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 - A : MASTER PLAN 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,

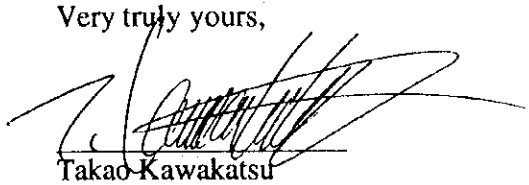
We have pleasure of submitting the Final Report of the Study on the Rehabilitation of Government-Developed Irrigation Schemes in the Kathmandu Valley in the Kingdom of Nepal, in accordance with the Scope of Work agreed upon between the Department of Irrigation of the Ministry of Water Resources, His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

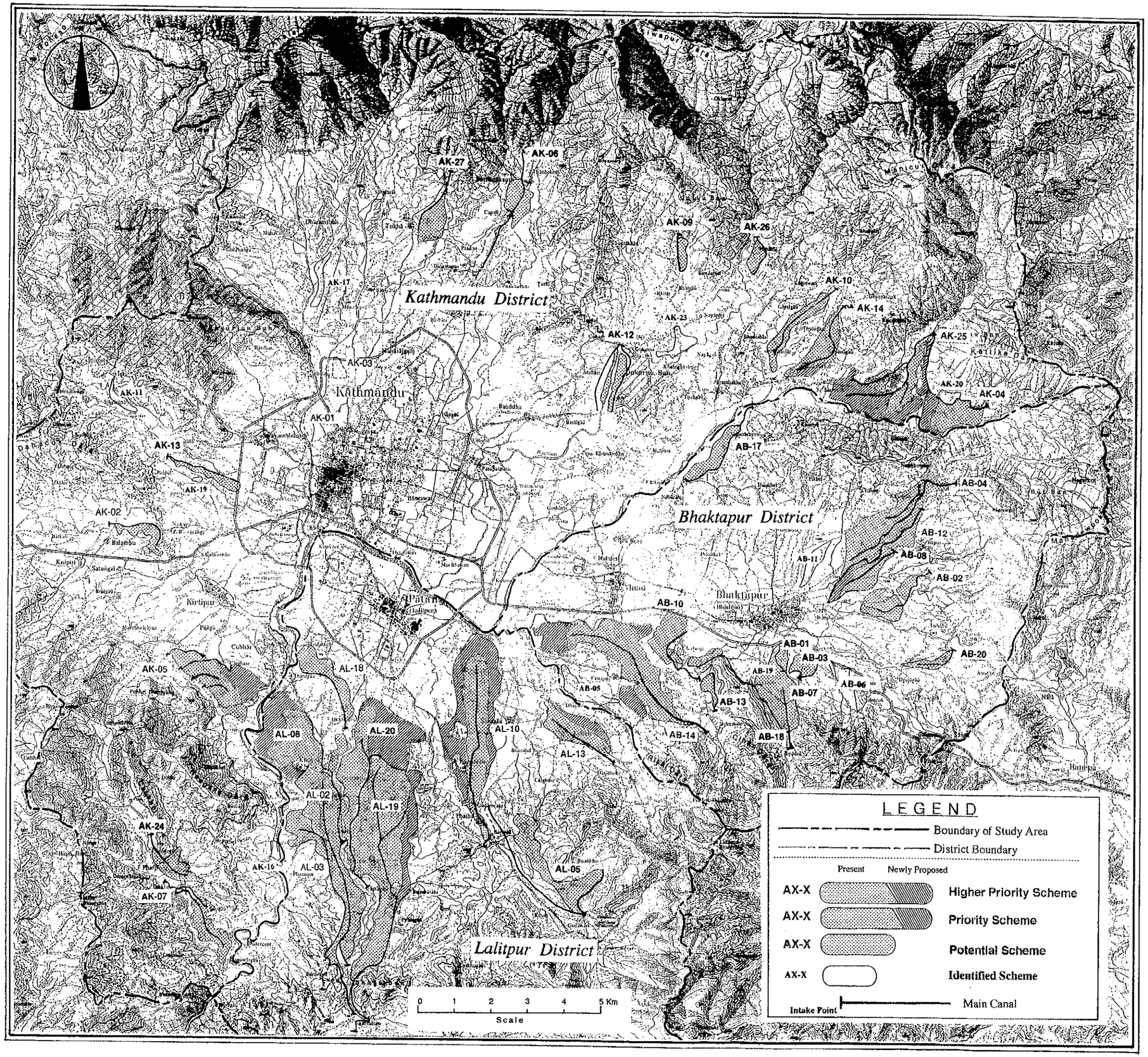
The field studies were carried out in collaboration with the counterpart personnel of the Central Regional Irrigation Directorate. Transfer of knowledge to the counterpart personnel was done through on-the-job training by each expatriate expert throughout the field study period.

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

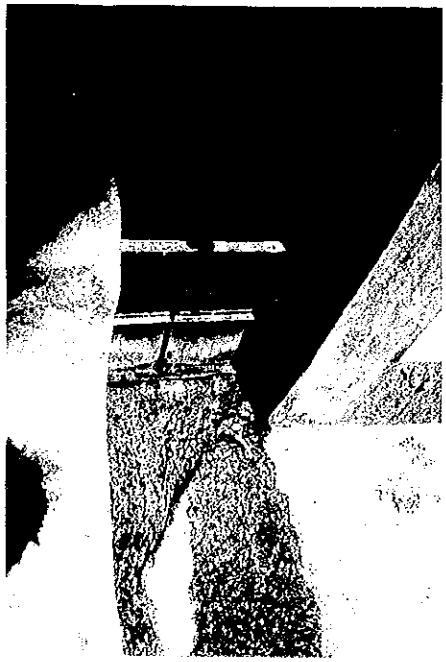


No.	Sub No.	Schem Name	Project Area (ha.) Informed (ha.)	Present (ha.)	Proposed (ha.)
[Kathmandu District]					
AK-01	K-09	Balaju	60	25	*urbanization
AK-02	K-20	Balambu	20	50	*ISP
AK-03	-----	Balkhu	25	25	*urbanization
AK-04	K-07	Biswambhara	200	80	125
AK-05	K-3	Boshan	260	150	210
AK-06	K-8	Budhanikantha	200	200	-----
AK-07	K-1	Dakshinkali	100	100	100
AK-08	-----	Dallu Kulo	10	Urbanization	
AK-09	K-17	Dhulopuro	25	25	*ISP
AK-10	K-13	Gogal Indrayani Kulo	162	130	-----
AK-11	-----	Ghatte Khola	15	ISP approved	
AK-12	K-6	Gokarna	375	75	-----
AK-13	K-5	Ichadol	70	35	-----
AK-14	K-11	Indrayani	145	100	140
AK-15	-----	Itakot	3	not identified by DOI	
AK-16	K-4	Kudali Kulo	10	too small	
AK-17	K-22	Lamabagar	40	ISP implemented	
AK-18	-----	Lupang	5	not identified by DOI	
AK-19	K-19	Manamatti	6	too small	
AK-20	K-15	Narayan Khola	30	ISP implemented	
AK-21	K-12	Panchmane	60	ISP implemented	
AK-22	-----	Pashupati	75	Urbanization	
AK-23	K-16	Patichaur	40	ISP approved	
AK-24	K-2	Pharping Dhunge Dhara	339	74	-----
AK-25	K-14	Shali Nadi	600	150	300
AK-26	K-18	Sundarijal	20	35	-----
AK-27	K-10	Tokha	200	100	90
AK-28	-----	Takucha Rajilulo	30	Urbanization	
		Sub-Total	3,125	1,354	965
[Bhaktapur District]					
AB-01	B-05	Balekhu	60	60	-----
AB-02	B-07	Bidol	65	100	60
AB-03	B-04	Chakhu Khola	100	60	-----
AB-04	B-10	Dhunge Dhara	520	210	210
AB-05	-----	Dhungre Kulo	28	ISP approved	
AB-06	-----	Doke and Triveni	180	ISP approved	
AB-07	-----	Ghatte Kulo	350	190	-----
AB-08	B-08	Hanumante	100	150	-----
AB-09	-----	Kathuraji Kulo	400	not identified by DOI	
AB-10	B-02	Katunje	95	100	90
AB-11	-----	Khasyan Khusung	20	ISP approved	
AB-12	B-09	Kutudhal	40	100	147
AB-13	-----	Lapsetar	60	60	-----
AB-14	B-01	Mahadev Khola	375	375	450
AB-15	-----	Nala Kulo	120	out of study area	
AB-16	-----	Narayanthali	30	not identified by DOI	
AB-17	B-11	Nil Barahi	60	60	-----
AB-18	B-03	Sipadol Katunje	100	100	
AB-19	-----	Surya Biyanak	50	lack of water source	
AB-20	B-06	Sweety (shishaugari)	23	23	-----
AB-21	-----	Thimi Manohara Kulo	40	not identified by DOI	
AB-22	-----	Walarkhe Kulo	40	not identified by DOI	
AB-23	-----	Yogdhara Kulo	400	not identified by DOI	
		Sub-Total	3,256	1,588	957
[Lalitpur District]					
AL-01	-----	Aphur Kulo	250	out of study area	
AL-02	L-06	Bhorle	50	150	*ISP
AL-03	L-09	Champi	100	100	*ISP
AL-04	-----	Gimdi	20	out of study area	
AL-05	L-03	Godawari	104	175	-----
AL-06	-----	Ikudhal Kulo	120	out of study area	
AL-07	-----	Kamabhu Kulo	50	out of study area	
AL-08	L-07	Khokana	300	150	250
AL-09	-----	Khumi Khola	15	out of study area	
AL-10	L-04	Kotkhu	100	240	445
AL-11	-----	Kumbheswar	50	out of study area	
AL-12	-----	Lele Kulo	25	out of study area	
AL-13	L-05	Lubhu	600	115	165
AL-14	-----	Lukani Besi	10	out of study area	
AL-15	-----	Manikhet	40	out of study area	
AL-16	-----	Mellar	10	out of study area	
AL-17	-----	Pyutar	20	out of study area	
AL-18	L-08	Saibu	50	90	*ISP
AL-19	L-01	Thika Bhairow (1)	400	800	600
AL-20	L-02	Thika Bhairow (2)	300	200	400
		Sub-Total	2,614	1,720	1,860
		TOTAL	8,995	4,862	3,782

Location Map

AK-02 Biswambhara

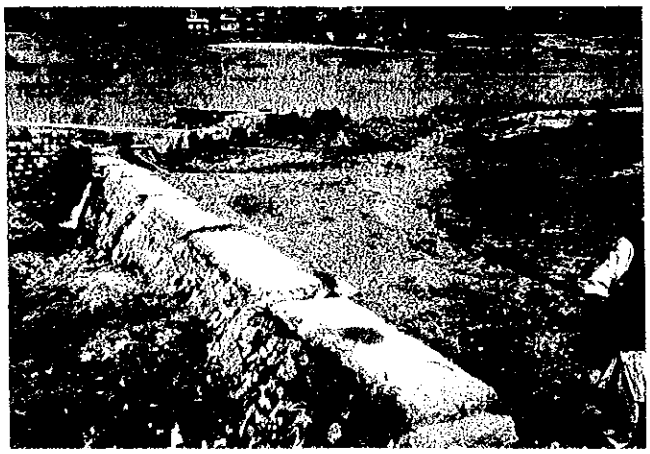
Intake, constructed in 1975. (downstream view)



Water leakage is observed at spill way gate.

Damaged portion of earthen canal.
Tentative repair works are being carried out by farmers, however, much amount of water leakage is being observed.

AK-05 Boshan



No.2 Intake,
Iron pipe for water supply is seen just behind the weir.

No.3 Intake,
Damag to the intake is less compared to other 3 intakes of Boshan scheme.

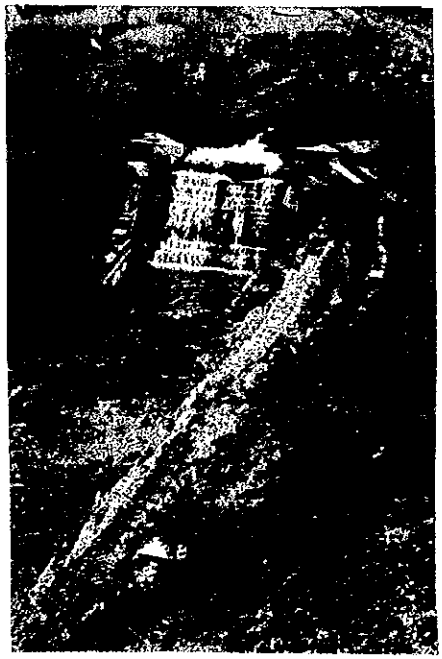
(AK-05 Boshan)

No.4 Intake, downstream portion of the intake is badly damaged and washed away.

No.5 Intake, most of the structure is damaged and washed away.

AK-07 Dhakshinkari

Intake of Upper scheme,
made of gabion and very simple structure.



No.6 Intake (under ISP)
The intake and canals were rehabilitated under ISP. Weir is made of gabion works.

Intake of Lower scheme,
constructed inside area of famous
Hindu temple *"Dhakshinkari"*.

The main canal is constructed along the ridge near the end of the canal of lower scheme.

AK-14 Indrayani

Intake (downstream view)
Due to aging, intake is badly functioning.

Condition of water diversion to the field.

AK-25 Shali Nadi

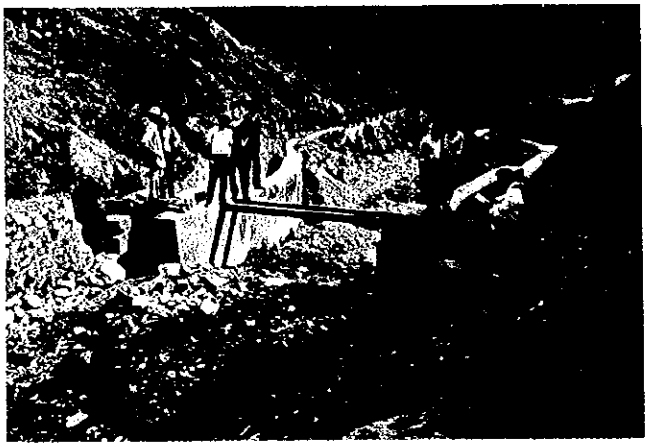
Intake (right bank site / upstream view)
Both sides of the intake are protected with gabion. Intake gate is located at the point where men are standing in the photo.

Broken canal
Repair work has not been done due to shortage of budget.

Diversion structure
Water control is done using sand and grass.

Puddles on the road are caused by water leakage from main canal made of wet masonry.
Main canals are used as side work when the road condition is not good due to rain etc.

AB-02 Bidol



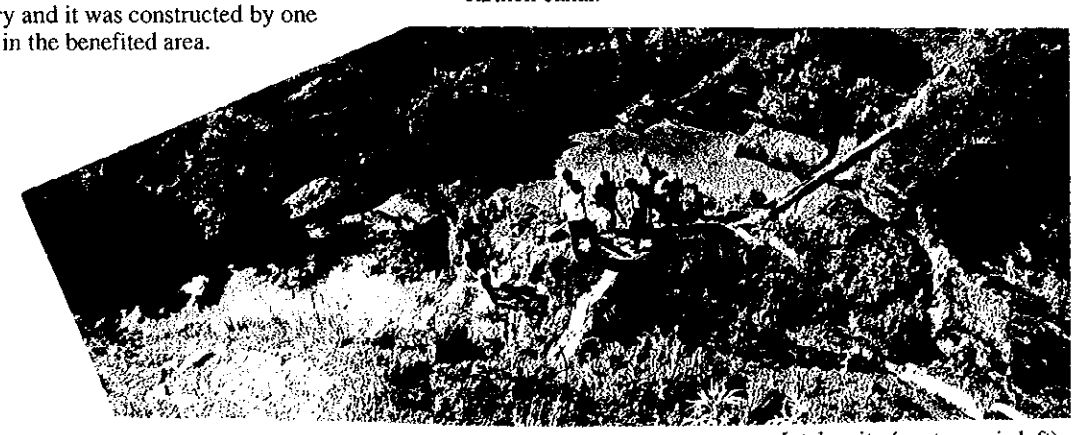
Intake (upstream view)
There are two intake gates on both sides. The left one is operated by the goverment under Bidol scheme and right one is operated by local farmer's group.

Main canal is filled up with quarried stone.
(at 200m downstream from the intake)
* Photographed in April, 1994.

AB-10 Katunje

The small intake is made of brick masonry and it was constructed by one farmer in the benefited area.

Typical water diversion to the field by cutting the shoulder of earthen canal.



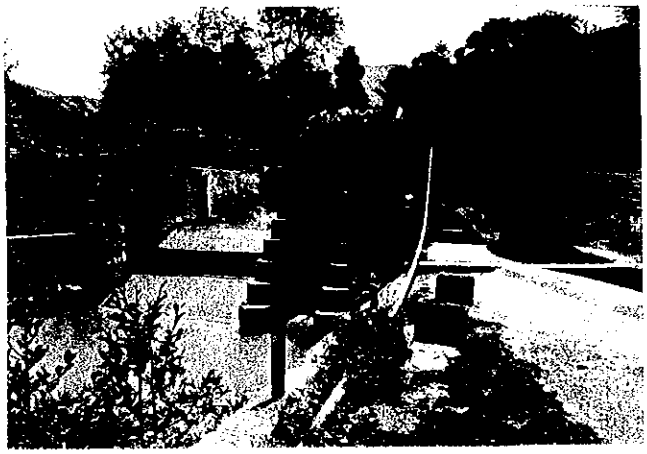
Intake site (upstream is left)

AB-12 Kutudhal

Intake (upstream view)

Simple intake gate is not functioning well.

AB-14 Mahadev Khola



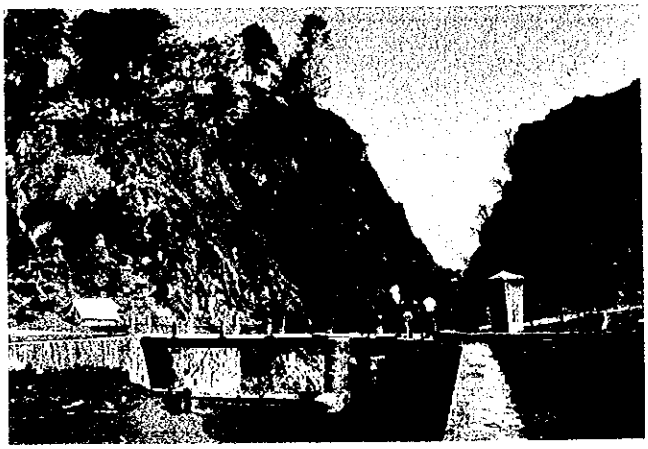
Intake (downstream view)

Sand and gravel flow into the canal at cross point of main canal and small stream.

Main canal just downstream of the intake.
In the canal, sedimentation of 10-20 cm thick is observed just downstream of the intake.

Diversion structure of branch canal, much amount of water leakage is being observed due to aging.

AL-10 Kotkhu



Intake (upstream view)
Construction of Kotkhu Dam is under planning on the V-shaped valley behind the intake.

Half portion of diversion structure is collapsed and much of water leakage is observed.

AL-13 Lubhu

Remains of the intake
The intake was washed away by a big flood in July, 1993. Alternative intake is planned to construct 200m upstream the previous intake.

Elevation of the field of both side of the canal is 1-3m lower than former elevation because soils in the field were taken away for the brick material. However, presently, these fields are used as agricultural farm again.

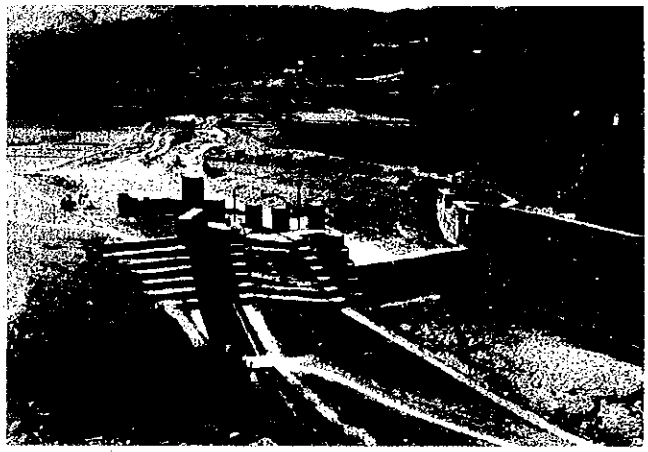
Construction site of alternative intake under planning.
Though tentative intake structure (made of gabion) was constructed by farmers, since the main canal has not been connected to the canal, the irrigation water cannot be conveyed to benefited area.

Broken portion of the main canal is repaired with concrete pipe by DIO (District Irrigation Office).

AL-19 Thika Bhairaw-I

Naldhu Khola Intake (upstream view, old intake gate can be seen in red circle in the photo)
The intake is not functioning at all, as it was badly damaged by big floods occurred 20 years ago, and the river section has been changing by floods every year.

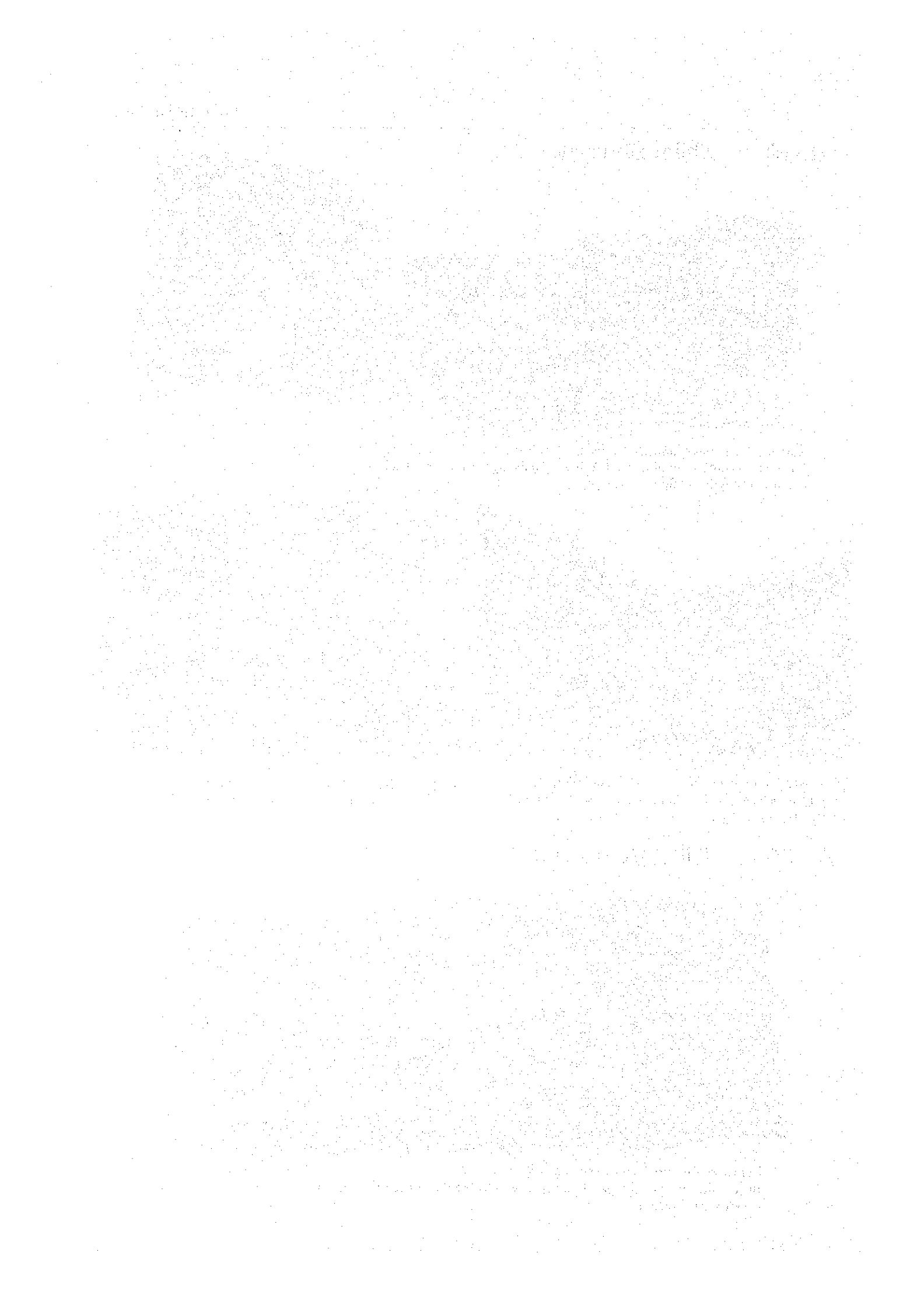
Proposed site for alternative new intake of Naldhu Khola.
The location is situated at 100m upstream of the old intake , presently gabion is put by WUA as tentative weir.



Lele khola intake (downstream / upper view)
The intake was constructed by Indian government in 1961.

AL-20 Thika Bhairaw-II

Remains of the intake (downstream view)
Intake structure was completely washed away by big floods occurred 20years ago except left bank river protection



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

PART - A : MASTER PLAN STUDY

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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
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

El. = elevation above mean sealevel

Exchange Rate 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

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-A, presents the results of the studies carried out mainly during the Phase-I Study; the Master Plan Study on the selection of priority schemes and model schemes for the Phase-II 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. 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 regarding 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-I 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-I Study

In accordance with the Plan of Operation detailed in the Inception Report and on the basis of the S/W agreed upon between DoI and JICA, the Phase-I Study commenced before the departure of the first group of the Study Team from Japan for Kathmandu on April 6, 1993, and included preparatory work prior to its departure. After the submission and discussion of the Inception Report (see Attachment 2), the Study Team commenced the field study with data collection, field surveys and studies, in collaboration with the counterpart personnel, by dividing the field study into two stages; dry season and rainy season, and home office work for the Phase-I Study.

(1) Dry Season Field Study: 40 days, from April 6, 1993 to May 15, 1993 :

- Collection of data and information concerning the natural conditions, socio-economic conditions, agriculture, agro-economy, agricultural foundation, rural infrastructure development, agricultural support services, and environmental aspects.
- Review of the existing study and plan.
- Field survey on hydrology including the discharge measurement and water quality tests, geology and soil mechanics, soil and land use, including physical and chemical analyses of the collected soil samples, existing topographic map, agriculture and agro-economy, present conditions of marketing, post harvest and agro-industry, irrigation and drainage conditions, water management, agricultural support services, rural infrastructure development, and environmental assessment.

(2) Rainy Season Field Study: 60 days, from June 24, 1993 to August 22, 1993 :

- Collection of supplementary data and information and field survey for confirming data and information collected.
- Preparation of an inventory list of the existing Government-managed irrigation systems in the Kathmandu Valley.
- Preliminary selection of potential schemes for rehabilitation.

- Detailed study and identification of constraints on the operation and maintenance (O&M) of irrigation and drainage in the Study Area.
- Establishment of a basic improvement plan.
- Preparation of the Progress Report (I).

(3) Phase-I Home Office Work: 45 days, from August 23, 1993 to October 6, 1993 :

- Detailed analysis of the fieldwork results.
- Formulation of a Master Plan for Rehabilitation of the Government Developed Irrigation System.
- Preparation of the draft O&M manual.
- Selection of model areas for the feasibility study.
- Preparation of the Interim Report.

(4) Submission and explanation of the Interim Report: 10 days, from October 14, 1993 to October 23, 1993

(5) Phase-II Study was commenced from March 31, 1994, as described in Part-B.

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 his role in the Study. Subjects and conclusions of the discussions were summarized in the Minutes of Meeting presented in Attachment No.3.

2. GENERAL SITUATION IN NEPAL

2.1 Land and Population

Nepal is a landlocked country with a total area of 147,200 km^2, which is situated between India and China and is located between 80°00' to 88°15' east longitude and 26°15' to 30°30' north latitude. Geographically, the country is divided broadly into three 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 and the flat Terai plain occupies the remaining 34,000 km^2 or 23%.

In 1991, the total population was about 18.5 million, of which 90% were living in rural areas and 1.1 million or 6% were living in the three districts in the Kathmandu Valley. The annual population growth rate was 2.1% from 1981 to 1991, while it was 2.7% from 1971 to 1981. It is projected to be some 22.8 million in the year 2001. The population density in 1991 was 126 people/km^2 in Nepal and 1,230 people/km^2 in the Kathmandu Valley, as shown in Table 2-1.

2.2 National Economic Situation

The Gross Domestic Product (GDP) of Nepal was estimated at NRs.145 billion or US$ 3 billion in 1992/93, which is equivalent to US$ 156 per capita. Economic growth in real terms averaged 4.4% during the last five years. This figure has decelerated from that of the mid 1980s, as shown in Table 2-2. This indicates that the per capita GDP increases annually by about 2.2%, after deducting the absorption by population growth. During the same period, the agricultural growth rate was as low as 3% and that of the nonagricultural sector was 6.1%. The contribution of the agricultural sector to GDP has declined from 56% in 1987/88 to 49% in 1991/92. However, the national economy is dominated by agriculture. The industrial sectors' share is very low, accounting for only 9% of GDP, but it has recorded accelerated growth.

The agricultural sector's dominance of the national economy is more distinguishable through the distribution of the labour force, which indicates that more than 80% of the economically active population still relies on agriculture, but this figure has decreased from 91% in 1981, as shown in Table 2-3. The notable change in the share of employment during the last decade is the increase in the share of the commerce and service sectors, whereas the share of GDP has remained constant.

Nepalese foreign trade is characterized by a chronic and large trade deficit. Although exports in 1991/92 almost doubled from those in 1990/91, the export earnings only covered 40% of the foreign currency expense for imports. As shown in Table 2-4, the total export and import values in 1991/92 were NRs.14 billion and NRs.33 billion, respectively. The trade deficit was NRs.19 billion, which was equivalent to 13% of GDP. During the 1980s, the trade structure notably changed in both commodities transacted and countries involved. The declining share of India in both exports and imports was the most noticable change in trade destination and the increasing export of nonagricultural products such as manufactured goods, classified as leather, textile, yarn, and fabric was the most noticable change in commodity composition. Trade with India which accounted for 67% of exports and 46% of imports in 1981/82, decreased to 11% of exports and 36% of imports in 1991/92. During the same period, the export of agricultural products lost their dominant position in the export industry, decreasing from 54% to 16%. Especially, the export of food crops, rice and maize which were traditional sources of export earnings for Nepal, decreased to almost zero by the middle of the 1980s. In contrast, there has been no remarkable change in the composition of imports. The share of agricultural products has remained constant, within the 10% to 15% range, but the imported value has been increasing rapidly.

Since 1956, HMGN has endeavoured to develop the national economy through seven

consecutive five-year plans. The results, however, were not satisfactory. After the establishment of the Multiparty Political System in 1990, the Government started to implement economic reforms in order to remove distortions from Nepal's economic structure and to transform the economy into "an open, liberal, transparent, and competitive market oriented economy." The Eighth Plan, which started in 1992, was formulated in conformity with this policy. Equity and sustainability in economic development are also important concerns of the plan. The plan seeks to achieve the following three principal objectives:

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

The plan gives special priority to the following:

a) Agricultural intensification and diversification
b) Energy development
c) Development of the rural infrastructure
d) Employment generation and human resources development
e) Reduction in population growth
f) Industry and tourism development
g) Export promotion and diversification
h) Macroeconomics stabilization
i) Administrative reform
j) Monitoring and evaluation

The target annual growth rate for the Eight Plan was set at 5.1%, which will be achieved by 3.7% of the agricultural sector's growth rate and 6.1% of the nonagricultural sector's growth rate. With an assumed population growth rate of 2.1%/year, the per capita GDP is planned to be increased by 3.0%/year.

2.3 Agriculture

Agriculture plays a dominant role in Nepal's 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 declining gradually.

Agriculture in Nepal is practized utilizing only 18% of the total land area. The farming areas extend into a variety of terrains from the plains of Terai to the marginal steep mountains. Paddy, maize, wheat, and millet are the major food crops cultivated on 80% of the total area cropped. Oilseed, legumes, potatoes, and sugarcane are the main cash crops cultivated on about 10% of the total area cropped.

Cereals such as paddy, maize, and wheat are the major crops, which account for 75% of the total area cropped. Until the mid 1980s, Nepal was an exporter of food grains with recorded exports of over 150,000 tons in the mid 1970s and even 35,000 tons in 1985/86, as shown in Table 2-5. In recent years, the amount of these crops imported has risen significantly, reaching 89,000 tons in 1987/88. Since 1989/90, Nepal was estimated to be nearly self-sufficient in food grain production. Surpluses are produced in the Terai plain, while deficits in the hills, including the Kathmandu Valley and mountainous areas.

Although the Government made significant efforts which resulted in the gradual increase of crop yields, crop yields are still generally low when compared with those in other Asian countries. The average yields of major crops during the last five years were 2.3 tons/ha, 1.5 tons/ha, 1.4 tons/ha, 0.6 ton/ha, 8.1 tons/ha, and 32 tons/ha, respectively for paddy, maze, wheat, oilseed, potato, and sugarcane, as shown in Table 2-6.

In the Eighth Plan (1992-1997), top priority is given to the development of the agricultural sector. The basic objectives are as follows:

a) To contribute to the national economy through increased agricultural production based on geographical features;

b) To increase agricultural production and productivity to meet the growing domestic food demand;

c) To increase production and productivity of raw materials for the expansion of the agro-based industries;

d) To increase employment opportunities for the majority of small and marginal farmers; and

e) To maintain a balance between agricultural development and the environment.

The targeted 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 placed on market-led production of livestock, fruit, vegetables, and cash crops taking into consideration the comparative geographical advantages, transportation facilities, market accessibility, and the demand and supply conditions.

2.4 Irrigation

Nepal has rich water resources for irrigation development, not only for surface water development but for ground water development also. Since the mid 1960s, Government agencies have been actively involved in constructing and managing new irrigation schemes and assisting farmer's groups in the construction or rehabilitation of Farmer's Managed Irrigation Schemes (FMIS). The DoI has played an important role in the development of new irrigation schemes, though ADB/N promotes and finances ground water development through the Shallow Tube-wells Development Program.

Agriculture in Nepal is still largely practized under rainfed conditions. It is estimated that about 933,000 ha or 35% of the total cultivated area has 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. 482,000 ha or 52% of the irrigated area have been developed for a long time by farmers themselves, as shown in Table 2-7 and summarized below:

Total Irrigated Area	933,000 ha	(35%)	(100%)
Total Government Assisted Area	451,000 ha	(17%)	(48%)
DoI Managed Area	265,000 ha	(10%)	(28%)
DoI Assisted FMIS	186,000 ha	(7%)	(20%)
Other FMIS	482,000 ha	(18%)	(52%)
Rainfed Area	1,708,000 ha	(65%)	
Total Cultivated Area	2,641,000 ha	(100%)	

DoI directed most of its efforts to developing medium and large-scale irrigation schemes

over the last two decades and has concentrated these efforts in the Terai plain. Consequently, the DoI Managed Projects, in particular, were concentrated in this area as seen in Table 2-7. The FMIS are generally well operated and maintained by the farmers themselves, but most of them suffer from high maintenance costs and high water losses, since the distribution systems are primitive and lack permanent structures.

The basic objectives of the irrigation development set out in the Eighth Plan are as follows:

a) To increase agricultural production through the application of irrigation technologies appropriate to diverse climatic and soil conditions, with minimum detrimental effects on the environment;

b) To enhance the credibility of the irrigation system through improvement in the management of the existing irrigation system; and

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

To achieve the above objectives, the Irrigation Policy was promulgated by MoWR in 1992. This "Irrigation Policy '92" emphasizes the following:

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

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

c) the continuation of the Nepalese farmers' tradition of construction and management of irrigation systems as autonomous entities in the private sector, by making them more stable and extensive.

According to the Eighth Plan, 294,000 ha of additional land will be irrigated during the plan period. A large-scale irrigation project of 108,000 ha and small and medium-scale schemes of about 53,000 ha will be developed by DoI. Small-scale schemes totalling about 120,000 ha will be developed by farmers with credit from ADB/N. Nongovernmental and private sectors will implement irrigation projects of about 13,000 ha. Thus, it is estimated that about 1.2 million ha will be under irrigation by the terminal year of the Eighth Plan as shown in Table 2-7.

Under the present Irrigation Policy, rehabilitation and improvement works for the irrigation projects, which are being operated by the Government at present, will be turned over to the Users' Association and will be carried out on the basis of the Users' Association's consent and participation on the condition that O&M works will be executed by this Association. If the Users' Association is unwilling to participate in the implementation of the programmes of the projects which were identified by HMGN for turning over to the Users' Association, HMGN will stop the O&M works of such projects. Under the programme, for the renovation or improvement of the Government-managed systems which will be turned over to the Users' Association, the users have to contribute 5% of the construction cost and 95% will be borne by the Government, as mentioned in Chapter 3.6. The Water Users' Association

will have to provide the necessary land for the renovation and improvement works, free of cost.

2.5 Government Budget and Foreign Aid

The Government budget in 1991/92 amounted to NRs.26.4 billion of expenditure, consisting of NRs.9.9 billion (36%) for regular expenditure and NRs.16.5 billion (64%) for development expenditure, which was equivalent to 21% of GDP, and NRs.15.6 billion for receipts, as shown in Table 2-8. During the period from 1986/87 to 1991/92, the expenditure and receipts increased at average annual rates of 18% and 16.5%, respectively.

The budget expenditure of both the irrigation and agricultural sectors for regular expenditure was low, the total for both sectors was less than 0.2% of the total Government budget each year. For development expenditure, the budget expenditure of the irrigation sector was NRs.2.2 billion or 5.8% of the total Government budget in 1991/92. Meanwhile, the budget expenditure of the agricultural sector was NRs.1.3 billion for economic development services or 4.8% of the total Government budget in 1991/92. However, the average share of the Government budget was about 7%, ranging from 9.0% in 1988/89 to 4.7% in 1990/91, for the irrigation sector and about 6%, ranging from 9.6% in 1981/82 to 4.8% in 1991/92, for the agricultural sector, as illustrated in Figure 2-1.

In 1991/92, the receipts consisted of revenue of NRs.13.3 billion or 50% of the total Government budget and foreign grants of NRs.2.3 billion or 9%. Government budgetary statistics show that the expenditure exceeded the receipts every year and that such financing deficits were supplemented by external and internal loans, as shown in Table 2-8.

Foreign aid in the form of loans and grants, which were incorporated in the Government budget, were disbursed to various sectors as shown in Table 2-9 and their share is illustrated in Figure 2-2. Over the past decade, about 25% to 33% of foreign aid was allocated to the agriculture, irrigation, and forest sectors. The major sources of foreign aid are shown in Tables 2-10 and 2-11 and illustrated in Figure 2-3.

3. PRESENT CONDITION OF THE PROJECT AREA

3.1 General Condition of the Kathmandu Valley

3.1.1 Administration, Demography, and Social Conditions

The Study Area is located in the Kathmandu Valley which has a total area of 656 km^2 in hilly terrain. Administratively, the Valley is composed of three districts; the Kathmandu, Lalitpur, and Bhaktapur districts, in the Bagmati Zone of the Central Development Region (CDR). Each district has some towns (urban areas) and villages (rural areas) which consist of 130 units in the Valley as a whole.

According to the 1991 census, the population of the Valley (three districts) was about 1,105,000, consisting of an urban population of 598,000 and a rural population of 507,000. In comparison with the 1981 census, the average annual population growth rate was 3.7% for the whole Valley, 5.1% for the urban area, and 2.3% for the rural area which was similar to the average annual growth rate of 2.1% of the whole of Nepal, as shown in Table 2-1.

The urban area comprizing Kathmandu, the capital city, and Lalitpur better known by the ancient name of Patan, is the centre of the politics, economy, and commerce of Nepal and contains the headquarters of all ministries, departments, and corporations of the Government. Industry is also extensively located in the urban area and the cottage industry is scattered throughout the Valley.

In 1981/82 the rural area in the Valley had a cultivated area of about 49,800 ha or 76% of the total Valley area. However, this figure decreases every year due to urbanization in the Valley. 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 of the inhabitants of the Valley.

The Study Area consists of 40 Village Development Committees (VDC) out of 130 units in the Valley, of which the total cultivated area is about 10,000 ha or 34% of the total Valley area. The population of the Study Area is 305,000 or 28% of the total population in the Valley, with 54,000 households and an average family size of 5.6, as shown in Table 3-1. Farm households in the Study Area number 36,000 or 37% of the total number in the Valley and have an average cultivated area of 0.28 ha per farm.

3.1.2 Physiography and Geology

The Kathmandu Valley is the shape of an indented circular basin and occupies about 656 km^2. The central part of the Kathmandu Valley consists of very gentle slopes and flatlands at elevations of 1,300 m to 1,400 m and the flatland is surrounded by high mountain ranges of an elevation of more than 2,000 m.

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 Bagmati river dissects the Mahabarat mountain range toward the southwest of the Valley. The landform of the Valley is classified into three categories: flatlands, high relief areas, and gently inclined slopes.

The Kathmandu Valley is composed of two series of geological successions: one is Quaternary which overlies the lower portion of the Valley, the other is Precambrian to Devonian (Paleozoic Era) which surrounds the Kathmandu Valley. Many mountain ridges extend to the Valley bottom, implying that there are many buried ridges. The surface of the Valley bottom is flat but the buried bedrock is thought to comprize many irregular shapes and high relief.

The thick geological deposits of the flat part of the Kathmandu Valley consist of

lacustrine deposits and fluvial deposits. The lacustrine deposits are classified into three types; arenaceous sediments, argillaceous sediments, and intermediate types.

The arenaceous deposits which, are composed of coarse to medium grained sand with small rock fragments, are believed to have been supplied from the northern mountainous areas which consist of gneissose rock.

The argillaceous deposits composed of clay materials are considered to have been supplied from the erosion of the limestone which underlies the southern mountainous areas.

The intermediate types of the above-mentioned deposits are distributed in the central part of the Valley from west to east, between the areas composed of arenaceous deposits and argillaceous deposits. Materials of this type are composed of silty clay or clayey silt with intercalation of sandy layers and clayey layers.

The arenaceous sediments are limited to the northern margin of the lower Kathmandu Valley. Most parts of the lower Kathmandu Valley are covered with clayey layers. High potentiality for ground water recharge is not expected. In addition, the Final Report on the Ground water Management Project in the Kathmandu Valley stated that ground water has been over exploited and that ground water recharge has not been attained sufficiently by natural methods. Accordingly, the potential for ground water development in the Kathmandu Valley for such a large demand as irrigation is low.

3.1.3 Population Projection and Urban Development

As mentioned above, the population in the Kathmandu Valley has 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 Kathmandu Valley Urban Road Development Study, which was completed by JICA in March 1993, the populations of the major areas in the Kathmandu Valley, in the year 2015, are forecasted below:

Area	Population	Annual Growth Rate *
Kathmandu District	1,355,000	3.0%
Urban	946,000	3.5% *
Rural	409,000	2.0% *
Lalitpur District	436,000	2.9%
Urban	268,000	3.5% *
Rural	168,000	2.0% *
Bhaktapur District	290,000	2.2%
Urban	110,000	2.5% *
Rural	180,000	2.0% *
Whole Kathmandu Valley	2,081,000	2.8%
Urban	1,324,000	3.4%
Rural	757,000	2.0%

Source : Final Report on the Study of Kathmandu Valley Urban Road Development, March 1993.
Note * : Annual growth rate estimated by the KVUDPP Study.

Based on these projections of population increase, the KVUDPP Study forecasts the following future 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;
- The city of Bhaktapur will be completely combined with Greater Kathmandu due to the

expansion of the urban area along the east-west corridor of the Valley;

- Due to geographical constraints, the western part of Greater Kathmandu will remain undeveloped within the foreseeable future. In particular, it will be difficult to urbanize the area located north of the Tribhvan Highway;
- 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 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 KVUDPP Study proposed the process of urban expansion as shown in Figure 3-1. The urban area is expected to almost reach the urban expansion boundary proposed by the Department of Housing and Urban Development (DoHUD) of HMGN, for the beginning of the 21st century. In the Final Report of the Kathmandu Valley Urban Road Development Study, expansion of the urban area by 1997 and 2015 is estimated based on the KVUDPP Study, as shown in Figure 3-2.

Land in the extended urban area will be for residential, industrial and governmental or institutional purposes, while the central core area will remain as the commercial and business centre with residential areas.

As for land use in the rural area, the KVUDPP Study has proposed minimum development concepts, except for the development of tourist spots, as shown in Figure 3-3. In the Final Report of the Kathmandu Valley Urban Road Development Study, it was also recommended that urbanization of the land should be controlled at a minimum level, for 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, wild life, and agricultural lands.

3.2 Meteorology and Hydrology

3.2.1 Meteorology

(1) Climate

The climate of the Kathmandu Valley, which is in the monsoon region and has a distinct rainy season, is classified as subtropical. Most rainfall occurs during the rainy season from June to September. October to November is warm, while December to February is cool with occasional snow in the mountainous areas. March to June is dry and hot, which is brought about pre-monsoon thunderstorms with occasional hail and showers.

(2) Precipitation

Rainfall varies substantially according to the altitude. The average annual rainfall varies from 1,220 mm at Khumaltar in the Valley bottom to 2,740 mm at Kakani in the hills. Rainfall generally increases in mountainous and hilly areas and is higher on the south facing slopes than on the north facing slopes, as shown in the isohyetal map in Figure 3-4. Based on this map, the annual basin rainfall in the Kathmandu Valley was estimated at about 1,900 mm.

Annual rainfall varies quite a lot, ranging from 1,000 mm to 2,000 mm in the Valley area to 1,500 mm to 3,300 mm in the mountainous area. The monthly rainfall at three representative stations in the Valley 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
Godawari (Station No. 1022, El. 1,400 m)													
	21	21	34	54	116	300	517	457	264	68	5	16	1,873
Thankot (Station No. 1015, El. 1,630 m)													
	18	24	43	77	142	275	513	461	323	88	7	22	1,994

The monthly rainfall variation indicates that some 80% of the annual rainfall occurs during the rainy season from June to September or about 90% in the period from May to October. The wettest months are July and August, while the driest month is November. In July and August 20 to 25 days are rainy, while 0 to 3 days are rainy in November, December, and January.

(3) Other Meteorological Conditions

Meteorological conditions other than rainfall, at three climatological stations; Kathmandu Airport, Khumaltar, and Nagarkot, are shown in Figure 3-5. The meteorological conditions at Kathmandu Airport, which represent the meteorological conditions in the Study Area, 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

(1) River System

In the Kathmandu Valley there is only one river system, the Bagmati river and its tributaries, which has a drainage area of 585 km^2 at Chobhar gauging station located close to the outlet of the Valley. The Bagmati river originates in Sivpuri Lekh on the northern border of the Kathmandu Valley, about 15 km northeast of Kathmandu City. This river runs in a southern or western direction from its origin and leaves the Kathmandu Valley almost 35 km from its origin, dissecting the mountain range at the Valley outlet and flows through the Mahabarat mountain range and Terai plain and then finally joins the Ganges river in Indian territory.

The major tributaries of the Bagmati river are the Nakhu Khola, the Balkhu Khola, the Bisnumati Khola, the Dhobi Khola, the Manohara Khola, the Kotkhu Khola, the Godawari Khola, and the Hanumante river in order from the river mouth. The catchment area of each tributary at the junction and the potential rehabilitation schemes in respective river basins are summarized below:

River	Catchment area	Potential scheme (Code No. see Annex-3)
Bisnumati Kh.	103.4 km^2	AK-01, AK-06, AK-13, AK-27
Dhobi Kh.	28.9 km^2	-
Manohara Kh.	73.1 km^2	AK-04, AK-10, AK-14, AK-25, AB-17
Hanumante river	91.2 km^2	AB-01, AB-02, AB-03, AB-04, AB-07, AB-08, AB-10, AB-12, AB-13, AB-14, AB-18, AB-20, AL-13
Godawari Kh.	45.1 km^2	AL-05
Kotkhu Kh.	34.6 km^2	AL-10
Nakhu Kh.	57.2 km^2	AL-02, AL-03, AL-08, AL-18, AL-19, AL-20
Balkhu Kh.	43.0 km^2	AK-02, AK-03
Bagmati river	585.0 km^2	AK-05, AK-07, AK-09, AK-12, AK-24, AK-26

(2) Runoff Characteristics

There are several hydrological stations within the Valley registered in the Department of Hydrology and Meteorology (DoHM). The monthly discharge at four major stations is summarized below:

Unit : m^3/sec

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Sundarijal (Station No. 505, Catchment area : 16.5 km^2)													
	0.30	0.24	0.21	0.22	0.28	0.81	2.36	3.39	2.68	1.19	0.60	0.41	1.06
Budhanilkantha (Station No. 536.2, Catchment area : 4.43 km^2)													
	0.05	0.04	0.04	0.04	0.07	0.25	0.71	0.92	0.80	0.39	0.17	0.08	0.30
Thika Bhairaw (Station No. 540, Catchment area : 42.5 km^2)													
	0.20	0.16	0.17	0.15	0.15	1.11	3.12	3.97	2.38	1.11	0.44	0.26	1.10
Chobhar (Station No. 550, Catchment area : 585 km^2)													
	2.48	1.89	1.44	1.73	2.49	15.50	47.30	53.87	35.39	16.73	7.00	3.88	15.81

The annual total runoff of the Bagmati river at Chobhar station is estimated at about 500 million m^3(MCM). 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. At Sundarijal station where there is natural runoff, the mean annual runoff is 1.06 m^3/sec and the runoff coefficient is estimated at 67%. The specific discharges at both the Sundarijal and Chobhar stations are presented below:

Unit : m^3/sec/100 km^2

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Sundarijal (Station No. 505, Catchment area : 16.5 km^2)													
	1.83	1.45	1.26	1.31	1.70	4.89	14.27	20.53	16.24	7.18	3.62	2.48	6.44
Chobhar (Station No. 550, Catchment area : 585 km^2)													
	0.42	0.32	0.25	0.30	0.43	2.65	8.09	9.21	6.05	2.86	1.20	0.66	2.70

(3) Flood

In the Valley, rainfall is heavy in the monsoon season and flood occurs within a short period of time due to the steep slopes of the rivers in the mountainous region. Maximum flood occurs in July or August, as seen in the table attached to Figure 3-6.

Based on the flood records of five gauging stations, the probable flood discharges of 1/10 and 1/50 recurrence were estimated and plotted against the catchment area, as shown in Figure 3-6. Using the results of the above, the probable design flood discharges at respective intake points of potential schemes were estimated, as shown in Table 3-4.

(4) Water Quality and Sedimentation

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 coming from the urban area in the Valley. During the field survey, water quality in situ was examined in relation to six items at the intake sites of the selected schemes. The results are shown in the following table, which indicates that the values are within the permissible ranges:

Scheme	Date	Water Temp. (°C)	DO (mg/l)	pH	EC (mS/cm)	NaCl (%)	Turbidity (mg/l)
AK-06 Gokarna	(25 Jul. 1993)	23.6	5.9	6.7	0.4	0.01	34
AK-11 Indrayani	(25 Jul. 1993)						
AK-14 Shali Nadi	(26 Jul. 1993)	24.1	6.0	6.9	0.4	0.01	24
AB-01 Mahadev Kh.	(29 Jul. 1993)	23.5	7.0	7.7	3.4	0.17	113
AB-02 Katunje	(29 Jul. 1993)	23.9	6.2	7.5	4.5	0.23	280
AB-10 Dhunge Dhara	(26 Jul. 1993)	25.7	5.7	7.4	0.6	0.02	24
AL-19 Thika Bhairaw							
(Lele intake)	(27 Jul. 1993)	21.7	5.8	7.6	3.4	0.17	150
(Nallu intake)	(27 Jul. 1993)	21.6	6.4	7.6	2.1	0.10	130

As for sedimentation, the following relationship between sediment flux and discharge was developed in the Study Report on the Ground water Management Project in the Kathmandu Valley, JICA, November 1990, based on the data obtained from DoHM:

$$Q_s = 0.00398 \cdot Q^{2.003}$$

where, Q_s : Suspended sediment load (ton/day)
Q : Discharge (m^3/sec)

3.2.3 Water Use in the Valley

(1) Irrigation

In the Kathmandu Valley, a number of irrigation systems abstracting a certain amount of water from the rivers exist, these are not only Government-developed schemes as objectives in this Study, but also the Irrigation Sector Program's (ISP) projects (see Chapter 3.4), and the small farmers-managed systems. Existing irrigation systems in the Valley are shown in Table 3-2, and their intake points are plotted in Figure 3-7.

(2) Water Supply

In the Kathmandu Valley, the first priority of water resources development is given to the municipal water supply in Greater Kathmandu (Kathmandu and Lalitpur municipalities). The municipal water supply systems are managed by the Nepal Water Supply Corporation (NWSC) under the Ministry of Housing and Physical Planning (MoHPP), while water supply in the rural area is the responsibility of the Department of Water Supply and Sewerage (DoWSS) of MoHPP. A list of municipal water supply systems and a summary of the rural water supply are shown in Table 3-3. The location of intakes for the municipal water supply including on-going and planned schemes are shown on Figure 3-7.

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.

In the Valley, the water supply systems are overloaded because of high population pressure. The master plan study on the water supply recommended the development of surface water resources within the Valley by the construction of run-of-river type intakes and new water supply systems from water resources outside the Valley. In line with this plan, NWSC is now implementing the construction of new run-of-river type intakes on the Dhobi Khola and the Bisnumati Khola in the Valley.

The storage reservoir schemes of the Kotkhu Khola and the Nakhu Khola were also recommended in the master plan study. The Kotkhu Khola dam scheme, known as the Kodkhu Water Supply Project, is now under examination for its implementation with technical assistance of the Thai Government. According to the feasibility study report for the Kodkhu Water Supply Project, the principal features of the proposed dam were designed as follows:

Dam type	:	Homogeneous earthfill type
Dam height	:	38.0 m (Crest El.1,393 m)
Surface water level	:	El.1,388 m
Gross storage capacity	:	4.5 MCM
Effective storage capacity	:	4.0 MCM
Design water supply capacity	:	18 MLD

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 on the Kotkhu and Nakhu dam schemes where the potential rehabilitation schemes will be carried out. On the other hand, water supply plans for Greater Kathmandu from outside the Valley were studied with technical assistance of the World Bank and NWSC put priority on the Rosi Khola Scheme and the Melamchi Diversion Scheme after the Kotkhu Khola Dam scheme.

The water supply sources in the rural area are generally small streams in the hilly areas or springs. Although their design capacities are small, some 0.1 to 10 lit/sec, they do not seem to affect the water availability for irrigation, with some exceptions at the intakes where drinking water and irrigation water are taken from the same place.

(3) Other Water Uses

Only one hydropower generation station at Sundarijal, with a capacity of 640 kW/h, is in operation and the tail water is utilized for the municipal water supply of Greater Kathmandu. In the dry season no water is expected to be released from this river basin.

The major industries which use water are the dyeing factory, brick factory, and some agro-industrial factories. Water abstraction is not so great and they mostly locate some distance from the irrigation intakes.

3.2.4 Preliminary Estimation of Available Water

Based on the specific discharge at the selected gauging stations, natural runoff at the ungauged intake points of the potential schemes was estimated on a monthly basis by applying the following equation:

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

where, Q_i : Natural runoff 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 shown in Figure 3-4.
a : Adjustment for supply from permanent springs, withdrawal for other purposes or fixed water rights etc. (m^3/sec)

Based on the monthly mean natural runoff and 80% reliable monthly natural runoff estimated for the respective intake points of the selected schemes, water balance simulation for preliminary assessment of the available discharge was carried out taking into consideration the amount of upstream water abstraction for irrigation and drinking water supplies, and expected return flow. As a result of water balance simulation, the water available for respective schemes is estimated preliminarily, as shown in Table 3-4. (Water balance simulation for selected model schemes was reviewed and carried out on a monthly basis for 24 years in the Phase-II Study, as described in Annex 4. The result was almost the same except for a few schemes.)

3.3. Soil and Land Use

3.3.1 Soil and Land Suitability

(1) Soil Survey

In order to identify the characteristics of the soil in the Study Area, the soil survey was carried out using the following survey components:

a) Collection and review of the existing data: reports and maps of the Land Resource Mapping Project and aerial photographs (on a scale of 1:20,000);

b) Test pits survey: investigation of soil profiles and sampling for the analysis of physical-chemical properties at 58 places in the Study Area; and

c) Physical-chemical analysis: analysis of the physical-chemical properties in surface and subsoil samples.

Location of the test pits and results of the soil survey are presented in Annex-2.

(2) General Features of the Soils

The soil map for the Kathmandu Valley is shown in Figure 3-9.

Soils in the Study Area have been influenced by soil forming factors, namely the parent material, climate, relief, vegetation, humans, and time. The lacustrine and deltaic origin of the parent material is responsible for the dissected landscape in the Study Area. It has resulted in the variability of land types and soil units.

The Study Area belongs to the subtropical zone. Although the annual rainfall is about 1,400 mm, 80% of the total precipitation is concentrated in the rainy season (monsoon period) from June to September.

The influence of native vegetation in the Valley floor is almost nonexistent now. This land is now being used for dense cultivation, particularly of paddy in summer followed by wheat, mustard, potatoes, and other vegetables in winter. Paddy cultivation with its typical growing conditions, e.g., water ponding, has altered the original soil profile of the Study Area. It has contributed to the typically mottled or gray coloured layer.

Most of the Kathmandu Valley's sediments are very young i.e., early Holocene or more recent. Soil development is very weak and often only a faint B-horizon can be noticed, except in the southern part of the Thika Bhairaw-I and II, Kotkhu, and Godawari schemes where strong clay illuviation in the B-horizon has been noticed.

The Kathmandu Valley has four main physiographic units, i) ancient lake/river terrace or erosional terrace (*tar*), ii) alluvial plain, iii) alluvial fan, and iv) hill slope. These units are responsible for the variation in soil and land use in the Kathmandu Valley. Characteristics of the soil in each physiographic unit are presented below:

a) Ancient Lake and River Terrace

The ancient lake and river terrace represent the former lake bed underlain by coarse loamy lacustrine sediments, but sometimes overlain by fluvial sediments. The dominant slopes are 0.5° to 2°, but sometimes reach 5°, with sandy loam/loam surface textures which are moderately well to poorly drained. The dominant land use is paddy followed by wheat and potatoes in winter.

The ancient lake and river terrace in the southern part of the Kathmandu Valley are underlain by fine loamy or clayey lacustrine sediments with no perceptible fluvial capping (except for Ap1 and Ap2 horizons which are always different from the rest of the soil profile). The dominant slope varies from 0.5° to 2°, but sometimes reaches 7°, consisting of a loam/silt loam/clay loam/silty clay loam surface texture which is moderately well to poorly drained. The dominant land use is paddy followed by wheat and mustard.

The relic terrace represents a landscape formation of an earlier age than that of the Kathmandu Valley lake formation. It has one of the oldest and most pedogenically developed types of Alfisol. The area is confined to the southern part of the Thika Bhairaw-I and II, Godawari, and Kotkhu schemes.

b) Alluvial Plains

The alluvial plains have similar land units with comparable soils. The active floodplains have dominant slopes of 0.5° to 1°, with loam surface textures which are well to poorly drained. The dominant land use is paddy, wheat, or fallow.

Similarly, the recent floodplain and basin have dominantly sandy loam, loam, or silt loam surface soils, which are moderately well to poorly drained. The only differences are in the dominant slopes and land use as conditioned by longer stream profiles in the southern part. The dominant slopes of the northern part are 0.5° to 2° and the land is used for paddy, wheat, and potatoes, while the slopes in the southern part are 1° to 3° and land is used for paddy, wheat, and mustard.

c) Alluvial Fans

The alluvial fans of the southern part of the Kathmandu Valley have longer profiles, hence they have different soils and slopes compared to the northern part. The convex shaped erosional fans in the northern parts have predominant 1° to 1.5° slopes with loam surface soils, which are moderately well drained, and paddy and wheat crop

rotation is practiced, while the slopes in the southern part are 3° to 5° with a silt loam surface soils, which are moderately well drained, and the land is used for paddy and wheat or mustard.

The concave shaped depressional fan has a predominant 1° to 3° slope with a loam surface texture, which is moderately well to poorly drained, consisting of paddy, potatoes, and wheat crop rotation in the northern part. In the southern part the same units have predominant 2° to 4° or even 8° slopes with silt loam or loam surface textures, which are moderately well to well drained and the land is used for paddy and wheat or mustard.

d) Hill Slope

The hill slope units are found in the Biswambhara and Katunje schemes lying in the northern and southern parts of the Kathmandu Valley. The gently sloping terraces of the Biswambhara scheme have predominant 5° to 8° slopes with loam surface textures, which are poorly drained, and the land is used for paddy and wheat.

The chemical properties of the soils in the Study Area are as follows:

- Electric conductivity (EC) values are 0.020 to 0.125 (ms/cm), indicating appreciable concentrations of salt in the Study Area;
- All total $CaCO_3$ values are very low, hence lime could be deficient;
- pH values of the soils are 4.8 to 7.5, indicating slightly acidic to neutral qualities;
- Cation exchange capacity (CEC) values range from 6.1 to 31.1 (me/100g) and CEC is almost saturated by Ca and Mg.

(3) Soil Classification

Soil classification in the Kingdom of Nepal was carried out by the Land Resource Mapping Project (LRMP: Land Systems Report 1986). In the LRMP Report, the Soil Taxonomy of the United States Department of Agriculture (USDA) was used for soil classification.

The soils in the Kathmandu Valley, including the Study Area, were classified into three Orders i.e., Entisols, Inceptisols, and Alfisols. Soil classification into Great Groups is as follows:

Order	Suborder	Great Group
Alfisols	Ustalfs	Haplustalfs
Entisols	Aquents	Fluvaquents
	Fluvents	Ustifluvents
Inceptisols	Ochrepts	Ustochrepts
		Dystrochrepts
	Umbrepts	Haplumbrepts

(4) Land Suitability

The land classification map for the Kathmandu Valley is presented in Figure 3-10.

Land classification was examined in the field survey using the existing data (LRMP: Land Capability Report 1986). The system for land classification is based upon the standards

of USDA and United States Bureau of Reclamation (USBR). Also, lands belonging to Classes I to III are classified as arable land and that of Class IV as the limit of arable land.

Land classification in the Kathmandu Valley, including the Study Area, is as follows:

Class	Area (km^2)	(%)
I	200.6	30.6
II	135.9	20.7
III	216.1	32.9
IV	103.4	15.8
Total	656.0	100.0

The land within the Kathmandu Valley, including the Study Area, is classified as Classes I, II, and III and the land in the surrounding mountains is classified as Class IV.

3.3.2 Land Use

Present land use in the Kathmandu Valley was examined in the field survey using the existing data and is shown in Figure 3-11. The land in the Valley is classified broadly into five land categories: urban area, agricultural land, forest, shrub and grass, and others which include river, brick works, etc. The total area of each land category is estimated below:

Category	Area (km^2)	(%)	Remarks
Urban area	58.2	8.9	
Agricultural land	386.7	59.0	including some residential areas
Forest	54.6	8.3	
Shrubs/Grass	141.2	21.5	
Others	15.3	2.3	rivers, brick works, etc.
Total	656.0	100.0	

The general characteristics of each land category are as follows:

a) Approximately 60% of the land within the Valley is utilized as agricultural land including some residential areas. Agricultural land is divided into two types i.e., lowland type, and upland type according to the cropping pattern;

b) In recent years, agricultural land has been changing into house yards in the Valley. Especially, in the northern part of the Thika Bhairaw-I and II schemes where urbanization is evident.

c) Likewise, some of the agricultural lands are utilized for brick works. In particular, the agricultural lands classified as Classes I and II, located in the central part of the Kotkhu scheme, are utilized for the above purpose.

3.4. Irrigation and Drainage

3.4.1 General Condition of the Existing Irrigation Facilities

Most of the existing irrigation facilities are relatively old. Some of them were constructed in the early 1960s by DoI or with the assistance of the Indian Government. A

typical irrigation system observed in the schemes consists of an intake facility and irrigation canals, which carry water by gravity. Usually, intake facilities are fixed type weirs made of concrete and stone or brick masonry and irrigation canals are lined with stone or brick masonry only in the upstream reaches; the remaining reaches are not lined. During the 1980s, these irrigation facilities were hit several times by severe floods. Some of them were washed away and others were badly damaged. Since then, efforts have been made by DoI and the District Irrigation Office (DIO) to rehabilitate them. Some of them have been temporarily rehabilitated and the others remain as they were. The problems with these irrigation schemes are summarized below:

(1) The intake facilities are generally not functioning well due to siltation in front of the weirs, difficulty in the operation of damaged and rusted gates, lack of river training, scoring of the apron, water leakage through the weirs, lack of attention to O&M, lack of manpower, and lack of gauging devices to measure the amount of water to be diverted, etc.

(2) The irrigation canals under these schemes generally consist of main canals, secondary or tertiary canals, and field channels rectangular in shape. Generally, only limited upper portions of the main canals are lined with stone or brick masonry. Siltation in the canals and water leakage from them are common problems. Since most of these canals pass through the slopes of hilly areas, sometimes, canals are badly damaged by landslides. This causes problems for the canals since they will be unable to carry smoothly the designed amount of irrigation water to on-farm canals (field channels). Further more, some of the feasibility study reports on these irrigation systems state that only about 40 to 50% of the diverted water at the intake sites, reaches on-farm canals. Another problem with the canal systems is that they do not have water regulating devices in the canals, which makes reasonable and timely water distribution to on-farm level channels very difficult.

3.4.2 Water Management

Generally speaking, water management activities under these irrigation schemes are not in place. It has been observed through the field survey that one of the main activities of water management under these irrigation systems is to open and close the gates at the head of and in the main canals (most of these gates are old and sometimes they are badly deformed and, in the worst cases, there are no gates, even at the diversion points), at the designated times decided by the authorities like DIO and farmers' organizations. For the above purpose, 1 to 3 watchmen (called "*Dhalpa*" in Nepalese), appointed by DIO and farmers' organizations, are attached to the respective irrigation schemes (to the limited schemes only). However, it has been observed that the gates have never been closed at the designated times, which results in a great loss of irrigation water. Water management of secondary to tertiary canals and on-farm channels is also carried out adequately, resulting in the same problems mentioned above occurring. However, it seems very difficult to attain high standards of water management in the existing canal systems unless more manpower and upgraded water controlling devices in the canals are provided.

3.4.3 Operation and Maintenance (O&M)

Presently, most of the existing medium to small-scale irrigation schemes are maintained by DIO and farmers' organizations. However, contribution by farmers' organizations to O&M of the irrigation facilities is poor. It has been discovered through the field survey that most of the existing irrigation schemes do not have any formal farmer's organizations like the Water User's Associations (WUA), except for some limited irrigation schemes. In addition, it has been observed in the field that there is no specific objective, target, function, rules, and regulations of WUA for running the systems in an organized way. Accordingly, it is felt

necessary that farmers' beneficiaries should be properly organized in order to enable effective group decision making and implementation of their tasks, system maintenance, conflict management, resources mobilization, etc. At present, each DIO has a technical section within its organization, which takes care of O&M of the irrigation schemes. However, manpower in this section is not sufficient and sometimes 1 to 3 men (farmers) are designated by DIO and attached to the respective schemes for O&M purposes, on a yearly-paid basis. Their main activities for O&M involve the operation of the gates, desilting, and weeding in the canals, which are carried out only 1 to 3 times a year. Partial maintenance of the irrigation facilities, such as spot rehabilitation of damaged canals by gabion works and stone/brick masonry, has also been carried out by DIO. However, it seems that O&M for all the canal systems has not been carried out properly due mainly to the shortage of budget allocation and manpower for the irrigation schemes. The recent budget allocation for some existing irrigation schemes of each DIO is presented in Table 3-5. Budget allocation seems to be too small to maintain the existing irrigation schemes in good condition. The officials of DIO have also revealed that budget allocation for the existing irrigation schemes is rapidly decreasing compared to the past decade, which makes O&M of the schemes even more difficult.

3.4.4 Farmers' Participation

It has been observed through the field survey that farmers' participation in the irrigation schemes is not so good. However, when interviewing the farmers in the field it was revealed that there are a large number of farmers who want to participate more in O&M activities for the irrigation scheme to which they belong, on the condition that the scheme is fully rehabilitated. At present, farmers' participation in the irrigation schemes is limited. Usually they only participate in the desilting and weeding of the canals 1 to 3 times a year, according to the responses of the farmers.

3.4.5 Involvement of Government Agencies

For many years, government agencies like DoI, CRID, and DIO have been actively involved in the construction, management, and rehabilitation of many irrigation schemes of different sizes and nature. DoI, with its board mandate to plan and implement large irrigation schemes and to manage large completed irrigation schemes, is obviously the most important government agency involved in the development of the irrigation sector. Owing to this, DIO has mainly been involved in the construction, management, and rehabilitation of medium to small-scale irrigation schemes. A typical organization chart for DIO is shown in Figure 3-14.

3.4.6 Irrigation Sector Program (ISP)

ISP is included in the Irrigation Sector Project. The total cost of the Project is US$ 47.41 million, of which HMGN will contribute US$ 4.7 million. Farmers have to contribute US$ 4.4 million of the latter amount and ADB will provide a loan of US$ 36.3 million. In addition, the United Nations Development Program's (UNDP) grant of US$ 2.01 million will be provided for the consulting services and training, i.e., technical assistance. The Project started in 1989 and is scheduled to be completed in 1994. To date, five schemes are under construction and about 100 schemes are under investigation and assessment in two regions, namely, the Eastern Development Region and Central Development Region. To ensure that a well-coordinated approach to the implementation of the Project is adopted, there exists a Project Implementation Unit at a central level. At a regional level, the Regional Irrigation Director acts as project manager. Mobile Irrigation Teams (MIT) are supporting and supervising DIOs in the implementation of the sub-project.

The development of small and medium-scale irrigation schemes has been included in

ISP. In line with the Government's emphasis on quick yielding and short gestation projects, the following irrigation schemes have been given priority:

a) Rehabilitation, extension, and upgrading of the existing farmer-managed irrigation schemes; and

b) Construction of new small and medium-scale gravity irrigation schemes.

On the basis of the cost sharing principle, the Government worked out the relative portions of farmers' contribution modality for different categories of gravity sub-projects as follows:

Farmers' Contribution Modality for the ISP Project

Unit construction cost of the sub-project (NRs./ha)	Government contribution (%)	Farmers' Contribution				
		Total (%)	Cash (%)	Labour (%)	Max. (NRs/ha)	Min. (NRs/ha)
1. <than 10,000	75	25	5.0	20.0	2,500	-
2. 10,000-20,000	85	15	2.5	12.5	3,000	2,500
3. 20,000-40,000	91	9	1.5	7.5	3,600	3,000
4. 40,000-60,000	93	7	1.0	6.0	4,200	3,600

On average, the farmers are expected to provide about 2.56% (maximum 5% and minimum 1%) of the total construction cost of the sub-projects, in the form of cash and about 11.44% (maximum 20% and minimum 6%) in the form of labour contribution. The actual proportions of farmers contribution towards the capital costs of the sub-projects would range from 7% to 25%, depending on the cost per hectare of the sub-project. However, the JICA Study Team has been informed by CRID that the above criteria have been slightly modified.

Table 3-6 shows the irrigation schemes which have been approved or will be appraised in the Kathmandu, Bhaktapur, and Lalitpur districts. However, the field survey carried out by the JICA Study Team has revealed that some of the projects listed in the Table have already been implemented. The names of the schemes implemented under ISP are presented in the inventory survey sheets.

During the Field Survey, the JICA Study Team surveyed several irrigation schemes implemented under ISP. Throughout the survey, the JICA Study Team felt that the implemented schemes do not always function well due mainly to low budgetary input on the intake facilities and canals, which suggests that more budgetary support will be required for each project to be implemented under ISP.

3.4.7 Water Users' Association (WUA)

Farmers' organizations were established by the Narayani Irrigation Project located in the Terai Plain, in 1984, in order to repair the canal systems damaged by floods. These organizations constitute the origin of WUAs. Later in 1989, they were formally established as WUAs in ISP. The formal organization of WUAs consists of farmers and selected board members from the farmers. The board consists of the following organizations:

a) General Assembly;

b) Managing Committee (consisting of the Committee on Information and Membership, Committee on Constitution and Rules and Regulations, and Committee on Construction); and

c) Farmers' Groups.

Usually, the board consists of 11 members selected from the farmers, however, the numbers change according to the size of the irrigation schemes. The main function of a WUA is to let the farmers themselves manage, maintain, and operate an irrigation scheme after the irrigation scheme has been transferred to the farmers from the Government.

The following are partial quotations from "The Irrigation Policy 1992":

a) The structure of WUA shall be based on the nature and extension of the irrigation system. Legal recognition shall be granted to the Users' Association and they shall be made self-reliant and strengthened gradually. Necessary emphasis shall be given to the provision that there shall be at least 20% female users in all the executive units of the WUA.

b) HMGN shall invest in the Project only after formal agreement with the WUA by clearly defining the function, duties, and rights of the Irrigation Office concerned and WUA by adopting a transparent method in relation to the construction, implementation, and O&M of the Project.

c) For the development of the irrigation system, the work shall be completed on the priority basis in accordance with agreements concluded between the Government and WUA. While implementing the program, the agreements concluded with the WUA shall be regarded as the basis of resource mobilization.

d) The user may claim for compensation in the case where he faces loss due to non-fulfilment of responsibility by HMGN under the agreement, and the WUA may take legal action under the prevailing law to enforce its entitlement and right.

It is understood from the above that the Government expects the farmers to participate more in the irrigation schemes to which they belong.

3.4.8 Inventory Survey for the Requested Irrigation Schemes

The JICA Study Team conducted an inventory survey on 71 existing Government-managed irrigation schemes in the Kathmandu Valley, which HMGN had formally requested be rehabilitated. The survey was conducted from April to July 1993 with the assistance of the counterparts. Prior to the survey, the JICA Study Team discussed the items to be surveyed and prepared an inventory survey list, which the JICA Study Team used to help carry out the survey. Emphasis was put on a field-based survey and interviewing authorized personnel and farmers under the related irrigation schemes.

(1) Results of the Inventory Survey

Of the 71 existing irrigation schemes, some schemes possessing the following characteristics and conditions were considered to have a low potential for rehabilitation and were dropped from the inventory survey list:

a) Schemes located outside the Kathmandu Valley;

b) Schemes which were too small to be considered for rehabilitation;

c) Schemes under consideration for ISP, schemes already implemented by ISP, and schemes which were heavily funded by other foreign aid; and

d) Schemes where rapid urbanization was observed and it was anticipated that agricultural pursuits would be difficult in the future.

The irrigation schemes dropped from the inventory survey list are shown below:

Kathmandu District	(ha)	Bhaktapur District	(ha)	Lalitpur District	(ha)
Dallu Kulo	10	Dhungre Kulo	28	Aphar Kulo	250
Dhulopuro	25	Doke/Triveni	180	Gimdi	20
Ghatte Khola	15	Kathuraji Kulo	400	Ikudhal Kulo	120
Itakot	3	Khasyan Khusung	20	Kamabhu Kulo	50
Kudali Kulo	10	Nala Kulo	120	Khurmi Khola	15
Lamabagar	40	Narayanthali	30	Kumbheswar	50
Manamatti	6	Surya Biyanak	50	Lele Kulo	25
Narayan Khola	30	Thimi Manohara Kulo	40	Lukani Besi	10
Panchmane	60	Walarkhe Kulo	40	Manikhet	40
Pashupati	75	Yogdhara Kulo	400	Meltar	10
Patichaur	40			Pyutar	20
Takucha Rajilulo	30				
12 schemes	344	10 schemes	1,308	11 schemes	610
			Total:	33 schemes	2,262

Thus, 16 existing irrigation schemes in the Kathmandu district, 13 in the Bhaktapur district, and 9 in the Lalitpur district, in total 38 schemes, were listed as potential rehabilitation schemes in the inventory list, for which detailed information was compiled in the inventory survey sheets in Annex-3, and summarized in Table 3-7.

(2) Major Findings and Problems with the Schemes

Based on the inventory survey, the major findings and common problems regarding the 38 irrigation schemes are summarized below:

a) All the schemes are relatively old, thus, almost all of them need immediate rehabilitation. Further more, most of the existing intake facilities of the schemes are badly damaged, about 80% of the intake facilities have been damaged by frequent floods. Especially the floods in 1980, which caused much damage to the intake facilities and some of them, like Thika Bhairaw-I and Saibu Kulo in the Lalitpur district, were washed away. Under these conditions, it has been observed that there are many temporary intake facilities in the schemes, which makes it very difficult to draw the originally designed amount of water to the canals.

b) Generally, the aprons both at the upstream and downstream of the intake facilities are scored, which results in much water seepage through the aprons. In addition, the gates of the intake facilities are sometimes deformed and rusted. Accordingly, operation of the gates in such schemes is almost impossible. Siltation both upstream and downstream of the intake facilities is also commonly observed, resulting in the river beds' level rising, which may cause further damage to the intake facilities during flooding.

c) The upstream portion of the irrigation canals under the schemes are generally lined with brick or stone masonry and the remaining part of the canals are not lined. This results in a great loss of water during transportation to the field canals. Under these conditions, it is roughly estimated that only 50-60% of the diverted water reaches the field canals, which results in a decrease in irrigated command areas under the schemes, annually.

d) An additional problem with the irrigation canals, which pass through the slopes of the mountains, is the damage caused by landslides, which occur frequently and in the worst case canals collapse and cannot be traced

e) Since the budget for O&M of the irrigation canals is decreasing annually, most of the canals are badly maintained and siltation in the irrigation canals is commonly observed. At the same time, manpower for the irrigation schemes is insufficient. Usually, 1 to 3 people are attached to the limited schemes and they carry out desilting and weeding in the canals only once or twice a year. Some schemes have WUAs, however, their

activities for O&M are nonexistent.

f) Organized farmers' participation in O&M of the irrigation facilities is nonexistent. This is common in almost all the schemes.

g) No remarkable water management activities carried out by farmers, for the existing irrigation canals, have been observed. Since the existing irrigation canal systems have less water controlling facilities, it seems difficult to conduct water management properly unless more water controlling facilities are provided.

These findings and problems with the existing irrigation schemes justify the immediate need for rehabilitation of the schemes as well as strengthening the function of O&M carried out by farmers, with reasonable planning and economic justification.

(3) Farmers' Participation in the 38 Potential Irrigation Schemes

By the middle of August 1993, out of the 38 potential irrigation schemes, farmers involved in 16 schemes submitted application forms for the Project, which were received by CRID. Farmers involved in these schemes deposited money in the joint bank account of DIO concerned, which amount to 0.5% of the estimated project costs, according to the regulations presented in "the Irrigation Policy 1992". This shows that farmers involved in the potential irrigation schemes expect early implementation of the Project. Also, the Project will be implemented on condition that 5% of the total project costs, in cash or labour or both, will be borne by farmers, according to the regulations presented in the "Irrigation Policy 1992". Regarding the turn-over of the irrigation systems to the users' organizations, the "Irrigation Policy 1992" states the following (partial quotation):

Provisions for the Turn-over of the Irrigation Systems to the Users' Organization

Clause 3.30.1 Having prepared programmes for the formation and strengthening of the Users' Association in the irrigation projects to be turned over to the Users' Association which are being operated at the government level at present, rehabilitation and improvement works shall be carried out on the basis of Users' Association's consent and participation on the condition that the O&M works are to be carried out by the Users' Association itself.

Clause 3.30.2 In case the Users' Association is not willing to participate in the implementation of the programmes in the projects identified by HMGN for turning over to the Users' Association, HMGN shall stop the O&M works of such projects.

Clause 3.30.3 The full ownership of the turned over irrigation system and the related structures shall lie with the Water Users' Association, registered by HMGN. All responsibilities relating to O&M of the irrigation system shall lie with Water Users' Association after the turn-over of such irrigation system.

Clause 3.30.4 While turning over the irrigation system, the related government agency may conclude a necessary agreement with the Water Users' Association for the proper development and utilization of irrigation facilities and related structures.

Clause 3.30.5 Under this programme, a minimum portion of the cost for the renovation or improvement is to be borne by the users as follows:

		Users	HMGN
		Labour or cash or both	
(a)	Surface Irrigation	5%	95%
(b)	Ground water Irrigation	5%	95%

3.4.9 General Characteristics of Drainage

At present, there are no systematic drainage canal networks under the irrigation schemes in the Kathmandu Valley. However, due to the prevailing topographic conditions existing irrigation networks under each scheme also function as drainage canals. A field survey carried out during the later stage of the Phase-I Field Study however, has revealed that even with a little rain, especially in the rainy season, floodwater often overflows from the irrigation canals. Therefore, existing farm roads, which are not paved, are flooded and damaged easily, resulting in access to farmlands as well as in the transportation of harvested agricultural products and communication between villages becoming more difficult. This situation may justify the need for the provision of drainage systems under the schemes, in future planning. However, such drainage planning should be carried out utilizing the existing small rivers and channels as much as possible, so that the construction costs of the drainage systems are economically justified.

3.5 Agriculture

3.5.1 Landholding and Land Tenure

The cultivated area in the Kathmandu Valley amounts to about 30,000 ha, with 97,000 farm households. In the Study Area, there are about 10,100 ha of cultivated land, with 36,000 farm households. The average landholding size in the Study Area is 0.28 ha. The distribution of farm households according to the landholding size is shown below:

Landholding size	Distribution (%)
without land	0.78
under 0.2 ha	41.21
0.2 - 0.5 ha	39.09
0.5 - 1.0 ha	15.76
1.0 - 5.0 ha	3.14
over 5.0 ha	0.02

With regard to the land tenure situation in the Kathmandu Valley, about 93% of the total number of farm landholders own their farmland, which comprizes 56% owner cultivators and 37% owners cum tenants cultivators. Tenant farmers comprize only 7% of the total number of farmers. Tenant charge is generally fixed according to the quantity of produce.

3.5.2 Cropping Patterns and Farming Practices

(1) Crops and the Cropping Pattern

The cropping season in the Study Area is divided into two seasons, the rainy season and the winter season. The present cropping pattern in the Study Area is illustrated in Figure 3-12.

In the lowland area, the main crops grown in the rainy season are paddy, followed by winter crops, mainly wheat. Potatoes and vegetables are also cultivated, but in a small area. In the reinfed upland area, the main crop in the rainy season is maize, with some winter crops to follow. Major crop rotation patterns in the Study Area are shown below:

Lowland		Upland	
- Paddy - Wheat	(49.5%)	- Maize - fallow	(21.0%)
- Paddy - Potatoes	(4.0%)	- Maize - other cereals	(8.0%)
- Paddy - Vegetables	(3.0%)	- Maize - Wheat	(3.0%)
- Paddy - Maize	(2.0%)	- Maize - Mustard	(2.0%)
		- Maize - Legumes	(1.5%)
		- Others	(6.0%)

Paddy occupies 5,900 ha or 59% of the 10,100 ha of cultivated land in the Study Area. Most of this area is cultivated by wheat in winter. The planted area and crop intensity in the Study Area are summarized below:

Crop	Planted area (ha)	%
Paddy	5,900	58.5%
Wheat	5,300	52.5%
Maize	3,800	37.5%
Other Cereals (millet etc.)	850	8.0%
Legumes	350	3.5%
Potatoes	650	6.5%
Mustard	200	2.0%
Vegetables	450	4.5%
Total	17,500	173.0%

(2) Crop Yield and Production

The planted area, yield, and production of crops in the Study Area are presented in Table 3-8. Generally, major crop yields in this area are higher than crop yields for the whole of Nepal. According to the results of the sample farm survey, the average yield of paddy in the areas covered by existing irrigation systems was about 10% higher than that under rainfed conditions. In the case of potatoes, the average yield under rainfed conditions was estimated at only 25% of that in irrigated areas.

In 1991/92, total paddy production in the Study Area was 28,000 tons. The average unit yield of paddy in the Study Area was estimated at 4.7 tons/ha, which was much higher than the national average of 2.3 tons/ha.

As shown in Table 3-8, the total amount of secondary crops produced such as wheat, maize, and potatoes in the Study Area is 9,000, 7,900, and 7,200, tons, respectively. The average unit yields of these crops are 1.7, 2.1, and 11.1 tons/ha, respectively.

Legumes cultivated in the Study Area are mainly soybeans and blackgrams in the rainy season and peas in the winter season. The total amount of legumes produced is estimated at 200 tons and the average unit yield is 0.6 ton/ha.

The major vegetables grown in the Study Area are cauliflower, radish, cabbage, and broadleaf mustard in the winter season and french beans, brinjal, and tomatoes in the rainy season. The total amount of vegetables produced is estimated at 4,450 tons in the Study Area and the average yield is 9.9 tons/ha.

(3) Farming Practices

Most of the farmers are using improved varieties of seed. As a result of the sample farm survey, it was discovered that the crops previously produced by farmers themselves were the main source of seed. Farmers usually prepare the seed themselves and sometimes, once every

two to three years, purchase new certified seed from the agencies. The number of farmers using home stored seed is high (60%), compared to those who are using purchased seed (40%).

Most of the farmers use chemical fertilizers in the Valley. These chemical fertilizers are monopolistically distributed by the Agriculture Input Corporation (AIC). The average amount of chemical fertilizer used in the Valley far exceeds that used in other areas of the country. The amount of chemical fertilizer supplied to the Valley was 11% of the total supplied to Nepal and the average amount supplied per hectare to the Valley was much higher than that supplied per hectare to the whole of Nepal, as summarized below:

(1991/92)

Description		Nepal	Kathmandu Valley
Total Amount Supplied by AIC	(ton)	185,800	20,700 (11.1%)
Average Amount Supplied	(kg/ha)	70	700
Average Amount of Nutrient Contents N : P : K	(kg/ha)	22 : 8 : 0.5	210 : 42 : 0.7

Farmers use mostly urea and complex. In addition to urea and complex, large amounts of compost manure are used by farmers.

According to the farm survey, the use of agro-chemicals such as pesticides, herbicides, and fungicides are not common in the Study Area.

Farmers in Nepal generally use bullocks for land preparation. However, such draught animals are not used for agriculture in the Study Area. Human labourers are the main labour force for farming activities in the Study Area. According to the National Sample Census of Agriculture (1991/92), the number of existing farm machines such as tractors and power tillers was 836 and 1,397, respectively, in the Study Area. The average number of these machines per hectare is 0.09 and 0.15, respectively. However, many tractors and power tillers are actually not used for cultivation, but for transportation purposes.

Regarding the processing practice, most farmers in the Study Area use threshers. In the case of paddy, farmers use the pedal thresher.

The general farming practices for major crops are briefly described as below:

- **Paddy**

The most popular varieties of improved paddy in the Study Area are *Taichung-176*, followed by *Masuli*. The local varieties of paddy, *Masino* and *Pokhareli*, are also cultivated by several farmers in some areas. The sowing of seeds is generally carried out in nursery beds in April/May and transplanting in the main field is carried out in June/July. Preparation of the main field is carried out by digging and ploughing. Organic manure is applied during land preparation and nitrogenous chemical fertilizer is applied in split doses, half at the time of land preparation and the remaining half as top dressing. Weeds are controlled manually. Plant protection is not practiced unless there is severe damage. Harvesting is conducted with sickles, in October/November. Threshing is conducted using pedal threshers. Winnowing is conducted using the traditional method.

- **Maize**

Maize is mostly grown in rainfed fields. Improved varieties of maize such as *Khumal Yellow* and *Rampur Yellow* are widely grown in the Study Area. As a result of the farm survey, it is evident that the area covered with these varieties is about 75% of the total planted area. Manure is broadcasted to the field prior to land preparation. Seeds are either broadcasted or line sown in April/May. Weeding is carried out manually. Using nitrogenous fertilizers for

top dressing is commonly practiced. Harvesting starts in August. Green maize leaves are lopped and used for animal fodder.

- **Wheat**

The improved varieties of wheat, *Lerma Rojo 64, Lerma 52, NL 297,* and *RR 21* are widely grown. However, in some areas, particularly in the upland areas, local varieties of wheat are also grown by some farmers. Land preparation is carried out manually in October/November. Seeds are generally broadcasted. During the growing period weeding is carried out once or twice. Chemical fertilizers are widely used and manure is also used. The crop is harvested with sickles in April/May and threshed, using threshers after drying. The grains are winnowed using the traditional method.

- **Potatoes**

Potatoes are generally planted during January and February and harvested in May. The amount of seed used is about 1,000 kg/ha. After land preparation, potatoes are planted. Organic manure, complex, and urea are the main fertilizers used. The amount of fertilizers applied is very high compared with the other main crops as shown below:

Crop	Seed	Fertilizer (kg/ha)			Compost	Human labour (m/d)		
	(kg/ha)	Complex	Urea	Total	(kg/ha)	Family	Hired	Total
Paddy	53	101	273	374	6,649	172	74	246
Wheat	114	63	249	312	6,506	98	24	122
Maize	23	55	207	262	4,997	133	33	166
Potatoes	1,015	196	437	672	10,688	300	50	350

Weeding is carried out two or three times during the growing period. Harvesting is conducted in April.

- **Mustard**

In the Study Area, the adoption of improved varieties of mustard has been limited. Mostly local varieties of mustard, namely, *Kalotori* and *Baltori* are grown. This crop is generally grown under residual moisture conditions and makes use of the fertility of preceding crops and cultivated by either monoculture or relay cropped with paddy. Farmers prefer to use a little fertilizer for this crop. Weeding and thinning are carried out at the same time. Harvesting is conducted by pulling out the matured plants. The plants are threshed with wooden sticks. The grains are then winnowed using the traditional method.

- **Legumes**

Soybeans and blackgram are major grain legumes grown in the Study Area as rainy season crops. These crops are planted as ridge cultivation crops with paddy and are inter-cropped with maize. They are raised with the minimum tillage operations. The matured plants are mostly pulled by hand and threshed with sticks manually.

- **Vegetables**

Farming practices for vegetables vary widely depending upon land location and availability of irrigation water. The major vegetables grown in the Study Area are cauliflower, radish, cabbage, and broadleaf mustard in the winter season and brinjal and tomato in the rainy season. Leguminous vegetable crops, such as garden peas in winter and french beans in the

rainy season, are also important vegetables in the Study Area. The general farming practice of each vegetable is shown in Table 3-9. In the case of cole vegetables and fruit vegetables, such as cauliflower, cabbage, brinjal, and tomatoes, seedlings are firstly raised in the nursery and later transplanted in the main field. Farmers grow both local and improved varieties. Most of the improved varieties are obtained from private dealers. Organic manure is supplied during land preparation and top dressing using complex, urea, or potash, is also practised. Farmers use very little plant protection chemicals. The vegetables are harvested over a long period of time, by hand or sickles due to their quick perishable nature.

3.5.3 Livestock and Inland Fishery

The population of livestock in the Study Area is estimated and presented in Table 3-10. Compared to other districts of the country, the role of livestock in the farming system in the Study Area seems to be low. The practice of not using draught power (particularly bullocks) in agriculture in the Valley is one of the main reasons for this. 41% of the total number of farm households raise cattle, mainly for milk production. The percentage of farm households keeping goats and poultry is 34%. These are kept for the purpose of earning cash income. Some of the poultry farmers keep a large number of poultry. Goat and chicken meat fetch good prices in the market, therefore most of the farmers raise goats and chickens. Production of livestock products in the Kathmandu Valley is presented in Table 3-11.

There are four research centres and nine production farms for inland fishery. Of these, two research centres are located in the Kathmandu Valley (Godawari and Balaju) and research work regarding inland water fish in the hilly area such as trout, is carried out. But in the Valley the role of inland fishery also seems to be low. The Fishery Office recommended the "Paddy cum Fish Culture", but the area of ponds operating under this type of fish culture is only 7 ha in the Valley and most of them are for home consumption purposes. The pond area, water surface area, and the amount of fish produced in the Study Area are presented in Table 3-12.

3.5.4 Farmers' Economy

Based on the data and information obtained from the Agricultural Marketing Division of DoAD, the District Agriculture Development Office (DADO) in each district, and the Farm Survey conducted by the Study Team, the annual farm budget of average sized farm households in the Study Area was worked out and is shown in Table 3-13.

The average holding size of farmers in the Study Area is 0.28 ha and 81% of farmers possess under 0.5 ha. Although farmers who own land and self-cultivate it are estimated at about 92% of the total number of farmers in the Study Area. Owing to rapid urbanization in the Kathmandu Valley, job opportunities are also rapidly increasing. The majority of farmers in the Kathmandu Valley have huge amounts of nonfarm income, estimated at about 75% of the total household income. Even farmers who cultivate more than 1.5 ha, are estimated to obtain half of their total household income from nonfarm activities. The sources of nonfarm income are services or salaries from government and nongovernment jobs, business income from shops, wages from construction works, cottage industries which mainly domestic made goods are produced, including bamboo baskets, ropes and mats, etc., and pensions which are given to retired government employees.

Farmers with average sized farms mostly balance their income and expenses, however, farmers with large-scale farms usually keep more reserves at hand.