- production demonstration,
- block demonstration program,
- mini-kit distribution,
- farmer's visit to research station,
- farmer's visit to demonstration plot, and
- crop competition program.

These activities will be carried out for major crops and vegetables.

4.7.3 Strengthening of Regional Workshop

In the project area, even in Birganj and Kalaiya area, there is no workshop fully equipped with appropriate machines and technicians to carry out the repair and maintenance of the plants and equipment to be used in the project. Therefore, it is envisaged that PEO will utilize the regional workshop of NZIDP. For the utilization of this workshop, however, it is necessary to equip the workshop with some additional equipment and tools such as bench grinding machine, bench drilling machine, air compressor, motor drier, bearing puller, coil winder, crimping tools, etc., all of which are very important particularly for the repair and maintenance of pumps and motors but not installed in the workshop at present.

In addition to the above-mentioned regional workshop, it is also necessary to establish three area repair shops for regular maintenance and minor repairs of tubewell pumps and motors. These repair shops will be attached to the agricultural service centers at Dohari, Persuani and Biruwaguthi.

These workshop and the area repair shops will have the following functions respectively:

Regional work shop

(a) Routine maintenance of pumps, motors, diesel engines, control panels and drilling rigs and their overhaul.
(b) Central holdings of spare parts, 2 sets of spare pumps and motors and diesel engines and other consumables.
(c) Planning and supervision of maintenance works to be carried out at the area repair shops.
(d) Supervision for installation of tubewell pumps and motors during the project implementation.
(e) Record keeping for repair and maintenance of the tubewell pumps and motors.

Area repair shops

(a) Minor repair of control panels.
(b) Routine greasing of electric motors.
(c) Timely replacement of bearings for electric motors.
(d) Change of engine oil, fuel and oil filters of diesel engines for shallow tubewells.
(e) Leak repairs for valves, glands and joints.
(f) Miscellaneous minor repairs.

4.7.4 Technical Supports

(1) Consulting Services

Consulting services will be required to advise and assist PEO in: (1) designing new tubewell irrigation facilities and associated works drainage and road systems; (2) preparing bid documents and bid evaluation; (3) providing construction techniques; (4) providing construction quality control; (5) monitoring of progress of work; (6) establishing operation and maintenance and water management criteria; (7) providing agricultural and farmers organization support; (8) monitoring and evaluating groundwater resource; (9) planning work programs and budgets; and (10) designing project training program.

(2) Survey and Study

(a) Aerial photo mapping

Detailed topographic map on a scale of 1: 5,000 with a contour interval of 0.50 m was prepared in the feasibility study time of 1971. This map, however, covers only the southern two-thirds of the project area. Other than this topographic map, 1: 50,000-scaled topographic map prepared by the Government of India in 1957 is only available in the study area. For future implementation of the project, therefore, the aerial photo

mapping would be required particularly for the northern one-third of the project area, about 200 km^2. The map should have a scale of 1: 5,000 and a contour interval of 0.50m.

(b) Groundwater Modelling

The groundwater simulation and optimization study made under this feasibility study shows that the area of 7,250 ha out of total irrigable area of 13,840 ha can be developed without giving any adverse effects to the existing shallow tubewells and spring-fed rivers running in the project area, and it is recommended, for the moment, that the remaining area of 6,590 ha be excluded from the development area dealt with in the present feasibility study. Through the above-mentioned simulation and optimization study, however, it is understood that the possibility of development for the remaining area should be confirmed based on another optimization study to be made based on the further detailed hydrogeological data which will be collected from the tubewells to be constructed for the development of above-mentioned 7,250 ha. Based on this understanding, it is proposed to conduct another groundwater simulation and optimization study in the fifth or sixth year from the start of the project implementation.

4.8 Implementation Schedule

(1) General

The time to be required for the implementation of the project is estimated to be 8 years including the time necessary for the survey, design, tender calling, construction , procurement of construction materials and mechanical and electrical works, procurement of construction and O&M machinery and technical support. A tentative implementation schedule is prepared and graphically shown in Fig. 4.4. The main construction season is from October to May. Provided that the financial arrangement for the project is concluded but the end of 1994/95 fiscal year of Nepal, the construction of the projected works would be completed by the end of 2002/03.

(2) Construction of Tubewells

The construction of both shallow and deep tubewells is intended to be made by contructors selected through the local competitive bidding (LCB) being divided into four tender lots respectively. Immediately after start of the project, the project office will inform the farmers of the concept, goals and objectives of the project and process and procedure of project implementation and guide them to organize WUAs/WUGs for the demand application of the project.

After receiving the formal application from WUA/WUG for demanding the project implementation, the design work for both shallow and deep tubewells will be started lot by lot with the test drilling in the middle of the first Project Year from the area extending along the Birganj-Hetauda Road, where the road network is well developed and will provide easy access to the sites for the transportation of the construction materials and equipment. The design work

will continue up to the end of rainy season in 7th Project Year. The construction work of the first lot will be started from the middle of second Project Year. All the construction works will be completed in the end of 7th Project Year.

(3) Construction of Irrigation and Drainage Systems

Immediately after completion of the drilling work in the first dry season of the work, detailed design of the irrigation and drainage system will be started for both shallow and deep tubewell areas in parallel. Since the construction work is scheduled to be made being divided into four tender lots for shallow and deep tubewell areas respectively, the design work will accordingly be made lot by lot. All the construction work will be made by local contractors selected through LCB. The first lot of the construction work will be started from the onset of dry season in the 4th Project Year and the total construction work will be completed by the end of 8th Project Year for both shallow and deep tubewell areas. The required time for completion of the construction work will be 2 years for each lot.

(4) Upgrading of Road Network

In order to facilitate the transportation of construction materials and equipment to the sites, the existing narrow earthen roads will be upgraded in early stage of the project period. The field reconnaissance, topographic survey and design will be started immediately after commencement of the project and completed by the end of the third Project Year. In order to expedite the construction work, the work will be divided into three tender lots, all of which will be undertaken by the local contractors selected through LCB. The first lot of construction work will be started from the onset of the dry season in the second Project Year and all the work will be completed by the end of 5th Project Year.

(5) Construction of Buildings

The renovation of existing office building and quarters is in urgent need. The renovation of these buildings will be started immediately after the start of the project and completed by the end of the second Project Year. The second lot of the work will include the construction of the agricultural training halls and agricultural input stores. The construction of these buildings will be started from the fifth Project Year and completed by the end of 7th Project Year. All the above construction works will be made by LCB-selected contractors.

(6) Procurement of Materials

The casing pipes and screens required for the construction of tubewells will be procured through the international competitive bidding (ICB) by dividing into four packages. The procurement of the first package should be completed before the start of the tubewell drilling work of the first lot; by the middle of second Project Year.

(7) Procurement of Mechanical and Electrical Works

This work category includes the procurement and installation of pumps and motors and their ancillary works to be used for both the shallow and deep tubewells. The procurement will be made in four lots under ICB procedure, following the progress of the tubewell construction.

(8) Construction of 11 kV Distribution Line

This construction work will be made in two lots: one for Parsa district and the other for Bara district. The construction work will be proposed to ensure that the completion of each section coincide with the requirement for power at each wellhead. From this viewpoint, the first lot of construction work will be started in Parsa district from the end of the second Project Year and completed by the end of 4th Project Year. Succeedingly the second lot will be started from the beginning of 5th year and completed by the end of 6th Project Year.

(9) Procurement of O&M Equipment and Vehicles

For the use of field survey, construction supervision and other movement of PEO staff and consultants, vehicles will be needed from the commencement of the project. For this immediate use of vehicles, procurement will be completed by the middle of second Project Year. The O&M equipment will be procured by the end of 4th Project Year, when the first lot of tubewell irrigation system and upgrading work of road network will have been completed. All these procurement s will be made through ICB procedure.

(10) Technical Supports

The consulting services and training will be required throughout the project Year. Particularly for the groundwater simulation and optimization study, PEO will collect hydrogeological data from the start of tubewell drilling for the use of study which is scheduled to be made in 5th Project Year.

5. PROJECT COST ESTIMATE

5.1 Basic Considerations and Assumptions for Cost Estimate

The project cost is estimated based on the following conditions and assumptions:

(a) All the costs are estimated based on the unit prices in June 1993.

(b) The exchange rate used in the estimation is US$ 1 = NRs. 50 = ¥ 110

(c) The procurement of materials such as casing pipes, screens, pumps, motors and electric supply system concerned with the tubewell construction, drilling equipment, O&M equipment and vehicles will be procured through the international competitive bidding (ICB).

(d) All the tubewell drilling and civil works including irrigation and drainage systems in both shallow and deep tubewell areas and buildings will be made by contractors selected through local competitive bidding (LCB).

(e) The project cost comprises the foreign currency and local currency portions, which are estimated on the basis of the basic costs prevailing in the markets.

(f) The physical contingency related to the construction quantities, 10 % of direct cost, is included in view of preliminary nature of the estimate.

(g) The price contingencies are estimated on the basis of 3.5 % per annum for the foreign currency portion and 10 % per annum for the local currency portion.

5.2 Project Cost

The project cost broadly comprises; (1) direct construction costs for tubewells and civil works, (2) procurement cost for materials and equipment, (3) costs for technical supports, (4) project administration cost and (5) physical and price contingencies.

The total project cost is estimated to be NRs.1,587 million (US$ 31.7 million) consisting of NRs.760 million (US$ 15.2 million) of local currency portion and NRs.827 million (US$ 16.5 million) of foreign currency portion including 5% of contract taxes and duties as detailed in Table 5.1 and summarized below.

(Unit : NRs. Million)

Work Items	Local Currency	Foreign Currency	Total
A. Tubewell	21.7	78.1	99.8
B. Water Distribution and Drainage Systems	176.5	116.5	293.0
C. Upgrading of Road Network	88.3	53.8	142.0
D. Buildings	5.0	2.7	7.7
E. Procurement of Materials	2.7	51.6	54.4
F. Procurement of Mechanical and Electrical Works	35.9	123.2	159.1
G. Procurement of O&M and Office Equipment	2.0	34.8	36.7
H. Technical Support	72.0	203.0	275.0
I. Project Administration	71.8	0	71.8
J. Land Acquisition	0.3	0	0.3
Total Investment Cost	**476.1**	**663.6**	**1,139.7**
Physical Contingencies	47.6	66.4	114.0
Price Contingencies	236.4	96.7	333.1
Total Project Cost	**760.1**	**826.7**	**1,586.8**

5.3 Annual Disbursement Schedule

The annual disbursement schedule is worked out based on the project implementation schedule shown in Fig. 5.1. The result is detailed in Table 5.2 and summarized below:

(Unit : NRs. Million)

Year	Local Currency	Foreign Currency	Total
1995/96	31	63	94
1996/97	58	71	129
1997/98	88	112	200
1998/99	111	121	232
1999/00	140	163	303
2000/01	113	122	235
2001/02	110	95	205
2002/03	110	80	190
Total	760	827	1,587

5.4 Annual Operation and Maintenance Costs for Tubewell Irrigation Areas

The major part of the operation cost is electrical charge for the deep tubewell and diesel oil cost for the shallow tubewell. This cost also includes the cost for a pump operator. In the cost estimate of the electric charge for the pump operation for deep tubewells, the irrigation tariff fixed by NEA is used as the financial cost. On the other hand, the maintenance cost is estimated based on the records collected from the BLGWP office and result of farm interview made in the ILC project area and the Birganj area.

The O&M cost per tubewell is estimated for the respective case of the conjunctive use areas; FMIS and SDIS areas, and the rain-fed area as detailed in Annex H. Based on above-obtained results, the total operation cost in the project area is calculated as follows:

(Unit: NRs.)

Irrigation Area	O&M Cost
(a) FMIS Area	
- shallow tubewell area (450 ha)	842,000
- deep tubewell area (750 ha)	1,221,000
(b) SDIS Area	
- deep tubewell area (970 ha)	1,579,000
(c) Rain-fed Area	
- shallow tubewell area (1,930 ha)	6,890,000
- deep tubewell area (3,400 ha)	10,023,000
Total	20,555,000 (NRs.2,835/ha) (US$ 56.7/ha)

5.5 Replacement Cost

Some project facilities, especially mechanical and electrical works, have a shorter economic life time than the project life and will require replacement during the proposed 50 years of the project life. The following table shows the economic life times and replacement costs of the works to be replaced.

(Unit : NRs. Million)

Items	Economic Life Time	Replacement Cost
- Tubewell	20	154.2
- Pump and Motor (STW)	5	6.0
- Pump and Motor (DTW)	15	77.7
- O&M Equipment	10	20.2

6. ORGANIZATION AND MANAGEMENT

6.1 Institutional Responsibilities

The Ground Water Development Board (GWDB), headed by Secretary of Water Resources, would be responsible for the central level inter-sectoral coordination, and for procurement decisions of goods and services costing more than NRs. 30 million in a package. The GWDB would make decisions necessary to support speedy project implementation in these areas. It would provide coordination and linkages between the project, Department of Irrigation (DOI), Ministry of Water Resources, Department of Agriculture Development, Nepal Electricity Authority , ADBN, and the Ministries of Finance, Home and Local Development. It would approve key project staff appointment, conduct semi-annual review of project implementation and progress reports on the project. The project manager who reports to the GWDB would manage project execution.

The Secretary of the Ministry of Water Resources as a chairman of the Board would be responsible for major policy matters, approval of contract awards above NRs 30.0 million, and ensuring necessary coordination with central level public and private sector agencies. The GWDB would provide oversight to the project.

6.2 Project Executing Organization (PEO)

6.2.1 General

Traditionally, irrigation projects have been planned, constructed, operated and maintained by DOI with little or no direct farmer input or role. This puts the entire burden of the project, especially for the operation and maintenance on the government's limited resources. As the proposed project would follow demand driven principles, a more unconventional, service-oriented, field-based and fully authorized project executing authority is required. For future sustainability of the project, therefore, fully decentralized service oriented organization has to be established for the project period, and within the project period, this organization will be caused to work to promote private sector maintenance and management support services in the project area.

In order to meet the above requirements and objectives of the project, it is proposed to establish the Project Executing Organization (PEO) as detailed in Annex G. The proposed organizational structure of the PEO is as shown in Fig. 6.1.

6.2.2 Project Management and Staffing

The chief executing officer of PEO would be the project manager responsible for day-to-day project administration and management, work programming and supervision, budgeting and financial control, and to whom all heads of sections would report in order to coordinate project activities. The project manager would:

(a) ensure implementation of project in accordance with the agreed time schedule,

(b) prepare annual implementation programs and progress reports for review and approval by the GWDB,
(c) prepare the project's annual budget proposal for approval by the Ministry of Finance,
(d) manage all project staff and consultants,
(e) authorize project works to be implemented by force account and works, materials and services procured under contracts up to the value of NRs. 30 million;
(f) supervise preparation of tender documents, issuance of calls for tender and evaluation of bids for procurement of works, goods and services; and
(g) ensure close collaboration and coordination of all project activities at the project and district level through Representative Committee.

The Representative Committee would be formed to review and facilitate implementation operation and to provide direct coordination between WUAs/WUGs, farmers, the project and field level line agencies. The Committee would comprise the project manager as member secretary and appropriate PEO officers including the institutional development officer and representatives of field/local level agencies. WUA/WUGs would send three representatives to the Committee. One of them would be the chairperson of the Committee. The Committee would regularly review the proposed works and construction programs, as it affects the local farmers and O & M of completed work. A major function of the Committee would be to prioritize and approve sub-projects and coordinate irrigated agriculture inputs in the project areas.

The project manager will require a matching and specialized staff support. The detailed requirement of the project staff is identified in Fig. 6.2.

6.2.3 Approach and Principles of PEO

The proposed organizational structure asks for minimum essential changes in the existing organizational structure of groundwater irrigation development. It is basically field implementation-oriented. It tries to operationalize HMGN's policy of decentralization and administrative reform. Therefore, the proposed organization is designed in a sectoral support and technical assistance mode. It is not visualized as the organization for the project development and management. Instead, it is an important organization which helps to promote groundwater irrigation development in partnership or association with local farmer community, private and public sector entities in project planning, construction, agriculture extension, system maintenance, marketing and management support.

6.2.4 Enabling Policy and Legal Provision

The new Irrigation Policy of HMGN has recognized that organizational structure and manpower requirement in the sector will be based on the type of irrigation development program. Similarly, the new Water Resources Act 2049 has empowered HMGN to enter into contract with private sector to develop or cause to develop water resources and to utilize and extend the services for such developments.

6.2.5 Authority and Accountability of PEO

Utilizing the enabling provisions of the Development Board Act, new Water Resources Act 2049 and Irrigation Policy, the HMGN (Cabinet level) would empower the PEO/project manager, among others, with the following authority:

(a) to handle the resources dedicated to the project,
(b) to work to form a Representative Committee,
(c) to provide services to WUA/WUGs on hire, and
(d) to negotiate with private sector institutions to promote those services in the area which will be demanded by the farmers.

The services will include agricultural extension, maintenance, mechanical/electrical training and marketing. In this task, promotion of private sector to provide maintenance support services to WUA/WUGs will get the highest priority.

On the other hand, the project manager, will have, among others, the following accountabilities:

(a) For every fiscal year, it will specifically allocate fund for the activities of its Sections and it will cause each Section to prepare an annual plan in consultation with other Sections.

(b) PEO will provide all necessary support to the Representative Committee for its efficient functioning.

(c) PEO will publish every four-month quarterly reports on project planning and institutional development, construction and quality control, project commissioning and servicing, and finance. These reports should be made available to WUAs, GWDB, DOI, other line agencies and the donors regularly.

(d) PEO will retain the maintenance service fee collected during project period. It will use the collected fee for organizational operation and maintenance. PEO should reflect earnings from services rendered in its annual budget. HMGN should make budgetary allocation to PEO taking into consideration the earnings received in the form of service fee.

(e) PEO will price its services at the level that is prevailing in the market. It will be alert not to do anything that will either be prejudicial for the promotion of private sector or help create a monopoly in the delivery of maintenance and management support services for the project purposes.

(f) Before the termination of the project, PEO after negotiation with private parties will work to install and operationalize private sector maintenance and management support services in the project area.

6.3 Farmer Organization

6.3.1 General

The present irrigation Policy 1992 of the HMGN has been based on the realization of a need to let the farmers participate in the irrigation project development, operation and maintenance and management process. The proposed project is visualized under the basic principle that the WUAs/WUGs formed in the project would get proper message about the project right from its inception. Users will get full information on project concept, objectives, procedures of implementation and roles and responsibilities of parties involved in the project and generate self-service support capabilities. Therefore, the proposed project would be implemented on the user's demand and their capability. The WUA in association with PEO would develop capability, by which operation and maintenance system would be done.

HMGN Irrigation Policy (1992) requires water users to form WUA to actively participate in the development, operation and maintenance and management of irrigation projects. The reason for having WUA is to make users capable of harnessing benefit from the project and get justifiable return to the investment through their organized participation from the very beginning of the project.

Under the project, a statutory body of farmers called Water User Association (WUA) would be established under Water Resources Act 1992, for each sub-project. The Planning and Institutional Development Section of PEO assisted by project consultants would be responsible to assist in organizing and strengthening WUAs.

6.3.2 Functions of WUA

The key functions of the WUA will be:

(a) to provide services for such as pump repair and maintenance, agriculture extension, farm inputs and credit, and farm product marketing,
(b) to resolve conflicts among users,
(c) to regulate system operation with respect to pump operation hour and timing,
(d) to coordinate with PEO for various kinds of services,
(e) to develop skill for pump operation, extension services, water management and marketing,
(f) to recommend farmers for training,
(g) to strengthen existing WUGs, and
(h) to cooperate to execute programs as agreed with PEO.

6.3.3 Types of WUA

There would be three types of WUA in the project area. First type of WUA would be deep tubewell (DTW) sub-projects, second type for shallow tubewell (STW) sub-projects, and third type for conjunctive use sub-projects, of which organization structures are as shown in Fig. 6.3, 6.4 and 6.5 respectively.

Formation of WUA in all three types of sub-projects would follow sector program principle that farmers would request for the sub-project, and commit to form a WUA, contribute to construction and take over O&M of the sub-project after its completion. Formation and development of WUA would be based on the provisions of Irrigation Policy and new Water Resources Act 2049.

6.3.4 Process for Farmer Participation

For the farmer participation in the project from its inception to completion, the following process would be adopted:

(a) Information Dissemination and Application: PEO through Association Organizer (AO) will inform water users of the possibility of the project. AO would disseminate information to users about the probable sub-projects and explain the policies and procedures for application. AO would help water users in filling the application forms. PEO would evaluate the application form and inform users of the decision on the application.

(b) Survey: AO would inform the date and arrival of PEO team for survey. AO would help water users to organize general meeting and would help them to choose five to six members of users representatives for representation in survey committee. Then the detail survey would be made in conjunction with users representatives and PEO officials.

(c) Design and Cost: PEO officials and users committee representatives would discuss about the features of the design and cost estimates.

(d) Negotiation and Agreement: PEO will have formal negotiation and agreement with officially registered WUA for the development of the sub-project.

(e) Resource Mobilization: To meet commitments under the agreement, WUA will mobilize resources. During construction, a supervision committee consisting of WUA representatives and PEO officials would be formed. This will facilitate users to observe the construction works and help ensure the quality of the project works.

(f) Commissioning: After completion of the project, the PEO and WUA will jointly commission sub-project. If constructed facilities are in operating order, PEO would withdraw from the completed system.

7. PROJECT EVALUATION

7.1 General

Justification of the project in terms of economic effect is made applying both quantitative and qualitative methods. Direct and tangible effects were assessed quantitatively from the view of national economy and farm economy. Indirect and intangible impacts including environmental aspect were discussed qualitatively.

The economic viability of the project was evaluated by the traditional methodology of the discounted cash flow analysis using shadow prices which reflect economic efficiency in the economy. The economic internal rate of return (EIRR) is used as a measure of economic feasibility in this analysis. Sensitivity of the project viability against possible risks are assessed by comparing EIRRs in several cases assumed, as well as estimating the switching values of major elements.

The effects of the project on farm economy were estimated to see the extent of benefit to accrue to farmers. The analysis was made for five different farm models which represent five farm size groups. The result shows farmers' capacity to bear the operation and maintenance costs, with which a cost recovery plan is proposed.

7.2 Economic Evaluation

7.2.1 Assumptions

The followings are assumed in the economic evaluation procedure. As for monetary terms, all prices are given in 1993 constant prices with an exchange rate of US$ 1.0 = NRs 50.0

(1) Assumptions on Period

(a) The economic life of the project is assumed to be 50 years from the start of implementation, considering the expected life as well as the durability of fixed assets.

(b) The construction period is 8 years including preparatory works and detailed design. Drilling of tubewells and construction of water distribution systems will be made for one system after another during the construction period. The irrigation area will then increase year by year up to total irrigable area of 7,250 ha.

(c) The build-up period from the beginning of irrigation to attainment of full cropping intensity and yield projected is assumed to be five years. The irrigation benefit is presumed to increase year by year in a following manner. The annual benefit will reach to its full value in 2006/67, or at the 12th year of the project implementation:

1st year	:	50% of full benefit	4th year	:	90%
2nd year	:	70%	5th year	:	100%
3rd year	:	80%			

(2) Economic Factors

In estimating economic prices from financial prices, the following methods and assumptions are applied.

(a) Standard Conversion Factor
A standard conversion factor (SCF) of 0.95 is used to adjust the foreign exchange premium or trade distortion. This is estimated in modifying the traditionally used 0.9 considering recent policy transition toward liberalization.

(b) Traded Commodities
The economic farm gate prices of traded agricultural inputs and outputs are estimated in forms of their export or import parity prices. These values are derived from the World Bank Commodity Price Forecasts of December 1992. Paddy, maize, wheat, and sugarcane are assumed to be import substitutes in view of increasing trend of import amounts. Derivation process of economic prices is given in Table 7.1. Pluses, mustard, vegetables and agro-chemicals which are traded on a commercial base are valued at prevailing farmgate prices after modifying with SCF of 0.95, since the forecasts of their world prices are not available.

(c) Non-traded Commodities
In valuing non-traded commodities, market prices are used assuming that they reflect the economic value through competitive marketing. The SCF of 0.95 is multiplied for converting financial prices to economic prices. Financial and economic prices of commodities to be produced or consumed in the project area are listed in Table 7.2.

(d) Price Prospect
For the commodities of which international prices are forecast by the World Bank, the long run forecasts for 2005 at 1993 constant price is used in the analysis considering the construction and build-up periods. Other commodities are evaluated at 1993 price assuming stable prices in real term.

(e) Labor Wage Rate
A shadow wage rate of NRs 21.4/day is used for farm labor cost. As discussed in Annex D, the project area is regarded as of labor excess economy. The average wage rate at NRs 30/day for farm labor is not the one that represents seasonal unemployment and underemployment broadly observed in the area. A conversion factor of 0.75 was assumed. The wage rate is also applied for unskilled common labor in construction works considering abundant labor supply. Unskilled labors are to be paid NRs 40 per day in the project cost estimation.

(f) Transfer Payment

All costs and benefits that are paid or received without receiving or serving any good or service are excluded in estimating economic cost and benefit. As for commodity prices, all transfer payments are omitted in the process of estimating economic prices. The estimation of construction cost is made on the basis of tax exemption except for the civil works which include contract tax of 5% in the estimated cost.

(g) Initial Investment Costs

The initial investment costs are first divided into foreign exchange costs and domestic currency costs. Foreign exchange costs are valued as they are, while domestic components are converted as shown below considering the proportion of unskilled labor cost in the estimated costs:

Cost Items	Unskilled Labor in Total Local Cost	First Conversion	Multiplied by SCF
Tubewells	21%	0.90	0.86
Water Distribution System	50%	0.77	0.73
Upgrading Road Network	35%	0.84	0.80
Buildings	23%	0.89	0.85
Procurement of Materials & Equipment*	55%	0.74	0.71
Procurement of O&M and Office Equipment	20%	0.91	0.86
Technical Support	0%	1.00	0.95
Project Administration	5%	0.98	0.93

Note: * Local cost in this item is mainly for installation of machinery and equipment.

(h) Discount Rate

The discount rate or the opportunity cost of capital is assumed to be 10 %.

7.2.2 Evaluation Results

(1) Economic Benefits

The benefits assessed in this economic analysis are those accrued from the increase of agricultural production. Indirect benefits are not accounted, though some are quantifiable. Incremental benefit is derived from the difference of production values between without and with project conditions which are discussed in Chapter 4.

Net agricultural returns in economic values are estimated at NRs 468.8 million and NRs 151.8 million per annum for with and without project conditions respectively. The annual incremental benefit at full development stage is thus NRs 317.0 million. The benefit will be fully attained from the year 2006/67, the 12th year from the commencement of the project.

(2) Economic Cost

(a) Initial Investment Cost

The total initial investment costs in economic value is estimated at NRs 1,414.6 million. The construction costs in financial prices are converted to economic value based on the aforementioned assumptions. Compensation for land acquisition is not included in the economic costs, since the loss of land is already valued in decreased agricultural production. The portion of farmers' participation in a form of labor dedication is valued by the shadow wage rate of farm labor.

(b) Replacement Cost

The machinery and equipment with shorter useful life than the project will be replaced after their useful periods. Conversion of financial prices to economic prices are made in the same way as the initial investment costs. Replacement costs in economic value are: NRs. 150.2 million for tubewell in every 20 years; NRs. 5.6 million for shallow tubewell pump sets in every 5 years; NRs 74.0 million for deep tubewell pump sets in every 15 years; and NRs 20.2 million for O&M equipment in every 10 years.

(c) Operation and Maintenance Cost

The operation and maintenance cost will annually incur at NRs. 21.5 million economic value. The energy cost for pump operation accounts for the largest part of the cost. The long run marginal energy cost at NRs 2.1/kWh[1/] is applied for economic electricity cost.

(3) Evaluation Results

On the basis of the cost and benefit flow shown in Table 7.3, the economic internal rate of return (EIRR) for the project is estimated to be 20.5%, and the net present value (NPV) of the project at 10% discount rate to be NRs 928.7 million. The results of sensitivity analysis are summarized below. The result indicates that the project viability would be rather insensitive to adverse changes except for the case of failing to realize the anticipated crop yields.

1/ Estimated by Nippon Koei in 1993 for *Master Plan Study for Water Resources Development of the Upper Karnali and Mahakali River Basin* (for Japan International Cooperation Agency).

	Item	Change in Variable	EIRR	Sensitivity Indicator	Switching Value (10%)
0.	Base Case	-	20.5%	-	-
1.	Cost increased	+20%	17.6%	0.71	+224%
2.	Benefit reduced	-20%	16.6%	0.94	-50%
	2a Output price decreased	-20%	15.6%	1.20	-40%
	2b Crop yield lowered	-20%	12.2%	2.02	-24%
3.	Project completion delayed	2 years	17.0%	-	more than 10 years

Note: Sensitivity indicator is % change in EIRR over % change in variable.
Switching value (10%) is a change in variable with which the EIRR will reach to 10%.

7.3 Financial Analysis

7.3.1 Farm Budget Analysis

The farm budget analysis is made for five representative farm models following the methodology given below. The analysis compares future situation if the project is implemented with that if not implemented. In the analysis, value of self-consumed crop is counted in both farm revenue and food expense, while family labor cost is not counted in farming cost. In addition to farm revenues and production costs, labor wage income and living expense are also assumed to be changed to some extent. The details of estimation procedure is given in Annex I.

The result of the analysis indicates that a substantial increase in income will be attained by every class of farms at full development of the project. Household incomes are estimated to increase by 123% on average, mostly brought by an increase in farm income by 195%. The net budget reserve is estimated to be more than six folds on average. The increase would be particularly significant for the marginal farm model, jumping to 14 folds of without project condition. The result of farm budget analysis is shown in Table 7.4, and summarized below.

(Unit : NRs/year)

Average Farm Size	Marginal 0.46 ha	Small 1.66 ha	Medium 3.63 ha	Large 7.14 ha	Average 1.11 ha
NPC Poverty Line*	30,611	41,464	45,592	61,639	34,785
Without Project					
Income	18,020	36,060	62,760	115,650	27,350
Expense	17,650	31,140	36,700	82,770	24,950
Net Reserve	370	4,920	26,060	32,880	2,400
With Project					
Income	32,490	85,600	170,420	320,800	61,010
Expense	26,200	55,390	72,500	180,150	42,260
Net Reserve	6,290	30,210	97,920	140,650	18,750
Increment					
Income	14,470	49,540	107,660	205,150	33,660
Expense	8,550	24,250	35,800	97,380	17,310
Net Reserve	5,920	25,290	71,860	107,770	16,350

Note: * Estimated by National Planning Commission at US$ 92.76/person (World Bank/UNDP *Nepal Relieving Poverty in Resource-Scarce Economy* 1990)

7.3.2 Cost Recovery

The operation and maintenance of the project facilities are planned to be transferred to farmers after the construction period is over. Farmers will manage the facilities by themselves through water users association. This participatory approach is expected to increase the efficiency of water use and tubewell management, and at the same time to reduce the burden of irrigation costs on HMGN's budget. For sustainable operation and maintenance, the water charge which cover at least annual O&M costs needs to be borne by farmers. The water charge required for running tubewell system is estimated based on the O&M costs and annual equivalent replacement costs as shown below.

(Unit: NRs/ha)

	Conjunctive Use		Rainfed Area	
	STW (15ha)	DTW (95ha)	STW (10ha)	DTW (65ha)
For O&M cost recovery only	1,900	1,700	3,600	4,000
For all running cost recovery	2,900	3,600	5,100	5,900
(40% of tubewell cost subsidized)	2,500	2,900	4,500	4,700

Note : Conjunctive use area includes the whole FMIS and SDIS areas.

The farm household budget analysis indicates that an increase generated by the project would be large enough to meet the water charge for all groups of farmers. The following table shows future farm budgets under with project condition. Even for the case of the highest irrigation fee, it would account for only around 13% of pre-water charge farm incomes, and 20% of incremental farm incomes.

(Unit : NRs/year)

Average Farm Size	Marginal 0.46ha	Small 1.66ha	Medium 3.63ha	Large 7.14ha	Average 1.11ha
Gross Farm Revenue	28,370	100,300	216,990	422,470	67,110
Input Cost + Land Tax	6,960	25,150	58,090	122,970	17,240
Pre-water charge Income	21,410	75,150	158,900	299,500	49,870
(Increment from Without)	13,670	48,950	107,470	205,150	32,970
Proposed Water Charge	2,714	9,794	21,417	42,126	6,549
Net Farm Income	18,696	39,156	137,483	257,374	43,321

Note: Water charge used in the calculation is of the highest case at NRs 5,900/ha.

The sustainability of tubewell systems is highly dependent on farmers' willingness to participate and consciousness of self-management. In this context, a program to encourage farmers to take over tubewell management and to ensure the necessity of paying water charge is highly recommendable. Farmers would otherwise be reluctant to pay for water because irrigation service has been subsidized historically by the government in Nepal.

7.4 Indirect and Intangible Effects

In addition to the direct benefit from an increase of agricultural production, the project will bring various tangible indirect benefits and intangible effects as described below.

(1) Poverty Reduction

An increase of income generated by the project will significantly reduce the number of households below the poverty line. The farm budget survey implies that at present about 80% (most of marginal class farms and more than a half of small class farms) of the households in the project area are living below the poverty line, if applying the definition in the National Planning Commission at $7.73 per capita per month (World Bank/UNDP 1990). More than half of them are expected to gain higher income than this after implementation of the project.

(2) Increase in Employment Opportunity

The project will generate incremental annual farm employment of about one million man-days per year at full development stage. In addition, a large number of farmers will be involved in construction works, though not permanently. The increased labor use will reduce present high level unemployment and underemployment and thereby intervene seasonal or permanent migration from rural area. There will be favorable effects in equity view as well, since labor force to be hired are mostly of smaller farms who seek for employment outside their tiny holdings.

(3) Improvement of Transportation

The project includes the upgrading works of existing roads in total 90 km extent. The access to market and agriculture support services will be bettered by the roads. The improved inter- and intra-regional transportation will vitalize economic activities in the region through better communication and access to market. Without the project, most of the villages are not easily accessible, particularly during the monsoon season.

(4) Foreign Exchange Saving

The increased agricultural products are mostly regarded as import substitutes and then contribute to reduction of country's chronic trade deficit. In total it is estimated that NRs 347.7 million or US$ 7.0 million equivalent can be saved annually from Nepal's foreign exchange payment (increment in gross production value of traded farm products). The opportunity cost of food import which is strictly for consumption purpose can be large considering the possibility of importing other productive capital goods instead of food.

(5) Linkage Effects

A production increase in agriculture sector will induce economic activities in other sector through linkage effects. The secondary and tertiary benefits will accrue in any sectors related to agriculture. Farm inputs suppliers and labors are those having backward linkage effects and traders and millers are those having forward linkage effects. The initial construction investment would also expand effective demand and then increase national income, although this Keynesian multiplier effects cannot be fully expected in a supply deficit economy like Nepal.

(6) Enhancement of Living Condition

An increase in income will inevitably better-off farmers. They can spend more on their housing, clothing, health care, sanitation, education and others. These collectively will improve social and cultural amenities of villages and give an impetus to further development within the region.

(7) Promotion of Replication

A successful operation of tubewell systems under the project with introduction of farmer management and full O&M cost recovery is expected to have a demonstration effect. Farmers in surrounding area would be motivated to replicate the tubewell irrigation systems. This diffusion may contribute to sustained growth and development of tubewell irrigation throughout Terai.

7.5 Environmental Aspects

The potential environmental impacts of the project are preliminarily studied employing the guideline of the Economic and Social Committee for Asia and Pacific (ESCAP). The check list for the assessment identifies the following potential adverse effects.

(1) Impacts of Groundwater Abstraction

(a) Land Subsidence

In the project area, groundwater will be abstracted from the confined aquifer which has well consolidated confining layers or from the unconfined shallow aquifer. Therefore, there will be very little possibility of occurring land subsidence in future.

(b) Effects on Spring Discharges

Effects of groundwater abstraction on spring discharge would be negligible. The spring discharge after the groundwater development is estimated to be 91% of the present one.

(c) Interference with Prior Water Rights

The development area is determined so as to keep the depth of groundwater table at most 7 m below ground surface through the optimization study. In most of the existing tubewell area, the depth of groundwater will be at about 4 - 5 m below ground surface. Groundwater abstraction will have no effect on the yields of existing shallow tubewells and then never interfere with prior water rights.

(2) Impacts of Groundwater Irrigation

(a) Change of Soil Fertility and Water Pollution

An increase in use of fertilizers and pesticides would affect on soil fertility and water quality and result in water pollution in downstream of the command area . However, the degradation of water quality is reversible and not cumulative. Improvement of soil, water and crop management practices are needed to mitigate the impact by reducing runoff and percolation losses.

(b) Biological Aspect

The life of aquatic biota may change in relation with water pollution due to increase use of fertilizers and pesticides. The impact area possibly covers the whole aquatic ecosystem downstream of the command areas. The impacts on aquatic biota and wildlife are regarded as important because the impact area is large and many environmental components are possibly affected.

(c) Socio-economic and Human Health Aspects

Positive impacts on job opportunity and social income are expected to occur, as envisaged in the main objective of the project. However, there would also be a negative effects such as a disturbance on human health resulting from pesticide contamination. Proper guidance and training by extension workers on the choice of pesticides, storage, application method and safe disposal of containers will reduce this impact to a minimum level.

In order to study above possible problems in detail and to ensure the proposed project environmentally more sound, an environmental management and monitoring plan is proposed to be formulated in the detailed design stage and be executed throughout the construction and post-construction stages.

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Tables

Table 3.1

Shallow Tubewells in the Project Area

(as of January 15, 1993)

S. N.	VDCs	Number	Area (ha)
Bara District			
1.	Simra	68	179
2.	Kailaya	378	747
3.	Balirampur	127	333
4.	Chhatapipra	43	81
5.	Dharampur	61	157
6.	Maheshpur	50	139
7.	Raghunathpur	65	163
8.	Baghban	29	120
9.	Dumarabana	58	161
10.	Jitpur	20	41
11.	Manharwa	60	183
12.	Motisar	36	83
13.	Prastoka	67	179
14.	Purainia	109	283
15.	Buniyad	35	100
16.	Bajnariya	67	228
17.	Bhodaha	62	247
18.	Bhatauda	96	289
19.	Dohari	73	248
20.	Jhitkhaiya	84	226
21.	Phatephur	50	103
22.	Inerwa Shera	13	31
23.	Sishania	11	28
24.	Pheta	26	90
25.	Phluahi Bharwalia	10	25
26.	Parsuani	7	18
27.	Pirparpati	2	5
	Total	**1,707**	**4,486**
Parsa District			
1.	Madhuban (Methol)	3	5
2.	Harpur	6	11
3.	Birwaguthi	28	93
4.	Parsauni (Sakhuwa)	8	27
5.	Bageshwari Titrauna	17	74
6.	Panchrukhi	2	13
7.	Bailwa Parsauni	26	84
8.	Chorni	23	59
9.	Lalparasa	5	13
10.	Bagahi	13	30
11.	Lipani Birta	3	3
12.	Maniyari	1	3
13.	Bagbana	1	3
14.	Basdilwa	2	6
	Total	**138**	**424**

Source : (1) Tubewell Inventory Study, WECS, 1992
(2) ADBN, Bara and Parsa Districts.

Canal Discharge at the Head of NEC

(1) Monthly Average Discharge

(Unit : m3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1980	6.83	6.57	6.81		7.28	11.12	16.57	15.63	14.62	17.17		4.03
1981	5.82	6.46	4.16	7.32	7.83	10.48	11.70	9.25	0.00	11.53		5.33
1982	7.89	6.79			8.46	9.83	15.37	15.67	16.19	14.22		9.48
1983	11.33	7.25	7.81		10.94	12.55	14.59	15.52	17.67	15.52		9.99
1984	11.07	10.62			10.17	11.87	12.79	14.99	9.08	14.72		
1985	9.18	10.78	10.24		18.28	19.00	17.62	13.77	11.25			
1986	7.11	5.36	10.06		10.11	16.53	15.22	14.25				
1991						6.19	10.48	13.84	13.07	11.94	6.65	
1992	5.49	10.64	7.77									

(2) Monthly Probable Discharge

Max.	11.33	10.78	10.24	7.32	18.28	19.00	17.62	15.67	17.67	17.17	6.65	9.99
Average	8.09	8.06	5.86	0.92	9.13	12.20	14.29	14.11	10.24	10.64	0.83	3.60
75%(6/8)	6.83	6.57	4.16	0.00	7.83	10.48	12.79	13.84	9.08	11.53	0.00	0.00
80%	6.2	6.5	4.0	0.0	7.0	9.3	12.0	12.0	8.5	10.0	0.0	2.0
Min.	5.49	5.36	0.00	0.00	0.00	6.19	10.48	9.25	0.00	0.00	0.00	0.00

Future Crop Budget Under Without Project Condition

Production Parameters	Irrigated Paddy		Rainfed Paddy		Maize	Wheat	Oilcrops	Potato	Sugarcane		Lentil& Pulses	Vege-tables
	Early	Monsoon	Early	Monsoon					Irrigated	Rainfed		
1.Gross Return												
a. Main Product (ton/ha)	3.0	2.8	1.7	2.1	2.2	1.6	0.7	10.6	45.0	38.0	0.6	5.5
Price (NRs/ton)	7,150	7,150	7,150	7,150	5,500	6,050	15,840	5,500	662	662	11,990	7,150
Value(NRs/ha)	21,450	20,020	12,155	15,015	12,100	9,680	11,088	58,300	29,799	25,164	7,194	39,325
b. Bi- Product (ton/ha)	3.3	3.1	1.9	2.3	1.8	1.6			4.5	3.8	0.3	
Price (NRs/ton)	300	300	300	300	200	250			50	50	150	
Value(NRs/ha)	990	924	561	693	352	400			225	190	45	
Gross Return(NRs/ha)	22,440	20,944	12,716	15,708	12,452	10,080	11,088	58,300	30,024	25,354	7,239	39,325
2.Production Cost (NRs/ha)												
a. Input Cost												
i) Seed	570	496	570	496	279	1,682	357	13,824	2,900	2,900	901	200
Seed Rate (kg/ha)	69	60	69	60	19	139	17	1,152	4,394	4,394	53	0.5
Price (NRs/kg)	8.3	8.3	8.3	8.3	14.7	12.1	21.0	12.0	0.7	0.7	17.0	400.0
Value(NRs/ha)	570	496	570	496	279	1,682	357	13,824	2,900	2,900	901	200
ii) Fertilizer Cost	904	1,281	709	1,026	1,236	1,018	275	1,585	1,617	1,164	214	1,469
Urea (kg/ha)	82	111	57	78	94	118	20	94	169	118	12	144
Price (NRs/kg)	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Value(NRs/ha)	455	616	316	433	522	655	111	522	938	655	67	799
Potash (kg/ha)					5	1		33	9	6		
Price (NRs/kg)	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Value(NRs/ha)					43	9		281	77	51		
TSP (kg/ha)	22	30	15	21	28	36	14	51	59	41	10	57
Price (NRs/kg)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Value(NRs/ha)	176	240	120	168	224	288	112	408	472	328	80	456
Manure (kg/ha)	1.09	1.70	1.09	1.70	1.79	0.27	0.21	1.50	0.52	0.52	0.27	0.86
Price (NRs/ton)	250	250	250	250	250	250	250	250	250	250	250	250
Value(NRs/ha)	273	425	273	425	448	67	52	375	130	130	68	214
iii) Pesticides (NRs/ha)	22	52	22	52	17	2		218	77	77		236
Input Costs (NRs/ha)	1,496	1,829	1,301	1,574	1,532	2,702	632	15,627	4,594	4,141	1,115	1,905
b. Labor Cost (NRs/ha)												
i) Human Labor (man-day)	2,490	2,490	1,980	1,980	1,320	750	690	1,800	6,120	4,890	510	810
Family Labor	58	58	58	58	57	39	60	160	63	63	35	209
Price (NRs/day)												
Value(NRs/ha)												
Hired Labor	83	83	66	66	44	25	23	60	204	163	17	27
Price (NRs/day)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Value(NRs/ha)	2,490	2,490	1,980	1,980	1,320	750	690	1,800	6,120	4,890	510	810
ii) Draft Labor (animal-day)	720	720	720	720	400	800	400	720	1,200	1,200	560	480
Family Labor	23	23	23	23	22	22	23	36	35	35	18	28
Price (NRs/day)												
Value(NRs/ha)												
Hired Labor	9	9	9	9	5	10	5	9	15	15	7	6
Price (NRs/day)	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Value(NRs/ha)	720	720	720	720	400	800	400	720	1,200	1,200	560	480
Labor Cost (NRs/ha)	3,210	3,210	2,700	2,700	1,720	1,550	1,090	2,520	7,320	6,090	1,070	1,290
Miscellaneous (5% of others)	235	252	200	214	163	213	86	907	596	512	109	160
Production Cost (NRs/ha)	4,941	5,291	4,201	4,488	3,415	4,465	1,808	19,055	12,509	10,743	2,294	3,355
Unit Net Return (NRs/ha)	17,499	15,653	8,515	11,220	9,037	5,615	9,280	39,245	17,515	14,611	4,945	35,970
Cultivated Area (ha) Project Area		2,064	91	5,033	142	1,552	318	45	104	130	1,628	31
Production Value (NRs 1,000)		43,228	1,157	79,058	1,768	15,644	3,526	2,624	3,122	3,296	11,785	1,219
Production Cost (NRs 1,000)		10,921	382	22,586	485	6,929	575	857	1,301	1,397	3,735	104
Net Return (NRs 1,000)		32,308	775	56,472	1,283	8,715	2,951	1,766	1,822	1,899	8,050	1,115
Total Net Return (NRs 1,000) =		117,156	Total Production Value =		166,428			Total Production Cost =			49,272	

Future Crop Budget Under With Project Condition

Production Parameters	Paddy	Maize	Wheat	Oil Crops	Potato	Sugar-cane	Lentil	Mung bean	Vege-tables
1.Gross Return									
a. Main Product (ton/ha)	4.2	4.0	3.5	1.0	20.0	65.0	1.2	1.2	19.0
Price (NRs/ton)	7,150	5,500	6,050	15,840	5,500	662	12,000	13,200	7,150
Value(NRs/ha)	30,030	22,000	21,175	15,840	110,000	43,030	14,400	15,840	135,850
b. Bi- Product (ton/ha)	4.6	3.2	3.5			6.5	0.6		
Price (NRs/ton)	300	200	250			50	150		
Value(NRs/ha)	1386	640	875			325	90		
Gross Return(NRs/ha)	31,416	22,640	22,050	15,840	110,000	43,355	14,490	15,840	135,850
2.Production Cost (NRs/ha)									
a. Input Cost									
i) Seed	590	441	1,205	210	18,000	2,970	680	450	200
a.Seed Rate (kg/ha)	50	30	100	10	1,500	4,500	40	30	0.5
Price (NRs/kg)	11.8	14.7	12.1	21.0	12.0	0.7	17.0	15.0	400.0
Value(NRs/ha)	590	441	1,205	210	18,000	2,970	680	450	200
ii) Fertilizer Cost	2,834	2,834	2,834	2,734	3,776	4,399	1,276	1,326	5,249
Urea (kg/ha)	174	174	174	130	152	217	43	43	217
Price (NRs/kg)	5.55	5.55	5.55	5.55	5.55	5.55	5.55	5.55	5.55
Value(NRs/ha)	966	966	966	722	844	1,204	239	239	1,204
Potash (kg/ha)	33	33	33	50	67	67			167
Price (NRs/kg)	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Value(NRs/ha)	281	281	281	425	570	570			1,420
TSP (kg/ha)	87	87	87	87	109	130	43	87	130
Price (NRs/kg)	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Value(NRs/ha)	1,088	1,088	1,088	1,088	1,363	1,625	538	1,088	1,625
Manure (kg/ha)	2	2	2	2	4	4	2		4
Price (NRs/ton)	250	250	250	250	250	250	250	250	250
Value(NRs/ha)	500	500	500	500	1,000	1,000	500		1,000
iii) Pesticides (NRs/ha)	200	300		200	400	400			400
Input Costs (NRs/ha)	3,624	3,575	4,039	3,144	22,176	7,769	1,956	1,776	5,849
b. Labor Cost (NRs/ha)									
i) Human Labor (man day)	3,312	2,148	2,148	1,440	3,000	7,332	1,140	1,440	1,530
Family Labor	70	68	68	72	160	76	42	42	209
Price (NRs/day)									
Value(NRs/ha)									
Hired Labor	110	72	72	48	100	244	38	48	51
Price (NRs/day)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Value(NRs/ha)	3,312	2,148	2,148	1,440	3,000	7,332	1,140	1,440	1,530
ii) Draft Labor (man day)	1,360	1,120	1,120	560	720	1,200	960	1,360	1,360
Family Labor	23	22	22	23	36	35	18	18	28
Price (NRs/day)									
Value(NRs/ha)									
Hired Labor	17	14	14	7	9	15	12	17	17
Price (NRs/day)	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Value(NRs/ha)	1,360	1,120	1,120	560	720	1,200	960	1,360	1,360
Labor Cost (NRs/ha)	4,672	3,268	3,268	2,000	3,720	8,532	2,100	2,800	2,890
Miscellaneous (5%of others)	415	342	365	257	1,295	815	203	229	437
Production Cost (NRs/ha)	8,710	7,185	7,672	5,401	27,190	17,116	4,259	4,805	9,176
Unit Net Return (NRs/ha)	22,706	15,455	14,378	10,439	82,810	26,239	10,231	11,035	126,674
Cultivated Area (ha)	5,800	1,813	3,335	363	218	725	363	363	436
Production Value (NRs 1,000)	182,213	41,046	73,537	5,750	23,980	31,432	5,260	5,750	59,231
Production Cost (NRs 1,000)	50,521	13,026	25,586	1,961	5,928	12,409	1,546	1,744	4,001
Net Return (NRs 1,000)	131,692	28,020	47,951	3,789	18,052	19,023	3,714	4,006	55,230
Total Net Return (NRs 1,000) =		311,477			Total Production Value =	245,986	Total Production Cost =		66,200

Summary of Project Cost Estiamte (1)

Work Item	Unit	Quantity	Unit Cost (NRs '000) L.C.	F.C.	Total	Amount (NRs.'000) L.C.	F.C.	Total
I. DIRECT COST								
A. Tubewell								
A-1 Shallow tubewell	nos.	200	44	161	205	8,800	32,200	41,000
A-2 Deep tubewell	nos.	70	184	656	840	12,880	45,920	58,800
Total for A						21,680	78,120	99,800
B. Water Distribution and Drainage System								
B-1 Shallow tubewell area								
(1) FMIS Areas						9,960	4,980	14,940
(2) Rainfed Areas						43,390	22,800	66,189
Subtotal for B-1						53,350	27,779	81,129
B-2 Deep tubewell area								
(1) FMIS Areas						16,160	10,870	27,030
(2) SDIS Areas						20,200	13,590	33,790
(3) Rainfed Areas						86,750	64,220	150,970
Subtotal for B-2						123,110	88,680	211,790
Total for B.						176,460	116,459	292,919
C. Upgrading of Road Network								
C-1 Janta road	L.S.	1				1,438	1,088	2,526
C-2 North-South Road	L.S.	1				59,343	38,407	97,750
C-3 Service road to pump house	L.S.	1				23,288	11,700	34,988
C-4 Miscellaneous works	L.S.	1				4,201	2,555	6,756
Total for C						88,270	53,750	142,020
D. Buldings								
D-1 Office & quarter at Parawanipur	L.S.	1				2,410	1,292	3,702
D-2 Stores for agricultural inputs	L.S.	1				990	510	1,500
D-3 Agricultural training center	L.S.	1				990	510	1,500
D-4 Miscellanous works	L.S.	1				628	341	969
Total for D						5,018	2,653	7,671
Total for Direct Cost						**291,428**	**250,982**	**542,410**
II. MATERIAL AND EQUIPMENT								
E. Procurement of Material								
E-1 Pipes and screen for STW	wells	200	2	34	35	350	6,700	7,050
E-2 Pipes and screen for DTW	wells	70	34	642	676	2,360	44,940	47,300
Total for E						2,710	51,640	54,350
F. Procurement of Mechanical and Electrical Works								
F-1 Pump Sets for shallow tubewells	sets	200	6	24	30	1,200	4,800	6,000
F-2 Pump Sets for deep tubewells	sets	70	180	930	1,110	12,600	65,100	77,700
F-3 Power supply	sets	70	316	761	1,077	22,090	53,290	75,380
Total for F						35,890	123,190	159,080

(Continued)

Summary of Project Cost Estimate (2)

Work Item	Unit	Quantity	Unit Cost (NRs '000) L.C.	F.C.	Total	Amount (NRs.'000) L.C.	F.C.	Total
G. Procurement of O&M and Office Equipment						1,010	19,290	20,300
G-1 O&M equipment	L.S.	1				290	5,700	5,990
G-2 Office equipment	L.S.	1				460	8,750	9,210
G-4 Aquifer testing equipment	L.S.	1				110	620	730
G-5 Mechanical workshop	L.S.	1				40	230	270
G-6 Electrical workshop	L.S.	1				50	190	240
G-7 Area repairshop						1,960	34,780	36,740
Total for G						**40,560**	**209,610**	**250,170**
Total for Material and Equipment								
III. TECHNICAL SUPPORTS								
H. Technical Support						57,980	165,020	223,000
H-1 Consulting services	L.S.	1				6,000	38,000	44,000
H-2 Survey & study	L.S.	1				8,040	0	8,040
H-3 Trainings	L.S.	1				72,020	203,020	275,040
Total for H						**72,020**	**203,020**	**275,040**
Total for Technical Supports								
IV. PROJECT ADMINISTRATION								
I. Establishment & O&M						65,280	0	65,280
I-1 Project office establishment	L.S.	1				6,540	0	6,540
I-2 Agricutural support fund	L.S.	1				71,820	0	71,820
Total for I								
J. Land Acquisition						300		300
J-1 Land acquisition	L.S.	1				300	0	300
Total for J						72,120	0	72,120
Total for Project Administration								
TOTAL INVESTMENT COST						476,128	663,612	1,139,740
US Dollar Equivalent (x 1000)						$9,523	$13,272	$22,795
per ha (x 1000)						$1.31	$1.83	$3.14
Physical Contingencies (10%)						47,610	66,360	113,970
Price Escalation						236,410	96,690	333,100
TOTAL PROJECT COST						760,148	826,662	1,586,810
US Dollar Equivalent (x 1000)						$15,203	$16,533	$31,736

Excange Rate = 50 NRs / $

Proposed Disbursement Schedule

(Unit : Million Rupees)

Description	Total Disbursement Amount			Fiscal Year 1995/1996		1996/1997		1997/1998		1998/1999		1999/2000		2000/2001		2001/2002		2002/2003	
	L.C	F.C	Total	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C
A. Tubewells																			
A-1 Shallow Tubewells	8.8	32.2	41.0	0.0	0.0	0.9	3.2	1.5	5.6	1.8	6.4	1.8	6.4	1.5	5.6	1.3	4.8	0.0	0.0
A-2 Deep Tubewells	12.9	45.9	58.8	0.0	0.0	1.1	3.9	2.2	7.9	2.6	9.2	2.6	9.2	2.2	7.9	2.2	7.9	0.0	0.0
B. Water Distribution and Drainage Systems																			
B-1 Shallow Tubewells Area	53.4	27.8	81.1	0.0	0.0	0.0	0.0	5.3	2.8	9.3	4.9	10.7	5.6	10.7	5.6	9.3	4.9	8.0	4.2
B-2 Deep Tubewells Area	123.1	88.7	211.8	0.0	0.0	0.0	0.0	10.6	7.6	21.1	15.2	24.6	17.7	24.6	17.7	21.1	15.2	21.1	15.2
C. Upgrading of Road Network	88.3	53.8	142.0	0.0	0.0	26.5	16.1	26.5	16.1	17.7	10.8	17.7	10.8	0.0	0.0	0.0	0.0	0.0	0.0
D. Buildings	5.0	2.7	7.7	1.0	0.5	2.5	1.3	0.5	0.3	0.0	0.0	0.5	0.3	0.5	0.3	0.0	0.0	0.0	0.0
E. Procurement of Material																			
E-1 Pipes for Shallow Tubewells	0.4	6.7	7.1	0.0	0.0	0.1	2.3	0.0	0.0	0.1	2.3	0.0	0.0	0.1	2.0	0.0	0.0	0.0	0.0
E-2 Pipes for Deep Tubewells	2.4	44.9	47.3	0.0	0.0	1.0	19.3	0.0	0.0	0.7	12.8	0.0	0.0	0.7	12.8	0.0	0.0	0.0	0.0
F. Procurement of Mechanical & Electrical Works																			
F-1 Pumpsets for Shallow Tubewells	1.2	4.8	6.0	0.0	0.0	0.0	0.0	0.1	0.5	0.2	0.8	0.2	1.0	0.2	1.0	0.2	0.8	0.2	0.7
F-2 Pumpsets for Deep Tubewells	12.6	65.1	77.7	0.0	0.0	0.0	0.0	1.1	5.6	2.2	11.2	2.5	13.0	2.5	13.0	2.2	11.2	2.2	11.2
F-3 Power Supply	22.1	53.3	75.4	0.0	0.0	0.0	0.0	1.9	4.6	3.8	9.1	4.4	10.7	4.4	10.7	3.8	9.1	3.8	9.1
G. Procurement of O&M and Office Equipr	2.0	34.8	36.7	0.4	7.0	0.0	0.0	1.6	27.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H. Technical Support																			
H-1 Consulting Services	58.0	165.0	223.0	17.4	49.5	5.8	16.5	5.8	16.5	5.8	16.5	5.8	16.5	5.8	16.5	5.8	16.5	5.8	16.5
H-2 Survey and Studies	6.0	38.0	44.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	38.0	0.0	0.0	0.0	0.0	0.0	0.0
H-3 Training	8.0	0.0	8.0	1.6	0.0	1.6	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.8	0.0
I. Project Administration																			
I-1 Project Office	65.3	0.0	65.3	8.2	0.0	8.2	0.0	8.2	0.0	8.2	0.0	8.2	0.0	8.2	0.0	8.2	0.0	8.2	0.0
I-2 Agricultural Support	6.5	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	1.3	0.0	1.3	0.0	1.3	0.0	1.3	0.0
J. Land Acquisition	0.3	0.0	0.3	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Investment Cost	476	664	1,140	29	57	48	63	66	95	76	99	87	129	64	93	56	70	51	57
Physical Contingencies	48	66	114	3	6	5	6	7	10	8	10	9	13	6	9	6	7	5	6
Price Escalation	236	97	333	0	0	5	2	15	7	27	12	44	21	43	19	48	18	54	17
Total Project Cost	760	827	1,587	31	63	58	71	88	112	111	121	140	163	113	122	110	95	110	80
Cost Accumulation				31	63	89	134	177	246	288	367	428	530	541	652	650	747	760	827
L.C + F.C					94		223		424		655		958		1,193		1,397		1,587

Price Escalation for L.C. = 10.0%
for F.C. = 3.5%

Table 5.2

Economic Price Derivation for Tradable Goods

Farm Products

Unit : per ton

Item		Unit	Paddy	Wheat	Maize	Sugarcane
1 Projected 2005 World Price (in 1990 price) /1		US$	237	129	82	280
2 Projected 2005 World Price (in 1993 price) /1		US$	262	143	91	309
3 Quality Adjustment		%	90	95	95	95
4 Projected Price Adjusted for Quality Difference		US$	236	135	86	294
5 International Shipping and Handling	+	US$	38	70	66	66
6 FOB/CIF Price at Calcutta Port		US$	274	205	152	360
7 Transport and Handling from/to Nepal Border	+	US$	35	35	35	35
8 Equivalent in NRs./ton /2		NRs.	15,440	12,020	9,360	19,750
9 Domestic Transport and Handling from/to Wholesale Point or Mill /3	+	NRs.	290	290	290	290
10 Processing Ratio		%	65	100	100	9
11 Processing Cost /3	-	NRs.	160	0	0	100
12 By-Product /3	+	NRs.	285	240	190	50
13 Transport/handling from/to Farmgate /3	-	NRs.	95	95	95	95
14 Farmgate Price		NRs.	10,255	12,455	9,745	1,655

Farm Inputs

Unit : per ton

Item		Unit	Urea	T.S.P	KCL /4
1 Projected 2005 World Price (in 1990 price) /1		US$	159	123	105
2 Projected 2005 World Price (in 1993 price) /1		US$	176	136	116
3 International Shipping and Handling	+	US$	60	66	66
4 FOB/CIF Price at Calcutta Port		US$	236	202	182
5 Transport and Handling from/to Nepal Border	+	US$	45	45	45
6 Equivalent in NRs./ton /2		NRs.	14,040	12,350	11,350
7 Domestic Transport and Handling from/to Wholesale Point /3	+	NRs.	290	290	290
8 Transport/handling from/to Farmgate /3	+	NRs.	100	100	100
9 Farmgate Price		NRs.	14,430	12,740	11,740
10 Price of nutrient content /5		NRs.	31,370	27,700	19,570

Remarks :

/1 Based on the IBRD Commodity Price Projection, December 1992.
The IBRD estimated are given in 1990 constant US$, in which have been adjusted by the factor of 1.1053 (MUV) to allow for price escalation between 1990 and 1993.

- Paddy : Rice : Thai, milled, 5% broken, FOB Bangkok
- Wheat : Canadian No.1, Western Red Spring, FOB St. Lawrence
- Maize : US No.2, Milo Yellow, FOB Gulf Ports
- Sugarcane : Sugar : ISA daily price, FOB and stowed at greater Caribbean Ports
- Urea : Bagged, FOB N.W Europe
- T.S.P : Bulk, FOB US Gulf
- KCL : Bulk, FOB Vancouver

/2 Exchange rate between US$ and NRs. : US$ 1.00 = NRs. 50.0

/3 Adjusted with SCF of 0.95

/4 Potassium Chloride (Muriate of Potash)

/5 Nutrient content is 46 %, 46 %, and 60 %, respectively for Urea, TSP and KCL.

Financial and Economic Prices

Item	Unit	Financial Price		Conversion	Economic Price	
		Crop	By-product	Method	Crop	By-product
Crops		/6				
Paddy	NRs./ton	7,150	300	/1	10,255	285
Wheat	NRs./ton	6,050	250	/1	12,455	238
Maize	NRs./ton	5,500	200	/1	9,745	190
Mustard	NRs./ton	15,840		/2	15,050	
Lentil	NRs./ton	12,000	150	/2	11,400	143
Mungbean	NRs./ton	13,200		/2	12,540	
Sugarcane	NRs./ton	662	50	/1	1,655	48
Potato	NRs./ton	5,500		/2	5,230	
Vegetable	NRs./ton	7,150		/2	6,790	
Seeds						
Paddy	NRs./kg	11.8		/3	12.5	
Wheat	NRs./kg	12.1		/3	24.8	
Maize	NRs./kg	14.7		/3	26.0	
Mustard	NRs./kg	21.0		/3	20.0	
Lentil	NRs./kg	17.0		/3	16.2	
Mungbean	NRs./kg	15.0		/3	14.3	
Sugarcane	NRs./kg	0.7		/3	1.6	
Potato	NRs./kg	12.0		/3	11.4	
Vegetable	NRs./kg	400.0		/3	379.9	
Fertilizer						
Urea (N)	NRs./kg	5.6		/1	14.4	(31.4) /7
T.S.P (P)	NRs./kg	8.0		/1	12.7	(27.7) /7
Muriate of Potash (K)	NRs./kg	8.5		/1	11.7	(19.6) /7
Complex	NRs./kg	10.0		/4	11.8	
Farm Manure	NRs./ton	250.0		/2	237.5	
Chemicals						
BHC Dust	NRs./kg	5.7		/2	5.4	
Chilamin	NRs./kg	35.7		/2	33.9	
Hinosan	NRs./lit.	460.0		/2	437.0	
Zink Sulphate	NRs./kg	27.0		/2	25.7	
Malathion Dust	NRs./kg	16.0		/2	15.2	
Nuvan	NRs./lit.	527.0		/2	500.7	
Hired Labour	NRs.day	30.0		/5	21.4	
Bullock Labour	NRs.day	80.0		/2	76.0	

Remarks :
/1 Derived from the data of IBRD Commodity Price Forcasts (see TableL.1).
/2 Financial value is converted to economic value multiplying SCF of 0.95
/3 Assume the same premiums for seed as in finacial prices. For paddy, one third of premium was applied assuming a replacement at onece in three seasons.
/4 Estimated from nutient composition
/5 Multiplied SCF of 0.9 and shadow wage rate of 0.75.
/6 Financial prices are derived from 1992 prices with a 10% inflation rate.
/7 Price per nutrient unit.

Economic Cost Benefit Flow

EIRR= 20.5% NPV(10%)= 928.7 B/C(10%)= 2.02 Unit: NRs million

Year in Order	Fiscal Year	Capital Cost	Replacement Cost	O&M Cost	Cost Total	Gross Benefit	Net Benefit
1	1995/96	92.1			92.1	0.0	-92.1
2	1996/97	112.2			112.2	0.0	-112.2
3	1997/98	162.4		1.5	163.9	16.0	-147.9
4	1998/99	173.7		4.7	178.4	49.6	-128.8
5	1998/00	216.9		8.8	225.7	95.7	-130.0
6	2000/01	156.6		13.1	169.7	149.1	-20.6
7	2001/02	125.9		17.0	142.9	204.2	61.3
8	2002/03	105.1		17.0	122.2	257.4	135.3
9	2003/04			21.5	21.5	285.3	263.8
10	2004/05			21.5	21.5	301.9	280.5
11	2005/06			21.5	21.5	312.2	290.7
12	2006/07			21.5	21.5	317.0	295.5
13	2007/08		5.6	21.5	27.1	317.0	285.1
14	2008/09			21.5	21.5	317.0	295.5
15	2009/10			21.5	21.5	317.0	295.5
16	2010/11			21.5	21.5	317.0	295.5
17	2011/12			21.5	21.5	317.0	295.5
18	2012/13		25.8	21.5	47.3	317.0	269.7
19	2013/14			21.5	21.5	317.0	295.5
20	2014/15			21.5	21.5	317.0	295.5
21	2015/16			21.5	21.5	317.0	295.5
22	2016/17			21.5	21.5	317.0	295.5
23	2017/18		79.7	21.5	101.1	317.0	215.9
24	2018/19			21.5	21.5	317.0	295.5
25	2019/20			21.5	21.5	317.0	295.5
26	2020/21			21.5	21.5	317.0	295.5
27	2021/22			21.5	21.5	317.0	295.5
28	2022/23		176.1	21.5	197.6	317.0	119.5
29	2023/24			21.5	21.5	317.0	295.5
30	2024/25			21.5	21.5	317.0	295.5
31	2025/26			21.5	21.5	317.0	295.5
32	2026/27			21.5	21.5	317.0	295.5
33	2027/28		5.6	21.5	27.1	317.0	289.9
34	2028/29			21.5	21.5	317.0	295.5
35	2029/30			21.5	21.5	317.0	295.5
36	2030/31			21.5	21.5	317.0	295.5
37	2031/32			21.5	21.5	317.0	295.5
38	2032/33		99.8	21.5	121.3	317.0	195.7
39	2033/34			21.5	21.5	317.0	295.5
40	2034/35			21.5	21.5	317.0	295.5
41	2035/36			21.5	21.5	317.0	295.5
42	2036/37			21.5	21.5	317.0	295.5
43	2037/38		5.6	21.5	27.1	317.0	289.9
44	2038/39			21.5	21.5	317.0	295.5
45	2039/40			21.5	21.5	317.0	295.5
46	2040/41			21.5	21.5	317.0	295.5
47	2041/42			21.5	21.5	317.0	295.5
48	2042/43		5.6	21.5	27.1	317.0	289.9
49	2043/44			21.5	21.5	317.0	295.5
50	2044/45		-154.0	21.5	-132.5	317.0	449.5
	NPV				915.2	1,845.4	928.7

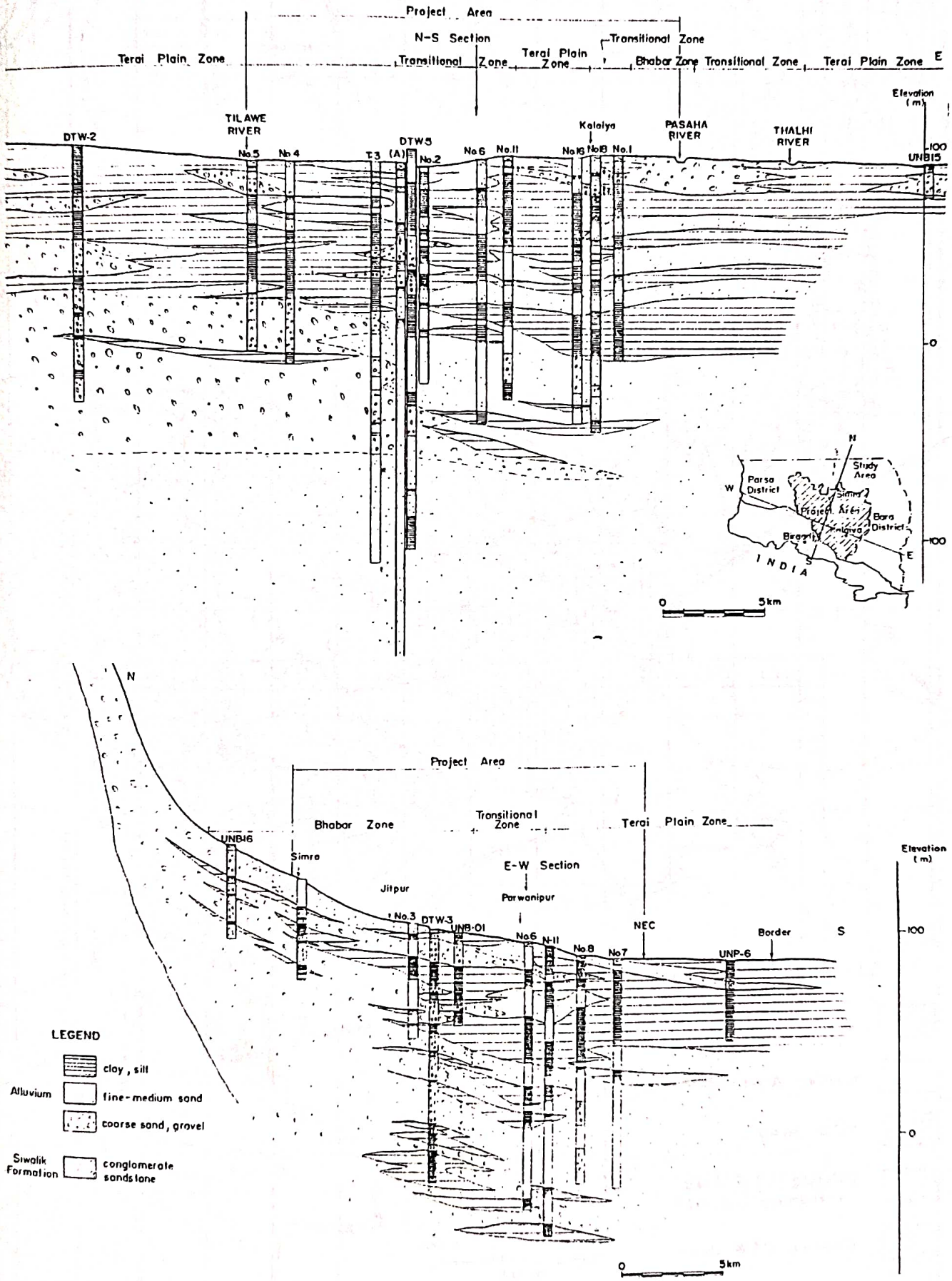
Change in Farm Budget

Unit: NRs

Item	Marginal	Small	Medium	Large	Average
Average Farm Size	0.46ha	1.66ha	3.63ha	7.14ha	1.11ha
Average Family Size	6.60	8.94	9.83	13.29	7.50
% Distribution	68%	22%	9%	2%	
NPC Poverty Line*	30,611	41,464	45,592	61,639	34,785
Without Project					
Income Total	18,020	36,060	62,760	115,650	27,350
Net farm Income	7,740	26,200	51,430	94,350	16,900
Non-farm Income	10,280	9,860	11,330	21,300	10,450
Expense	17,650	31,140	36,700	82,770	24,950
Food	11,081	18,659	20,586	28,873	15,484
Non-Food	6,564	12,476	16,117	53,902	9,470
Net Reserve	370	4,920	26,060	32,880	2,400
With Project					
Income Total	32,490	85,600	170,420	320,800	61,010
Net farm Income	21,410	75,150	158,900	299,500	49,870
Non-farm Income	11,080	10,450	11,520	21,300	11,140
Expense	26,200	55,390	72,500	180,150	42,260
Food	14,606	27,951	33,003	46,618	22,488
Non-Food	11,598	27,434	39,496	133,535	19,773
Net Reserve	6,290	30,210	97,920	140,650	18,750
Difference (With-Without)					
Income Total	14,470	49,540	107,660	205,150	33,660
Net farm Income	13,670	48,950	107,470	205,150	32,970
Non-farm Income	800	590	190	0	690
Expense	8,550	24,250	35,800	97,380	17,310
Food	3,525	9,292	12,417	17,746	7,004
Non-Food	5,033	14,958	23,379	79,633	10,303
Net Reserve	5,920	25,290	71,860	107,770	16,350
Change in Per cent					
Income Total	80%	137%	172%	177%	123%
Net farm Income	177%	187%	209%	217%	195%
Non-farm Income	8%	6%	2%	0%	7%
Expense	48%	78%	98%	118%	69%
Food	32%	50%	60%	61%	45%
Non-Food	77%	120%	145%	148%	109%
Net Reserve	1600%	514%	276%	328%	681%

Note: Budgets without project are of rained farms.
Details are in ANNEX-D
* Estimated by National Planning Commission at US$ 92.76/person for Terai area.

Figures



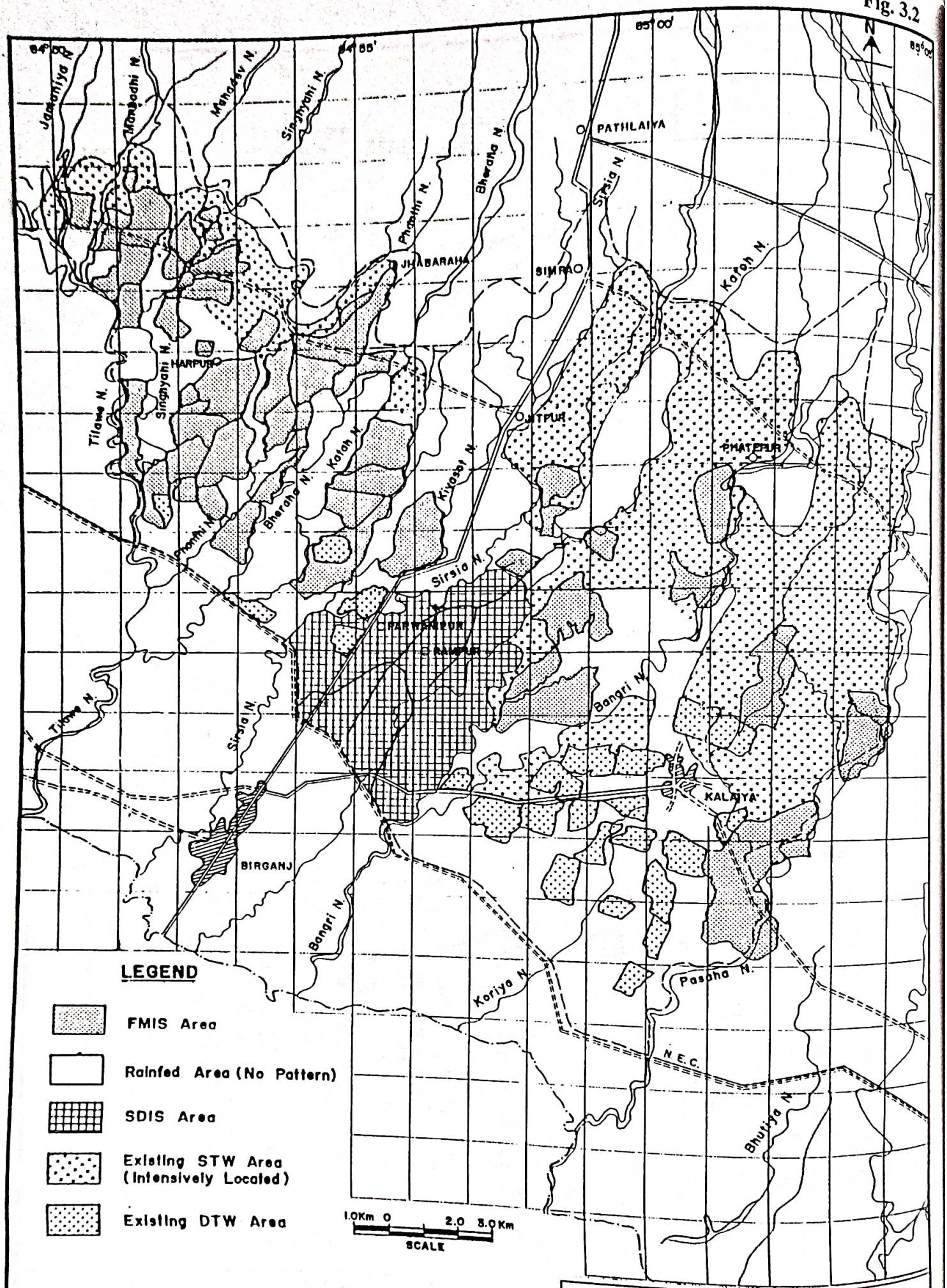
Schematic Hydrogeological Profile of the Study Area

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY

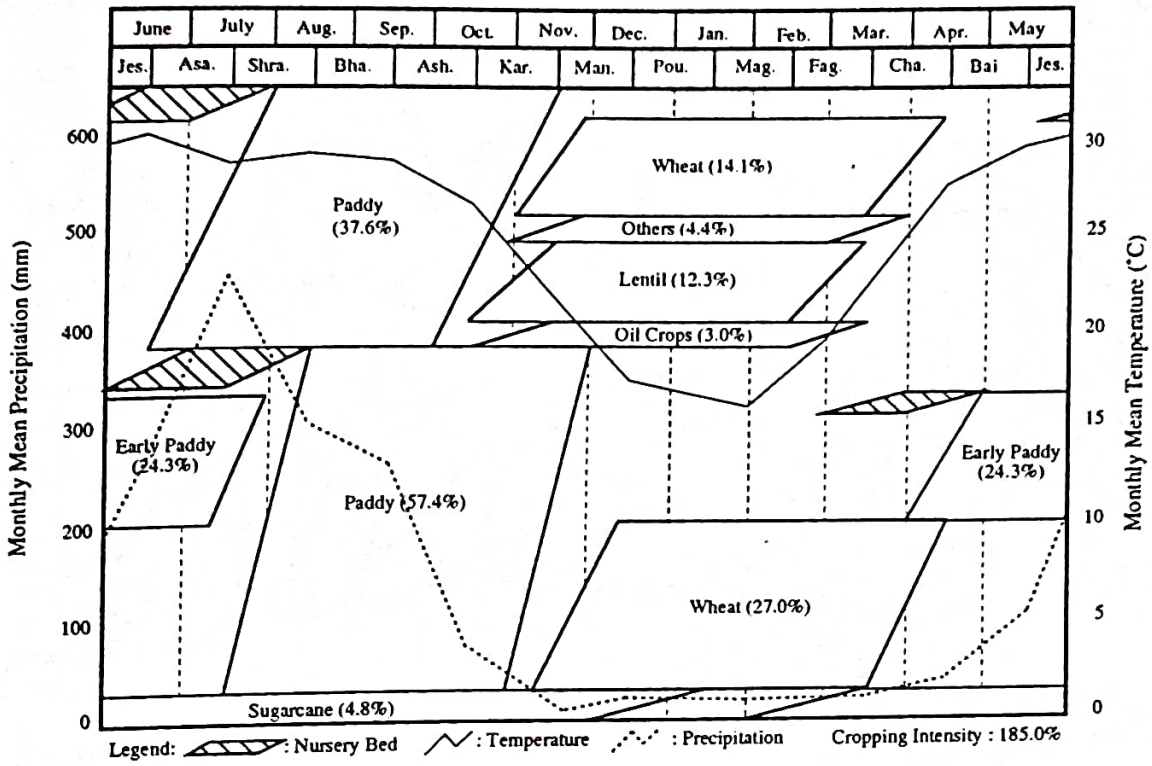
EXPANDING GROUNDWATER DEVELOPMENT FOR IRRIGATION IN THE BIRGANJ AREA OF THE TERAI

INTERNATIONAL DEVELOPMENT ASSOCIATION

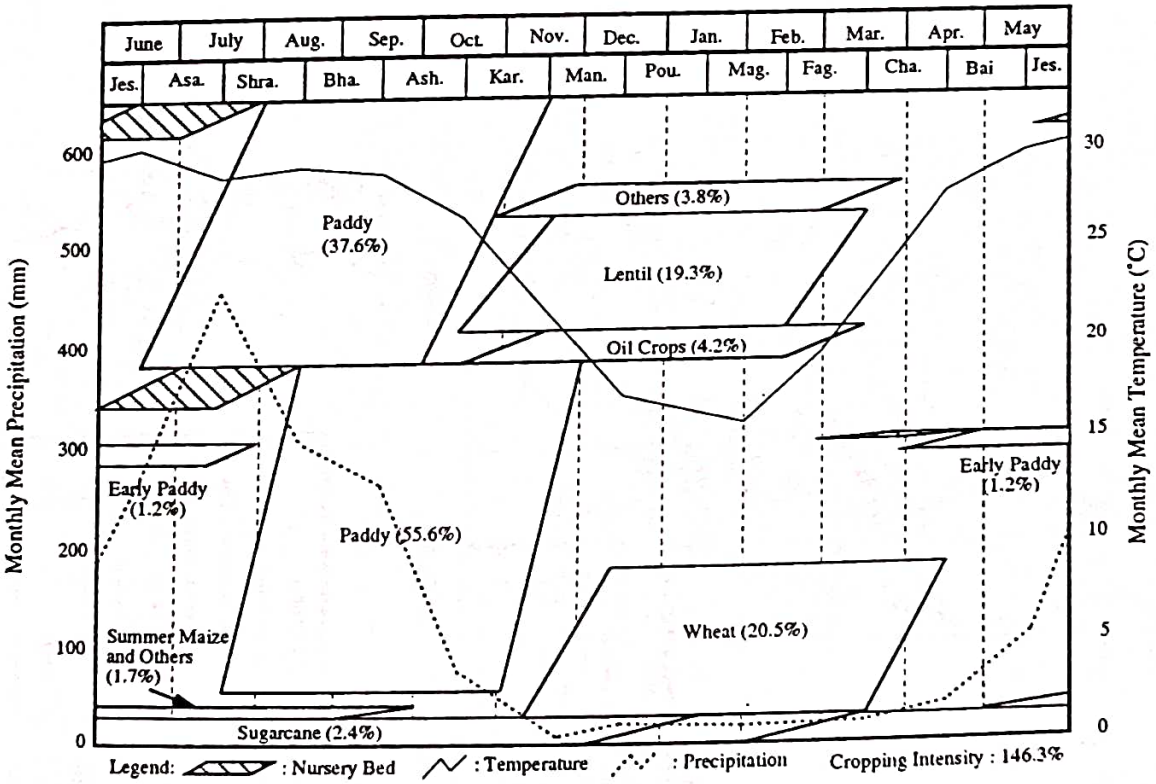


Location of Existing Irrigation schemes

HIS MAJESTY'S GOVERNMENT OF NEPAL
FEASIBILITY STUDY
EXPANDING GROUNDWATER DEVELOPMENT
FOR IRRIGATION IN THE BIRGANJ AREA OF THE TERAI
INTERNATIONAL DEVELOPMENT ASSOCIATION



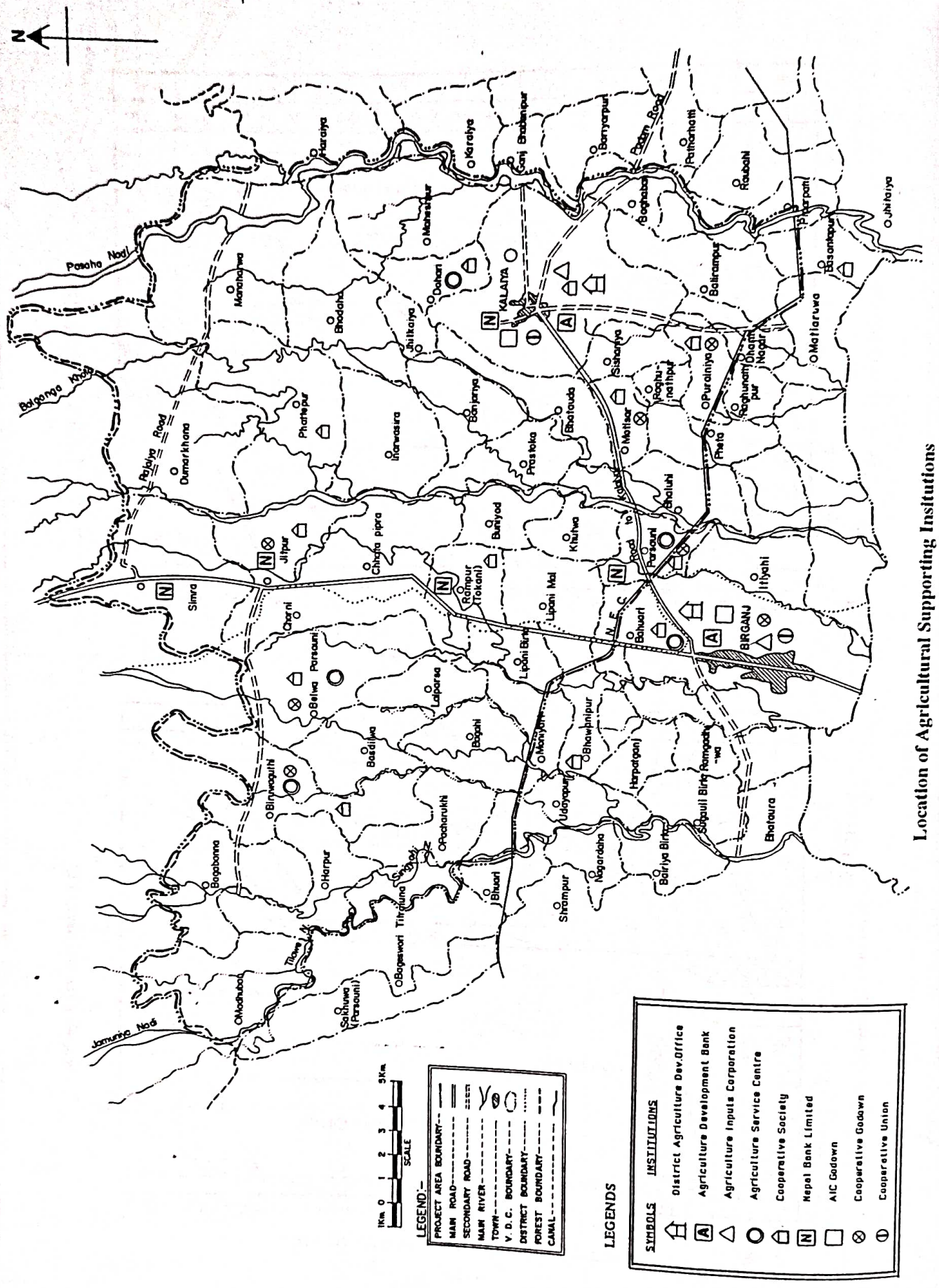
Present Cropping Pattern in Fully Irrigated Area



Present Cropping Pattern in Rainfed Area

Present Cropping Pattern

HIS MAJESTY'S GOVERNMENT OF NEPAL
FEASIBILITY STUDY
EXPANDING GROUNDWATER DEVELOPMENT FOR IRRIGATION IN THE BIRGANJ AREA OF THE TERAI
INTERNATIONAL DEVELOPMENT ASSOCIATION



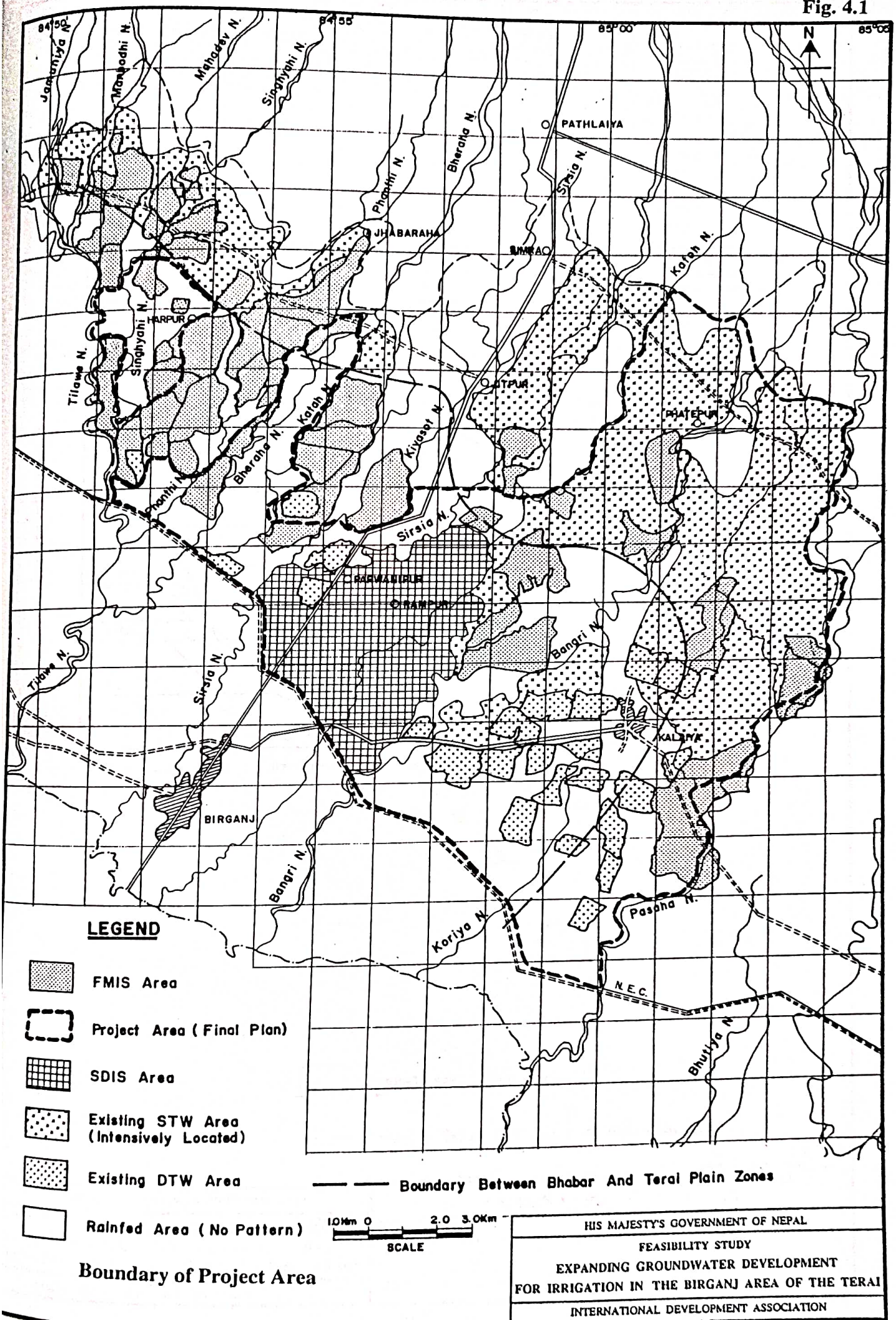
Location of Agriculture Supporting Institutions

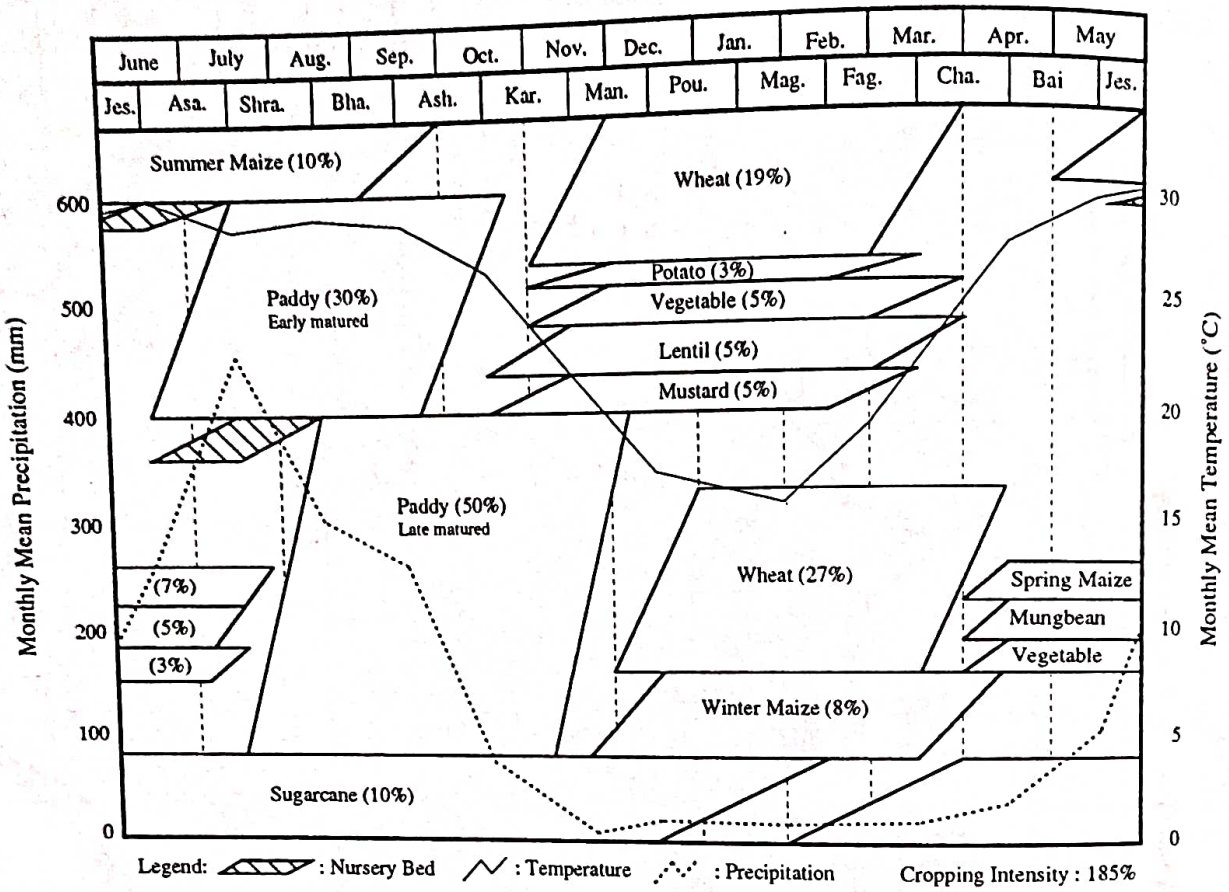
HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY
EXPANDING GROUNDWATER DEVELOPMENT
FOR IRRIGATION IN THE BIRGANJ AREA OF THE TERAI

INTERNATIONAL DEVELOPMENT ASSOCIATION

Fig. 4.1

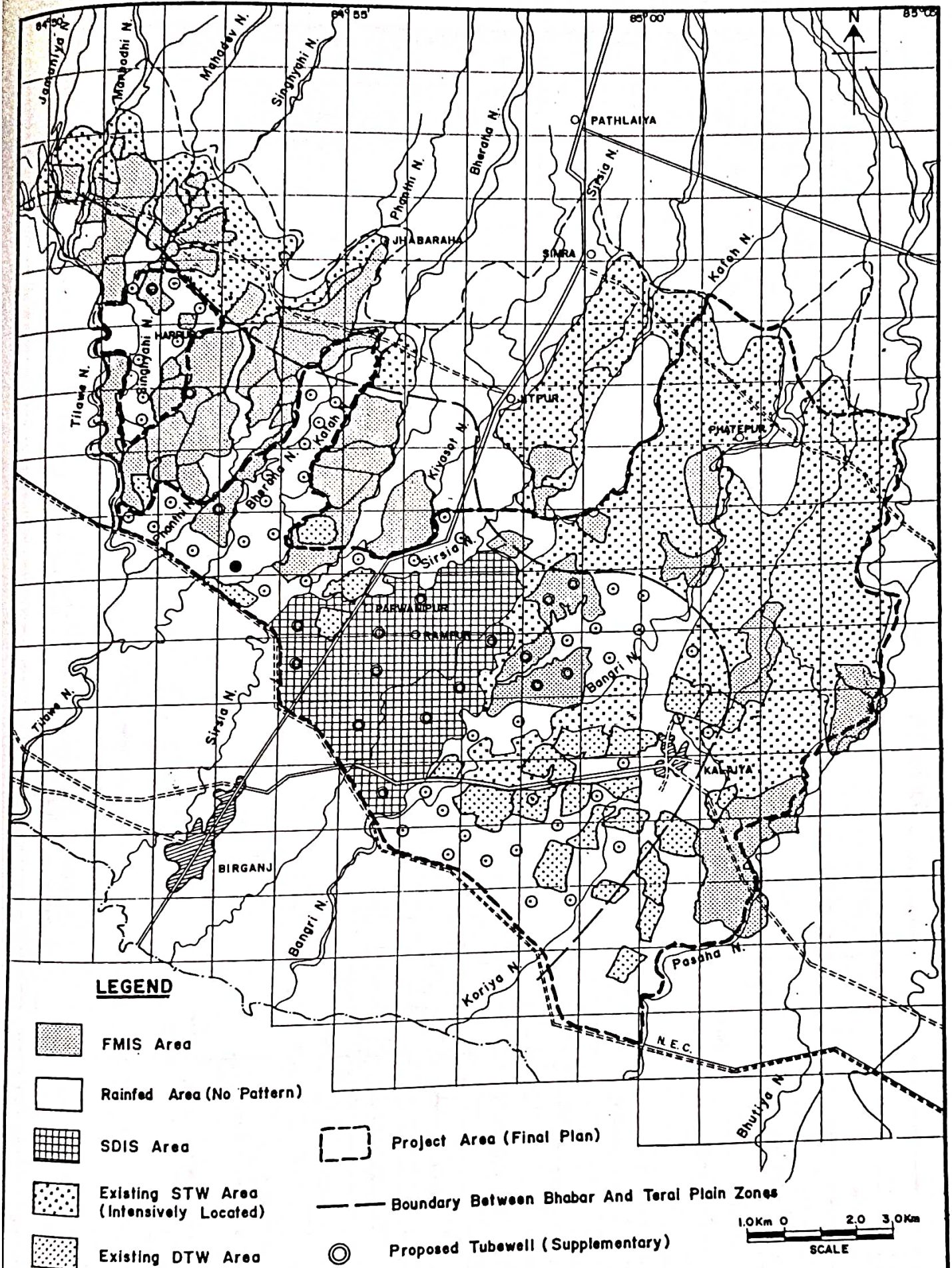

84°50'
84°55'
85°00'
85°05'
N
Jamuniya N.
Manjodhi N.
Mahadev N.
Singhyahi N.
Bhereha N.
Phanthi N.
Sirsia N.
Kolah N.
Kiyasi N.
Tilawe N.
Bangri N.
Koriya N.
Pasaha N.
Bhutiya N.
PATHLAIYA
JHABARAHA
SIMRAO
HARPUR
TPUR
PHATEPUR
PARWANIPUR
RAMPUR
KALAIYA
BIRGANJ
N.E.C.
LEGEND
FMIS Area
Project Area (Final Plan)
SDIS Area
Existing STW Area (Intensively Located)
Existing DTW Area
Rainfed Area (No Pattern)
Boundary of Project Area
Boundary Between Bhabar And Terai Plain Zones
10Km 0 2.0 3.0Km
SCALE
HIS MAJESTY'S GOVERNMENT OF NEPAL
FEASIBILITY STUDY
EXPANDING GROUNDWATER DEVELOPMENT
FOR IRRIGATION IN THE BIRGANJ AREA OF THE TERAI
INTERNATIONAL DEVELOPMENT ASSOCIATION



Proposed Cropping Pattern

HIS MAJESTY'S GOVERNMENT OF NEPAL
FEASIBILITY STUDY
EXPANDING GROUNDWATER DEVELOPMENT
FOR IRRIGATION IN THE BIRGANJ AREA OF THE TERAI
INTERNATIONAL DEVELOPMENT ASSOCIATION

Fig. 4.3



Location of Proposed Deep Tubewells

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY

EXPANDING GROUNDWATER DEVELOPMENT FOR IRRIGATION IN THE BIRGANJ AREA OF THE TERAI

INTERNATIONAL DEVELOPMENT ASSOCIATION

Project Implementation Schedule

Project Works	Quantity
A. Construction of Tubewells	
A-1 Shallow Tubewells	200 STWs
1. Collection of Demand from WUAs	
2. Design	
3. Tender and Award	
4. Drilling and Testing	
A-2 Deep Tubewells	70 DTWs
1. Collection of Demand from WUAs	
2. Design	
3. Tender and Award	
4. Drilling and Testing	
B. Construction of Irrigation and Drainage Systems	
B-1 Shallow Tubewell Area	2,130 ha
1. Preparation of Design and Tender Documents	
2. Tender and Award	
3. Construction	
B-2 Deep Tubewell Area	5,120 ha
1. Preparation of Design and Tender Documents	
2. Tender and Award	
3. Construction	
C. Upgrading of Road Network	Earth work:
1. Preparation of Design and Tender Documents	490,000 cu.m
2. Tender and Award	Gravel work:
3. Construction	98,000 cu.m
D. Construction of Buildings	Renovation:
1. Preparation of Design and Tender Documents	2,500 sq.m
2. Tender and Award	New construction:
3. Construction	2 buildings
E. Procurement of Material	Casing pipes:
1. Preparation of Design and Tender Documents	16,200 m
2. Tender and Award	Screens:
3. Procurement	7,800 m
F. Procurement of Mechanical and Electrical Works	Shallow tubewell:
F-1 Pump Sets and Motors	200 sets
1. Preparation of Tender Documents	Deep tubewell:
2. Tender and Award	70 sets
3. Procurement and Installation	
F-2 Construction of 11 kV Distribution Line	235 km
1. Preparation of Design and Tender Documents	
2. Tender and Award	
3. Construction	
G. Procurement of O&M and Office Equipment	Heavy equipment:
1. Preparation of Tender Documents	2 Nos.
2. Tender and Award	Vehicles:
3. Procurement	10 Nos.
H. Technical Support	
H-1 Consulting Services	
H-2 Survey and Study	
H-3 Training	
I Project Administration	
I-1 Project Office Activities incl. Formation of WUAs	
I-2 Agricultural Support	

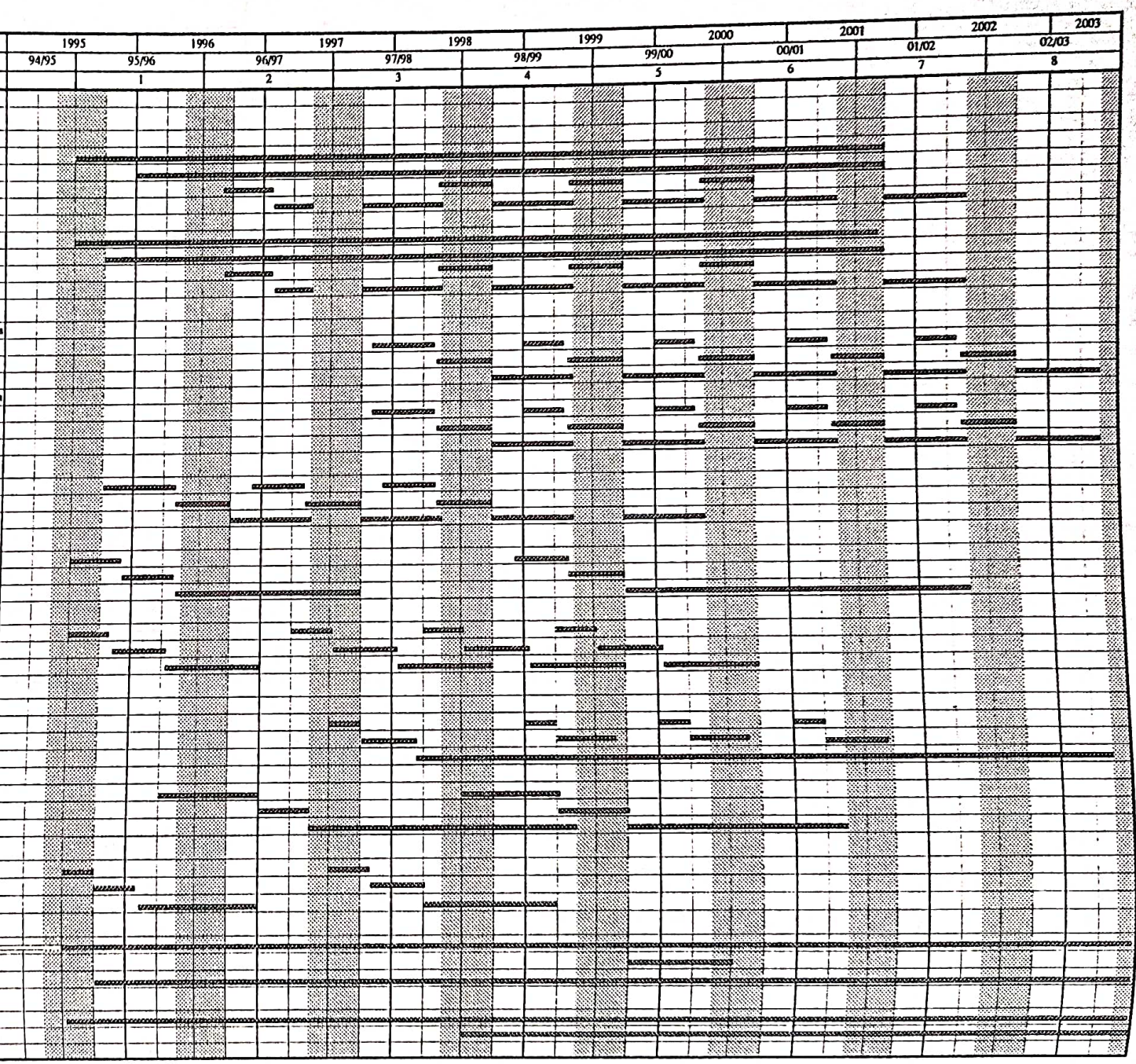
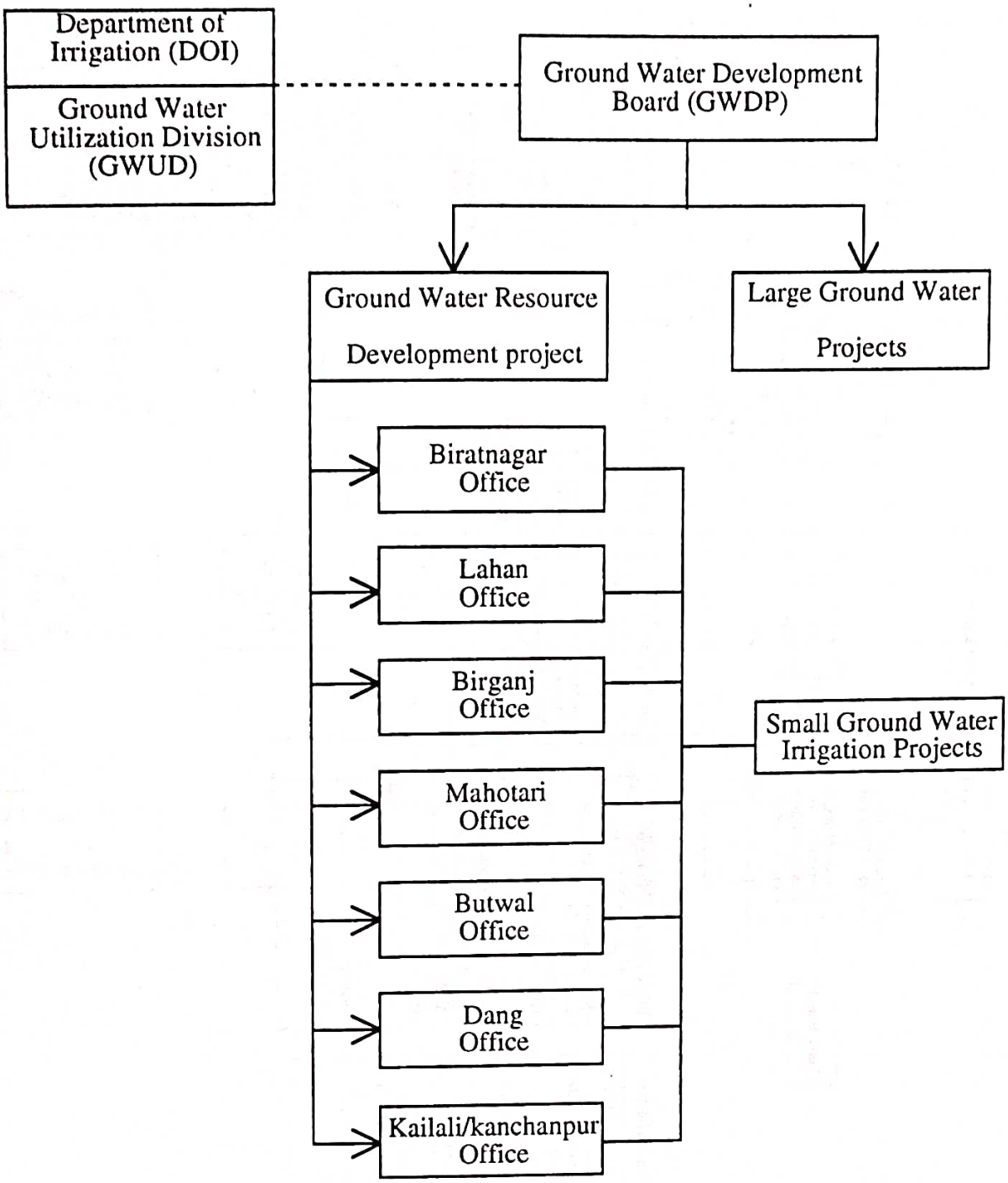


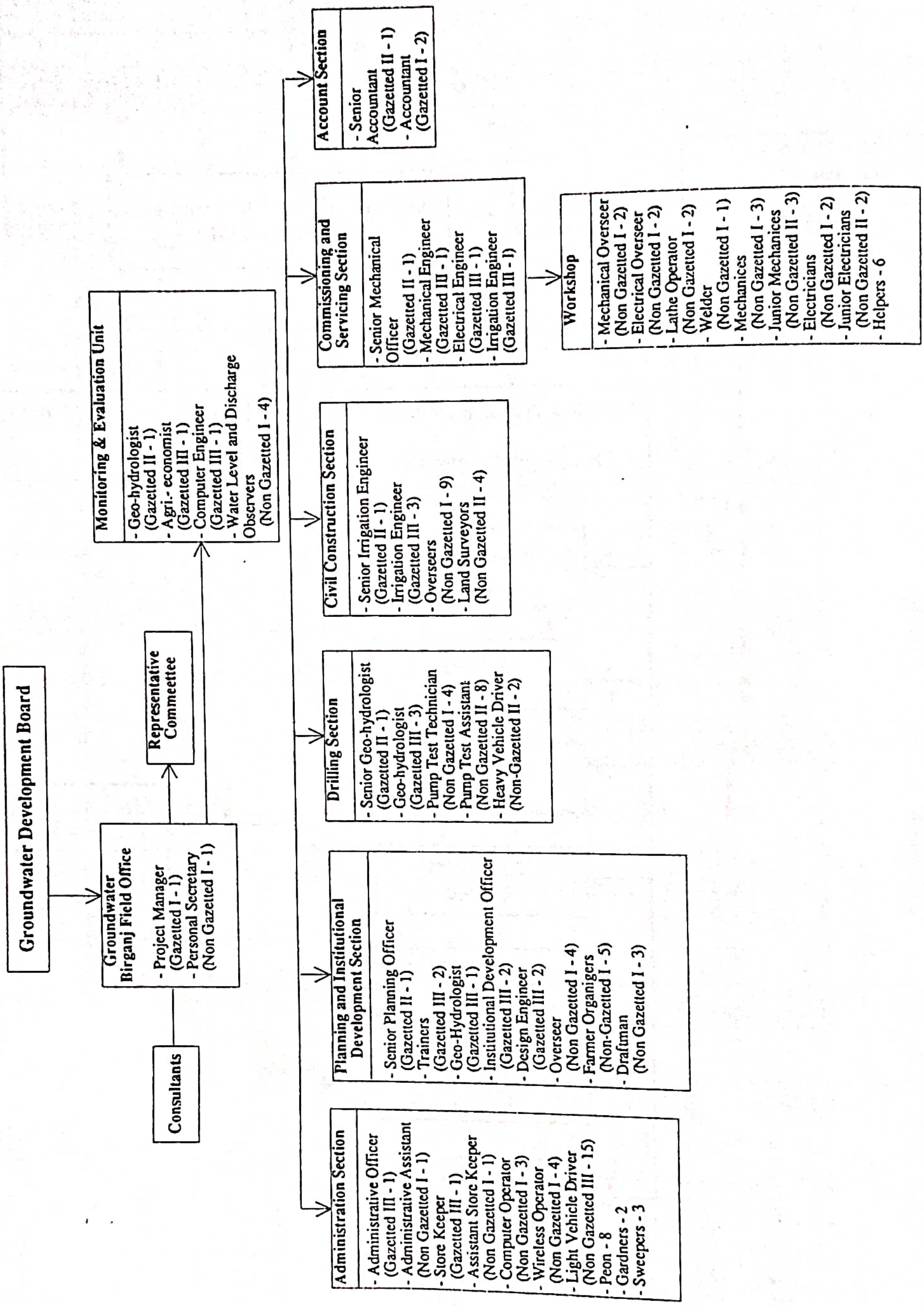
Fig. 4.1



Existing Organization of Ground Water Irrigation

HIS MAJESTY'S GOVERNMENT OF NEPAL
FEASIBILITY STUDY
EXPANDING GROUNDWATER DEVELOPMENT FOR IRRIGATION IN THE BIRGANJ AREA OF THE TERAI
INTERNATIONAL DEVELOPMENT ASSOCIATION

Fig. 6.2



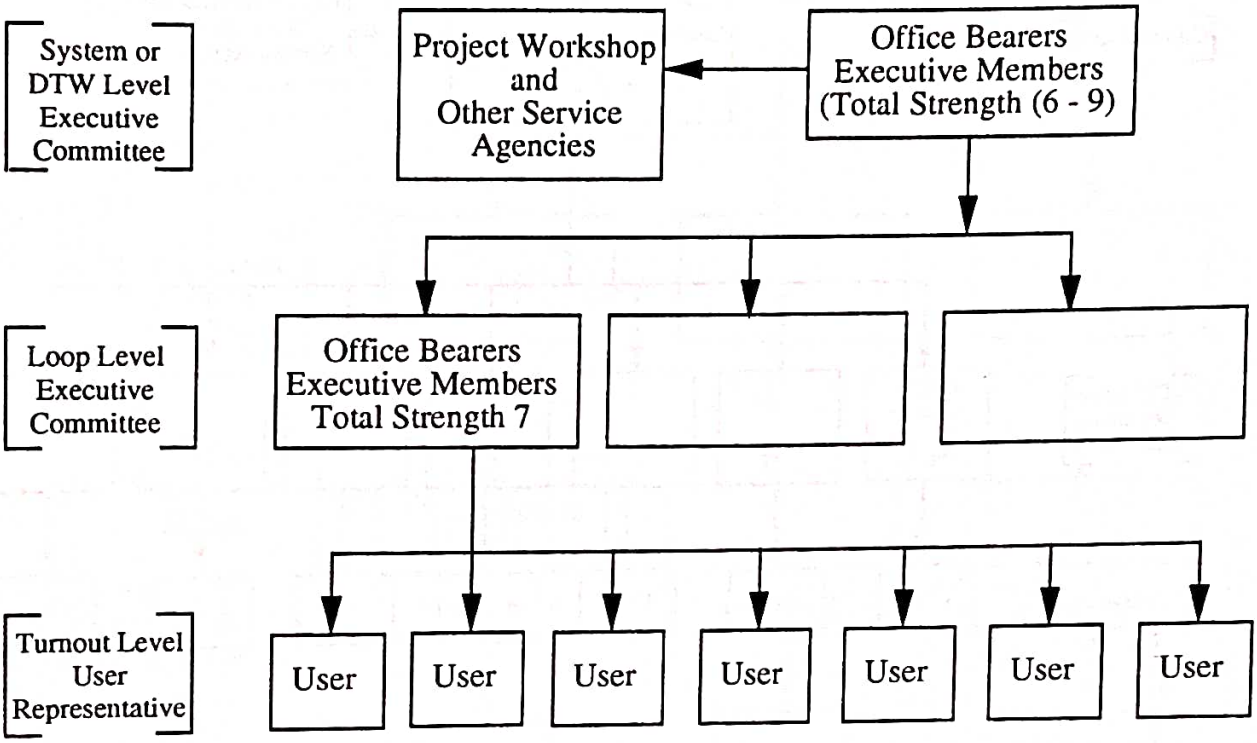
Structure of Proposed Project Executing Organization

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY
EXPANDING GROUNDWATER DEVELOPMENT
FOR IRRIGATION IN THE BIRGANJ AREA OF THE TERAI

INTERNATIONAL DEVELOPMENT ASSOCIATION

Fig. 6.3



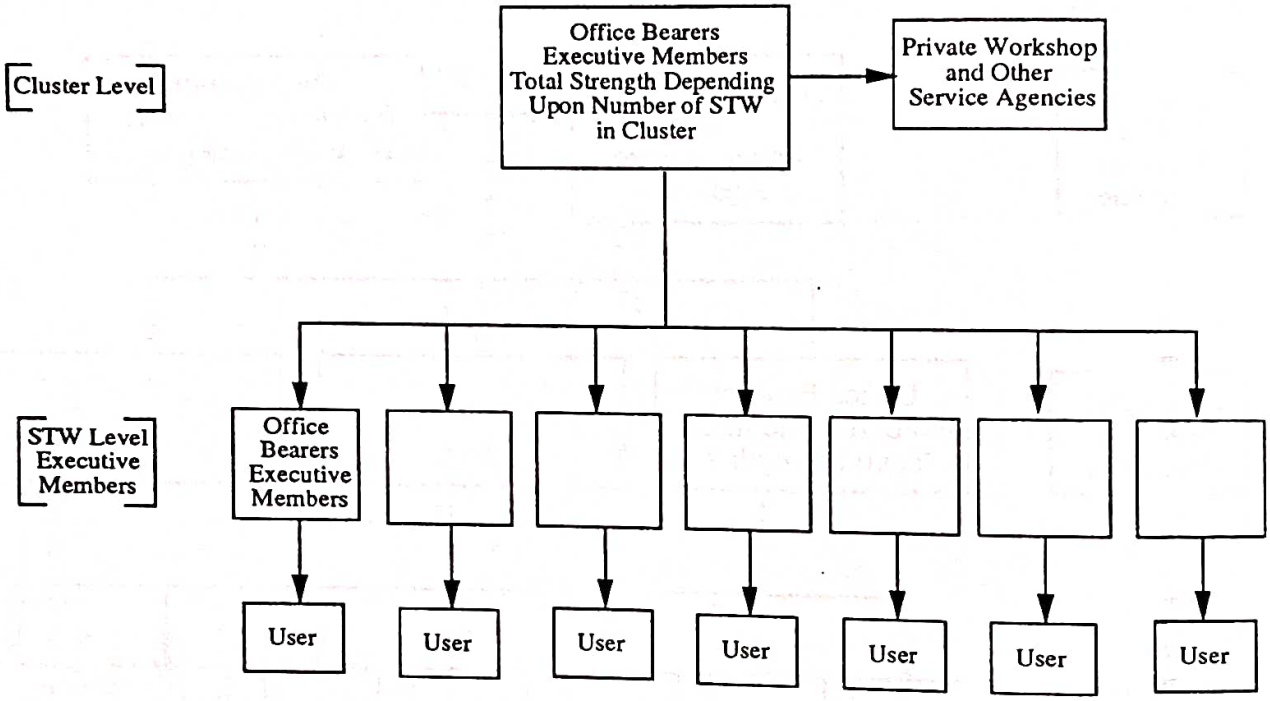
Organizational Structure of WUA for Deep Tubewell

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY

EXPANDING GROUNDWATER DEVELOPMENT FOR IRRIGATION IN THE BIRGANJ AREA OF THE TERAI

INTERNATIONAL DEVELOPMENT ASSOCIATION



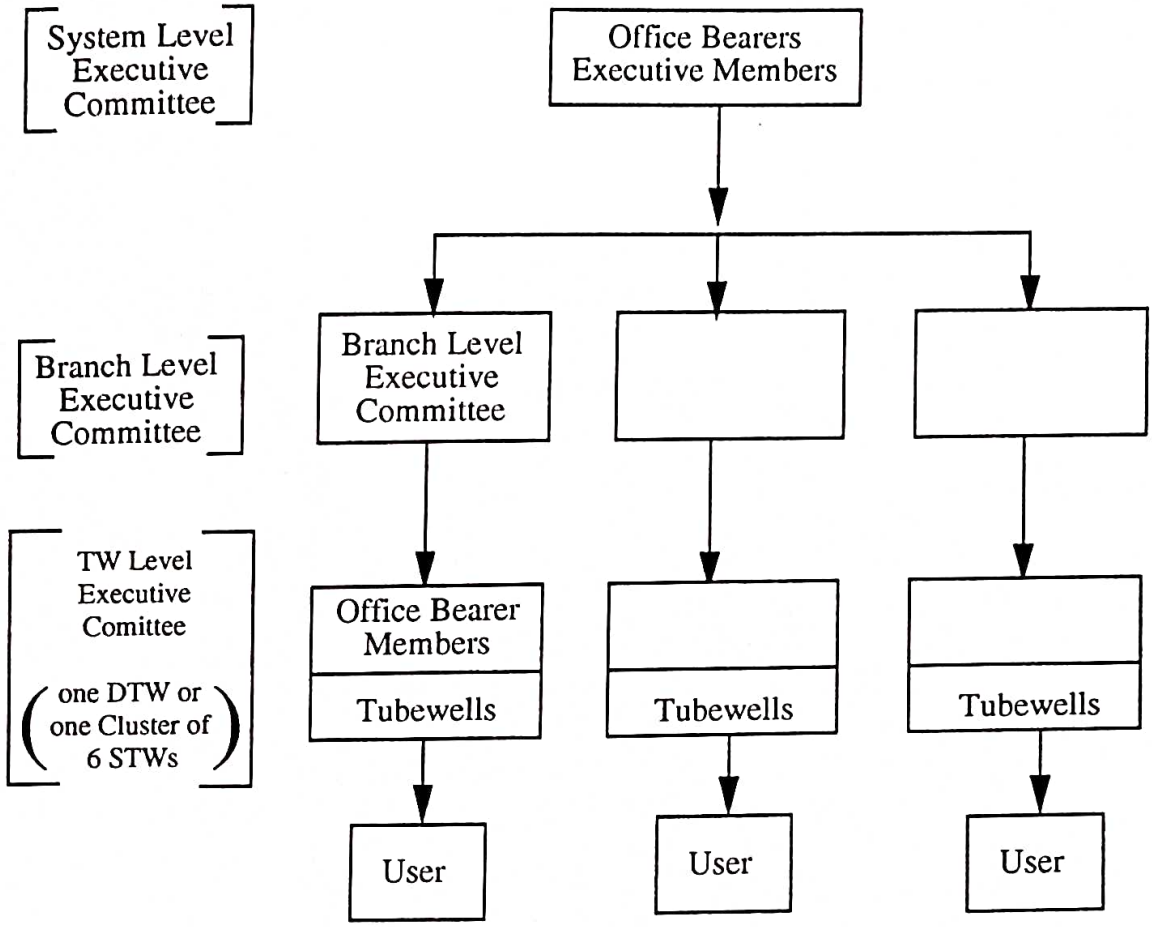
Organization Structure of WUA for Shallow Tubewell

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY
EXPANDING GROUNDWATER DEVELOPMENT
FOR IRRIGATION IN THE BIRGANJ AREA OF THE TERAI

INTERNATIONAL DEVELOPMENT ASSOCIATION

Fig. 6.5



Organization Structure of WUA for Conjunctive Use

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY
EXPANDING GROUNDWATER DEVELOPMENT
FOR IRRIGATION IN THE BIRGANJ AREA OF THE TERAI

INTERNATIONAL DEVELOPMENT ASSOCIATION