16
333
AFA

27598
JICA LIBRARY
1119498[2]

国際協力事業団
27599

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF IRRIGATION
MINISTRY OF WATER RESOURCES
HIS MAJESTY'S GOVERNMENT OF NEPAL

THE STUDY ON THE REHABILITATION OF GOVERNMENT DEVELOPED IRRIGATION SCHEMES IN THE KATHMANDU VALLEY

FINAL REPORT
MAIN TEXT
PART - B : FEASIBILITY STUDY

FEBRUARY, 1995

NIPPON KOEI CO., LTD.
CHUO KAIHATSU CORPORATION

PREFACE

In the response to a request from His Majesty's Government of Nepal, the Government of Japan decided to conduct the Master Plan Study on the Rehabilitation of The Government-Developed Irrigation Schemes in the Kathmandu Valley and entrusted the study to the Japan International Coorperation Agency (JICA).

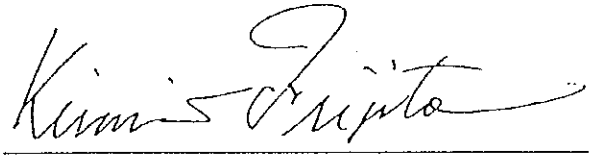
JICA sent to Nepal a study team headed by Mr. Takao Kawakatsu, Nippon Koei Co., Ltd., five times between March 1993 and November 1994.

The team held discussions with the officials concerned of His Majesty's Government of Nepal, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

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

February, 1995



Kimio Fujita
President
Japan International Cooperation Agency

February, 1995

Mr. Kimio Fujita
President,
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir,

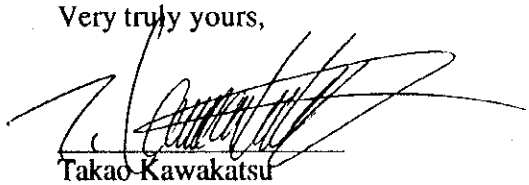
We have pleasure of submitting the Final Report of the Study on the Rehabilitation of Government-Developed Irrigation Schemes in the Kathmandu Valley in the Kingdom of Nepal, in accordance with the Scope of Work agreed upon between the Department of Irrigation of the Ministry of Water Resources, His Majesty Government of Nepal and the Japan International Cooperation Agency.

The Study was carried out in two phases, Phase-I and Phase-II, for a total period of 20 months from March 1993 to November 1994. In Phase-I Study, a master plan was formulated through the field survey and studies on natural and social conditions including environmental aspects, agriculture and agro-economy, agricultural infrastructure and agricultural supporting system, as well as an inventory survey on the existing Government-Developed Irrigation Schemes in the Kathmandu Valley. In Phase-II Study, the agricultural development plan for the 13 model schemes which were selected in Phase-I Study, was formulated. The plan is aimed at rehabilitating the irrigation facilities in order to maintain the agricultural areas and increase the crop intensity, with a view of creating a vegetables supply base to meet the urban demand of Kathmandu through the efficient use of limited irrigation water. The rehabilitation plan and O&M plan were formulated on the basis that the rehabilitated facilities should be operated and maintained by farmers themselves.

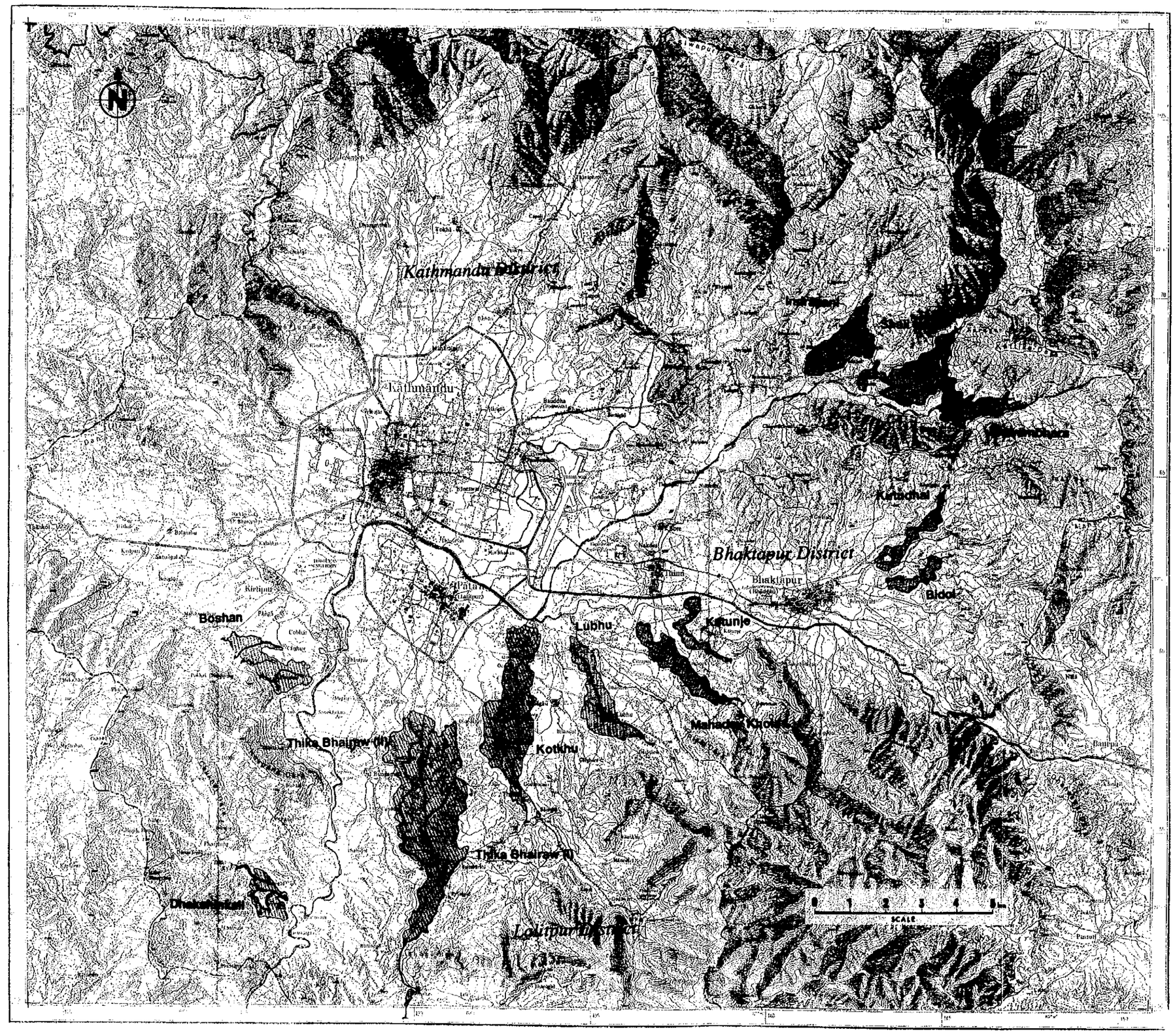
The field studies were carried out in collaboration with the counterpart personnel of the Central Regional Irrigation Directorate. Transfer of knowledge to the counterpart personnel was done through on-the-job training by each expatriate expert throughout the field study period.

We wish to express our deep appreciation and gratitude to the personnel concerned of your Agency, your Nepal Office, the Embassy of Japan in the Kingdom of Nepal and the Authorities concerned of His Majesty Government of Nepal for the courtesy and cooperation extended to us during our field surveys and studies.

Very truly yours,



Takao Kawakatsu
Team Leader of the Master Plan Study on
the Rehabilitation of Government-Developed
Irrigation Schemes in the Kathmandu Valley



List of Selected Irrigation Schemes for Feasibility Study

No.	Scheme Name	Project Area (ha)	Irrigation Area (ha)
Kathmandu District			
AK-04	Biswambhara	135	92
AK-05	Boshan	194	122
AK-07	Dhakshinkali	100	67
AK-14	Indrayani	268	101
KA-25	Shali Nadi	257	157
	Sub-total	954	539
Bhaktapur District			
AB-02	Bidol	65	32
AB-10	Katunje	54	40
AB-12	Kutudhal	83	43
AB-14	Mahadev Khola	180	112
	Sub-total	382	227
Lalitpur District			
AL-10	Kotkhu	466	246
AL-13	Lubhu	220	130
AL-19	Thika Bhairaw (I)	892	497
AL-20	Thika Bhairaw (II)	153	88
	Sub-total	1,731	961
	Total	3,067	1,727

LEGEND

Study Area

Intake Point

Main Canal

Boundary of District

Boundary of the Kathmandu Valley

LOCATION MAP

FINAL REPORT
FOR
THE STUDY ON
THE REHABILITATION OF GOVERNMENT DEVELOPED IRRIGATION SCHEMES IN THE KATHMANDU VALLEY

PART - B : FEASIBILITY STUDY

CONTENTS

page

page

LIST OF TABLES

page

LIST OF FIGURES

ATTACHMENTS

STANDARD ABBREVIATIONS

ADB	Asian Development Bank
ADB/N	Agricultural Development Bank, Nepal
ADO	Agricultural Development Office
AIC	Agricultural Input Corporation
AO	Association Organizer
CDR	Central Development Region
CRID	Central Regional Irrigation Directorate
CSSC	Cooperative Saving and Service Centre
DADO	District Agricultural Development Office
DAO	District Administration Office
DCO	District Cooperative Office
DIO	District Irrigation Office
DoAD	Department of Agricultural Development
DoCD	Department of Cooperative Development
DoHM	Department of Hydrology and Meteorology
DoI	Department of Irrigation
EIRR	Economic Internal Rate of Return
EOJ	Embassy of Japan
FAO	Food and Agriculture Organization of the United Nations
FMIS	Farmer Managed Irrigation Scheme
GDP	Gross Domestic Product
GOJ	Government of Japan
HMGN	His Majesty's Government of Nepal
ISP	Irrigation Sector Program (ADB)
JICA	Japan International Cooperation Agency
JT	Junior Technicians
JTA	Junior Technical Assistants
KVUDPP	Kathmandu Valley Urban Development Plan and Programs
KWM	Kalimati Fruits and Vegetable Wholesale Market
LRMP	Land Resources Mapping Project
MIT	Mobile Irrigation Team
MoA	Ministry of Agriculture
MoWR	Ministry of Water Resources
NARC	Nepal Agricultural Research Council
NPC	National Planning Commission
NWSC	Nepal Water Supply Corporation
O&M	Operation and Maintenance
RID	Regional Irrigation Director
SFDP	Small Farmer Development Program
S/W	Scope of Works for the Study
UNDP	United Nations Development Program
VDC	Village Development Committee
VGG	Vegetable Grower's Group
WUA	Water Users' Association

Local Name

BTP	Bhaktapur
KTM	Kathmandu
LTP	Lalitpur
Kh.	Khola = River or Stream

ABBREVIATIONS OF MEASUREMENTS

Length

mm	= millimetre
cm	= centimetre
m	= metre
km	= kilometre

Time

s	= sec	= second
min		= minute
h	= hr	= hour
d		= day
y	= yr	= year

Area

cm^2	= sq.cm	= square centimetre
m^2	= sq.m	= square metre
ha	= hectare	= 10,000 m^2
km^2	= sq.km	= square kilometre
Ropani		= 509 sq.m
Bigha		= 0.66 ha

Electrical Measures

W	= watt
kW	= kilowatt
MW	= megawatt
kWh	= kilowatt hour
V	= volt

Volume

cm^3	= cc	= cubic centimetre
l	= lit	= litre
m^3	= cu.m	= cubic metre
MCM	= 10^6 m^3	= million cubic metre

Other Measures

%	= percent
°	= degree
'	= minute
"	= second
°C	= degrees Celsius

Weight

mg	= milligram
g	= gram
kg	= kilogram
ton	= metric ton

Derived Measures

m^3/sec	= cubic metre per second
lit/sec	= litre per second
lit/s/ha	= litre per second per hectare
MLD	= million litre per day

Currency and Others

NRs. = Nepalese currency Rupee
US$ = US Dollar
J.Yen = Japanese Yen

Exchange Rate as of July, 1994

US$ 1.00 = NRs.49.0 = J.Yen 100
NRs.100 = US$ 2.04 = J.Yen 204

Note : Exchange Rate used in the Master Plan Study was as of July, 1993
US$ 1.00 = NRs.49.0 = J.Yen 108.89
NRs.100 = US$ 2.04 = J.Yen 222.22
J.Yen 100 = NRs.45.0 = US$ 0.9184

El. = elevation above mean sealevel

1. INTRODUCTION

1.1 Authority

This Final Report has been prepared in accordance with the Scope of Works for the Master Plan Study (the Study) on the Rehabilitation of Government Developed Irrigation Schemes in the Kathmandu Valley in the Kingdom of Nepal agreed upon between the Department of Irrigation (DoI), Ministry of Water Resources (MoWR), His Majesty's Government of Nepal (HMGN), and the Japan International Cooperation Agency (JICA), an official agency responsible for the implementation of technical cooperation programs of the Government of Japan (GOJ), on December 16, 1992.

The Final Report consists of the following six volumes:

Executive Summary

Main Text Part-A : Master Plan Study

Main Text Part-B : Feasibility Study

Annex including
- Annex - 1 : Present Condition of Agriculture and Agro-economy
- Annex - 2 : Soil and Land Use
- Annex - 3 : Results of the Inventory Survey
- Annex - 4 : Data and Results of the Hydrological Study
- Annex - 5 : Rehabilitation Plans and Preliminary Design
- Annex - 6 : Agricultural Development and Farm Economy
- Annex - 7 : Project Evaluation

Drawings, and

O&M Manual

This Report, Main Text Part-B, presents the results of the studies carried out during the Phase-II Study; Feasibility Study on the 13 model schemes selected in the Phase-I Study.

1.2 Background of the Project

By the end of the 7th National Development Plan HMGN had completed the irrigation development of about 451,000 ha. Irrigation development by farmers themselves has been carried out for a long time and has reached a total of 482,000 ha. Some of them command more than 1,000 ha of farmland. Their facilities have been managed by themselves.

In 1992, HMGN has revised its irrigation policy in order to enlarge the irrigation area instead of promoting large-scale irrigation development. Following this policy revision, HMGN stressed the importance of improving and rehabilitating the existing irrigation projects, from the point of view of the effective use of the existing facilities and agricultural land.

The irrigation projects in the Kathmandu Valley are well developed compared to other regions due to its advantageous location which makes it the base for food supply to the Kathmandu metropolitan area. Therefore, the irrigated area has reached about 9,000 ha. However, some of the irrigation facilities in the Valley have been superannuated and damaged. Thus, with the increase in food demand due to the concentration of people in Kathmandu and diversification in the type of food that they want, it is desired to improve production in order to yield a higher quality of agricultural product by rehabilitating the existing facilities.

In addition, HMGN has a policy whereby the completed irrigation projects are handed over to the farmers, not only to facilitate self-support but also to strengthen the agricultural constitution on the basis of agreement with the beneficiaries.

In line with the above situation, HMGN requested technical assistance for the formulation of the Master Plan on the Rehabilitation of Government Developed Irrigation Schemes in the Kathmandu Valley (the Project) to GOJ in December 1991. In response to this request, GOJ dispatched a preliminary study team, and the Scope of Work (S/W) for the Project was concluded on December 16, 1992 (see Attachment No.1). Based on this S/W, JICA dispatched this Study Team to Nepal.

1.3 Objectives of the Study and Study Area

The objectives of the Study are as follows:

a) to formulate a master plan for the rehabilitation of Government-developed irrigation schemes in the Kathmandu Valley and to conduct a feasibility study in the selected model areas identified in the master plan; and

b) to carry out the transfer of technology the Nepalese counterpart personnel during the course of the Study.

The Study Area comprizes about 9,000 ha of land, which is covered by the Government-developed irrigation schemes located in the Kathmandu Valley, in three districts: Kathmandu, Bhaktapur, and Lalitpur districts, as shown in Figure 1-1.

1.4 Work Schedule of the Study

The Study was divided into two phases, Phase-I and Phase-II and carried out for 20 months from late March 1993 to November 1994, as illustrated in Figure 1-2.

The Phase-I Study commenced in late March 1993 and was completed with the submission of the Interim Report and explanation and discussion of the Interim Report with DoI officials, in October 1993. In the Phase-I Study, fieldwork at two different times in Nepal and home office work were carried out, as follows:

a)	Preparatory work in Japan :	From March 28, 1993 to April 5, 1993
b)	Fieldwork in the dry season :	From April 6, 1993 to May 15, 1993
c)	Fieldwork in the rainy season :	From June 24, 1993 to August 22, 1993
d)	Home office work in Japan :	From August 23, 1993 to October 5, 1993
e)	Explanation of the Interim Report and Discussion with DoI officials	From October 14 to 23, 1993

A field survey, based on the results of the discussion of the Interim Report, for topographic mapping (by a separate team) was conducted from January 20, 1994 to March 20, 1994. Following the field survey, home office work in Japanwas commenced and a topographic map on a scale of 1/5,000 with contour intervals of 1.0 meter, was prepared.

The Phase-II Study commenced in late March 1994 and was completed with the submission of the Final Report in November 1994. In the Phase-II Study, fieldwork in Nepal and home office work in Japan were carried out, as follows:

a)	Field work in Nepal :	From March 31, 1994 to May 26, 1994
b)	Home office work in Japan :	From June 30, 1994 to August 28, 1994
c)	Explanation and discussion of the Draft Final Report :	From September 23, 1994 to October 2, 1994

d) Submission of the Final Report : November 1994

1.5 Organization and Assignment of the Study Team

The Study was carried out by the Study Team under the guidance of the Advisory Team organized by GOJ/JICA, in collaboration with the counterpart personnel assigned by DoI of MoWR, which is the counterpart agency of the Study Team.

HMGN established a Regional Appraisal and Coordinating Committee consisting of the following organizations, for the smooth implementation of the Study:

a) Department of Agriculture Development (DoAD)
b) Department of Irrigation (DoI)
c) Agricultural Development Bank, Nepal (ADB/N)
d) National Planning Commission (NPC)

The organization of the Study with a list of the counterpart personnel for the Phase-II Study, and the assignment schedule of the Study Team, are presented in Figures 1-3 and 1-4, respectively.

1.6 Outline of the Activities of the Study Team in the Phase-II Study

In accordance with the Plan of Operation detailed in the Inception Report and revised in Interim Report, following discussions on the Interim Report between the Study Team and DoI (see Attachment No.2), and on the basis of the S/W agreed upon between DoI and JICA, the Study Team commenced Phase-II Study upon completion of the topographic map, on the last day of March 1994, with the following supplementary data collection, field survey and study in collaboration with the counterpart personnel, and home office work for Phase-II Study.

(1) Phase-II Field Study: 57 days, from March 31, 1994 to May 26, 1994 :

- Additional data collection.
- Field surveys and investigations for the feasibility study on the 13 selected model schemes.
- Formulation of the basic concept on agricultural development including the irrigation and drainage plan, land use plan, agricultural development plan, training plan for the farmers' organizations, and a proposed plan for the transfer of facilities to the farmers' organizations.
- Preparation of the Progress Report (II).

(2) Phase-II Home Office Work: 60 days, from June 30, 1994 to August 28, 1994 :

- Formulation of agricultural development plans, including land use, cropping pattern and farming plan, irrigation and drainage plan, social and rural infrastructural development plan, farmers' organizations and agricultural supporting services strengthening plan, and marketing and post-harvest processing plans.
- Preparation of the preliminary design for major facilities.
- Preparation of the O&M plan and plan for the transfer of facilities to the farmers' organizations.
- Preparation of the project implementation plan and schedule.
- Estimation of the project cost and benefit and project evaluation
- Preparation of the Draft Final Report.

(3) Submission and explanation of the Draft Final Report: 10 days, from September 23, 1994 to October 2, 1994.

(4) Preparation and submission of the Final Report: Taking the results of discussion and comments from the HMGN into consideration, the Final Report was prepared and submitted.

Meanwhile, the transfer of knowledge to the counterpart personnel was carried out through on-the-job training by each expert throughout the field study period. In addition, the activities of the Study Team were explained to all the counterparts who attended the joint meeting every weekend. The progress of the Study, findings and schedule were discussed, so that every person understood their role within the Study. Subjects and conclusions of the discussions were summarized in the Minutes of Meeting presented in Attachment No.3.

2. MASTER PLAN AND HIGH PRIORITY SCHEMES

2.1 General Situation of Nepal

Nepal is a landlocked country with a total area of 147,200 km^2, situated between India and China, and consists of three geographical zones: the Terai plain, the hills, and the mountains. The hills and mountains occupy about 113,200 km^2 or 77% of the total area. In 1991, the total population was about 18.5 million, increased from 15.0 million in 1981. That is the average annual population growth rate was 2.1%. Population density in 1991 was 126 people/km^2.

The Gross Domestic Product (GDP) of Nepal was estimated at NRs.145 billion or US$ 3 billion in 1992/93, which was equivalent to US$ 156 per capita. Although economic growth in real terms averaged 4.4% during the past five years, the annual rate of increase of GDP per capita was 2.2%. The Eighth Plan started in 1992 with a target GDP annual growth rate of 5.1% and 3% per capita.

Agriculture in Nepal, which utilizes 18% of the total land area, plays a dominant role in the economy, accounting for 49% of GDP in 1992/93, employing 81% of the labour force according to the 1991 population census, and earning 16% of exports in 1991/92, but these shares have been gradually declining. In the Eighth Plan, top priority has been assigned to the development of the agricultural sector with its growth rate of 3.7%. The target increase in production for the plan period is 5.4% for food grain, 9.1% for cash crops, 5.4% for horticultural produce, and 3.8% for livestock products. It has been pointed out that although programs aimed at attaining national self-sufficiency in food production will be continued, emphasis will be put on market-led production of livestock, fruit, vegetables, and cash crops, taking into consideration comparative geographical advantages, transportation facilities, market accessibility, and the demand and supply conditions.

Nepal has rich water resources for irrigation development. Since the mid 1960s, Government agencies have been actively involved in constructing and managing new irrigation schemes and assisting farmers' groups in the construction or rehabilitation of Farmers' Managed Irrigation Schemes (FMIS). However, agriculture in Nepal is still largely carried out under rainfed conditions. It is estimated that about 933,000 ha or 35% of the total cultivated area have some kind of irrigation facilities, of which about 451,000 ha, including Government-assisted FMIS of about 186,000 ha, were completed by HMGN by the end of the 7th National Development Plan. On the other hand, irrigation development by farmers themselves has been carried out for a long time. The total area irrigated by them reached 482,000 ha or 52% of the total irrigated area. Some of them command more than 1,000 ha of farmland. Their facilities have been managed by themselves. According to the Eighth Plan, 294,000 ha of additional land will be irrigated during the plan period. Therefore, it is estimated that about 1.2 million ha will be under irrigation by the terminal year of the Eighth Plan.

Recently, HMGN has revised its irrigation policy in order to enlarge the irrigation area, instead of the promoting large-scale irrigation development. Following this policy revision, HMGN stressed the importance of improving and rehabilitating the existing irrigation projects, from the point of view of the effective use of the existing facilities and agricultural land.

The Government budget in 1991/92 amounted to NRs.26.4 billion (about US$ 540 million) of which NRs.16.5 billion or 64% was for development expenditures including NRs.2.2 billion (5.8%) for the irrigation sector, and NRs.1.3 billion (4.8%) for the agriculture sector. The expenditures exceeded the receipts every year, for instance receipts in 1991/92 consisted of revenue of NR.13.3 billion (50%) and foreign grants of NRs.2.3 billion (9%), and such financing deficits were supplemented by external and internal loans. About 25% to 33% of foreign aid was allotted to agriculture, irrigation, and forest sectors in the past decade.

2.2 Present Conditions in the Kathmandu Valley

2.2.1 General

The Kathmandu Valley covering about 656 km^2 is located in the hilly area and is composed of three districts: Kathmandu, Lalitpur, and Bhaktapur in the Bagmati Zone of the Central Development Region (CDR). The population of the Valley was about 1.1 million or 6% of the total population of Nepal in 1991, which has increased at an average annual growth rate of 3.7% during the past decade. In the rural area of the Valley, there had been about 49,800 ha (76% of the total Valley area) of cultivated land in 1981/82. However, this area decreased annually due to urbanization. In 1991/92, the cultivated area was about 30,000 ha or 46% of the total Valley area and produced 83,000 tons of paddy, 30,000 tons of maize, 27,000 tons of wheat, and 21,000 tons of potatoes, mainly as the staple food for the inhabitants in the Valley.

The Kathmandu Valley has the shape of an indented circular basin. The central part of the Valley consists of very gentle and flat lands at elevations of 1,300 m to 1,400 m, and the flat land is surrounded by high mountain ranges of more than 2,000 m in elevation.

Most parts of the base of the Kathmandu Valley are covered with clayey layers. High potentiality for ground water recharge is not expected. The ground water in the Valley has been over exploited and ground water recharge has not been sufficiently attained by natural methods. Accordingly, the potential for ground water development in the Kathmandu Valley for such a big demand as irrigation is low.

The population in the Kathmandu Valley increased at an average annual growth rate of 3.7% for the whole valley, 5.1% for the urban area, and 2.3% for the rural area, during the period from 1981 to 1991. Based on the annual population growth rate estimated by the Kathmandu Valley Urban Development Plan and Programmes (KVUDPP) Study which was completed with the technical assistance of the Asian Development Bank (ADB) in 1991, the population in the Kathmandu Valley in 2015 was forecast at about 2.1 million, consisting of 1.3 million in the urban area and 0.8 million in the rural area.

With these projections, the KVUDPP Study forecast the following urban trends:

- The expansion of urban areas will proceed revolving around the two core cities (Kathmandu and Lalitpur known as Greater Kathmandu) in the Kathmandu Valley;
- With the expected population increase in the urban areas, urbanization will proceed along most of the radial roads. Starfish-shaped urban areas will be formed around the city centres of Kathmandu and Lalitpur;
- The city of Bhaktapur, which has long been isolated from Greater Kathmandu, will be exposed to urbanization. It will be completely combined with Greater Kathmandu due to the expansion of the urban area along the east-west corridor of the Valley, and will become one of the urban cores in the Kathmandu Valley; and
- With the future population increase, the agricultural areas in between the legs of the starfish-shaped urban areas will be exposed to urbanization. This will result in an outward shift of Greater Kathmandu.

In the context of the above urban trends, the extended urban area will be used for residential, industrial and governmental or institutional purposes, while the central core area will remain as the commercial and business centre with residential areas. Regarding land use in the rural area, it was recommended that the development of lands for urbanization should be controlled at a minimum level, for the protection against further deterioration of the ecology of the Valley, and that haphazard urban sprawl should be controlled under orderly and well planned development programmes for the protection of the watershed, wildlife, and agricultural lands.

2.2.2 Meteorology and Hydrology

The Kathmandu Valley which is located in the monsoon region, has a distinct rainy season and a subtropical climate. Most rainfall (about 80%) occurs during the rainy season from June to September. Rainfall varies substantially according to the altitude. Annual basin rainfall in the Kathmandu Valley is about 1,900 mm ranging from about 1,000 mm to 2,000 mm in the Valley area to 1,500 mm to 3,300 mm in the mountainous area.

The mean air temperature is 18°C. The period from October to November is warm with a mean temperature of about 23°C, while that from December to February is cool with a mean temperature of about 11°C. The coldest month is January and the temperature rarely falls below 0°C. The spring months, March to June, are dry and hot and experience pre-monsoon thunderstorms with occasional hails and showers. The hottest month is July or August, where the maximum temperature occasionally exceeds 30°C. The average relative humidity is about 76% and it varies from about 60% in the dry season to about 82% in the rainy season. The mean daily pan evaporation varies from 1.9 mm/day in December to 5.0 mm/day in April and May, and averages 3.7 mm/day.

The Bagmati is the only river system in the Valley, and drains all the water collected in the Valley basin to the south. The Bagmati river with a drainage area of 585 km^2 at the Chobhar gauging station located close to the outlet of the Valley, dissects the mountains of the Mahabarat range to the south-west of the Valley. The major tributaries of the Bagmati river are the Mai Khola, Nakhu Khola, Balkhu Khola, Bisnumati Khola, Dhobi Khola, Manohara Khola, Kotkhu Khola, Godawari Khola and Hanumante river. All these tributaries, which originate on the mountainside near the border of the Valley, run toward the centre of the Valley and finally flow into the Bagmati river. The annual total runoff of the Bagmati river is estimated at about 500 million m^3 at the Chobhar station. Since a number of water users abstract a certain amount of river water in the Valley, the runoff coefficient is estimated at 45% at the Chobhar station, while it is estimated at 67% at the Sundarijal station with a mean annual runoff of 1.06 m^3/sec.

Generally, water quality of the rivers at the intake points of the irrigation schemes is sufficiently suitable for cultivation. However, water pollution has been observed in the urbanized area particularly in the lower reaches of the Bagmati river due to sewerage water from the urban area in the Valley.

In the Kathmandu Valley, there exist a number of irrigation systems abstracting a certain amount of water from the rivers, which are not only Government-developed schemes as objectives in this Study, but are also the Irrigation Sector Program (ISP) projects and small farmers-managed systems. According to DoI, the water rights for these existing systems was authorized as a custom. However, the first priority of water resources development is given to the municipal water supply in Greater Kathmandu (Kathmandu and Lalitpur municipalities) which is managed by the Nepal Water Supply Corporation (NWSC) under the Ministry of Housing and Physical Planning. The water supply systems in the Valley are overloaded because of high population pressure. At present, the amount of water supplied to the Valley is 61 million lit/day (MLD) by surface sources and 30 MLD by ground water sources, through 11 existing systems for Greater Kathmandu and Bhaktapur. NWSC is now implementing the construction of new run-of-river type intakes on the Dhobi Khola and the Bisnumati Khola in the Valley. A storage reservoir scheme involving the Kotkhu Khola dam is now under examination for its implementation with technical assistance of the Thai Government as the Kodkhu Water Supply Project. Although, the irrigation water requirements for the existing schemes are considered in these studies, the detailed arrangement of the share of water is necessary both for drinking water supply and irrigation, especially where the potential rehabilitation schemes will be implemented. On the other hand, water supply plans for Greater Kathmandu from outside the Valley were also studied with technical assistance of the World Bank. NWSC puts priority to the Rosi Khola Scheme and the Melamchi Diversion Scheme after the Kotkhu Khola Dam Scheme.

2.2.3 Soil and Land Use

The Kathmandu Valley has four main physiographic units: (1) the ancient lake and river terrace; (2) alluvial plain; (3) alluvial fan; and (4) hill slope. The ancient lake and river terrace and alluvial plains are dominant in the Study Area. The soil in the Kathmandu Valley is classified into three orders, five sub-orders, and six great soil groups according to the Soil Taxonomy of the United States Department of Agriculture (USDA). The land in the Kathmandu Valley is classified into four classes. The arable land in the Valley belongs to Classes I, II, and III, while the land in the surrounding mountains belongs to Class IV.

Present land use in the Valley is as follows: 58 km^2 (9% of the Valley) of urban areas, 387 km^2 (59%) of agricultural land, 55 km^2 (8%) of forest, 141 km^2 (22%) of shrubs and grass, and 15 km^2 (2%) of other lands for rivers, brick works, etc. Recently, the agricultural land has been converted into house yards in the southern part of the Valley.

2.2.4 Irrigation and Drainage

The irrigation projects in the Kathmandu Valley are well developed compared to other regions due to its advantageous location which makes it the base for food supply to the Kathmandu metropolitan area and now the irrigated area has reached about 9,000 ha. However, most of the existing irrigation facilities in the Valley are relatively old as some of them were constructed in the early 1960s. A typical irrigation system consists of an intake facility and irrigation canals which carry water by gravity. The intake facility is usually a fixed weir made of concrete and stone or brick masonry. Irrigation canals are lined with stone or brick masonry. However, this lining is limited to short distances in the upper reaches only. During the 1980s, most of the facilities were hit several times by severe floods and some of them were washed away and others were heavily damaged. Although some of the damaged facilities were repaired by DoI and the District Irrigation Office (DIO), they still have the following problems:

(1) Intake facilities are generally not functioning well due to siltation in front of the weirs, difficulty in operation of damaged and rusted gates, water leakage through weirs, and so on.

(2) Siltation in the canals and water leakage from the canals are common problems, even in the upper reaches which are lined with stone and brick masonry. Some canals passing through the slopes of hilly areas were badly damaged by landslides, therefore they cannot carry smoothly the design amount of irrigation water to on-farm canals. In addition, since there are no regulating devices in the canals, it is difficult to carry out reasonable and timely water distribution to on-farm canals.

Water management activities for the irrigation schemes in the Valley are limited to the opening and closing of the gates at the intakes. For this purpose, one to three watchmen per scheme are appointed by DIO and farmers' organizations, if any. However, gates are usually not closed at designated times, and water management for the secondary, tertiary, and on-farm canals is not carried out adequately due to the lack of regulating facilities in the canals. It will be very difficult to attain high standards of water management in the existing schemes unless more manpower and upgraded water control devices are provided in the canals.

At present, most of the existing medium and small-scale irrigation schemes are maintained by DIO and farmers' organizations. However, the contribution of farmers' organizations to O&M of the irrigation facilities is poor. The technical section of each DIO takes care of O&M of the existing Government-managed schemes by designating one to three persons per scheme on a yearly payment basis. Repair works for the damaged facilities have also been carried out by DIO. However, due to the insufficient budget allocation and manpower, O&M for all the canal systems has not been carried out properly. There are no formal farmers' organizations except for a few which are involved with a limited number of

irrigation schemes. It is essential to further promote farmers' participation by organizing proper Water Users' Associations (WUA) in order to enable effective group decision making and implementation of their tasks, system maintenance, conflict management, resources mobilization, etc.

Farmers' participation in the existing irrigation schemes is not so good. Usually, they only participate in the desilting and weeding of the canals one to three times a year. However, there are a large number of farmers who want to participate more in O&M activities of the irrigation scheme to which they belong, with the condition that the scheme is fully rehabilitated.

ISP is being implemented in the Eastern and Central Development Regions under the loan from the ADB. To date, 5 schemes are under construction and about 100 schemes are under investigation and assessment in the two Development Regions. At present 46 sub-projects are listed as approved schemes or those to be appraised as sub-projects (schemes) under ISP, which consist of 16 in Kathmandu district, 15 in Bhaktapur district, and 15 in Lalitpur district. Among them, there are 12 Government-managed irrigation schemes which were included in the list of subject schemes for the inventory survey in this Master Plan Study.

Of the 71 existing Government-managed irrigation schemes included in the HMGN's formal request for rehabilitation, with a total commanding area of about 9,000 ha, 33 schemes were excluded from the inventory survey list, because they were: (1) located outside the Kathmandu Valley; (2) too small to be considered for rehabilitation; (3) already implemented or under process of implementation under ISP and it was considered that no further rehabilitation would be required; and (4) located inside or close to the Ring Road where rapid urbanization has been observed and where it would be difficult to continue agriculture. Consequently, an inventory list was compiled for 38 existing schemes, covering about 6,700 ha, which consists of 16 schemes in the Kathmandu district, 13 in the Bhaktapur district, and 9 in the Lalitpur district.

According to the results of inventory survey of the 38 schemes, beneficiaries from some schemes have intention to continue agricultural in the area and requested that repairs be carried out on the damaged facilities. Farmers who will benefit from some 16 schemes, were expected to mobilize WUAs. They submitted their intention to participate in the rehabilitation and O&M of the schemes, in the form of a "Request Form", and deposited the necessary amount in the joint bank account, as security in accordance with the Irrigation Policy 1992.

There are no systematic drainage systems under the existing irrigation schemes in the Valley. The excess water in the irrigation areas under the existing schemes is usually drained through irrigation canals located at a lower level than the irrigated areas or through natural streams located in the lower gouges of the beneficiary area. Accordingly, floodwater often overflows the irrigation canals, thus, the existing farm roads are flooded and damaged easily, resulting in difficult access to the farmlands as well as difficult transportation of harvested agricultural products and communication between villages.

2.2.5 Agriculture

The Study Area consists of 40 Village Development Committees (VDCs) out of the 130 units in the Valley, of which the total cultivated area is 10,100 ha or 34% of the Valley's area. The population of the Study Area is 305,000 or 28% of the total population of the Valley, with 54,000 households and an average family size of 5.6. There are 3,600 farm households or 37% of the total number of households in the Valley and the average cultivated area per farm is 0.28 ha. In 1991/92, 56% of the farmers were owner cultivators, 37% were owner cum tenant farmers, and 7% were tenant farmers.

The cropping pattern in the Valley is classified into the lowlands and the rainfed uplands. In the lowland area of the Valley, the main crops grown in the rainy season are paddy, followed by winter crops, mainly wheat. Potatoes, winter vegetables, and maize are also cultivated, but in a small area. In the rainfed upland area, maize is the main crop in the

rainy season and such winter crops as mustard, wheat, and legumes follow. However, the majority of land is left fallow, as summarized below:

Paddy - wheat	50%
Paddy - other winter crops (potatoes, vegetables, maize, etc.)	9%
Maize - winter crops (wheat, mustard, millet, barley, legumes, etc.)	14%
Maize - fallow	21%
Others (summer vegetables, etc.)	6%

Of the 10,100 ha of cultivated area in the Study Area, paddy occupies 5,900 ha or 59%, and followed by wheat of 53%, maize of 38% and others of 23%. Accordingly, the crop intensity in the Study Area is 173% at present.

The average unit yields of the major crops in the Study Area are higher than those of the whole of Nepal as shown below:

Unit : ton/ha

Crops	Nepal	Study Area
Paddy	2.28	4.74
Wheat	1.36	1.69
Maize	1.60	2.08
Potatoes	8.59	11.12
Vegetables	7.91	9.88

Most of the farmers are using improved varieties of seeds. Farmers usually prepare the seeds themselves (about 60%), and once every two or three years, purchase new certified seeds from the agencies (about 40%).

The average amount of chemical fertilizers used in the Valley far exceeds that used in other areas of the country. For instance, in 1991/92, the amount of chemical fertilizer supplied to the Valley is about 11% of the total amount supplied to Nepal as shown in the following table:

Description	Nepal	Study Area
Total Supply Amount by AIC	185,800 tons	20,700 tons (11.1%)
Average Supply Amount	70 kg/ha	700 kg/ha

Farming operations are done mainly by human labourers. At present there are 836 tractors and 1,397 power tillers in the Study Area. However, many tractors and power tillers are actually not used for cultivation, but for transportation.

Of the total number of farm households, 41% raise cattle, mainly for milk production. Goat and chicken meat fetches good prices in the market, therefore, most of the farmers raise goats and chickens. The percentage of farm households which raise goats and poultry is 34%. Some of the poultry farmers keep large numbers of poultry.

As for inland water fishing, of the four research centres in Nepal, two are located in the Kathmandu Valley. These centres carry out research work concerning inland water fish in the hilly area. The Fishery Office recommended the "Paddy Cum Fish Culture", but the total area of the ponds, which operate under this type of fish culture, is only 7 ha in the Valley, and most of them is for home consumption purposes.

The majority of farmers, whose average holding size is 0.28 ha in the Study Area as well as in the Kathmandu Valley, have huge nonfarm income, estimated at about 75% of their total household income. It is estimated that even the farmers cultivating more than 1.5 ha obtain half of their total household income from nonfarm activities. Farmers with average sized farms mostly balance their income and expenses, however farmers with large-scale farms usually

keep more reserves at hand.

Agricultural research work in Nepal is carried out under the umbrella of the Nepal Agricultural Research Council which is now an autonomous body mandated with all the powers and responsibilities for the development of plans, programs, and policies on any matters and issues regarding agricultural research work in the country.

Agricultural extension services in Nepal are carried out under the responsibility of the Director General of the Department of Agriculture Development (DoAD). The Director of the Regional Directorate of Agricultural Development has overall responsibility for coordination and supervision of agricultural development programs including agricultural extension services in the region. Under the supervision of the Regional Director, the District Agricultural Development Office (DADO) has responsibility for all activities concerning agricultural development programs in the district. Agricultural extension services in each district are carried out through field extension workers, who are stationed in each Agricultural Service Centre: 6, 6, and 7 in the Lalitpur, Bhaktapur, and Kathmandu districts, respectively. Each Agricultural Service Centre covering 6.8 villages and 1,600 ha of cultivated land in the three districts is staffed with 7.5 extension workers, consisting of 2.5 Junior Technicians (JT) and 5 Junior Technical Assistants (JTA), on average. The average number of villages and farm families and the average cultivated area covered by a centre per extension worker is 0.9 villages, 680 farm families, and 209 ha, respectively. As for the number of extension workers, it can be said that there is no shortage in this area.

Production of stock and foundation seeds is carried out by government farms. Most of the commercial seeds are produced by the private sector, by contract growers in the areas identified and recommended by DoAD. AIC also handles commercial seed production. In the Kathmandu Valley , there are two seed multiplication programs (total 20 ha) for radish and broad-leaf mustard.

2.2.6 Agro-economic and Social Conditions

The major crops (paddy, wheat, and maize) produced are mainly for home consumption by farmers. Most of the farmers in the Study Area do not sell any main cereal products. The main agricultural products marketed in the Kathmandu Valley are vegetables, although the total planted area is quite limited at present. Kathmandu, Lalitpur, and Bhaktapur municipalities have urban populations of about 414,000, 117,000, and 61,000, respectively. These urban populations are constant consumers of vegetables with a total annual purchase amount of 61,000 tons of vegetables. The amount of vegetables handled annually by the Kalimati Fruits and Vegetables Wholesale Market (KWM) was about 29,000 tons in 1992/93 which was about 47% of the total amount handled by the main vegetable markets.

Chemical fertilizers are monopolistically distributed by AIC, through appointed dealers totalling 127, 240, and 398 in the Lalitpur, Bhaktapur, and Kathmandu districts, respectively. AIC distributes chemical fertilizers and seeds.

Recently, 164 commercial rice mills were developed in the area. The total capacity of these rice mills is estimated at 82,000 tons per year. Since paddy production in the Study Area amounted to 83,130 tons in 1991/92, the present post-harvest facilities are sufficient for processing paddy in the area.

The number of agro-based processing industries has been increasing in recent years. At present, the total number of small-scale agro-based factories is 74. The total number of rather large-scale agro-based industries, registered in the Department of Industry is 9. Most of the factories mainly procure their raw materials from other districts (about 53% of the total raw materials). Imported raw materials account for about 34% of the total raw materials and those purchased in the Kathmandu Valley accounted for about 13%.

According to the food balance of Nepal, it could be said that self-sufficiency has been

generally achieved in Nepal. However, some people in the Kathmandu Valley always have a deficit in food grains. About 100,000 tons of rice are distributed annually from the Terai region. As for vegetables, 30% of the total amount supplied to KWM is from the Kathmandu Valley. The other 70% of the vegetables is provided by other districts in the hilly and Terai regions.

Initially, a Land Reform Saving Corporation (LRSC) was established in 1966, in order to collect the compulsory savings from the farmers, 5% of their annual production. Through the daily operation of LRSC, it was expected that every village and ward in the whole country would be facilitated with banking services. However, due mainly to insufficient business management skills, LRSC has been amalgamated with the Agricultural Development Bank, Nepal (ADB/N) since 1974.

Therefore, Agricultural Cooperative Societies (ACS) were started based on the compulsory saving funds. There was some confusion among member farmers of ACS. In some ACS, many of the farmers didn't know that they were in fact members of the Society. In each district, a District Cooperative Union (DCU) was set up, but no federation was established on a national level. Under each DCU, there are 9, 9, and 15 primary ACS in the Lalitpur, Bhaktapur, and Kathmandu districts, respectively. Most of ACS in the Study Area are not active in credit, savings, and sales of farm products. However, there is a new independent farmers' organization, which was set up in order to solve the common problems of inhabitants.

The Cooperative Saving and Service Centre (CSSC), which was established in Bhaktapur in November 1991, is a kind of agricultural credit cooperative organized by the farmers themselves. At the onset of CSSC there were 51 members, but at present there are 85. An amount of NRs.50 to NRs.100 as the monthly savings, per member, was collectively deposited in the CSSC account, which had amounted to NRs.151,400 by the end of May 1993. The total saving amount was lent to the members. These loans were used for the acquisition of land, businesses, and cottage industries, etc. Most of the members of CSSC are vegetable growers. They jointly invested in the construction of tube-wells, or purchased water pumps to be used by neighbouring groups of around 10 members. These members usually discussed vegetable growing techniques and assisted in acquiring farm inputs and selling farm products.

One of the demographic characteristics of the Study Area is that the male population exceeds the female population, even though in the whole of Nepal the male population is smaller than the female population. In addition, the annual population growth rate during 1981-1991 in the Study Area was as high as 3.7%, compared to 2.1% in the whole Nepal. These figures show that a rapid population increase is taking place in the Study Area.

Based on the farm survey, the literacy rate in the Study Area is estimated at 65%, of which 20% would only be just able to read and write and 21% have been educated to primary level. Lower secondary, secondary, and higher education levels are estimated at 15%, 27%, and 17%, respectively.

The proportions of major ethnic/caste groups living in the Study Area are estimated at 62% Newar, 14% Brahmin, and 23% Chettri. In most cases, one ethnic/caste population is clustered in one area and another ethnic/caste population in another area.

Exchanging family labour, locally known as "*Perma*", is widely practised in the area. Usually the farmers' own labour and the exchange labour constitute 80% and 20% of the total family labour, respectively. Because religious beliefs, no bullocks are used for labour in the Kathmandu Valley.

There is no information available on the number of radios owned by households in the Study Area, however, it is believed that a significant number of farmers in the Study Area would already have radios. Recently, Radio Nepal has started broadcasting the previous days' vegetable prices, every morning.

2.3 Rehabilitation Plan

Of the 38 existing irrigation schemes in the inventory list, 16 schemes were selected as potential irrigation schemes for rehabilitation (See Figure 2-1 and Table 2-1), based on the following selection criteria:

(1) relatively large schemes with badly damaged facilities;

(2) stable water resources;

(3) farmers' strong intention to continue with agricultural activities in the future and farmers' willingness to cooperate in the implementation and O&M;

(4) no or less urbanization;

(5) DoI's high priority schemes; and

(6) areas with easy access.

The following 16 schemes were selected: 6 in Kathmandu, 5 in Bhaktapur, and 5 in Lalitpur:

Kathmandu District		Bhaktapur District		Lalitpur District	
Biswambhara	125 ha	Bidol	60 ha	Khokana	250 ha
Boshan	210 ha	Dhunge Dhara	210 ha	Kotkhu	445 ha
Dakshinkali	100 ha	Katunje	90 ha	Lubhu	165 ha
Indrayani	140 ha	Kutudhal	147 ha	Thika Bhairaw-I	600 ha
Shali Nadi	300 ha	Mahadev Khola	450 ha	Thika Bhairaw-II	400 ha
Tokha	90 ha				
6 schemes	965 ha	5 schemes	957 ha	5 schemes	1,860 ha
			Total	16 schemes	3,782 ha

Note : Irrigation areas shown above are proposed gross command areas estimated based on the topographic map of 1/10,000 scale prepared by HMGN, which were revised after confirmation with a detailed topographic map of 1/5,000 scale prepared for the model scheme areas for Phase-II Study, as described in the following chapters.

The 16 schemes selected as potential irrigation schemes would be rehabilitated under the following basic strategy :

(1) To establish safer irrigation systems against floods and canals with better water saving capabilities;

(2) To establish farmer-friendly irrigation canal systems, particularly with respect to O&M and water management;

(3) To provide upgraded irrigation facilities in order to enable the farmers to control irrigation water easily;

(4) To promote farmers' participation in O&M, water management, and other related activities;

(5) To encourage DIOs so that they can play a more important role in the implementation of the Project; and

(6) To coordinate well with ongoing ISPs during the implementation of the Project.

Since the Project aims to establish irrigation canal systems (1) with less water losses; (2) which can be maintained and operated by the farmers easily; and (3) which are resistant to natural hazards, etc., a rehabilitation plan was prepared under the following general concepts:

(1) Targeted irrigation facilities will be rehabilitated according to their present status and their remaining structures will be utilized as much as possible;

(2) Existing temporary intake facilities and badly damaged intake facilities, under the selected schemes, will be replaced with new ones;

(3) Canal lining will be provided up to the tertiary canals in order to raise the transportation efficiency of irrigation water;

(4) To strengthen the function of the existing canal systems, such canal structures as check structures with gates, turnouts, drops, side spillways, and cross drainage structures will be provided for the canals to be rehabilitated, where necessary; and

(5) Gravel-metalled roads with a width of 1.2 to 1.5 m will be constructed along the canals, where necessary, for O&M of the canals.

Since the rehabilitated irrigation schemes under the Project will be handed over to the farmers and they have to maintain the irrigation facilities at their own expense and with their own labour for a long period, without the support of the Government, O&M of the rehabilitated irrigation schemes shall be carried out under the following general concepts:

(1) Farmers' organizations under the rehabilitated schemes should be established with the understanding that all farmers must cooperate with each other and regularly participate in checking the condition of all the irrigation facilities and canals, etc., by themselves at least twice a month. And if it is found that minor repairs in and along the canals or of the gates are necessary, these must be immediately executed by the farmers themselves at their own expense and with their own labour. In addition, desilting and weeding of the canals should also be carried out regularly;

(2) Since a higher technical level of O&M will be introduced for the rehabilitated irrigation schemes, farmers are requested to acquire at least the techniques necessary to repair the damaged portions of the canals and gates, etc. using simple equipment and tools. For this purpose, DoI is requested to pay full attention to the prior training of the farmers on: (1) O&M of the irrigation facilities including the repair of canals and gates using simple equipment; (2) the method of operation of the gates; and (3) the method of water measurement by gauging devices, etc.

To apply such O&M methods considered above, the existing schemes to be rehabilitated were designed preliminarily under the following basic design concepts:

For the Weirs and Intake Structures:

(1) Concrete fixed type weirs without gates (not barrage type) will be considered;

(2) Concrete aprons shall be provided both upstream and downstream;

(3) Riverbank protection works using gabions, etc. shall be carried out both upstream and downstream; and

(4) Silt excluders shall be provided for each intake facility, where necessary.

For the Canal:

(1) The canals to be rehabilitated shall be lined with concrete, etc. up to the tertiary canals

(2) Steel gates and water measuring devices shall be provided at the heads of the main canals and diversion points, from main to secondary canals and from secondary to tertiary canals in order to strengthen control of the irrigation water, as much as possible;

(3) Gravel-metalled roads with a width of 1.2 to 1.5 m shall be provided along the main canals as required; and

(4) All the canals will be designed to be rectangular, in general, so that additional land acquisition will be minimized.

2.4 Agricultural Development Plan

The major constraints on agricultural development in the Study Area are:

(1) Unstable production which basically depends upon the rainfed agricultural conditions;

(2) A shortage of irrigation water due to the superannuated and damaged conditions of the existing irrigation facilities and the increasing demand for domestic water supplies; and

(3) Decreasing farmland due to urbanization.

Since most of the agricultural support system is fairly well organized and operated intensively, although it will be necessary to strengthen the staff and activities through more intensive training in each sector, there is not much room to develop new functions for the agricultural support system.

The basic concept of agricultural development for the Rehabilitation Project of the Irrigation Schemes in the Kathmandu Valley is as follows:

(1) To maximize the potential agricultural benefits through the efficient use of limited available water and land resources; and

(2) To maintain the existing agricultural areas and increase the crop intensity in order to create a vegetables supply base to meet the urban demand of Kathmandu.

In order to achieve these objectives, the strategy for agricultural development under the Project is as follows:

(1) To maintain a stable amount of cereals for self-consumption which minimizing the cereal production area, by maximized the unit yields of cereal crops through the provision of stable irrigation water.

(2) To extend the cultivated area of vegetables by maximising the efficiency of irrigation water supply.

Taking the above conditions into consideration, the proposed cropping pattern was prepared preliminarily for the Master Plan Study. The proposed cropping pattern consists of 80% paddy and 20% summer vegetables in the monsoon season and 40% wheat, 20% vegetables, 20% potatoes, 10% mustard, and 10% maize in the winter season. Thus, the overall cropping intensity will reach 200%. (In the Feasibility Study in the Phase-II Study, cropping pattern was reviewed and revised taking into consideration that availability of irrigation water, Government policy on agricultural development in the Valley, etc., as described in following chapters.)

The unit yields of major crops under the "with" project condition in the future are estimated below:

Paddy	5.0 tons/ha
Wheat	2.0 tons/ha
Maize	2.5 tons/ha
Potatoes	13.0 tons/ha
Mustard	0.8 ton/ha

2.5 Preliminary Assessment of Water Resources for the Selected Schemes

For the preliminary assessment of water resources for the selected schemes, a water balance study was carried out based on the estimated irrigation water requirement of the

cropping pattern prevailing in the Valley and the proposed cropping pattern of the Phase-I Study, the natural runoff estimated at respective intake points taking into consideration the amount of upstream water abstraction for municipal water supply and irrigation, and the return flow with a mean monthly discharge and 80% dependable discharge.

The results of the preliminary assessment of water resources show that water is sufficient in the rainy season to cover the existing command areas of 15 of the 16 selected schemes, but not the Tokha scheme, while the irrigable area in the dry season is limited to 6 schemes due to the lower availability of water. The irrigable area in the dry season is usually 60% less than that of the rainy season.

It is necessary for the Khokana (AL-08), Thika Bhairaw-I (AL-19), and Thika Bhairaw-II (AL-20) schemes, to share water with each other and other potential schemes such as Bhorle (AL-02), Champi (AL-03), and Saibu (AL-18), because these schemes are situated a series depending upon the same water source, the Nakhu Khola, with a small residual catchment area in its lower reaches.

For the Kotkhu (AL-10) scheme in the Kotkhu river basin and the Khokana (AL-08), Thika Bhairaw-I (AL-19), and Thika Bhairaw-II (AL-20) schemes in the Nakhu river basin, it is necessary to determine adequately the share of water between the Kotkhu Dam and the Nakhu Dam projects, of which implementation is under study for water supply by NWSC.

2.6 Preliminary Cost Estimate and Economic Evaluation

Based on the rehabilitation plan, the preliminary design and cost estimate were carried out for the 16 selected schemes. The estimated cost varies from NRs.146,000/ha to NRs.326,000/ha and the average is about NRs.188,000/ha. The irrigation benefit was estimated at about NRs.42,900/ha per year, which is a balance of the annual net production values under the "with" and "without" project conditions.

According to the result of the economic evaluation, the highest Economic Internal Rate of Return (EIRR) is 22.6% for the Kotkhu (AL-10) scheme, followed by 22.1% for the Boshan (AK-05) scheme. Seven schemes have an EIRR of above 18%, which is the interest rate of the loan from ADB/N for irrigation projects. Another seven schemes have an EIRR of more than 10% but less than 18%, which is the minimum standard rate for selection by DoI. EIRR of remaining two schemes is less than 10%.

2.7 High Priority Schemes and Implementation Schedule

In the formulation of the implementation schedule, priority was basically decided based on EIRR values and was further assessed in relation to the: (1) influence of urbanization, (2) size of farmlands, (3) availability of irrigation water, and (4) accessibility were (See Figure 2-1 and Table 2-2). The results are discussed below:

1) The following 7 schemes which have an EIRR of more than 18% were finally selected as the first priority schemes to be implemented within the duration of the Eighth Plan (1992 - 1997):

Code and Name of the Scheme		Irrigation Area Gross (ha)	Net (ha)
AK-05	Boshan	210	168
AK-25	Shali Nadi	300	240
AB-12	Kutudhal	147	118
AB-14	Mahadev Khola	450	360
AL-10	Kotkhu	445	356
AL-13	Lubhu	165	132
AL-19	Thika Bhairaw-I	600	480
Total	7 schemes	2,317	1,854

However, consideration of two schemes, i.e., Kotkhu (A-10) and Thika Bhairaw-I (AL-19), at the feasibility study stage may be necessary with regard to their water sources which may concern the "Kathmandu Valley Drinking Water Development Plan". Accordingly, it may be suggested that the implementation of these two schemes be delayed until a solution is found.

2) The following 6 schemes which have an EIRR of more than 10% but less than 18% were selected as the second priority schemes to be implemented in the second stage following the first priority schemes, i.e., from 1997 to 2002 or at the latest by the year 2005:

Code and Name of the Scheme		Irrigation Area Gross (ha)	Net (ha)
AK-04	Biswambhara	125	100
AK-07	Dakshinkali	100	80
AK-14	Indrayani	140	112
AB-02	Bidol	60	48
AB-10	Katunje	150	120
AL-20	Thika Bhairaw-II	400	320
Total	6 schemes	915	732

Considering the possibility of the early implementation of the Project with foreign aid which HMGN may procure, a feasibility study will be carried out by the Study Team on these 13 first and second priority model schemes. In the feasibility study, further in-depth studies with regard to the rehabilitation and improvement plan, project cost, construction plan with the farmers' participation, economic viability of the Project, and O&M plan for the rehabilitated irrigation facilities with the farmers' participation, etc. should be carried out for each selected model scheme.

An aero-topographic survey which will cover the 13 selected schemes should be carried out immediately. A topographic map will be prepared based on the aero-topographic survey results on a scale of 1/5,000 with contour intervals of 1.0 m (5.0 m for mountainous areas and 0.5 m for relatively flat areas).

It has been suggested that 3 schemes, which were excluded form the model schemes of the feasibility study, and another 9 schemes, which were identified as having less potential, may be implemented after the completion of the 13 high priority schemes. However, the implementation of these schemes should be carefully examined by taking the surrounding conditions in future, etc. into consideration.

2.8 Necessary Supporting Organizations and Farmers' Involvement

It is considered that three DIOs in the Kathmandu, Bhaktapur, and Lalitpur districts,

must play an important role in the successful implementation of the Project. Therefore, prior to the commencement of the Project, it is necessary for HMGN to strengthen the manpower of each district office, especially for the Project. It is recommended that one irrigation engineer, who will be in charge of the Project, and two assistant engineers shall be assigned to each of the district offices.

It is necessary to make it clear that the farmers' participating in the Project should be organized, which means that all the farmers under the schemes to be rehabilitated are requested to attend to the welfare of all, not just a few, of the beneficiary farmers through the Project, so that all the farmers who participate in the Project could equally benefit from it.

3. PRESENT CONDITION OF THE PROJECT AREA

3.1 General

Based on the additional survey results and supplementary data collected, a review of the previous study and further detailed studies were conducted during the Phase-II study period. The results of the study on the 13 irrigation schemes of the selected model areas carried out are described hereinafter.

3.2 Meteorology and Hydrology

3.2.1 Meteorology

All 13 schemes of the selected model areas are located in the Kathmandu Valley, where climatic conditions are not so different from each other, except for precipitation. Rainfall varies substantially according to the altitude. The annual basin rainfall in the Kathmandu Valley was estimated at some 1,900 mm, as described in the Master Plan Study Report.

The selected schemes of the model areas of the Phase-II study, are located a relatively low level in the Valley. There are two representative rain gauge stations for estimating the effective rainfall for agriculture in the Valley, i.e. Kathmandu airport (Station No.1030, El.1,336 m) for Zone-A and Changu Narayan (Station No.1059, El.1,543 m). The monthly rainfall are shown in Table-3.1 and the monthly average rainfall at these two stations are summarized below:

Unit : mm

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Kathmandu Airport (Station No. 1030, El. 1,336 m)													
	14	18	33	53	105	234	356	289	187	66	6	14	1,375
Changu Narayan (Station No. 1059, El. 1,543 m)													
	16	24	32	60	148	237	421	395	229	62	6	21	1,651

Meteorological conditions at Kathmandu Airport, other than rainfall, are summarized below:

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Air Temperature	(°C)	9.9	11.7	15.6	19.2	21.6	23.6	23.8	23.8	22.5	19.3	14.8	10.9	18.1
Relative Humidity	(%)	80	74	64	60	67	75	82	82	83	82	82	82	76
Pan Evaporation	(mm/day)	2.4	3.0	4.1	5.0	5.0	4.7	4.5	4.6	3.7	3.3	2.6	1.9	3.7
Sunshine	(hrs/day)	7.0	7.3	8.1	7.7	8.0	5.8	4.2	5.4	5.5	7.1	7.4	6.7	6.7
Wind Speed	(km/hr)	2.5	3.4	4.4	5.0	4.8	4.1	3.8	3.0	2.6	1.9	1.8	1.6	3.2

3.2.2 Hydrology

As mentioned in the Master Plan Study Report, the Bagmati river is the only river system in the Valley, and drains all the water collected in the Valley basin to the South. The major tributaries of the Bagmati river are the Mai Khola, Nakhu Khola, Balkhu Khola, Bisnumati Khola, Dhobi Khola, Manohara Khola, Kotkhu Khola, Godawari Khola and Hanumante river. All these tributaries, originating on the mountainside near the border of the Valley, flow towards the centre of the Valley and finally flow into the Bagmati river. All the model schemes are located along these tributaries, which are the main source of irrigation water for the schemes.

The catchment area of each tributary at the junctions and intake sites of the model areas are shown below:

River	Catchment area	Model Scheme & Catchment Area at the Intake
Bisnumati Khola	103.4 km^2	-
Dhobi Khola	28.9 km^2	-
Manohara Khola	73.1 km^2	AK-04 (Manohara Khola, 5.84 km^2), AK-14 (Manamatta Khola, 5.2 km^2), & AK-25 (Shali Nadi Khola, 12.0 km^2)
Hanumante river	91.2 km^2	AB-02 (Saraswiti/Tholo Khola 3.6 km^2), AB-10 (Budhi Ganga/Gatte Khola, 2.4 km^2), AB-12 (Gatte Khola, 7.3 km^2), & AB-14 (Mandev Khola, 4.4 km^2)
Godawari Khola	45.1 km^2	AL-13 (Sineri (Lubhu) Khola, 5.2 km^2)
Kotkhu Khola	34.6 km^2	AL-10 (16.0 km^2)
Nakhu Khola	57.2 km^2	AL-19 (Lela & Nallu Khola, 39.0 km^2), & AL-20 (47.0 km^2)
Balkhu Khola	43.0 km^2	-
Bagmati river	585.0 km^2 at Chobhar	AK-05 (Boshan Khola, 6.8 km^2), & AK-07 (Mai Khola, 10.0 km^2)

River discharge was observed at 7 hydrological stations; Sundarijal (Station No. 505), Mahnkal (Station No. 507), Shyamdado (Station No. 510), Gauri Ghat (Station No. 530), Budhanilkantha (Station No. 546.2), Thika Bhairaw (Station No. 540) and Chobhar (Station No. 550). The monthly discharge of these stations is shown in Table-3.2.

Based on the relationship between annual basin rainfall and specific discharge at respective gauging stations, natural runoff at respective intake points of the selected irrigation schemes was estimated, using the following equation:

$$Q_i = 100 \times q_s \times A_i \, (R_i / R_s) \pm a$$

where, Q_i : Natural runoff at the intake points (ungauged basin) (m^3/sec)
q_s : Specific discharge at the gauged basin (m^3/sec/100km^2) $= Q_s/A_s/100$
Q_s : Natural runoff of the gauged basin (m^3/sec)
A_s : Catchment area of the gauged basin (km^2)
A_i : Catchment area of the ungauged basin (km^2)
R_i : Annual basin rainfall in the ungauged basin (mm/yr)
R_s : Annual basin rainfall in the gauged basin (mm/yr)
The annual basin rainfall in both gauged and ungauged basins is estimated using the isohyetal map.
a : Adjustment for supply from permanent springs, withdrawal for other purposes or fixed water rights etc. (m^3/sec)

The estimated monthly natural runoff at respective intake points of the selected irrigation schemes is shown in Table-3.3.

Using the estimated figures for the monthly natural runoff and amount abstracted by the existing municipal water supply and irrigation systems, which were calculated based on the present cropping pattern prevailing in the Valley, water balance was simulated for the selected irrigation schemes on a monthly basis. As a result, monthly available discharge for respective selected schemes is estimated and the mean monthly discharge and 80% reliable discharge at respective intake sites of the model areas are summarized in Table-3.4.

3.3 Soil and Land Use

3.3.1 Soil and Land Suitability

(1) General Features of the Soil

The survey results suggested that the soils in the selected irrigation schemes possess the following general characteristics:

- Fully influenced by submergence, since the soils in the selected irrigation schemes are being used for paddy cultivation during the rainy season.
- Parent materials of the soils are almost lacustrine deposits.
- Soil texture class of the top soil is mainly loam to silty loam.
- Soil reaction (pH) in the topsoil is acid.
- Effective soil depths are sufficient.

The general features of the soils in each irrigation scheme are as follows:

Kathmandu district

Biswambhara: Steep slope in the northern part and moderate slopes in the southern part. The two parts are divided by a road which runs in an east/west direction through the irrigation scheme area. The texture class of the topsoil is loam, the drainage regime* is somewhat poor, the efficient soil depth is 140 cm on average and the pH of the topsoil is 5.0 to 5.4. A buried horizon is observed in some places.

Note: * Drainage regime of each scheme was estimated from soil morphology.

Boshan: The texture class of the topsoil is loam to silt loam (silty clay loam), the drainage regime is moderately good to poor, the efficient soil depth is 104 cm on average and the pH of the topsoil is 6.2 to 6.8.

Dakshinkali: Most of the land in the scheme is steep. The texture class of the topsoil is silt loam, the drainage regime is relatively poor, the efficient soil depth is more than 70 cm and the pH of the topsoil is 6.0 to 6.3.

Indrayani: The texture class of the topsoil is loam, the drainage regime is relatively poor to moderately good, the efficient soil depth is 74 cm on average and the pH of the topsoil is 5.2 to 5.4.

Shali Nadi: The texture class of the topsoil is loam, the drainage regime is relatively poor to moderately good, the efficient soil depth is 68 cm on average and the pH of the topsoil is 5.2 to 6.0. A buried horizon is observed in some places.

Bhaktapur district

Bidol: The texture class of the topsoil is loam, the drainage regime is relatively poor, the efficient soil depth is more than 30 cm and the pH of the topsoil is 5.3 to 5.9.

Katunje: The texture class of the topsoil is loam to silty clay loam, the drainage regime is relatively poor to good, the efficient soil depth is 114 cm on average and the pH of the topsoil is 4.8 to 5.4. In some places Kalimati (Black clay) is observed from 40 cm depth.

Kutudhal: The texture class of the topsoil is silt loam, the drainage regime is poor to moderately good, the efficient soil depth is 89 cm on average and the pH of the topsoil is 5.2 to 5.3.

Mahadev Khola: The texture class of the topsoil is silt loam, the drainage regime is poor to moderately good, the efficient soil depth is 104 cm on average and the pH of the topsoil is 5.6 to 5.7. I the topsoil in some places, Kalimati is observed.

Lalitpur district

Kotkhu: The texture class of the topsoil is loam to clay loam, the drainage regime is relatively poor to moderately good, the efficient soil depth is 124 cm on average and the pH of the topsoil is 5.6 to 6.4. In the southern part of the scheme, relatively developed soil (Alfisol) is observed.

Lubhu: The texture class of the topsoil is loam to clay loam, the drainage regime is relatively poor to moderately good, the efficient soil depth is 133 cm on average and the pH of the topsoil is 5.5 to 6.3.

Thika Bhairaw-I and II: The texture class of the topsoil is loam to clay loam, the drainage regime is relatively poor to moderately good, the efficient soil depth is 108 cm on average and the pH of the topsoil is 5.6 to 6.4. In the southern part of the scheme, relatively developed soil (Alfisol) is observed.

(2) Soil Classification

Soil classification in the selected irrigation schemes was carried out with reference to the Soil Taxonomy of USDA. The distribution of the soils in the selected schemes is worked out in ANNEX-2 and summarized below.

Most of the soil in the selected irrigation schemes are classified into Inceptisols, according to the level of the Order of the Soil Taxonomy. The soil classification into subgroups is as follows:

Order	Suborder	Great Group	Subgroup
Inceptisols	Aquepts	Endoaquepts	Aeric Endoaquepts
			Fluvaquentic Endoaquepts
			Typic Endoaquepts
		Eplaquepts	Aeric Eplaquepts
		Fluvaquepts	Typic Fluvaquepts
	Ochrepts	Dystrochrepts	Aquic Dystrochrepts
			Fluvaquentic Dystrochrepts
			Oxyaquic Dystrochrepts
			Typic Dystrochrepts
		Eutrochrepts	Anthraquic Eutrochrepts
			Aquic Eutrochrepts
			Authraquic Eutrochrepts
			Fluvaquentic Eutrochrepts
			Fluventic Eutrochrepts
			Ruptic-Alfic Eutrochrepts
	Plaggepts		(Aquic Plaggepts)
			(Typic Plaggepts)
Entisols	Orthents	Udorthents	Aeric Udorthents
			Aquic Udorthents
			Oxyaquic Udorthents
	Fluvents	Udifluvents	Typic Udifluvents
Alfisols	Ustalfs	Haplustalfs	Aquic Haplustalfs
			Typic Haplustalfs
Mollisols	Udolls	Hapludolls	Typic Hapludolls

(3) Land Suitability

Land classification was carried out based upon the Design Manuals for Irrigation Projects in Nepal, M.4 Soils and Land Use Manual Volume 1, February 1990, as described in ANNEX-2. In the manuals, lands belonging to classes S1 to S3 are classified as suitable land for agriculture and those of N1 and N2 as unsuitable land. The results of land classification are summarized in Table 3-5.

As a result, unsuitable land for agriculture which would be classified as N1 (Currently not suitable) and N2 (Permanently not suitable) land, is not existent and all land in the selected irrigation schemes are classified as S2; Moderately suitable (65.6%) and S3; Marginally suitable (29.7%) land. There is no S1; Highly suitable land. The remaining areas (4.7%) are classified into others like main settlements and river channels.

3.3.2 Land Use

During the Phase-II fieldwork, an additional survey on land use in the selected irrigation schemes was carried out based on the topographic maps on a scale of 1/5,000 prepared for the Project. As a result, land use in the selected irrigation schemes has been worked out as shown in ANNEX-2 and summarized in Table-3.6.

In Table-3.6, it is observed that most of the land in the selected irrigation schemes are utilized for agriculture. This land has been influenced by urbanization and brick-making plants, as described below:

(1) Land influenced by urbanization

Urbanization is remarkable in the northern part of Thika Bhairaw-II (AL-20) and along the road to Godawari in Kotkhu (AL-10), especially between Harisiddhi and Thaiba. In addition, urbanization is in progress in the northern part of Thika Bhairaw-I (AL-19). Accordingly, in these areas, most of the agricultural land is changing into fallow land. Urbanization is also in progress in Lubhu (AL-13) and 13 ha of agricultural land in the scheme were allotted, in 1993, for the New Settlement Plan by Housing and Service Project.

(2) Land influenced by brick-making plants

Agricultural land in the selected irrigation schemes, especially in the Kotkhu (AL-10) and Bidol (AB-02) schemes, is being used for brick-making works. Brick-making plants are also observed in the northern part of Mahadev Khola (AB-14), lower part of Kutudhal (AB-12), northwestern part of Lubhu (AL-13), and lower part of Thika Bhairaw-II (AL-20) schemes. These brick-making plants use much soil from the relatively flat agricultural land in the scheme. In the Kotkhu (AL-10) scheme, the number of brick-making plants are increasing and at present they occupy a large part of the agricultural land under the scheme. The brick-making plant located at Harisiddhi is relatively big and is considered to be the core brick-making plant of all the areas. For many years, these brick-making plants have used much soil from the agricultural land of the related irrigation schemes. As a result, in some areas, the surface of the agricultural land has been lowered by 2.0 m at maximum, which results in difficulties for cultivation occurring.

The agricultural land in the selected irrigation schemes is used for paddy cultivation during the rainy seasons and wheat cultivation during the dry seasons. However, in such areas comprizing alluvial plain where seepage water is available, vegetable cultivation is observed. Vegetable cultivation is generally observed near and around the houses of farmers under the selected irrigation schemes. Up land type land use is also observed in some areas of the Thika Bhairaw-I (AL-19) and Mahadev Khola (AB-14) irrigation schemes.

3.4 Irrigation and Drainage

3.4.1 General

As a result of the Phase-I study and through discussions held between DoI and the JICA Study Team in October, 1993, at the time of the explanation of the Interim Report of the Project at the master plan study stage, 13 existing irrigation schemes located in Kathmandu, Bhaktapur, and Lalitpur districts in the Kathmandu Valley have been selected as model areas to be further studied under the feasibility study of the Project. The selected irrigation schemes are as follows:

Name of the irrigation scheme	Priority	Proposed Net Irrigation Area in the Master Plan	
		Rainy season(ha)	Dry season(ha)
Kathmandu District			
Biswambhara(AK-04)	II	100	57
Boshan(AK-05)	I	168	168
Dakshinkali(AK-07)	II	80	80
Indrayani(AK-14)	II	112	112
Shali Nadi(AK-25)	I	240	240
Sub-total Kathmandu District (5 schemes)		700	657
Bhaktapur District			
Bidol (AB-02)	II	48	48
Katunje (AB-10)	II	72	38
Kutudhal (AB-12)	I	118	49
Mahadev Khola (AB-14)	I	360	213
Sub-total Bhaktapur District (4 schemes)		598	348
Lalitpur District			
Kotkhu (AL-10)	I	356	356
Lubhu (AL-13)	I	132	132
Thika Bhairaw-I (AL-19)	I	480	480
Thika Bhairaw-II (AL-20)	II	320	320
Sub-total Lalitpur District (4 schemes)		1,288	1,288
Total (13 schemes)		2,586	2,293

Note : Irrigation area proposed in the master plan study will be finally fixed by this feasibility study.

From April to May 1994, the JICA Study Team conducted a field survey for the 13 irrigation schemes using topographic maps on a scale of 1/5,000, which were prepared in March 1994 by a topographic survey team dispatched by JICA. In addition, the JICA Study Team conducted a supplemental plane table survey, levelling survey, and traversing survey for the intake sites and main canals of the 13 irrigation schemes in order to obtain more detailed information regarding each irrigation scheme for the preliminary design of the irrigation facilities to be rehabilitated under the Project. Additional information regarding each irrigation scheme, obtained through the field survey, is summarized in the following sections.

3.4.2 General Conditions of the Selected Irrigation Schemes

General conditions of the selected irrigation schemes as model areas for the Phase-II study are summarized below:

(1) It has been observed that urbanization is progressing slowly but steadily in several selected irrigation schemes, especially in the Kotkhu (AL-04), and the lower part of Mahadev Khola (AB-14), Thika Bhairaw-I (AL-19), and Thika Bhairaw-II (AL-20)

schemes. It has also been observed that a number of brick-making plants in the lower benefited area of the Bidol (AB-02), Kotkhu (AL-10), and Mahadev Khola (AB-14) schemes, has increased.

(2) Severe scoring both upstream and downstream of the intake site of Lubhu (AL-13) has washed away the intake facilities completely and apparently. The physical condition of the intake site has worsened every year. Local landslides have been observed along the main canals of the selected irrigation schemes, especially The Thika Bhairaw-I (AL-19) and Thika Bhairaw-II (AL-20) schemes, which were caused by heavy rains last year. In addition, it has been found that 150 m length of the main canal of the Indrayani (AK-14) scheme collapsed due to landslides which occurred six years ago. This condition justifies not only the need for quick rehabilitation of the existing intake facilities of the selected irrigation schemes, but also the urgent need for rehabilitation of their irrigation canal systems.

(3) Stream flow at the lower water stage, in the driest season, has been observed at 13 intake sites of the selected irrigation schemes. Generally speaking, it has been found that the river flow at most intake sites is stable even in the driest season, except the Mahadev Khola (AB-14), Katunje (AB-10), and Kutudhal (AB-12) schemes where little stream flow is observed. Considering the general hydrological tendency in the Kathmandu Valley, the situation observed is believed to be normal because rainfall from November to April is usually less in the Kathmandu Valley. According to the hydrological analysis on the availability of water for the three schemes mentioned above, water shortage in the dry season is anticipated to occur. As a result, the areas of the three irrigation schemes to be irrigated under the Project should be reduced taking into consideration the limitation of available water in the dry season.

(4) A field survey has revealed that more hydraulic structures in and along the canals of the selected irrigation schemes are needed for the proper maintenance of the canals as well as for effective water management in the irrigation systems. Additional structures to be provided under the Project will be as follows:

(i) Water gauging devices at the intake structures as well as at the diversion points in the main canals.
(ii) Permanent diversion structures (turnouts) with steel gates on the main, secondary, and tertiary irrigation canals.
(iii) Escape structures on the main canals in order to release excessive water.
(iv) Cross-drain structures.
(v) Landslide protection structures along the main canals.
(vi) Drop structures with energy dissipators on the main canals.

In addition, a field survey has revealed that the partial provision of covered irrigation canals would be necessary in order to protect the canals from landslides, which are observed mainly at the toe of the hills along the main canals of the Thika Bhairaw-I (AL-19) and Thika Bhairaw-II (AL-20) schemes. In addition, in the Kotkhu (AL-10) and Bidol (AB-02) schemes, additional maintenance roads along the main canals would be necessary for effective O&M of the canals and related irrigation facilities.

3.4.3 Net Irrigation Command Area of the Selected Irrigation Schemes

In order to decide the net irrigation command area to be studied under this feasibility study, a more detailed field survey for the selected 13 irrigation schemes was conducted by the JICA Study Team using a topographic map on a scale of 1/5,000, which was prepared by the JICA topographic survey team in March 1994. During the field survey, the team was accompanied by not only the engineers and overseers of Kathmandu, Lalitpur, and Bhaktapur DIOs, but also, occasionally, by the chairmen of WUAs of the related irrigation schemes. In

addition to the above field survey and study, further detailed studies on water balance simulation and present land use were carried out.

Based on the above study, the net command area of the selected irrigation schemes is estimated taking into consideration information concerning the extent of urbanization or areas being urbanized, extent of existing brick-making plants in the command areas, topographic condition of each irrigation scheme, length of the main, secondary, and tertiary irrigation canals under the present irrigation systems, presently irrigated area, location of the existing irrigation canals, other irrigation schemes, related drinking water supply projects which are on-going or under study, availability of water, prevailing and proposed cropping patterns, and irrigation water requirements, etc.

As a result, the net irrigation command area of the selected irrigation schemes to be studied under this feasibility study has been estimated, as shown in Table-3.6 and summarized below:

Unit : ha

Under the Feasibility Study	Irrigation Area Estimated in the Master Plan			Irrigation Command Area		
	Gross	Net Irrigation Area		Total	Agricultural Land	
Name of Scheme	Area	Rain Season	Dry Season	Area	Gross	Net
Kathmandu District						
Biswambhara	125	100	57 (57%)	135	115	92
Boshan	210	168	168(100%)	194	153	122
Dakshinkali	100	80	80(100%)	100	84	67
Indrayani	140	112	112(100%)	268	126	101
Shali Nadi	300	240	240(100%)	257	196	157
Sub-total Kathmandu District	875	700	657 (94%)	954	674	539
Bhaktapur District						
Bidol	60	48	48(100%)	65	40	32
Katunje	90	72	38 (53%)	54	50	40 *1
Kutudhal	147	118	49 (42%)	83	54	43 *1
Mahadev Khola	450	360	213 (59%)	180	140	112 *1
Sub-total Bhaktapur District	747	598	348 (58%)	382	284	227
Lalitpur District						
Kotkhu	445	356	356(100%)	466	308	246
Lubhu	165	132	132(100%)	220	163	130
Thika Bhairaw-I	600	480	480(100%)	892	621	497
Thika Bhairaw-II	400	320	320(100%)	153	110	88
Sub-total Lalitpur District	1,610	1,288	1,288(100%)	1,731	1,202	961
Total	3,232	2,586	2,293 (89%)	3,067	2,160	1,727

Note : The net irrigation command area under the feasibility study has been calculated based on present land use, water balance study with water requirements and available water.

*1 : In the dry season, irrigation area of Katunje and Mahadev Khola schemes will be about 70% of the net command area and irrigation area of Kutudhal scheme will be about 30% due to low water availability. Irrigation area of the other schemes in the dry season is the same as the net command area, but crop intensity in some schemes is reduced because the available discharge is low.

3.4.4 Existing Irrigation Canal Alignment

It has been observed that the existing irrigation canal alignment under each irrigation scheme is generally appropriate for gravity irrigation. However, it has been observed that local landslides in some places affect the existing alignment, causing damage to the irrigation canals, especially along the main canals of the Thika Bhairaw-I (AL-19) and Thika Bhairaw-II (AL-20) schemes, against which measures to protect the canals must be taken by the provision of gabion works etc., along the canals. In the rehabilitation plan the existing canal alignment will be fully respected unless the canals, which will be rehabilitated, pass through the areas where the local landslides were observed.

3.4.5 Drainage in the Selected Schemes

There are no systematic drainage networks in the selected irrigation schemes. However, a field survey conducted during the rainy season of 1993 suggested the need for the provision of drainage networks in the selected irrigation schemes. Accordingly, the provision of the drainage networks will be planned for the selected schemes. However, in the planning, the construction cost should be minimized by utilizing the existing small rivers and channels as much as possible.

3.4.6 Activities of Water Users' Associations under the Selected Irrigation Schemes

It was observed during the field survey in Nepal that WUAs carried out no remarkable activities in the selected 13 irrigation schemes. This situation suggests that it is not easy to activate the organization of WUAs in a short period of time. This would be taken into account during the preparation of the O&M Manual for the irrigation facilities to be rehabilitated/constructed under the Project. The present status of WUAs under the selected 13 irrigation schemes is summarized below.

Name of Scheme	District	Nos. of WUAs	Remarks
Biswambhara	Kathmandu	1	Not registered to DAO*
Shali Nadi	-do-	1	Registered to DAO
Indrayani	-do-	1	-do-
Boshan	-do-	1	-do-
Dakshinkali	-do-	None	
Thika Bhairaw(I)	Lalitpur	1	Not registered to DAO
Thika Bhairaw(II)	-do-	1	-do-
Kotkhu	-do-	1	-do-
Lubhu	-do-	1	Registered to DAO
Katunje	Bhaktapur	1	Not registered to DAO
Mahadev Khola	-do-	1	-do-
Kutudhal	-do-	1	Registered to DAO
Bidol	-do-	None	

Note: DAO means District Administration Office. After having registered to DAO, WUAs are then legally recognized by HMGN as authorized Organizations.

3.4.7 O&M of the Selected Irrigation Schemes

(1) O&M of the irrigation facilities of the selected irrigation schemes is being conducted by WUAs attached to each scheme, in collaboration with several farmers. However, the present level of O&M is not acceptable based on WUAs' activities and budgetary allocation, since siltation in and damage to the canals and much loss of irrigation water during its transportation to the farmlands have occurred, which suggests not only the urgent need for the improvement of present O&M of the irrigation facilities but also the urgent need for an increase in budgetary allocation in order to support the O&M activities.

(2) Budgetary allocation for O&M of the selected 13 irrigation schemes for the fiscal year 1993/94 is summarized below.

Name of Scheme	District	Budget allocated (NRs.)
Thika Bhairaw-I	Lalitpur	50,000
Thika Bhairaw-II	-do-	36,000
Lubhu	-do-	20,000
Kotkhu	-do-	Nil
Sub-total		106,000
Biswambhara	Kathmandu	25,000
Boshan	-do-	32,000
Dakshinkali	-do-	25,000
Indrayani	-do-	18,000
Shali Nadi	-do-	Nil
Sub-total		100,000
Bidol	Bhaktapur	8,000
Katunje	-do-	6,000
Kutudhal	-do-	5,000
Mahadev Khola	-do-	95,000
Sub-total		114,000
Total		320,000

It is observed from the above Table that yearly budgetary allocation for the selected 13 irrigation schemes is considered almost nil. Therefore, only limited parts of the damaged irrigation canals could be rehabilitated. This situation is considered very serious. Accordingly, for the successful implementation of the Project, it is strongly requested that the beneficiaries (farmers), leaders of WUAs (also farmers) and HMGN must pay more attention to O&M of the irrigation facilities, including necessary budgetary allocation, because one of the most important components of the Project involves the handing-over of the rehabilitated irrigation facilities to the farmers, who must maintain these facilities by themselves without budgetary support from the Government, according to the Irrigation Policy declared by HMGN. The above is considered to be one of the most important factors for the successful implementation of the Project.

3.4.8 Water Charge

At present no water charge is collected from the farmers who belong to the selected 13 irrigation schemes. According to verbal information by farmers, about 20 years ago HMGN once fixed the irrigation water charge at a rate of NRs.1.08/Ropani/crop (1 Ropani = 0.05ha). However, the collection of the water charge was not successful. Since that time, this regulation has not been functioning legally. Apparently, the water charge does not meet the present standard required by each irrigation scheme to be rehabilitated. During the field survey, the chairman of the Village Development Committee (VDC) under the Indrayani (AK-14) scheme, suggested that it would be possible to collect the water charge from the farmers at a maximum rate of NRs.5.0/Ropani (NRs.100/ha equivalent), provided that irrigation water is fully assured through rehabilitation of the irrigation canal systems. However, this rate is still considered low. Under the above circumstance, in the formulation of the Project, water charge collection from the beneficiary farmers must be considered as one of the most important components of the Project. It may be noted that the water charge to be collected under the Project should be utilized for maintaining the WUAs and O&M of the rehabilitated irrigation facilities only. And the collected water charge shall not be used for rehabilitation or construction of the canal systems during implementation of the Project.

3.4.9 Necessity for Strengthening the Function of DIO

It has been noticed through the field survey, that the present function and role of each DIO should be strengthened, since each DIO is expected to play a more important role in various stages of the Project, as a leading organization to properly guide and train the farmers

who are expected to be the main participators in O&M activities of the selected irrigation schemes which will be rehabilitated. At present, each DIO is suffering from a shortage of technical manpower, vehicles for visiting sites, equipment necessary for handling daily work, as well as a budget shortage for maintaining the irrigation schemes concerned. This situation must be improved as quickly as possible. Accordingly, a plan to strengthen the function of DIOs will be prepared in the course of formulation of the Project, paying attention to the role to be borne by DIOs.

3.5 Agriculture

3.5.1 Land Holding and Land Tenure

The Project Area of the 13 model schemes is located within 116 wards of 24 VDCs. The total Project Area is 3,067 ha in gross and the total cultivated area is 1,727 ha in net.

In the total Project Area, about 51,480 people are living in 8,630 households, of which about 80% or 6,820 households are farmers. In addition, about 370 farmers who are living outside the scheme areas are cultivating in the Project Area. Therefore, the estimated total of farm households is about 7,190. The average size of a farm family in each scheme ranges from 5.3 to 6.5, with an average size of 5.8.

The results of the farm survey indicate that the average farm size in the Project Area is 0.24 ha, which is a little smaller than 0.28 ha average of the whole Kathmandu Valley, where the farm size ranges from the smallest size of 0.13 ha in Thika Bhairaw-II (AL-20) scheme to the largest size of 0.41 ha in Biswambhara (AK-04) scheme. Over 50% of the total number of farmers have land less than 0.2 ha in land holding size in the Project Area. Large-scale farmers, owning more than 1.0 ha, are generally few in number. Farmers who own more than 1.0 ha of land account for only 2.0% of the total number of farmers, as shown below.

Land holding size	Distribution (%)
under 0.2 ha	53
0.2 - 0.5 ha	29
0.5 - 1.0 ha	16
1.0 ha - above	2

As for the land tenure condition in the Project Area, about 74% of the farmers own their farmland, 38% of which are owner cultivators and 36% are owner cum tenant cultivators. The number of tenant farmers is estimated at 26% of the total number of farmers in the Project Area. It is reported that there is not a large number of absentee landlords in the Project Areas.

3.5.2 Agricultural Production

(1) Crops and Cropping Pattern

Like the Kathmandu Valley, paddy-wheat is the dominant cropping pattern in the Project Area. The present cropping pattern in each model scheme is illustrated in Figure 3-1 and summarized as follows :

Irrigated Land		Rainfed Land	
Paddy - Early potatoes - Late potatoes	(1 %)	Maize - Mustard	(3 %)
Paddy - Wheat	(69 %)	Maize - (fallow)	(3 %)
Paddy - Potatoes	(11 %)		
Paddy - Mustard	(7 %)		
Paddy - Broad beans	(2 %)		
Paddy - Garden peas	(1 %)		
Paddy - (fallow)	(3 %)		

Note: ( ) is extent rate of the land under the cropping pattern to the total farmland area.

The planting season of the main crops such as paddy, wheat, maize, potatoes, and mustard is almost the same as that in the whole Kathmandu Valley. Especially, in the Shali Nadi (AK-25) scheme where farmers plant potatoes twice a year during the period from October/November to April. In the case of leguminous crops, broad beans and garden peas are cultivated in the winter season.

In the net farmland of about 1,727 ha in total, paddy occupies about 1,616 ha or 94% in the summer season. Meanwhile, wheat occupies 1,184 ha or 69% in the winter season. Other crops such as potatoes, mustard, broad beans and garden peas are also cultivated in the winter season, but the cultivated areas are not very large, as summarized below:

Crop	Planted area (ha)	%
Paddy	1,616	93.6%
Maize	91	5.3%
Wheat	1,184	68.6%
Potatoes	229	13.3%
Mustard	163	9.4%
Broad beans	40	2.3%
Garden peas	25	1.4%
Total	3,349	193.9%

As shown in the above table, the total planted area is 3,349 ha, thus the cropping intensity in the Project Area is estimated at 194%, which is higher than that of 173% in the whole Kathmandu Valley. Out of the 13 schemes, the highest cropping intensity is 207% which is in the Shali Nadi (AK-25) scheme.

(2) Farming Practices

Farming practices in the Project Area are characterized by i) intensive manual farming and ii) an extremely high supply of chemical fertilizer. The average amount of farm inputs in the Project Area such as seeds, dosage of fertilizers, and labour requirements are summarized below:

Crop	Seed	Fertilizer (kg/ha)		Compost	Human labour (man-day)		
	(kg/ha)	Complex	Urea	(kg/ha)	Family	Hired	Total
Paddy	50	211	151	2,951	152	64	216
Wheat	139	160	133	1,926	89	35	124
Maize	23	84	87	2,674	96	18	114
Potatoes	695	207	157	5,295	187	39	226
Mustard	228	16	74	611	95	17	108

Like the Kathmandu Valley, most of the farmers in the Project Area are using moderate quantities of chemicals on their crops. The amount of compost applied is different

in places and depends mainly on the number of livestock raised by farmers. In urbanized areas, some farmers do not keep any livestock and do not apply compost manure to their farmland.

Most of the farmers are using improved varieties of seeds. The average apply rate of improved varieties of seeds is shown below:

Paddy		Wheat		Maize		Potato	
Taichung-176,242	60%	Lerma Rojo 64	60%	Rampur Yellow	22%	British Cardinal	96%
Masuli	30%	Lerma 52	35%	Khumal Yellow	78%	Kufri Joti	4%
Khumal-2,4	2%	Others	5%				
Local (Pokhreli)	8%						

The general farming practices for major crops are almost the same as those described in the Master Plan Study Report.

The annual labour force in the Project Area is estimated at 4.03 million man-days excluding labour force engaged for non-agricultural activities, and only 15% of the available yearly labour force has been absorbed in the present farming practices. Furthermore, even at the peak requirement period in July, 33% of the total available labour force is participating in present farming activities. The labour force surplus is considered to be sufficient for agricultural activities. The availability of a family labour supply is not a problem in the Project Area.

(3) Crop Yield and Production

Crop yield and production are different in each scheme due to irrigation conditions, amount of fertilizers, soil conditions, and so on. Table 3-7 indicates crop yield and production figures of the major crops according to each of the 13 model scheme areas. The unit yield of paddy ranges from 3.6 tons/ha to 4.6 tons/ha and is an average 4.2 tons/ha, as summarized below:

Crop	Planted Area (ha)	Unit Yield (ton/ha)	Production (tons)
Paddy	1,616	4.2	6,842
Wheat	1,184	2.0	2,343
Maize	91	1.5	133
Mustard	163	0.6	99
Potatoes	229	9.7	2,227
General	185	10.0	1,853
Early & Late	44	8.5	374

In general, yields of paddy in the Project Area are higher than in other parts of Nepal, even though yields are different every year due to fluctuations in rainfall. Rainfall delays result in yield decrease due to late transplanting.

(4) Vegetable Cultivation

The main vegetables grown in the Project Area are cauliflower, cabbage, and onions in the winter season and chillies in the summer season. Leguminous crops, such as garden peas in the winter are also important vegetables in the Project Area. The few vegetables, which most of the farmers grow, are for home consumption purpose only. According to the vegetable farm survey carried out in the areas surrounding the Project Area, vegetable farmers grow many kinds of vegetables through out the year. They are able to grow vegetables three times a year. The main crops cultivated in the areas surrounding the Project Area are summarized below:

Cole crop	:	Cauliflower, Cabbage
Fruit crop	:	Chilli, Tomatoes, Brinjal, Sweet pepper
Root crop	:	Radish, Carrots
Cucurbit crop	:	Cucumber
Leguminous crop	:	Garden peas, Cow peas, French beans
Leaf crop	:	Broad leaf mustard, Spinach, Garden cress
Bulb crop	:	Onions, Garlic
Other minor vegetables		Okra, Turnip, Summer squash, Fenugreek, Coriander, Bitter gourd

(5) Livestock

Various kinds of livestock such as buffalo, cow, goats, and poultry are raised in the Project Area, especially poultry. In general, however, animal husbandrys contribution to the farm economy of the Project Area of the selected 13 model schemes and the whole Kathmandu Valley is limited compared with other areas of Nepal. The population of livestock in the Project Area is summarized below:

Livestock	Nepal		Kathmandu Valley		Project areas	
	Total ('000 head)	No./FH* (head)	Total ('000 head)	No./FH (head)	Total ('000 head)	No./FH (head)
Cattle	6,246	8.3	82	0.8	5	0.7
Buffalo	3,058	4.1	32	0.3	1	0.2
Goat / Sheep	6,318	8.4	120	1.3	7	1.0
Chicken	13,496	17.9	1,096	11.3	122	17.9
Duck	390	0.5	10	0.1	1	0.1

Note: * average livestock holding number per farm household

3.6 Agro-economic and Social Conditions

3.6.1 Agricultural Marketing

(1) Marketing and Price of Agro-products

As mentioned in the Master Plan Study Report, the major cereal crops produced in the Kathmandu Valley, such as paddy, wheat, and maize, are mainly for home consumption purposes only. Most of the farmers do not sell any main cereal products. The main agricultural products marketed in the Kathmandu Valley are vegetables, although the total planted area is quite limited at present.

The Kathmandu, Lalitpur, and Bhaktapur municipalities have urban populations of about 414,000, 117,000, and 61,000, respectively. These urban populations are constant consumers of vegetables. A total amount of 61,000 tons of vegetables are purchased annually. The amount handled annually by KWM, which supplies the vegetables, was about 29,000 tons in 1992/93 or about 47% of the total amount handled by the main vegetable markets.

According to the food balance of Nepal, self-sufficiency has been generally achieved in Nepal. However, some people in the Kathmandu Valley always have an insufficient amount of food grain. About 100,000 tons of rice are distributed annually by the Terai region. As for vegetables, 30% of the total amount supplied to KWM is provided by the Kathmandu Valley. The remaining 70% of the vegetables are distributed by other districts in the hilly and Terai regions.

The prices of vegetables fluctuate according to the harvest period. Even in KWM, prices were decided by face to face trading between sellers and buyers. Auctions and grading have not yet been introduced.

(2) Supply and Price of Farm Inputs

Chemical fertilizers are monopolistically distributed by AIC, through appointed dealers totalling 127 in Lalitpur, 240 in Bhaktapur, and 398 in Kathmandu districts, including the cooperative societies and private dealers, as described in the Master Plan Study Report. The distribution of seeds is generally carried out through private dealers and/or AIC. Seeds are purchased from farmers including contract farmers, by dealers or AIC and then sold to the growers.

(3) Post-harvest and Marketing Facilities

In the Project Area, there are 209 processing facilities in total. There are 6 types of mills such as rice mills, rice and flour mills, flour mills, beaten rice mills, oil mills, and rice, flour and oil mills. The processing capacity would be sufficient for present outputs of agricultural crops.

As mentioned in the Master Plan Study Report, most of the market centres operate in open areas either on road squares or along the roads, except for KWM. The latter was established in 1987 with a 2.05 ha operating area. Currently, a master plan is being initiated in order to construct a multipurpose shade, service buildings, and cold storage areas. For the construction of these facilities, the United Nations Capital Development Fund has provided grant assistance of some US$ 4.6 million.

There are two cold storage buildings in the Kathmandu Valley with a total capacity of 3,000 tons. These are used mainly for storage of seed potato during the summer season, about six months. The total storage amount in 1993 was 1,700 tons or 57% of the total capacity. The rental charge is NRs.1.7/kg. In addition to the low utilization rate, some problems exist such as the high electricity charge for operation and maintenance of the cold storage facilities.

3.6.2 Agricultural Supporting System

(1) Agricultural Extension Services

The Project Area is covered by 11 agriculture sub-centres with 16 JTs and 34 JTAs. There are 59 result demonstration farms, 24 production demonstration farms, and 557 mini kit distribution programs for kitchen gardening, in the Project Area.

(2) Farmers' Organizations and Cooperatives

As mentioned in the Master Plan Study Report, under each District Cooperative Union there are 9, 9, and 15 primary ACSs in Lalitpur, Bhaktapur, and Kathmandu districts, respectively. However, most of ACSs in the Project Area in the selected irrigation schemes are not active in credit, savings, and sales of farm products.

An agricultural credit cooperative, which is organized by farmers themselves and is known as CSSC, exists in Bhaktapur. The CSSC was established in November 1991 with 51 members and at present it has 85 members. They collectively deposit their monthly savings in the CSSC account, which is used for the acquisition of land, businesses, and cottage industries, etc. Most of the members of CSSC are vegetable growers. They jointly invest in the construction of tube-wells or purchased water pumps for groups of around ten members.

These members usually discuss vegetable growing techniques and assist in acquiring farm inputs and selling farm products.

3.6.3 Farm Economy

Based on the data and information obtained from the Agricultural Marketing Division of DoAD, DADO in each district, and the Farm Survey carried out by the Study Team, the annual farm budget for typical farm size households in each scheme was worked out as shown in Table 3-8.

The farm income of typical farm size households in the respective schemes varies from NRs.7,500 to NRs.31,000 depending on the farm size, location, etc. Owing to rapid urbanization in the Kathmandu Valley, job opportunities are also rapidly increasing. The majority of farmers in the Project Area have huge amounts of non-farm income estimated at 50% to 75% of the total household income on an average. Thus, gross farm income ranges between NRs.31,200 and NRs.52,700.

Present living expenses in each scheme vary according to farm size, family number, and location, however, annual living expenses per capita are estimated at about NRs.5,000.

3.6.4 Present Social Conditions and Farmers' Intention

All the scheme areas are located outside the metropolitan City of Kathmandu, which has a population of over 410,000. Recently, the population in the Kathmandu Valley is rapidly increasing, at an annual increase rate of 3.7% during 1981-1991, compared to 2.1% for the whole of Nepal. As mentioned in the Master Plan Report, rapid urbanization is bringing about the following drastic changes in the surrounding rural areas including the scheme areas.

- Increasing domestic water supply is starting to compete with the agricultural water supply.
- Decreasing farmland due to the use of the land for house yards and industrial lots, especially brick factories.
- Increasing land prices, especially land by the road side.

On the other hand:

- Increasing paved road network connecting the urban areas of Kathmandu, Bhaktapur, and Lalitpur. As a result transportation will improve, non-farm jobs will be provided for rural people, market amount of agro-products and farm-inputs will expand and modern agricultural technical information and services will be disseminated.
- Increasing demand of the urban population for agro-products especially fruits and vegetables.

Although the economic circumstances are rapidly changing, the rural people in the scheme areas could not adapt so quickly. Therefore, they stick to their traditional practices to some extent, such as cereal production, using no draught animals, and measuring by traditional measurements such as Ropani, Muri, Pathi, Mana, and so on.

One of the main causes of the traditional practices is ethnic groups. The main ethnic groups in the scheme area are the Newar (56%), Chhetri (29%), and Brahmin (10%). The number of schemes where the majority of people are the one ethnic group is 7, such as the AK-07 Dakshinkali (Newar 65%), AK-25 Shali Nadi (Newar 91%), AB-12 Kutudhal (Newar 60%), AL-13 Lubhu (Newar 68%), AL-19 Thika Bhairaw-I (Newar 68%), AL-20 Thika Bhairaw-II (Newar 80%) and AL-10 Kotkhu (Chhetri 55%) schemes. Among those ethnic groups, Newar tends to cluster in one community. Newar farmers who own farmland outside their villages are not willing to live in other villages where most of their farmland is located.

Females of the Chhetri tribe are known to be hard workers. Although labour charge of females is generally about half that of males, in the Chhetri tribe labour charge of females is the same as that of males.

The farmers in the Project Area are characterized as small scale, high labour intensive, and high fertilizer application farmers. Although most of the farmers give first priority to paddy cultivation at present, the above mentioned farmer's characteristics are more suitable to high value and high labour intensive crop production such as vegetables or cash crops.

According to the results of the farm survey, labour productivity (net income/man-days) of vegetables is three times or more than that of paddy in the scheme areas. Most of the farmers reported that the amount of irrigation water was inadequate, which is the main limiting factor for increasing productivity and crop diversification. They will continue to grow paddy. However, they are willing to diversify by producing seasonal vegetables for commercial purposes after the completion of the Project.

Taking the above phenomenon and economic circumstances into consideration, it is expected that vegetable production will expand as early as possible in the scheme areas when a sufficient supply of water becomes available.

4. THE PROJECT

4.1 Basic Concept of the Development Plan

4.1.1 Development Needs

HMGN has given top priority to the development of the agricultural sector and emphasized agricultural diversification towards cash crops such as vegetables taking into consideration the comparative geographical advantages, transportation facilities, market accessibility as well as the demand and supply conditions, as mentioned in the Master Plan Study Report.

The selected 13 model schemes are located in the high potential area for agricultural production although the average holding size is as small as 0.24 ha. These schemes are expected to play an important role as a food supply base to the Kathmandu metropolitan area and as a model area for commercialized agriculture.

Development needs of the Project were assessed from the viewpoint of production stabilization, crop diversification, and socio-economic conditions. The conclusions are summarized below:

Production stabilization :

Agriculture in the Project areas is mainly depending upon the rainfed condition due to the superannuation and damage of facilities in the selected irrigation schemes, and there is considerable variation of rainfall year by year. These are the main factors causing unstable production in the Project areas. Irrigation water supply, although on a supplementary basis, is important for stabilizing farm production. Rehabilitation and improvement of those schemes are urgently required.

Crop diversification :

Most of the farmers in the Project areas have not yet introduced vegetable farming due to the shortage of irrigation water in the dry season and at the beginning of the rainy season. Moreover, crop intensity in the Project areas is limited because of the shortage of irrigation water, but these areas have abundant potentials for full agricultural development. It is envisaged to diversify the crops into high value crops and to increase the cropping intensity for economical development of these areas through the stable and continuous irrigation water supply.

Socio-economic condition :

Rapid urbanization causes a rapid increase in urban food demand, job opportunities, and non-farm income in rural areas. On the other hand, the selling of farmlands for housing or the renting of farmlands for brick making results in a rapid decrease in good farmlands. It is necessary to keep superior farm areas as a base of supply of fresh vegetables to the Kathmandu metropolitan area and to secure higher income to the farmers by introducing high value crop cultivation. It is also recommended to create intensive agricultural areas such as "green belts".

4.1.2 Agricultural Development Strategy

As mentioned in the Master Plan Study Report, the basic concept of agricultural development under the Project is set as follows:

(1) To maximize the potential agricultural benefits through the efficient use of limited available water and land resources; and

(2) To maintain the existing agricultural areas and increase the crop intensity in order to create a vegetables supply base to meet the urban demand of Kathmandu.

In order to achieve these objectives, the strategy for agricultural development under the Project is as follows:

(1) To maintain a stable amount of cereals for self-consumption which minimizing the cereal production area, by maximized the unit yields of cereal crops through the provision of stable irrigation water.

(2) To extend the cultivated area of vegetables by maximising the efficiency of irrigation water supply.

4.2 Purpose of the Project

4.2.1 General

The Project intends to rehabilitate irrigation systems selected from the 13 existing irrigation schemes, for which the feasibility study was carried out the JICA Study Team in order to attain the following, taking into consideration present conditions of completed/on-going project under ISP, etc. which are described in Part-A Chapter 3:

(1) To establish safer and stronger irrigation systems against natural hazards such as floods, landslides, etc. and more water-saving irrigation systems which will contribute to the stabilization of crop cultivation, as well as to the expansion of irrigated agricultural lands under the rehabilitated irrigation schemes, in comparison with ISP, etc.

(2) To establish more farmer-friendly irrigation systems through the Project in comparison with ISP, etc., especially with respect to O&M of the irrigation facilities and water management by the farmers, considering that the rehabilitated irrigation schemes will be handed-over to the farmers and will be maintained by the farmers themselves, as suggested and recommended in the "Irrigation Policy 1992" of the Government of Nepal.

(3) To provide more up-graded irrigation facilities than ISP, etc., which will enable farmers to control irrigation water easily and economically, paying full attention to the existing Government Irrigation Policy, especially for the hilly areas, as well as to the prevailing conditions of the other irrigation schemes observed in the Study.

(4) To promote farmers' participation in O&M, water management, and other activities through the training of farmers at each DIO, as set forth in the O&M manual.

(5) To encourage the three DIOs concerned in the Kathmandu, Bhaktapur, and Lalitpur districts so that they can play a more important role in the guidance of farmers, as well as in training, with the help of more up-graded irrigation facilities and equipment necessary for O&M activities.

To successfully attain the above, the following technical considerations have been considered for the Project:

(1) To introduce improved cropping patterns to each irrigation scheme to be rehabilitated through the Project with the condition that the irrigated areas in the dry season will be extended through the implementation of the Project, thus enabling the farmers to cultivate vegetables where possible during the dry season.

(2) To activate the agricultural extension work, which will gradually make farmers more aggressive in agricultural activities as well as in daily O&M activities and water management.

(3) To provide proper and timely guidance to the farmers under DIO through Water Users' Groups and WUAs as well as in water management, under the Project, considering farmers maximum participation in various activities at various stages in the Project, in comparison with ISP, etc.

4.2.2 Project Concept and Description

Through the Phase-I and Phase-II Studies, it has been worked out that the rehabilitation of the selected priority irrigation schemes should be carried out under the following engineering concepts:

(1) Rehabilitation of the target irrigation schemes' facilities will be carried out considering their present status and utilizing their remaining value as much as possible from an economic point of view.

(2) Existing temporary intake facilities and badly damaged intake facilities of the target irrigation schemes will be improved or replaced. Hence more up-graded facilities will be provided by the Project.

(3) In general, canal lining with reinforced concrete will be done up to the tertiary canals and the rehabilitated canals will be aligned following the existing canal routes and longitudinal slopes as much as possible in order to avoid extra land acquisition.

(4) To strengthen the functions of the existing irrigation canal systems, more up-graded supporting facilities and canal structures such as check structures with gates, turnouts with gates and measuring devices, drops, side spillways, cross drainage structures, etc., will be provided where necessary.

(5) Construction of gravel-metalled roads along some of the main canals has been considered where possible for the purpose of O&M of the irrigation facilities. However, the provision of additional roads along the main canals has been limited in order to avoid additional land acquisition.

With these concepts as well as with more participation by the farmers in O&M activities, water management, as well as in construction of tertiary and on-farm level irrigation canals, the Project aims to establish irrigation canal systems i) with less water losses; ii) which can be maintained and operated by the farmers themselves; and iii) which are resistant to natural hazards; etc.

It may be stressed here that although the improvement or replacement of the existing irrigation facilities with new ones occupies an important part of the project, more important purposes of the project are, firstly, to implement the rehabilitation plan aiming at effective use of the limited water resources in the valley and to construct the irrigation systems which can surely deliver the irrigation water to the farmlands to be irrigated and thereby to achieve high performance in water use and materialize the proposed agricultural development plan and, secondarily, to help materialize the irrigation policy by the HMGN by supporting the farmers so that they can be well organized, and support them to smoothly participate in O&M activities and water management both from hard and soft engineering point of view. Also another important key to successful implementation of the project depends largely upon the strong willingness of the farmers to participate in the project and cooperation between the farmers especially in O&M and water management activities. In this sense, much attention should be paid by the concerned government agencies to the soft engineering part of the project, such as farmers training programs etc.

4.3 Rehabilitation Plan

Rehabilitation under the Project aims to improve or replace the existing irrigation systems including facilities such as intakes, irrigation canals with related structures, etc. by providing up-graded additional infrastructures. In general, rehabilitation of the target irrigation schemes will be carried out according to the following criteria:

(1) For badly damaged intake facilities, concrete fixed type weirs will be provided and for irrigation schemes where the existing intake facilities of the schemes were slightly damaged, the intake facilities will be improved utilizing their remaining value as much as possible.

(2) Unless otherwise specified, the existing irrigation canals of the target irrigation schemes will be replaced and, in general, the canals will be lined with concrete up to the tertiary canals.

(3) Unless otherwise specified, concrete aprons and riprap works will be provided at the upstream/downstream of the intakes, which will be rehabilitated under the Project. The length of the aprons and riprap works will be subject to the design factors peculiar to each existing irrigation scheme.

(4) River bank protection works using gabions or masonry, etc. will be provided at the upstream/downstream of the intake facilities. The length of the protection works will be subject to the scoring condition at and around the existing intake facilities, as well as to the hydraulic conditions peculiar to each existing irrigation scheme to be rehabilitated.

(5) No gates shall be provided on the fixed portions of the weirs owing to the strength of the flow during floods. However, small steel gates, which can be operated manually, may be installed at the heads of the sluice ways and main canals to control the water.

(6) Sluice ways will be provided at the heads of the main canals to avoid the intrusion of silting materials into the canals. The width and length of the sluice ways will be subject to the hydraulic conditions at the intakes and grain size distribution of gravel around the intakes to be rehabilitated.

(7) In the rehabilitated irrigation systems, additional facilities such as check structures, turnouts with gates and water measuring devices, side spillways, drop structures, aqueducts, etc. shall be provided according to the requirements of each irrigation scheme to be rehabilitated.

(8) The construction of gravel-metalled roads with a width of about 1.0 m along the some main canals will be carried out, where possible, for the purpose of O&M of the irrigation facilities. However, provision of such roads will be limited to avoid extra land acquisition.

(9) Generally, the main, secondary, and tertiary canals shall be rectangular in shape so that additional land acquisition will be minimized.

In consideration of the above, a rehabilitation plan for each irrigation scheme has been prepared in Annex-5, and summarized in Tables 4-1 and 4-2.

4.4 Agricultural Development Plan

4.4.1 Proposed Cropping Pattern

The potential for crop diversification of each of the selected model schemes has to be

evaluated and the farm lands are classified into the following 5 types. The farmland of each scheme is indicated as a combination of each farmland type.

Intensive-I area:

This area has the highest potential for agricultural development and it should become a model agricultural area. Farming in this area shall be converted to high value crop cultivation under the fully irrigated condition. The most intensive cropping pattern should be adopted in this area. About half of the area will be used for vegetable cultivation three times a year, including green leaf vegetables. It is desired that this area will be kept as an intensive agricultural area.

Intensive-II area:

This area also has high potential for agricultural development. But water availability is less than in the "Intensive-I area". In the dry season, the cropping intensity will be kept lower in order to save water.

Intensive-III area:

From the viewpoint of land suitability and socio-economic condition, this area has also the potential of introducing vegetable farming. However, water availability is the least among the Intensive areas. In the dry season, the cropping intensity will be kept lower than in the "Intensive-II area" in order to save water.

Remote-I area :

Most of this area is located far from access roads and villages, so it is difficult to manage the farmland under the most intensive cropping pattern and it takes time to carry the products to the market. The area extends in the lowest water distribution area. Topographic condition also is not so suitable for fresh vegetable cultivation. Drought-resistant crops such as legumes and bulb crops would be introduced in this area.

Remote-II area :

This is the driest area among the "Remote type area". In this area, irrigation water is insufficient in the winter season, mainly in February or March. Winter crops of shorter growing period than above would be introduced just after harvest summer season crops so that they would be harvested before February or March.

Considering the basic strategy for agricultural development under the Project, vegetables in addition to paddy, wheat, potatoes have been selected as the main crops in the framework of the proposed cropping pattern. A basic cropping pattern has been selected for each farmland type area by taking into account the water requirement based on the availability of irrigation water during the dry season, present farming practices and crops, availability of family labour, and socio-economic conditions. These basic cropping patterns are shown in Figure 4-1.

As for the future labour requirement, even at the peak requirement period in early November, 43% of the total available labour force will be participating under the proposed condition. Labour force is therefore considered to be sufficient under the "with project" condition.

The planted area under the proposed cropping pattern for each scheme is shown in Table 4-3 and summarized below. The average cropping intensity of the 13 schemes is 226%, ranging from 208% for the Kutudhal (AB-12) and Mahadev Khola (AB-14) schemes to 248% for Shali Nadi (AK-25) scheme.

Unit : ha

Crops	Without Project	With Project
Paddy	1,616	864
Wheat	1,184	0
Maize	91	0
Mustard	163	0
Legumes	65	268
Early potatoes	22	212
Late potatoes	22	130
Potatoes	185	383
Summer vegetables	0	864
Winter vegetables	0	603
Green leaf vegetables	0	309
Bulb crops	0	261
Total planted area (Total Intensity	3,349 194%	3,894 226%)

4.4.2 Proposed Farming Practice

As the expansion of cultivated area of vegetables is one of the major strategies for agricultural development under the rehabilitated irrigation schemes, introduction of an improved farming practice for the vegetables is proposed as briefed below and the details are described in Annex-6.

Introduction of improved seeds is essential for increasing crop yields. Not only the variety but also the quality of the seeds influence crop yields. Improved varieties of each vegetable crop recommended by the Vegetable Development Division are shown below;

Crops	Varieties
Cauliflower	Kathmandu, Snowball, Pusa Deepali, Kibo Giant
Cabbage	Copenhagen Marhet, Pride of India, Late Large Drum Head
Radish	Mino Early, White Neck, Pyuthane Red, 40-days, Tokinashi
Carrot	Nantees, New Kuroda
Turnip	Purple Top
Tomato	Pusa Ruby, Monprecos, Chinese, Roma, Pusa Early Dwarf, Cold set, CL-1131
Chilli	Pusa Jwala, NP46, Kathmandu
Brinjal	Pusa Purple Long, Sarlahi Green, Nurki, Pusa Kranti
Broad leaf mustard	KBL, Marpha Broad Leaf
Spinach	Patane
Onion	Red Creole, Light Red, Dark Red, Nuwakote
Cucumber	Kusume, Local, Pointset

The following fertilizer application rates are recommended for attaining the target yields of the respective crops:

Crop	Seed	Fertilizer (kg/ha)			Compost
	(kg/ha)	Complex	Urea	Potash	(ton/ha)
Cauliflower	0.7	300	90	40	20
Tomato	0.5	300	90	133	10
Broad leaf mustard	6.0	200	133	66	10
Onion	10.0	200	45	85	10

Fertilizer application for root crops is recommended to be carried out by broadcasting after ploughing. Fertilizers for fruit crops and leaf crops are to be applied between plant rows by mixing with compost to prevent the loss of elements.

There are two seedling techniques for the proposed farming. One is to prepare seedlings in a nursery bed, and thereafter, to transplant the seedlings in a main field. This practice will be applied to cole, fruit, cucurbit, leaf, and legume crops. The other farming technique is direct sowing in the main field. This technique will be applied to root crops.

The first irrigation for vegetables should be done quickly with a little quantity till the seeds germinate and plants survive, and the subsequent irrigation should be done according to their requirements.

As for the plant protection measures at present, damage of crops, not only vegetables but also other crops, is not so serious. However, when vegetable cultivation is introduced on a commercial basis, it will be necessary to apply agro-chemicals properly for pest and disease prevention.

Weeding is one of the essential works to be done according to the proposed farming practices for crop protection. After seeding and transplanting, weeding would be carried out two or three times, depending on the condition of the weed growth.

4.4.3 Anticipated Yields and Production

The unit yields of crops in the case of "with Project" are estimated on the basis of the trainers' manual prepared by HMGN and the farm survey results. Vegetable yields in areas surrounding the Project area, such as "Thimi", represent the typical unit yields in advanced vegetable cultivation areas under full irrigation in the Kathmandu Valley. Then, the vegetable yields in the Project areas under the "with" project condition are estimated based on the present yields in advanced vegetable cultivation areas. The unit yields of paddy and legumes in these areas have already attained a high level compared with other areas in Nepal, therefore the anticipated unit yields of these crops are set at a slightly high level, considering the proposed proper water management under the Project.

On the other hand, the present unit yields are adopted as the anticipated unit yield of crops in the case of "without Project" condition in future as these in the Valley have been already attained a high level as mentioned above, and it is considered that there is almost no room for increase unit yield without irrigation.

Consequently, the anticipated unit yields under the future "without" and "with" Project conditions are estimated as follows:

Unit : ton/ha

Crops	Present Condition	Without Project	With Project
Paddy	4.2	4.2	5.2
Potatoes	10.0	10.0	13.0
Early & Late potatoes	8.5	8.5	12.0
Broad beans	1.4	1.4	1.5
Cauliflower	15.9	-	16.0
Tomato	12.0	-	12.0
Broad leaf mustard	19.6	-	20.0
Onion	18.3	-	18.0

Based on the crop yields mentioned above, the anticipated crop production in the case of "with" and "without" Project in each model scheme is estimated as presented in Table 4-4 and summarized below:

Unit : ton

Crops	Without Project	With Project	Balance
Paddy	6,840	4,490	- 2,352
Wheat	2,340	0	- 2,340
Maize	130	0	- 130
Mustard	100	0	- 100
Legumes	70	390	310
Potatoes	2,230	8,750	7,630
Vegetables	0	30,710	30,710

5. PRELIMINARY DESIGN AND COST ESTIMATES

5.1 Proposed Works and Other Project Components

The proposed works under the Project include i) rehabilitation of the target irrigation schemes and ii) provision of guidance to the farmers, which includes farmers' training programs and an O&M Manual for the farmers' use. As already mentioned in the previous section, the proposed works under the Project include hardware and software parts which should be carried out simultaneously for the successful implementation of the Project.

The hardware part of the Project includes the following works:

(1) Improvement or replacement of the existing intake facilities. These works have been considered for the 13 target irrigation schemes based mainly on the priorities determined through the economic evaluation.

(2) Improvement of the existing irrigation canals of 13 target irrigation schemes by concrete lining. In general, the lining will extend up to the tertiary canal level.

(3) Strengthening the function of the irrigation canals by providing additional hydraulic structures such as gates and water gauging devices at the heads of the main canals, turnouts with gauging devices on the main canals and secondary canals, and gates on the tertiary canals, side spillways, drop structures, cross-drains, aqueducts, etc.

(4) Provision of gravel-metalled roads where possible, for O&M of the canals. However, the provision of roads should be minimized in order to avoid additional land acquisition.

Details of the proposed works for each target irrigation scheme are given in Annex-5.

The software part of the Project includes the following works:

(1) Strengthening of the O&M activities and water management by the farmers themselves.

(2) Recommended organizations to be established to attain the above-mentioned and its expected functions to attain the same.

(3) Expected farmers' role and duties in O&M activities and water management.

(4) Expected farmers' role and duties under the Project, especially in the initial and construction stages of the Project.

(5) Sample training programs for the farmers to be benefited by the Project and the method and timing of the training lectures.

(6) Collection of the water charge from the farmers who will benefit from the Project with regard to the collection method, amount, timing, use, deposition and audit of the collected water charge, and use of the banks, etc.

(7) Expected roles of the government agencies concerned in the different stages of the Project, especially the expected roles of the three DIOs (Kathmandu, Bhaktapur, and Lalitpur districts) for guiding and helping the farmers.

All the details of these works are presented in the O&M Manual for the Project which was prepared separately. Accordingly, it is expected that the said manual should be widely distributed among the engineers of each DIO, Association Organizers (AOs), Mobile Irrigation Teams (MITs), and leaders of the farmers who are expected to play an important role in every

stage of the Project.

5.2 Preliminary Design

The preliminary design for the rehabilitation of the 13 target irrigation schemes has been carried out, paying attention to the present condition of the schemes, the Irrigation Policy of HMGN, and expected farmers' roles to be carried out in the rehabilitated irrigation schemes under the Project. The conditions and important design criteria which were taken into consideration for the preliminary design for rehabilitation of the 13 target irrigation schemes are summarized below:

(1) Considering the limitation of available water for irrigation, much attention has been paid to the delineation of the area of each irrigation scheme to be irrigated under the Project. The availability of the planned irrigation water for each scheme was is based on 80% reliability of water resources. Accordingly, in general, the planned irrigation area has been reduced compared to the irrigation area under the existing schemes, as shown in Table 3-6.

(2) To stabilize the existing intake facilities, improvement or replacement of these facilities has been considered for all the target schemes. In general, the improvement or replacement of the existing intake facilities shall be carried out using concrete. In addition, front/rear aprons, riprap works, upstream/downstream river protection works, and sluice ways have been envisaged based on the topographic and hydraulic conditions at and around the intake facilities to be rehabilitated, paying attention to the design manual for canal structures prepared by DoI, and other technical papers.

(3) Considering the prevailing condition of the existing irrigation canals, i.e., in most cases, the planned amount of irrigation water does not reach the terminal irrigation facilities, resulting in a chronic shortage of water for irrigation. This has been caused by poor irrigation canal systems consisting mainly of earth canals. Accordingly, it has been planned, unless otherwise specified, that all the irrigation canals to be rehabilitated under the Project should be lined with concrete up to the tertiary canals in order to minimize water losses during transportation. In addition, canals to be reconstructed should have more resistivity against natural hazards, and problems which may occur during O&M carried out by the farmers, should be reduced (see Table 4-1).

(4) In consideration of the collection of water charge from farmers who will benefit from the Project, the provision of gates with gauging devices on the main, secondary, and tertiary canals has been considered as much as possible in order to measure the water to be diverted accurately. Owing to the latter the anticipated problems which the farmers may have with irrigation water distribution, will be avoided. (see Table 4-2)

(5) The canals have been planned to be aligned following the existing canal routes and longitudinal slopes as much as possible in order to minimize additional land acquisition. The above is considered very difficult due mainly to topographic conditions along the existing canals and the size of farmers land holdings which are generally very small.

(6) In the preliminary design of the weirs (intake facilities), attention was paid to the minimization of the height of the weirs so as not to hinder the passage of floodwater. In addition, it was planned that no gates will be provided on the fixed weirs, owing to the strength of flooding water observed during the field survey which was carried out in the rainy season.

(7) In the preliminary design, unless otherwise specified, one turnout under the tertiary canals will command about 20 ha of farmland. However, in consideration of O&M of the irrigation facilities by the farmers, unit organizations of the farmers for O&M have been recommended to be about 5 ha of farmland, which will account for 15 to 20

households on an average.

(8) In the calculations to decide the various dimensions of the hydraulic structures of the target irrigation schemes, internationally recognized formulas, such as Manning's formula, etc. have been used.

(9) Considering the availability of rainfall records and their accuracy, as well as the Project life, the flood discharge with a 50-year return period has been considered sufficient to decide the scale of the intake facilities and extent of river protection works, etc.

(10) In the preliminary design, attention has been paid to the provision of up-graded facilities and additional facilities so that the rehabilitated irrigation facilities under the Project will be farmer-friendly, especially in O&M activities.

Based upon these criteria, the preliminary design for each target irrigation scheme has been carried out and, as a result, the rehabilitation plan for each irrigation scheme has been worked out as shown in Annex-5.

5.3 Implementation Schedule

The Project may be implemented by divided it into four stages, i.e., i) preparatory stage, ii) construction stage, iii) handing-over stage, and iv) O&M stage.

(1) Preparatory Stage of the Project

In the preparatory stage of the Project, explanations will be given to the farmers who will benefit from the Project by the government officials concerned, with respect to the nature of the Project, expected roles of the farmers at different stages of the Project, farmers' participation in the construction stage of the Project, organizations to be established by the farmers for O&M of the irrigation facilities, necessary guidance from AOs and MITs for giving the Project's orientations to the farmers selected from each target irrigation scheme to be rehabilitated, etc. For these preparatory works, at least 8 to 10 months will be necessary.

(2) Construction (Rehabilitation) Stage

Rehabilitation of the target irrigation schemes will be started based on the priorities determined through the economic evaluation. Two or three schemes will be rehabilitated at the same time. Considering the scale of the target irrigation schemes, it is judged that one and half years would be sufficient for rehabilitation of each scheme. Accordingly, four to five years are necessary for the rehabilitation of the 13 target irrigation schemes.

(3) Handing-Over Stage

After the completion of the rehabilitation works, the rehabilitated irrigation schemes will be handed-over to the farmers according to the Irrigation Policy 1992. At the handing-over stage of the Project, all the drawings of the rehabilitated irrigation schemes will be handed-over to the responsible farmers, and during this period various lectures will be given to the farmers based on the training programs. About 8 months are necessary for the handing-over stage of the Project.

(4) O&M Stage

According to the Irrigation Policy 1992, all the rehabilitated irrigation schemes are handed-over to the farmers. They must maintain the handed-over irrigation schemes without governmental assistance. However, the farmers are not accustomed to O&M activities. Accordingly, one year is necessary for providing assistance required by the farmers. However, this period is not considered to be a Project implementation period.

As a result, six years are the minimum period required to rehabilitate 13 target irrigation schemes smoothly under the Project. It may be mentioned here that the success of the Project greatly depends on the O&M stage, accordingly, it is recommended that the assistant engineers of the team attached to each DIO, should attend to the farmers who participate in O&M activities described in the O&M Manual. In addition, the assistant engineers should also give the necessary advice to the farmers in the form of on-the-job training, so that the farmers can manage the rehabilitated irrigation systems by themselves as early as possible and can be self-reliant in every activity necessary for O&M.

5.4 Cost Estimates

The costs for the 13 target irrigation schemes have been estimated taking the following components, which are basis on the unit rates issued by DoI, into consideration:

(1) Direct cost which include the cost of construction and/or rehabilitation of the intake facilities, canals, and related structures.

(2) Administrative cost: 15 % of the direct cost.

(3) Price escalation: 3.9 % in foreign currency and
12.0 % in local currency.

(4) Engineering cost: 7 % of the direct cost.

(5) Physical contingencies: 3 % of the total construction costs.

(6) Conversion rate : US$ 1 = NRs.49.00 = J.Yen 100.00
Note : In the Master Plan Study, the conversion rate of US$ 1 = NRs.49.00 = J.Yen 108.89 was used.

Based on the above-mentioned assumptions, the cost estimates and their annual disbursement schedule for the target irrigation schemes have been prepared as shown in Tables 6-3 to 6-9 in Annex-5 and the cost of each irrigation scheme is summarized in Table 5-1. In the said cost estimates, the maximum use of locally available construction materials has been taken into account. However, in the cost estimates for construction materials and equipment such as reinforcing bars, cement, fuel, wire, steel gates, measuring devices, gate-lifting devices, etc., which are considered to be not fully available in Nepal, the combined costs in local and foreign currencies have been taken into account, considering the prevailing availability of these materials in the construction markets of Nepal.