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A Feasibility Study on Integrated Community Based Flood Disaster Management of Banke District, Nepal

Phase 1: Baseline Study

September 2008

United Nations
Educational, Scientific and
Cultural Organization

in collaboration with

International Centre for Water Hazard and Risk Management
under the auspices of UNESCO (ICHARM)
Public Works Research Institute(PWRI)

The present comprehensive study is a joint research study by ICHARM/PWRI and NDRI, Nepal aimed at investigating the root causes of flood disasters in West Rapti river basin in Nepal and devising strategy to manage flood with community-based approach by targeting improvement in the resilience of the community within the broader framework of enhancing livelihood options and poverty alleviation. This phase i.e. first phase of the study has focused on the investigation of socio-economic impact of flood in the lower part of the basin. It has been found that the anthropogenic factors like construction of poorly designed infrastructures, river training works on an ad-hoc basis, and control of river flow through construction of barrage, levees etc are the culprits for the increasing flood extent in the study area. As a consequence, huge amount of agricultural land has been damaged due to the deposition of sand and bank cutting. This leads to affect greatly the livelihood of local people, who are based on agriculture. The nexus between poverty and the increased flood risk in the study area is clearly seen. Currently, local people are using their beliefs, local knowledge and practices for forecasting of heavy storms, early warning and emergency management; however the efficiency of traditional flood management practices is now being questioned especially in changing environment. It is important to develop the current level of awareness while enhancing traditionally accepted system. This is possible by integrating scientific knowledge in to the existing system with consensus and understandings by local people as well as other stakeholders. The integrated community based flood hazard map was developed by the community and it was cross-checked with the map that produced through hydrological modelling.

Acknowledgements

The International Centre for Water Hazard and Risk Management (ICHARM) of the Public Works Research Institute (PWRI) of Japan has presented this technical report. It is a study conducted in close collaboration with the Nepal Development Research Institute (NDRI). I am very grateful for being given a chance to carry this research task with NDRI researchers under the framework of "Localism," which has been promoted by ICHARM/PWRI as one of its priority working principles.

On behalf of the research team members and in the capacity of the coordinator for this research at ICHARM/PWRI, I would like to thank NDRI officials, especially Dr. Nawa Raj Khatiwada, director of NDRI, and Dr. Mahesh Raj Gautam, coordinator of the research at NDRI, for their interest and firm support through out the time. I would also like to extend my sincere thank to Dr. Krishna Pahari and Dr. Tara Nidhi Bhattarai for their generous support and guidance in formulating a research methodology and executing research activities. I thank a group of NDRI researchers, Mr. Man Bahadur Chetri, Mr. Dhurba Gautam, and Mr. Samir Dhakal, for helping us in conducting field surveys and flood vulnerability mapping activities in the field.

I owe this work to the inspiration from all participants in the series of consultation meetings that we held at local and national levels in Nepal on different dates. The study team has learnt many things from flood-affected people. The information provided by them was extremely valuable. My team and I are particularly indebted to community members of the two Village Development Committees (VDCs) of the Banke district, Nepal, for their patience, cooperation and good understanding. Without their support, it would not have been possible to complete this study. I hope the outcomes of this research will help to formulate a long-term strategy for flood mitigation and poverty alleviation in the basin. The know-how can be disseminated to other parts of the country and region or even beyond, where the flood risk characteristics are similar to the West Rapti River basin.

Rabindra Osti
ICHARM/PWRI

EXECUTIVE SUMMARY

Water induced disaster including flood accounts over 30 % of total losses of lives due to natural disaster in Nepal. On one hand, spatial variation on geography over short reach, young and complex geology, and uneven temporal distribution of rainfall contribute significantly to the occurrences of such water induced hazards, exposure to such hazards and vulnerabilities of people mainly due to poverty, and lack of well preparedness explain the escalating loss of lives and property. The present comprehensive study is a joint research study by Nepal Development Research Institute (NDRI), Nepal and International Center for Water Hazard and Risk Management (ICHARM), Japan aimed at investigating the flood disaster problem for finding the root causes and devising strategy to manage flood with community-based approach by targeting improvement in the resilience of the community within the broader framework of enhancing livelihood options and poverty alleviation with Matehiya and Gangapur VDCs of Banke District in West Rapti River Basin as a case.

The objectives of the study are to assess the situation, the history, the causes, aggravating factors, extent and effects of the flood, to document hazard and vulnerability, and various capacities of the community; to study the local knowledge, practices and beliefs in the community; to formulate community based plans for flood mitigation and flood disaster risk reduction. Findings of this phase of study is aimed to be input to second phase when a broader framework of community based disaster management targeting poverty alleviation and improved livelihood options is planned to be prepared.

The report is the outcome of number of methods used for the study purpose. To understand the study context review of relevant literature was supplement by consultation meetings and workshops. A highly effective consultation workshop of stakeholders at district level comprising of politicians, line agencies, domestic and international Non-Governmental Organizations, key donor organizations working in the region, and representatives from four flood affected VDCs was held at Nepalgunj (district headquarter of Banke District) for stakeholder analysis, cause-and-effects analysis of flood, and for discussion on the research agenda. Similarly a central level consultation meeting with representatives from relevant stakeholders from government and non-government organizations, donors, and academicians was successfully held at Kathmandu to discuss the outcome of Nepalgunjj workshop, the research framework and objectives of the present study, and to form a research-interest-team to discuss and monitor the progress of the research.

Reconnaissance field visits and meeting with stakeholders at district was made before the detailed social and technical field survey. As part of the technical field survey, GPS survey along West Rapti River Bank sides for tracking the river bank location, and rapid assessment of bank condition was made. This provided a quick and rough approach for bank cutting hazard mapping along the West Rapti from Indo-Nepal boarder to Sikta. Simlarly, the GPS survey provided data of present river bank situation of West Rapti River which when overlaid over 1997 topographic map showed the extent of migration towards west. Over last 10 years, the channel has migrated over 1.8 Km near the southern boarder. Such migration of river channel has created huge loss of agricultural land and settlement areas on Nepalese side besides creating fear and threat to more settlements near Indo-Nepal boarder.

Flood inundation mapping based on HEC-RAS (US Army Corps of Engineer, 2002) was used to simulate various scenarios of flooding (2, 5,10,25,50,100 years) and to assess the impact of Kalkaluwa bandh(dyke). Based on the gradually varied steady flow analysis a number of inundation maps were prepared for various return period floods, and the settlements under high hazard zones were identified. Similarly, the effect of kalkaluwa bandh was clearly evaluated as resulting into the increased depth of flood water in the Nepalese side and decreased flood extent on India.

Before conducting detailed social survey using participatory tools and techniques, a participatory workshop involving the key stakeholders of the VDCs was conducted at the VDC level. Participatory flood hazard and physical vulnerability maps, and risk map of the settlements and infrastructures which are under imminent threat were prepared. In addition, the causes and effects of hazards were identified, the local knowledge, beliefs and practices related to flood forecasting, early warning and flood management at various stages were documented, and community action plans for flood mitigation were prepared towards the end of the fieldwork. The recent flood of 2006 and 2007 provided an opportunity to investigate the flood situation in the study area and institutional arrangement in the district.

The people living in the study area are continuously distressed from the flood of Rapti River and flash flood of small torrents flowing from churia range. In order to systematize the study in detail, these VDCs were further divided in to four clusters. Similar types of flood issues, severity and frequency of flood events, extent of damage and scale of casualties for last five-year trends were taken as basis for the selection of the clusters. The total households and population in the study area are 2,028 and 13,256 respectively. Female slightly outnumber the males and the people of Terai origin are the major ethnic group in the study area. The composition of caste and ethnic groups in the study area consists of Brahmin, Chhetri, Dalit, Tharu, Rana Magar, Terai Non Dalit, Terai Dalit and Muslim.

The main source of livelihood in the study area is agriculture (85%). Other sources include: on and off farm seasonal labor (13%), service (1%) and business (1%). The level of food sufficiency is very miserable. On an average, only 24% HHs have food sufficiency for year round, and 10% HHs have food not enough for even 2 months. The food sufficiency is highly affected by increased flooding and inundation problem in the study area. About 60% of households have one or more family members away for labor purposes during some period of the year. It is learnt that the seasonal migration has not been fruitful for improved economic condition of the families.

The study found that there are several causes of flood hazards. They are: construction of infrastructure such as roads, culverts etc. without assessing the monsoon flood, narrow drainage capacity of the torrents, haphazard channel excavation for irrigation due to the absence of proper irrigation canal system ,and poor drainage due to dense settlements. Similarly, construction of Laxmanpur Barrage on Indian side, overgrazing in the churia area, slash and burn practices in the upland areas, encroachment of marginal land and forest, haphazard extraction of boulders and sand from the upland churia range, and expansion of *jalkumbhi* (water hyacinth) and *besarm* (hedge plants) in both banks of torrents are some other reasons cited by the community.

Flood is found to be a recurrent phenomenon in the study area. The last 2006 and 2007 year floods have made some devastating impact on the study area. These flood events were unique in a sense that the

floods were mainly due to the heavy precipitation in the Terai belt. The flood has damaged the physical infrastructures like houses, schools, sub-health post, hand pumps, culvert etc as well as productive agriculture land, and livestock. Floods have caused difficulty in mobility, increased risk for living at houses, trends of fear and trauma, and erosion of social assets such as neighborhood, brotherhood, *Parma* system, and strong bondage of kinship. Likewise, damage of stored grain and spread of water borne diseases are other distresses. Increased heath hazards, increased investment in treatment and farming, increase in price of seed, less return from animal husbandry, poor performance of social institutions, changes in cropping pattern and reduction in the crop production are immediate impacts of flood on the livelihood of farmers.

Flood forecasting, early warning system and community based flood management saves many lives and properties. Some of the indicators for the people for forecasting heavy storms as shared by them during the field study are: position of the cloud in the sky, extent of rainfall in upper catchments and churia area, mobility of ants, abnormal fly bite, abnormal crying/voices of animals and birds, intensity of thunderstorm and wind, position of stars, and magnitude of hotness. Strange sounds from river/torrents, muddy smell in the water, rising level of water flow are some indicators perceived as early warning of flood.

Before the flooding, people have some practices as part of the flood management. These include management of basic materials in advance, psychological preparedness for flood, collection of non-timber forest products (NTFPs) to treat livestock, creation of small drainage in each plot of land and storage of the valuable materials in *aati/attaiya.* Other practices include storage of the valuable materials in a*ttaiya,* preparation of the *khatiya/palang of bigger height, Weaving Doko* to save poultry from flood, Storage of grains and dry foods, preparation of informal self plan for evacuation, arrangement of evacuation place, and management of livestock in advance and making of temporary *aatiya*. Similarly, procurement of essential drugs in advance, management of firewood, storage of dry food for livestock, construction of *pihan,* arrangement of evacuation place and plan, drainage improvements, homestead raising, and increase of the height of hand pumps are other activities people perform as part of their preparedness to flood disaster. During the flooding, they usually take care of children and elderly first, keep valuable goods safely, use rescue and relief materials, mobilize youths, inform the Red Cross and other stakeholders and decide the appropriate location to stay. They use tents and plastics to live, manage proper places for livestock, aware children not to swim in the muddy water and fill sand bags to divert the flood. Immediately after the flood, there is a general practice to assess damage, dry grains and clothes, construct/repair the houses, and manage food and clothes. Likewise, maintenance of tube well for drinking water and use of local treatments to manage the water borne diseases are other practices taken by the community to cope with the flood disaster.

The upland-lowland and upstream-downstream linkages are important for understanding and finding solution to flood problems. Acknowledging such linkages holistic approach on scientific investigation and planning at a river-basin scale are recommended. However, action at local scale of community level is still the most appropriate approach as this matches the institutional and financial capacity of the country. The nexus between poverty and the increased flood risk in the study area is clearly seen. Thus In order to reduce disaster risk, improvement in the resilience of the community within the broader framework of enhancing livelihood options and poverty alleviation should be targeted. The diversified technical mitigation options as well as skills development, awareness and capacity building of flood

affected communities are also required in addition to the programs for improved livelihood opportunities. This will help to improve the flood resistance capacities of people living in the flood prone area and help them to live with floods in a better way.

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Abbreviations and Acronyms

amsl	Above mean sea level
APF	Armed Police Force
ASSC	Agriculture Sub-service Centre
CBOs	Community Based Organizations
CDO	Chief District Officer
CFUG	Co Community Forest Users Group
CSP	Community Support Programme
Cumecs	m^3/sec
DADO	District Agriculture Development Office
DAO	District Administration Office
DAO	District Administration Office
DDC	District Development Committee
DFID	Department for International Development
DHM	Department of Hydrology and Meteorology
DMC	Disaster Management Committee
DNDRC	District Natural Disaster Relief Committee
DoLIDAR	Department of Local Infrastructure Development and Agricultural Roads
DPHO	District Public Health Office
DPO	District Police Office
DRR	Disaster Risk Reduction
DWIDP	Department of Water Induced Disaster Prevention
FGD	Focus Group Discussion
GDP	Gross Domestic Product

GLOF	Glacial Lake Outburst Floods
ha	Hectare
HDI	Human Development INdex
HH	Household
ICHARM	International Center for Water Hazard and Risk Management
IDDO	Irrigation Development Division Office
MOHA	Ministry of Home Affairs
NDRI	Nepal Development Research Institute
NGO	Non-Government Organization
NGOs	Non-Governmental Organizations
NRCS	Nepal Red Cross Society
NRs.	Nepali Rupees
NTFP	Non-Timber Forest Products
PRA	Participatory Rural Appraisal
PVA	Participatory Vulnerability Analysis
PWRI	Public Works Research Institute
UNICEF	United Nations Children's Fund
UNMIN	United Nation's Mission to Nepal
UN-OCHA	United Nations Office for the Coordination of Humanitarian Affair
VDC	Village Development Committee
WFP	Word Food Programme
WHO	World Health Organization
WR	West Rapti

GLOSSARY OF SOME LOCAL WORDS/TERMS

Word	Meaning
Attaiya	The upstairs used to storage materials in order to save from flood
Bandh	Dyke
Barro	A kind of local spice having medicinal values
Bhakari	A bin (usually used for keeping grains)
Bigha	Unit of measurement of Land in Nepal. 1 Bigha=0.67772 ha
Bojo	A kind of local spice having medicinal values
Dal	Lentil soup
Dehari	Bin made up of mud for storing grain
Doko	a large sized basket made of bamboo
Duban	Inundation
Ghar	House
Gharelu	Domestic
Gurjo	A kind of local spice having medicinal values
Harro	A kind of local spice having medicinal values
Kachhi Ghar	Houses with earthen thatched walls usually with thatched roof.
Kala jira	A kind of local spice having medicinal values
Katan	Bank Cutting
Kattha	Unit of measurement of Land in Nepal. 1 Bigha= 20 Kattha=0.67772 ha
Khar	Hay
Khatiya/Palang	Bedstead
Khola	Small River
Khoret	Foot and mouth diseases
Machan	An elevated platform usually for storing wood, hay etc.
Marich	Pepper
Nala	Rivulet
Pakki Ghar	Houses made of cement/lime mortar, wood etc
Parma	
Patan	Sediment deposition on the land
Pihan	A kind of cooking stand made up of mud.
Roti	A kind of bread eaten in South Asia
Sakarkhanda	Sweet Potato
Savah	Drain
Sidra	Sun dried fishes
Village Development Committee (VDC)	Smallest administrative unit in Nepal
Village	Settlements. A VDC has a number of villages or settlements.

CHAPTER 1: Introduction

1.1. Background

Nepal is known all over the world as a hot spot for disasters. Over the last 24 years (1983-2006), every year 867 people lost their lives in Nepal on an average (DWIDP, 2006). Landslide and floods have claimed about 300 people per year (Table -1.1), which is almost one third of the total deaths due to all disasters together. It is widely felt that the number of deaths is still high because many of the deaths remain unreported. Quite a significant portion of GDP is lost every year due to natural disasters, and is a burden to a poor country like Nepal. It is said that the poor, marginalized and disadvantaged group of people is hit hardest by any natural calamity. The most known natural hazards in Nepal are floods, earthquakes, landslides, debris flows, drought, snow avalanches, Glacial Lake Outburst Floods (GLOF), hailstorms, thunderbolts, cold waves, hot waves and epidemics.

TABLE 1.1: DAMAGES DUE TO FLOOD, LANDSLIDE AND AVALANCHES (1983-2006)

YEAR	Death of Persons (Nos.)	Injured Persons (Nos.)	Loss of Livestock (Nos.)	Houses Destryoed (Nos.)	Family Affected (Nos.)	Land Affected (Ha.)	Damage of Public Infrastrcutre (Nos.)	Estimated Direct Loss (Million NRs.)
1983	293	NA	248	NA	NA	NA	NA	240
1984	363	NA	3114	7566	NA	1242	869	37
1985	420	NA	3058	4620	NA	1355	173	58
1986	315	NA	1886	3035	NA	1315	436	16
1987	391	162	1434	33721	96151	18858	421	2000
1988	342	197	873	2481	4197	NA	NA	1087
1989	700	4	297	6203	NA	NA	NA	29
1990	307	26	314	3060	5165	1132	NA	44
1991	93	12	36	817	1621	283	25	21
1992	71	17	179	88	545	135	44	11
1993	1336	163	25425	17113	85254	5584	NA	4904
1994	49	34	284	569	3697	392	NA	59
1995	246	58	1535	5162	128540	41867.28	NA	1419
1996	262	73	1548	14037	36824	6093.4	NA	1186
1997	87	69	317	1017	5833	6093.4	NA	104
1998	273	80	982	13990	33549	326.89	NA	969
1999	209	92	309	2538	9768	182.4	NA	365
2000	173	100	822	5417	15617	888.9	NA	932
2001	196	88	377	3934	7901	NA	NA	251.1
2002	441	265	2024	18181	39309	10077.5	NA	418.91
2003	232	78	865	3017	7167	NA	NA	234.78
2004	131	24	495	3684	14238	321.82	NA	219.28
2005	141	31	360	1102	2088	-	NA	130.56
2006	114	39	9980	3334	18385	3396.84	NA	288.63
TOTAL	7185	1612	56762	154686	515849	99544.43	1968	15024.26
AVERAGE	299	81	2365	6725	27150	5530	328	626

Source: DWIDP/2006 NA: Not available

Global Natural Disaster Risk Hotspots analysis report (Dilley *et al.*, 2005) shows that Nepal falls on 11th position on disaster venerability in the world and half of its population is under the threat of 4 types of disaster at a time including flood. It is estimated that more than 1000 people die and around 40 thousand peoples get displaced with the overwhelming damage of infrastructure and economic resources of the nation by a number of disasters recurring every year.

While Nepal's unique geographical and climatic conditions and complex geology can explain the severity of water induced hazards, the vulnerability due to poverty, lack of public awareness, or inadequacy in preparedness, weak governance practices, little coordination among government and other agencies, inadequate financial resources, lower level of technical knowledge in mitigation of natural disaster explain the increasing impact of disasters.

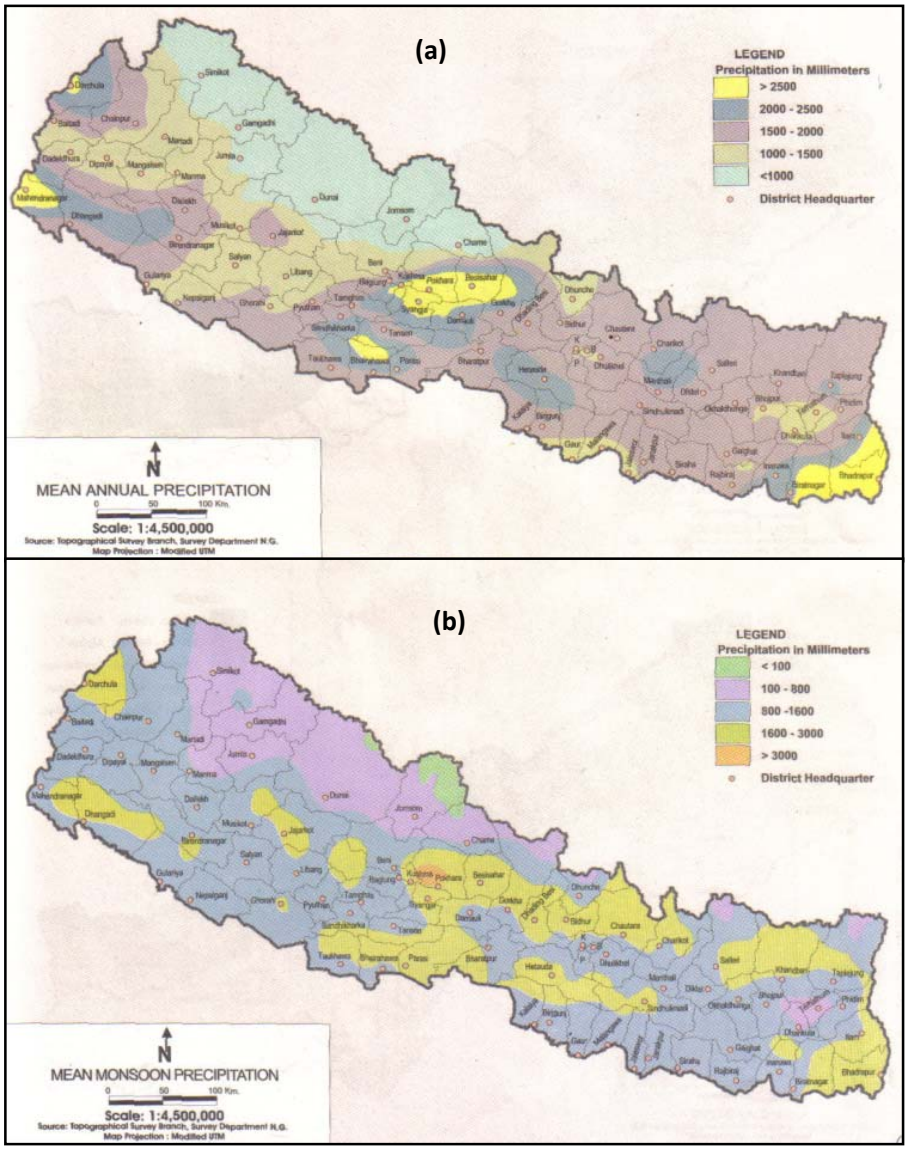

Figure 1.1 Temporal Distribution of Precipitation a) Monsoon (Jun-Sept) b) Annual

Source: Everest Atlas, Everest Map Publication, 2005

Hydrology

The distribution of precipitation in Nepal is uneven and is mainly governed by topography and location of the area. The Figure 1.1(a) and 1.1(b) shows the average annual and monsoon precipitation. Nepal experiences major floods during the monsoon season (June to September) which accounts about 80 % of the total annual rainfall. High monsoon precipitation within a short

span of time results into large runoff from different catchments and consequently high water levels in the rivers causing widespread inundation and river bank cutting in the Terai plains.

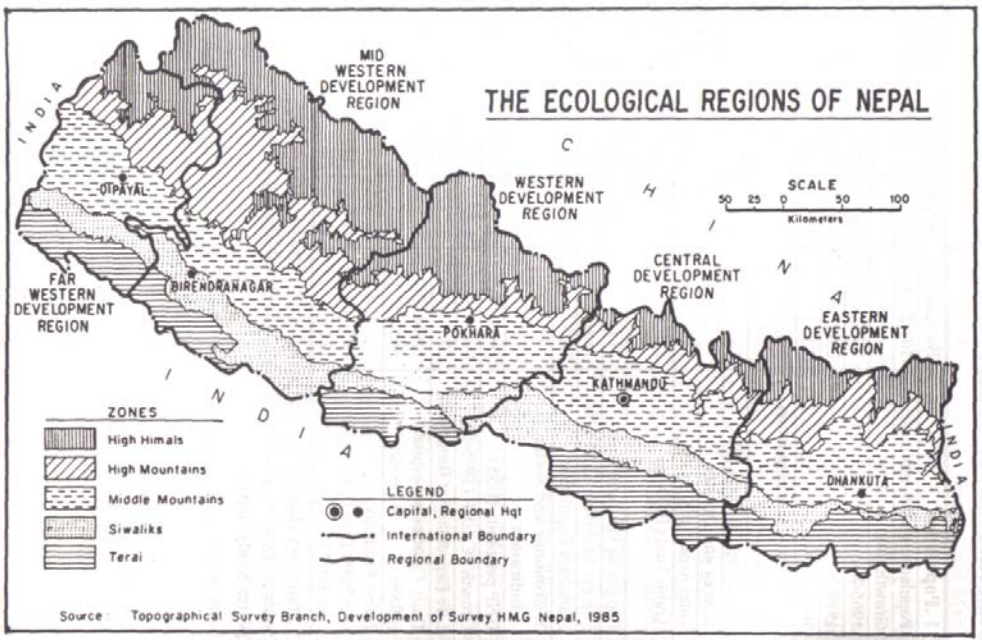

Figure. 1.2. The Physiographic/Ecological Regions of Nepal (Source: C.K. Sharma, 1997)

Physiographic and Geological Zones of Nepal

The country's topography rugged with over three-fourth area covered by fragile mountains can be susceptible to flash floods, landslides and debris flow. Just within an average north-south width of 193 km, the altitude varies from 90 msl in south to 8,848 msl in north. This north-south zone with diverse topographic features are represented by 5 physiographic zones namely Terai plains, Churia hills (Siwalik), Middle Mountains, High Mountains and High Himalayas. The Terai plains starts from the foothills of the Siwalik and is generally flat. It runs east-west in the southern part of the country bordering India and cover a narrow stretch of width 20-50 Km. The Siwalik zone covers a narrow strip of land running east-west in between Terai and Middle Mountains. As one goes north from the Siwalik, the Middle Mountains, and High Mountains zones followed by the High Himalayas come across. Similarly, the tectonic framework of about 800 km long Nepalese Himalayan belt is generally divided into five major contrasting tectonic zones having east-west extension. From south to north, these zones are: Terai Zone, Churia (Siwalik) Zone, Lesser Himalayan Zone, Higher Himalayan Zone, and Tibetan-Tethys Zone. Separated by major faults, each of these zones is characterized by their own distinct lithology, tectonics, structure and geological history.

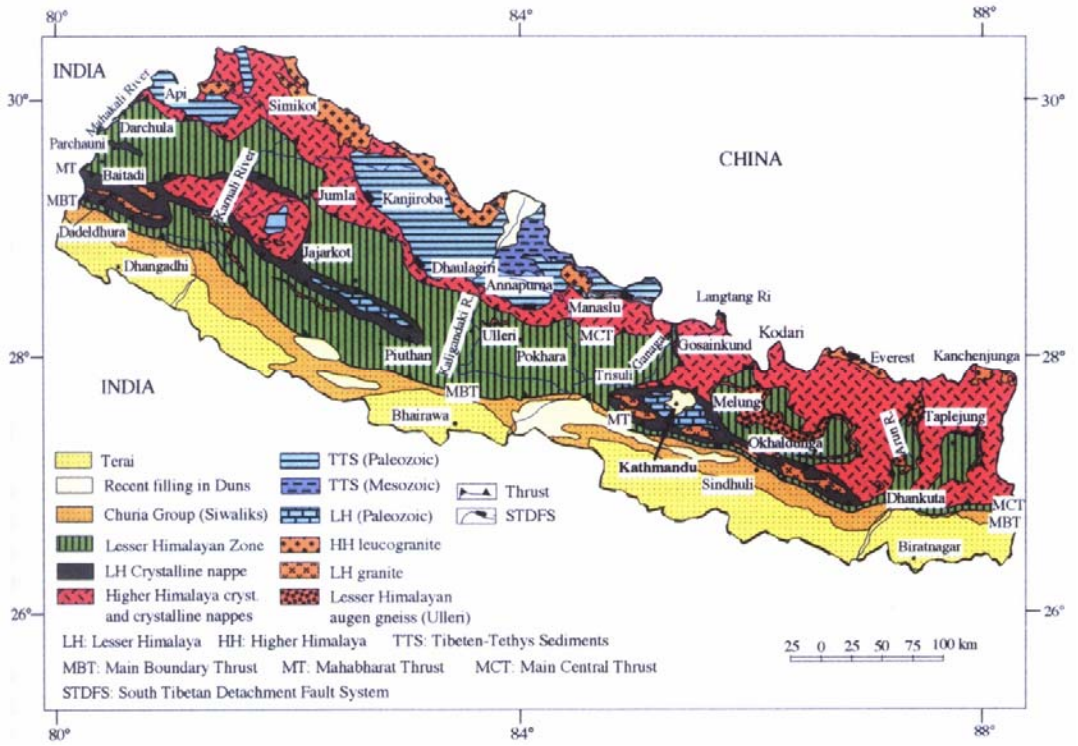

Figure 1.3 Geological Map of Nepal (Source: Uprety, 1999)

The Terai Zone is a part of the Indo-Gangetic alluvial basin with northern boundary marked by the Himalayan Frontal Thrust (HFT), also known as the Main Frontal Thrust (MFT) that separates the Terai Zone with Churiya (Siwalik) Zone. The Terai zone is made up of about 1500 m thick alluvium of Pleistocent to recent age (1.8 million years to the present). Underlying these sediments are rocks of Siwalik Group.

The Siwalik Zone lies just to the north of the HFT and it includes the Himalayan's southernmost hill ranges that rise abruptly from the plane of the Terai. Rocks found in this zone are consisted of fluvial sedimentary rocks of Neogene to Quaternary age (14-1 million years ago). Major rock types include sandstone, shale, conglomerate and mudstone. Due to the fragile character of the rocks, during the monsoon a great amount of sediment is washed out from the Siwalik hills into the rivers originating within or to the north of the range. Landslides, riverbank cuttings and debris flows are common problem in the Siwalik Zone. The northern boundary of the Churia Zone is marked by a fault known as main Boundary Thrust (MBT).

The Lesser Himalayan Zone is bordered to the south by the MBT and to the north by a major fault of the Himalaya known as the Main Central Thrust (MCT). The MBT is a low-angle reverse fault that has brought the older Lesser Himalayan Rocks over the youngest Siwalik rocks. Rocks found in this zone are sedimentary, and meta-sedimentary rocks such as shale, sandstone, limestone, dolomite, slate, phyllite, schist and quartzite, ranging in age from Precambrian (as old as 1,800 million years) to Eocene (about 40

40 million years). Since the rocks in this zone are highly folded and faulted, major geological problems include stability of slopes, riverbank cutting, debris flows and landslide dams.

The Higher Himalayan Zone is bordered to the south by the MCT and to the north by a major fault of the Hiamalaya known as the South Tibetan Detachment System (STDS). The STDS is a normal fault. This zone consists of high-grade metamorphic rocks such as gneiss, migmatites, schists, quartzite and marbles. Because of very steep slopes and highly jointed rock masses, rock slide problem is the major geological problem of this zone.

Tibetan-Tethys Zone adjoins the Higher Himalayan Zone with a normal fault contact (the STDS) and extends north into Tibet. This zone is composed of sedimentary rocks such as shale, limestone and sandstone, ranging in age from Cambrian (570 million years ago) to Cretaceous (70 million years ago). Most of the High Himalayan peaks of Nepal are made up of these Tethys Himalayan rocks and of young granites intruding into them. Snow avalanche, landslide and debris flow are the major geological problems of this zone.

Flood Problems in Terai

Nepal's Terai region is the part of the Ganges/Brahmaputra River Basin, which is one of the most disaster-prone regions in the world. The Terai region amounting to only 17% of the total area of the country and regarded as the granary of Nepal is continuously suffering from flooding. The rivers in this area become wide and braided with wide spread damages to agricultural lands. The damages are further characterized by erosion of banks and deposition of infertile coarse material on the cultivated land. The channel capacity of the rivers in this regime is said to be decreasing due to increased sediment coming from increased erosion rate at upland, thus making these rivers unable to accommodate large floods; as a result the adjoining area suffers from inundation.
Besides, natural factors, anthropogenic factors also trigger floods and disasters. Encroachment of floodplains, obstruction of natural flow of rivers and sheet flow, faulty drainage system and river training works also contribute to the increased flooding and disaster. In Terai, devastation due to flood is also increasing due to rapid increase in population and human activities. The flood plains are being increasingly crowded to meet ever-increasing demands of food and fiber, and consequently the flood problem is exacerbated. Similarly, many hydraulic structures (dams/barrage, and bunds) constructed in some places just a few kilometres downstream of Indo-Nepal boarder on the Indian side could have also exacerbated the flood situation in the Terai of Nepal (Bhusal,2004).

The devastating floods and incessant rains affect Terai region and cause extensive damage to standing crops, physical and social infrastructure, environment, people's lives and livelihood and weaken the capacity of rural poor. Many people who live along the flood plains are poor, and are frequently overwhelmed by floods and other life-threatening extremes of weather. Because of economic reason, the poor and disadvantaged people of the rural communities are forced to settle in the areas adjoining riversides, marginal and vulnerable areas and therefore are the victim of flood disaster every year.

Figure 1.4 Map of Banke District with study VDCs shown (Source: District Profile Analysis of Banke, 1998)

Although various flood management measures are introduced in many places to prevent the negative consequences of flood disaster, the challenges are still at the forefront. It is generally found that the national government, local administration and the government have been mostly reliant on reactive approach to disaster management focusing mostly on the relief operation. Although relief operation is essential for proper flood disaster management, this is not adequate in itself and thus there is a need of measures for preventing hazards turning into disaster. Moreover, under proactive approach of reducing disaster risk, it is necessary to reduce the vulnerability of the people through improved livelihood opportunities and capacity build up and thus increased resilience. For designing an effective and efficient framework of disaster management there is a need to understand the grassroots problems, the institutional set up, and the livelihood assets of the community including local knowledge in flood management. Under these assumptions, this study aims to identify the current problems at local level, the initiatives undertaken by the community through their local knowledge to manage the flood disaster. While many studies have been conducted for reducing the disaster risk in many river basins of Nepal, most of these studies have been lopsided with major emphasis on the structural measures and have failed to address the root cause of disasters. The West Rapti (WR) River is one of the major rivers of Nepal which supports and affects lives of several thousand population in the Banke district having one of the lowest Human Development Index (HDI), high population and low infrastructure facilities (Fig.1.4) in

Nepal. There have been a few studies in the basin and even those studied are not comprehensive. The present study is a joint research study by Nepal Development Research Institute (NDRI), Nepal and International Center for Water Hazard and Risk Management (ICHARM), aimed at investigating the flood disaster problem for finding the root causes and devising strategy to manage flood with community-based approach by targeting improvement in the resilience of the community within the broader framework of enhancing livelihood options and poverty alleviation.

1.2 Objectives

Broadly, this study is in line with the exploration for a best practicable strategy for the implementation of suitable projects or programme to mitigate flood disasters and to alleviate poverty in the region and nation in a long run. The specific objectives of the study are:

i) To assess the flood situation in the study area, the history of flood, the causes, aggravating factors, extent and effects.
ii) To assess the flood hazard and vulnerability, and various capacities of the community.
iii) To assess the sustainable livelihood strategy of people in the study area and the activities required for the improvement of the assets.
iv) To study the local knowledge, practices and beliefs on flood forecasting, early warning and flood management in the community.
v) To formulate community based plans for flood mitigation and flood disaster risk reduction.
vi) To devise a broader framework of community based disaster management strategy targeting poverty alleviation and improved livelihood options.

1.3 Framework for Implementation of the Study

The study consists of three phases described below. It has started in August 2007 and will extend until March 2010. Figure 1.5 presents the broader framework of activities of the research.

Phase I- Basic Study on Socio-economic Aspects of Flood Disaster and Community Based Approach of Mapping Flood Vulnerability (August 2007 to March 2008) : The study consists of literature review, primary and secondary data collection, field investigation, consultation meetings, formation and meetings of research-interest team, preliminary hydrological analysis and hydraulic modelling. The core component of the research output is based on the household survey and community based flood risk mapping.

Phase II- Engineering Study (April 2008-September 2009) : This study will consist of further data collection, improved hydrological analysis and hydrological and hydraulic modelling including the investigation of river shifting. The results from this phase of study will lead to the exploration of potential countermeasures and their quantitative and qualitative evaluations.

Phase III- Compilation of Results and Recommendation for Suitable Countermeasures (October 2009-March 2010)- Current and past approaches of flood disaster management from other parts of the country or region will be analyzed and the feasibility study of the potential project or programme will be recommended from the consensus of all stakeholders involved.

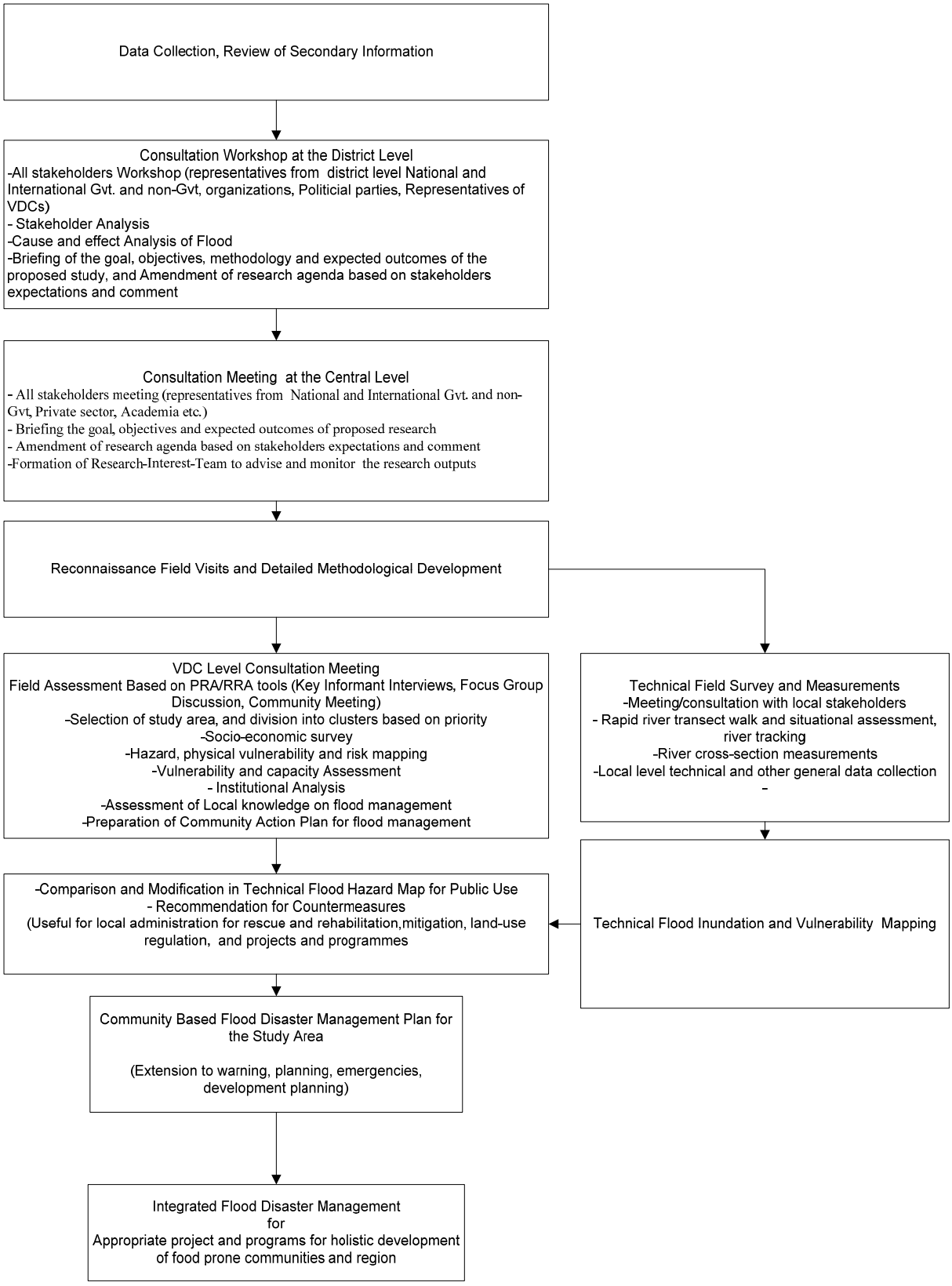

Figure 1.5 Framework of Study with Major Activities Identified

Phase 2: The study will consist of detail investigation for proposing structural and non-structural countermeasures, preparation of project proposal and policy recommendations for submission to the government and funding agencies.

1.4 Methodology

The methodology for the two phases of the proposed work is outlined in the flow chart (Fig. 1.7).

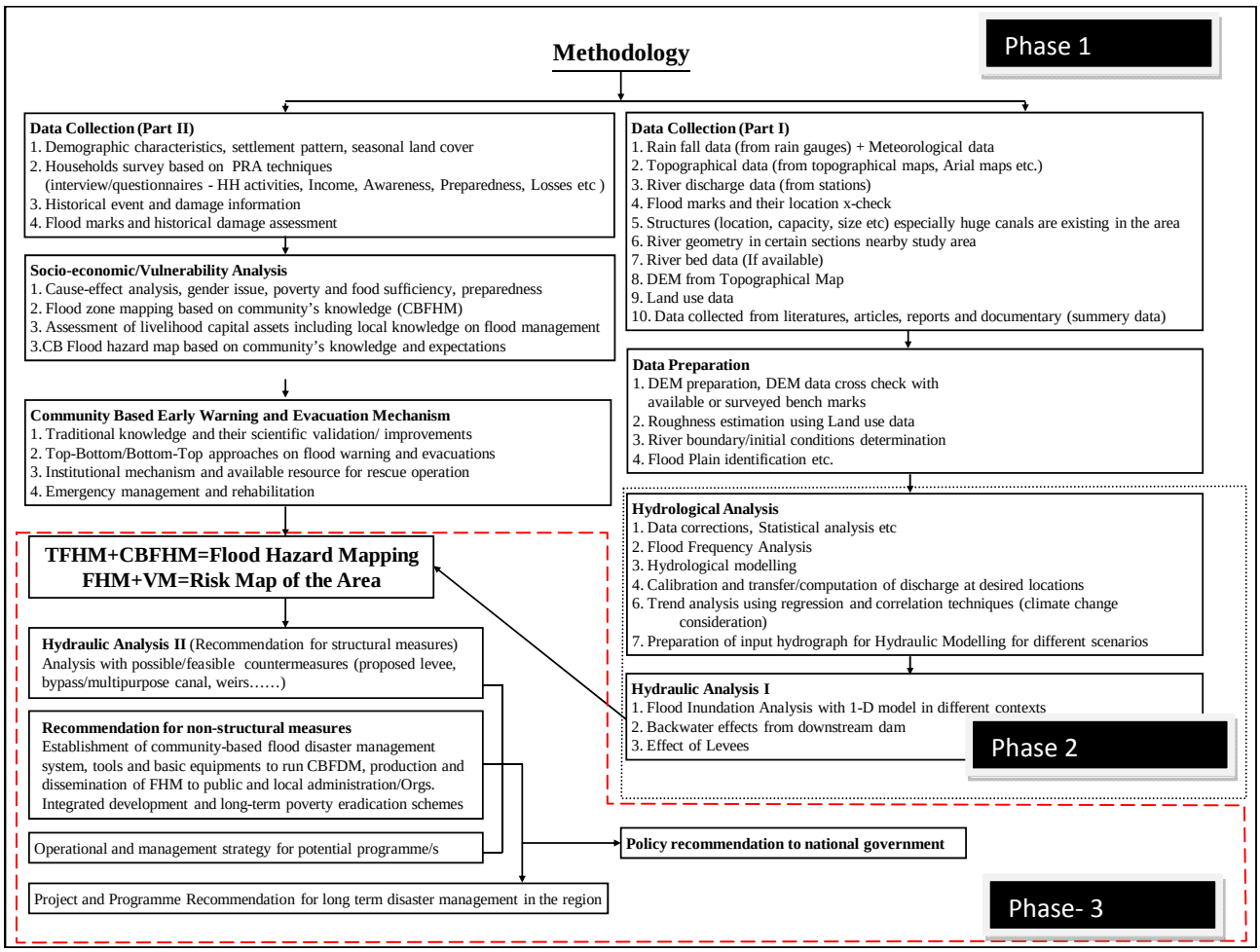

Figure 1.6 Methodology of the Study

As outlined in the research flow chart, consultation with potential stakeholders is the principal aspect of this study. The study began with consultation workshop and meeting (Annex I) at district and central levels respectively. In order to foster better coordination and consultation, a research-interest-team has been formed at the central level which has been meeting for discussion on the research issues and is proposed to continue until the next phase. Regular consultation with local stakeholders such as District Administration Office, District Development Office, Divisional Office of Department of Water Induced Disaster Prevention, and other national and international NGOs has been made. The detail methodology of the research includes a) literature review, b) data collection e.g. hydro-meteorological, topographical, river discharges, DEM, satellite images, land-use, infrastructures from secondary sources with

supplementation from field work for primary data collection, c) data preparation and validation, d) corrections to the missing or misleading data using statistical and other mathematical tools and determination of flood frequency e) hydrological modeling, f) Hydraulic modeling especially inundation analysis for different scenarios of magnitude of flood and in different contexts e.g. presence of obstructions in the natural flow of river such as levee, and barrage , g) socio-economic survey using participatory rural appraisal (PRA) techniques (Annex-VI), h) community based flood hazard mapping, and i) preparation of community action plan for flood management

1.4.1 Study Area

After consultation meeting with stakeholders and other agencies involved in the region, in order to avoid duplication and bring synergy , the feasibility study was mainly targeted on the left bank of the WR River, relatively inaccessible part of the Banke district (Fig. 1.4). The selection of Matehiya and Gangapur VDCs as research sites for the detailed socio-economic investigation was made in recommendation of relevant government's district line agencies and with inputs from the district level interaction workshop on October 2007. Nevertheless, the technical analysis was extended to all the relevant riparian VDCs. The Figure 1.7 also shows the clusters, major settlement areas and river networks in the research sites.

In order to systematize the study in detail, these VDCs were initially divided in to three main clusters. The division of the clusters was made in consultation with local stakeholders through introductory workshop in both VDCs in November 2007. Similar types of flood issues, severity and frequency of flood events, extent of damage and scale of casualties for last five-year trends were taken as basis for the selection of the clusters. However, to cover the two VDCs completely, a fourth cluster comprising of villages (settlements) of remaining wards of Matehiya VDC was later added. This was done to give a complete picture of the situation of the two VDCs.

The first cluster consists of Motipur, Mahadevnager, Kohala and Naibasti villages, all towards the northern parts of the VDCs. Similarly, the villages like Bhagwanpur, Newajigoun, Bhojpur and Dondra are in cluster 2 and are at the south-east section of the VDCs. While Sonbarsa, Jamuni, Gangapur and Kudarbetwa make the third cluster in south-west corner of the VDCs, Mateheiya, Hulaspur, Jamunaha, Sarbarajpurwa and Maheshpur constitute the remaining (south-east) part of the Matehiya VDC.

These villages are continuously affected by floods from small, flashy rivers and West Rapti River. The description of the villages under each cluster is discussed here under.

Cluster 1: Northern Villages

Located in the northern part, the villages of cluster 1 are affected by flash flood of rivers originating from Siwalik/Churia. The Churia range has been mostly deforested contributed largely by the encroachment from the neighbouring settlements and excessive grazing. The geography of these villages is partly sloping and mostly flat. The major flashy rivers are Saunjwa, Jhaparchalli and Dondra (please refer Table 1.2). These rivers begin at high elevation and therefore are especially devastating in nature with high velocity during monsoon. They carry boulders, stones, sand, wooden trunk with water

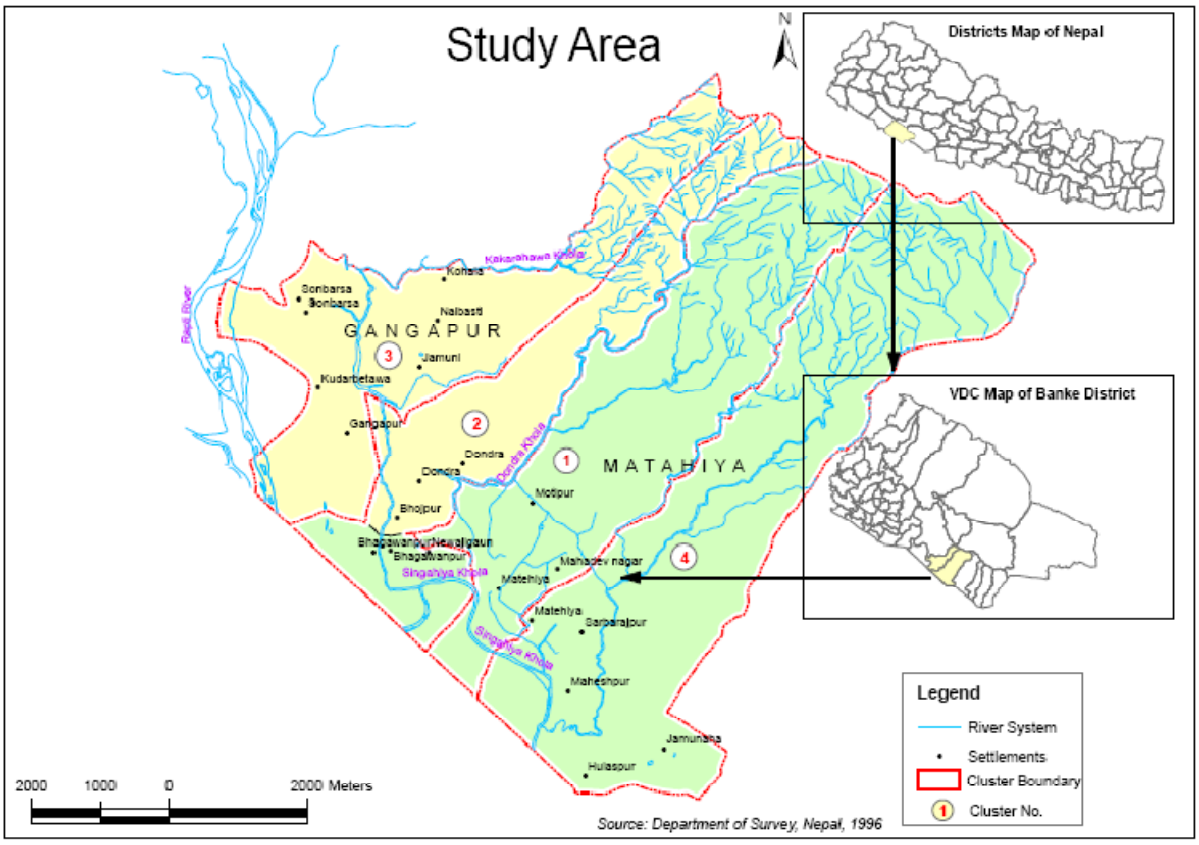

Figure 1.7 The Study Area With River Networks and Settlements Shown

which gets silted in the lower area when the velocity is decreased. Flood from these rivers also erodes banks and damages hundreds of hectare paddy land alongside. In the winter season, however, all these rivers dry completely.

It is reported that Motipur, Mahadevnagar, Kohala, Naibasti and Dondra villages are being affected by these rivers to a greater extent. During Monsoon (June to September), these rivers create havoc to the communities settled along the bank.

Despite the presence of two community forests (Ganapati and Gaza Community Forest Users group, CFUGs, of Metehiya), the rate of forest depletion is at rise since the last decade. It was reported that the extraction of stone and boulders from the lap of Churia has caused further increase in the soil erosion rate. Even with a small flood, the villages along bank are affected because of rise of the bed level of these torrents due to over siltation. Despite of resourcefulness of CFUGs, they were not effectively mobilized for the flood control measures.

Flood disaster in this cluster is in increasing order. Until 1993 only Motipur village was affected from flood but slowly the villages towards the southern part of the Motipur are also affected. According to the local farmers, the rate of crop (paddy, wheat, oilseeds, maize, mustered etc.) damage is also increasing in the recent years.

Clusters 2 and 3: Southern and Western Villages

The villages under these clusters are completely flat and low lying. Consequently, during monsoon they are mostly affected from flooding and inundation. The northern parts of these clusters are also affected by flashy rivers. Hence, these villages have multiple incidences of floods. People shared that the problem of flooding and inundation worsened after the construction of Laxmanpur barrage in India.

Each year, the flashy rivers carry boulders and sand and deposit near Newajigaun. As a result, these rivers have been changing their courses and making their own way to old earthen road. As a result, Dondra village has been badly affected by flood. It was observed that the route of Sinhaiya River (near the earthen road) has been closed due to sand deposition by Dondra River. Such sedimentation started from 1995. During the monsoon, Dondra River is highly hazardous. Local people during the discussion argued that the improved canal coming from Phattepur VDC links with Sinhaniya River and creates havoc several parts in its route.

Cluster 4: Southern and Eastern Villages

This cluster also has flat topography but is relatively far from the WR River. It was relatively less affected during the floods compared to other clusters. Nevertheless, it was affected by the continuous heavy rain and floods of 2006 and 2007.

Table 1.2: Name of VDCs/villages and Rivers by Cluster

Cluster	VDCs/villages	Location	Major Rivers
1	Matehiya-Motipur, Mahadevnager,	Northen part of the VDCs	Saunjwa, Jhaparchalli and Dondra
	Gangapur- Kohala, Naibasti		
2	Matehiya- Bhagwanpur, Newajigoun	South-east part of the VDCs	Sinhaiya, Dondra/Rapti River
	Gangapur-Bhojpur, Dondra,		
3	Gangapur-Sonbarsa, Jamuni, Gangapur, Kudarbetwa	South-west part of the VDCs	Sinhaiya, Rapti River
4	Matehiya- Mateheiya, Hulaspur, Jamunaha, Sarbarajpurwa & Maheshpur	South-east Part of the VDC	Mahadevnagar Saujahawa, Dui Muhane and Gijarahawa

Source: Discussion with people, 2007

1.4.2 Data Collection and Analysis Tools

The details of data collection and analysis tools for the socio-economic part of the study are given in

Annex VI (1). For the inundation modelling using hydraulic model, HEC-RAS (USACE, 2002) was used and the details of the modelling are given in Chapter 6.

1.5 Structure of the report

This report is an outcome of findings of baseline study covering technical and social aspects of flood in the Banke District, Nepal. There are eight chapters in the report.

The first chapter describes the background, objectives, framework for implementation of study, and methodology of the study with overview of the research sites. The chapter gives overview of the flooding problems in Nepal, Banke district and the research sites.

Chapter Two describes the existing condition of the study area with overview of socio-economic and demographic setting, infrastructure and transportation network, historical flood disasters and their impact on livelihoods. The details of involving agencies and community based local institutions contributing towards livelihood improvement and poverty alleviation are given. The chapter also describes the flood problems in the district and the study area in details with discussion on the cause-effects analysis, institutional arrangement including stakeholder analysis, and characteristic of most recent flood events.

The second chapter also covers basic information of the study area in terms of topography, river geomorphology, geology, hydrology and meteorology. The chapter also includes some general hydrological and statistical analysis (flood frequency and trend analysis of rainfall and temperature), information about river bank situation observed during the technical field survey, and brief overview of river channel migration of the WR River.

Chapter Three describes the existing hazard, vulnerability and capacities of the community in the study area in details. The chapter also presents participatory flood hazard and physical vulnerability maps, and risk map of the settlements and infrastructures which are under imminent threat besides potential evacuation route and shelters. In addition, the local knowledge, beliefs and practices related to flood forecasting, early warning and flood management at various stages are also discussed in depth.

Chapter Four describes flood and livelihood aspects in the research sites with options and strategies for sustainable livelihood. The livelihood assets in the study area are described in details in relation to flood disasters with recommendation for activities for enhancement.

Chapter Five presents the action plan prepared by the communities in the study area for flood control and mitigation. Similarly, Chapter Six covers the details of hydraulic analysis carried out for inundation mapping and assessment of impact of flood control structures in Indian side on Nepal. While the Seventh chapter gives an overview of the possible outline of the next phase study based on the feedback of the first phase, the eighth chapter gives conclusions over key issues and recommendations.

The Draft Final Report of Phase 1(a) study consists of the following components.

i) Main Report

ii) ANNEX I: Report of Consultation Workshop at Nepalgunj and Consultation Meeting at Kathmandu

iii) ANNEX II: Geomorphologic Features of the WR River at Different Reaches of the Rivers between the Cross-Sections (Field Survey,2007)

iv) ANNEX III: Various Methods of Flood Frequency Analysis

v) ANNEX IV: Cross-Sections and Results of Inundation Mapping using HEC RAS

vi) ANNEX V: Photos in the Field and Areal photos from Google Earth

vii) ANNEX VI: Supporting Report

viii) ANNEX: VII Additional Maps and Data

a. DEM data of lower basin based on contour data from Department of Survey.
b. Rainfall and meteorological data
c. Discharge data
d. Land use/Land cover data of lower basin
e. Cross sectional data measured in the field.
f. GPS survey River tracking data

Chapter 2: Existing Condition of the Study Area

2.1 General

Participatory Rural Appraisal (PRA) tools were applied to study the existing condition of the study area, the details of which are provided in the supporting report (ANNEX VI-1). The study was initiated after consultation workshop held at Nepalgunj. A short visit to the flood affected areas was made in the study area to interact with local leaders and other community members as a precursor to the detailed PRA Survey and planning. In addition, a local level consultation workshop comprising of flood affected people, VDC functionaries, local level political leaders, social workers, teachers, deprived group members, etc. was held at the beginning. The main agenda of the workshop was to share the rationale and objective of the study and role of local people and stakeholders in the study.

2.2. Socio-economic Aspects

2.2.1. Population, Ethnic and Religious composition

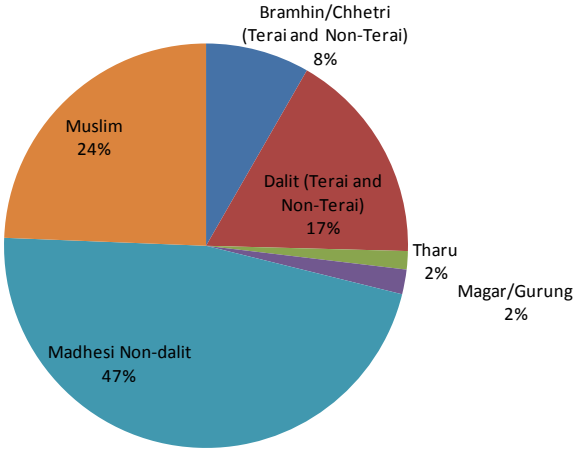

Figure 2.1 Ethnic Composition of the Study Area

The total households (HHs) and population in the study area is 2028 and 13256 respectively (Annex VI-2), which gives the average population size per HH as 6.01. Female with 51.1 % of the total population, slightly outnumber the males in the study area. The ethnic composition of the study area is show in Fig. 2.1. Details of disaggregation of population in terms gender and ethnicity in each settlement in the study area is given in the supporting report (Annex VI-3). In terms of religion, Hinduism and Islam are the major faiths practiced in the area. More than 70% population practice Hinduism or its variants and about 24 % of the population practice Islam. The caste and ethnic composition in the study area include Brahmin/Chhetri (both Terai and Hill origin), Dalit (lower caste on caste hierarchy) of hill origin, Tharu, Rana Magar, Terai Non Dalit[1], Terai Dalit[2] and Muslim. The majority of the population in the study area belongs to Madhesi ethnic group which has caste systems like Bramhin/Kshatriaya, other non-dalits and dalits. While non-dalits belonging to Terai and hill origin inclusive of Bramhin/Kshatriya account 55% of the total population, the dalits belonging to both origins account 17%. The Terai indigenous group like Tharu, and hill ethnic groups like Gurung and Magar are in minority accounting only about 4 % of the total population.

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[2] *Terai Non Dalit includes Maurya, Yadav, Thakur, Mishra, Rad/ Kurmi, Gupta, Gosain, Kumhal, Kandu, Gadariya, Sahani/ Mahi/ Godiya, Sonar, Mali, Bhujwa.*

[3] *Terai Dalit includes Bhangi, Pasi, Luniya, Dhobi, Lohar, Bishwakarma, Baskhor, Chamar, Badhahi, Bahi, Bari, Khatik, Kalwar and Gaddi.*

2.2.2. Sources of Livelihood

The main source of livelihood in the study area is agriculture. Apart from this, seasonal labor (both on and off farm), services and businesses are other sources of livelihood. The percentages of these sources in the study area are 85, 13, 1 and 1 respectively (Figure 2.2). The practice of seasonal labor is high in cluster 3. Details of occupational composition by cluster are given in Annex VI-4.

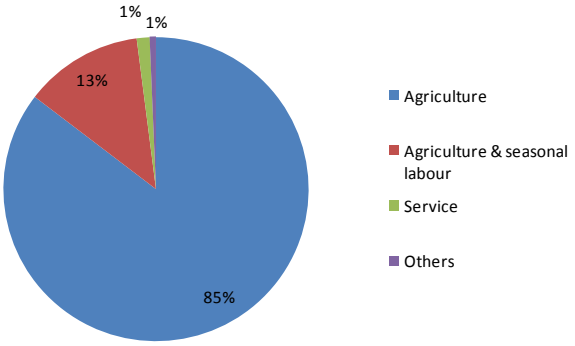


Figure 2.2 Sources of Livelihood in the Study Area

2.2.3 Food Sufficiency

The level of food sufficiency is very miserable. On an average, only about 19% HHs have food sufficiency for year round. A significant number of HH (12%) have food not enough for even 2 months. The number of months with food sufficiency is said to be decreasing with the increasing flooding and inundation problem in the study area. The level of food sufficiency of the farmers who reside along the Rapti riverbank is particularly very poor.

Table 2.1 Food Sufficiency Status in the Study Area

Number of Food Sufficient Months	% of Food Sufficiency HHs				
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Study Area
12 and surplus	35	20	18	13	18.8
6-11	15	60	34	52	46.0
2-5	40	15	32	20	23.7
< 2	10	5	16	15	11.5

Source: FGDs, 2007

2.2.4 Seasonal Migration

It was shared that after the heavy flood of 1985, people started to migrate seasonally in seeking alternative income sources. Since then, seasonal migration has become a common practice. About 60% of households have one or more family members away for labor purposes during some period of the year. While this secures a certain level of income and therewith food security, the earning is not impressive as it does not even suffice to pay back loan and run the family and house reconstruction. Seasonal migration normally peaks during November – January, after harvesting of the paddy fields and broadcasting of the winter crop. Some go even early before the monsoon crops plantation. As far as possible, male family members opt to stay at home to attend to rebuilding or securing of their houses before the seasonal migration.

The factors causing some population to migrate seasonally in search of livelihood are as follows:

- Continuous flooding, inundation and sedimentation cause the failure of crop production.
- With the population pressure land is fragmented, and people are not in the position to grant their land to others as sharecropping and on rental basis. People cultivate their land themselves.
- Less opportunities of on-farm labor within the village.
- Loss of livestock due to outbreak of diseases.
- Less interest in subsistence agriculture due to continuous distress and trauma on the crop failure.
- Less land being cultivated within the village.

In search of alternative employment opportunities many people and mostly the youth are forced to go outside the village and work in nearby cities within Nepal and India, leaving women, children and old-aged people at home. In such situation, these groups of people become further vulnerable from flood disaster.

2.2.5 Infrastructures

It has been several years since the construction of a bridge linking Nepalgunj and the eastern part of WR River has started. Without bridge, the areas east of West Rapti River have been isolated from Nepalgunj, the district headquarter. This isolation is felt more during monsoon when there is inundation all around and there is risk of travelling across the river in boat (many people died when a boat drowned in 2007). There are old and new earthen roads in the study area which have been found to have inadequate cross drainage structures. A number of culverts and cross drainage structures have been found to be defunct due to silting up of the torrents/rivulets. In general, most of the earthen roads in the areas go out of order during monsoon. There is no electricity in the study area, although some electric poles without wire can be seen extending from west to east of the area. Similarly there is no telephone facility in the study area. The area in general can be said to have been less privileged in terms of infrastructure.

Very few flood protection activities have been carried out in the study area. There have been some initiation at the community level, but most of those initiations have either failed to materialize or did not bring the effect as desired. The issues related with these initiatives are reported in the Supporting Report. The Figures 2.3 through 2.5 show the infrastructure and other facilities in the Banke district including the study area.

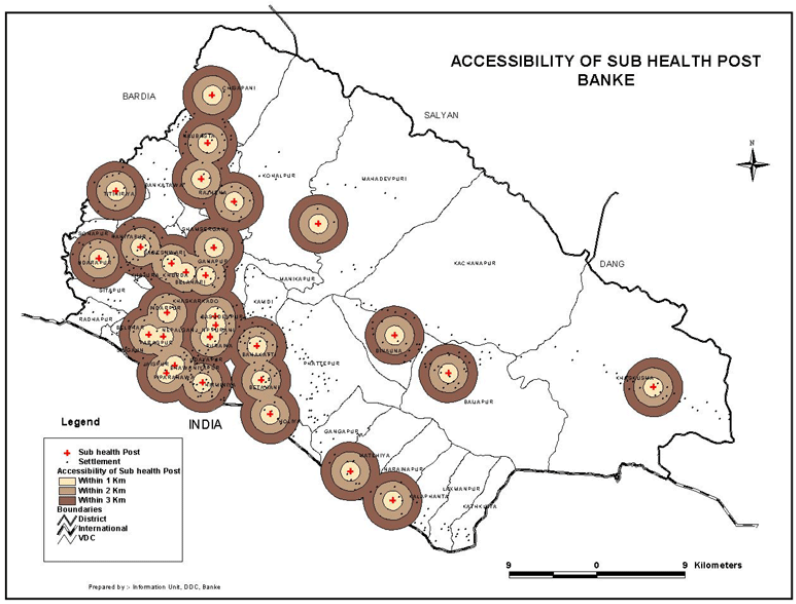


Figure 2.3 Accessibility of Sub-Health Post in the District and the Study Area
(Source: District Periodic Plan, 2001 DDC, Banke)

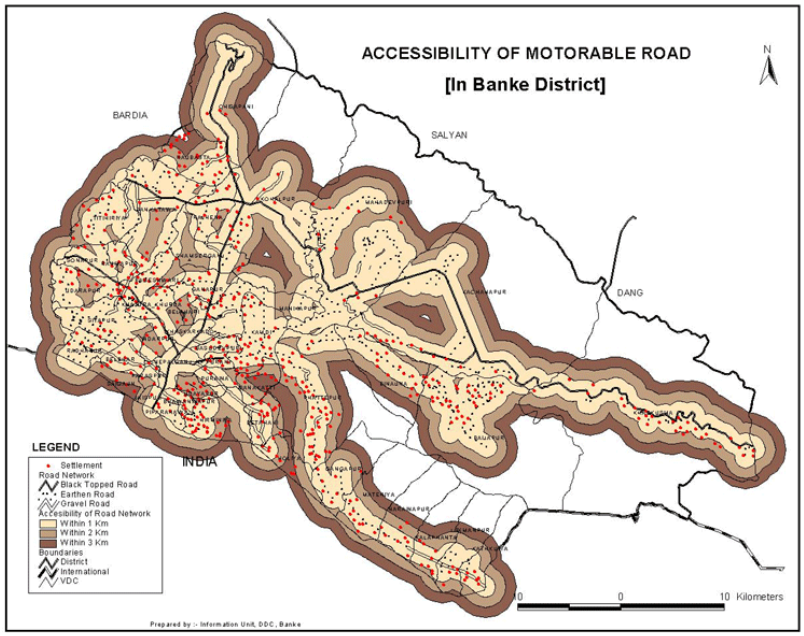


Figure 2.4 Accessibility of Motor Road in the District and the Study Area
(Source: District Development Plan, 2001 DDC, Banke)

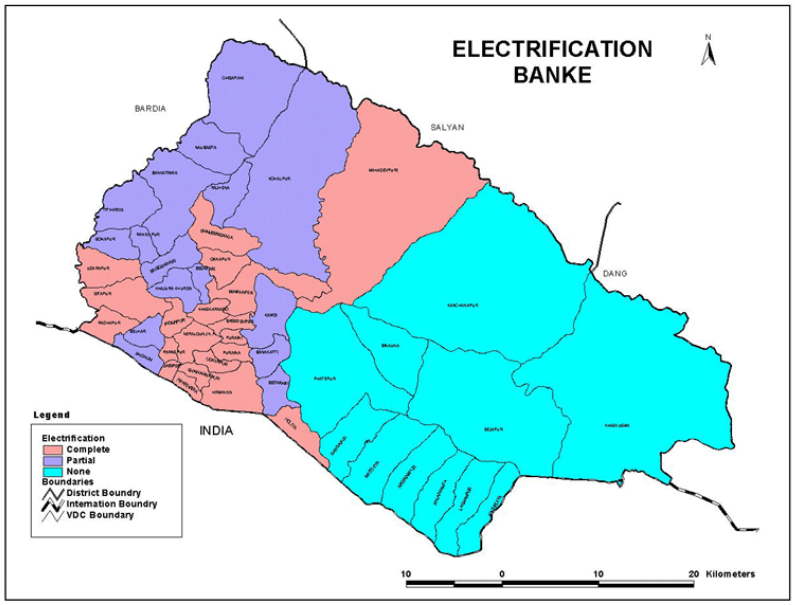


Figure 2.5 Electrification status in the District and the Study Area
(Source: District Periodic Plan,2001 DDC, Banke)

2.2.6 Historical Flood Disasters and Their Impact on Livelihoods

Recurrence of flood is common during the monsoon season. It is learnt that the area under inundation and flooding is increasing in the study area since last twenty years. The flood damage situation is further divided into two parts: damage of physical assets and social assets. People in the study area shared that there is increasing trend of damages due to flood in the study area.

a) Physical damages

People during the Focus Group Discussions(FGDs) stressed that flood recurrently damages physical infrastructures like houses, schools, sub-health post, road, culverts, marketing centers, gabion embankments, spurs, hand pumps, etc. Flood also damages the productive agriculture land, and livestock.

Fig. 2.6 Scene of damaged thatched house in Mahadevnager

Houses: The damage of houses is more visible and prominent. The extent of damage to the houses depends on the roofing and wall structures. It was found that unlike roofs with CGI sheets, straw roofs (thatched house)

exhibited water leakage after continuous rain. Further, mud walls that soak water were reported to collapse easily. The thatched houses are completely damaged after flooding whereas houses with cemented pillar, brick wall and concrete houses are partially damaged from the flood. The percentage of completely and partially damage of houses in Matehiya and Gangapur VDCs in the 2007 year flood is 30% and 40% respectively.

Agriculture land: Agriculture is the mainstay of the study area's economy. Almost 85% people directly depend on agriculture for their livelihood. For majority of the people, there is hardly any surplus land since the size of the landholding is very small. Very few well-off farmers have switched from domestic to commercial farming as a large area of agriculture land is being swept away or made unproductive by the flood through river cutting, sedimentation and inundation. It was seen that mostly the villages along the Rapti River and at the lap of *Churia (Shiwalik hills)* are suffering from river cutting whereas other villages are suffering from flooding, inundation and sedimentation. Four major crops paddy, maize, wheat and vegetable are reported to be damaged by the flood. The highest damage is seen in paddy and the lowest in wheat (wheat being the winter crop). The estimate made by the community suggests that crop production has reduced in recent years when compared to the production some 20 years ago. As per their estimate, the land productivity for paddy in the inundated area has reduced by over 36 %, 80% and 74% in cluster 1, 2 and 3 respectively. The land productivity has been reduced for almost all types of crops in all these clusters (Please refer the supporting report for details). The Table 2.2 below shows the production scenario of cluster three and rest others are given in Annex VI-5. The production of paddy was reported reduced due to inundation, flooding and sand deposition whereas that of the winter crop is due to dampness and late cultivation. The delay in cultivation of paddy hampered and delayed the cultivation of winter crop; flooding and inundation resulted into the land damp and difficult to plough for broadcasting of winter crops.

Table 2.2: Comparison of crop production within 20 years in Cluster 3

Crop	**20 Years ago (quintal/B*igha*)**	**Present (quintal/B*igha*)**	**Reasons**
Paddy	27	7	Sedimentation of sand in farm land, reduced the farm land due to flooding
Maize	9	4	sedimentation of sand in farm land, effects of applying fertilizers
Wheat	18	5	sedimentation of sand in farm land, effects of using fertilizers and improved variety of seed
Mustard	12	0	sedimentation of sand in farm land
Oilseed	9	0	Over moisture, sedimentation of sand
Chana	8	0	Over moisture, sedimentation of sand

Source: Discussion with Farmers, FGDs and KIIs

Livestock: The flood also caused losses of the livestock like goat/sheep, chicken, buffalo, cow/oxen, pig, etc. As the animal husbandry is the second largest means of livelihood after agriculture, sweeping of some of the livestock and deaths by flood of many others from unidentified diseases after the flood had impact on the livelihood of the people. While chicken suffered maximum death, buffalo suffered the minimum in the last years' floods.

Physical infrastructures: The flood has damaged the existing hume pipes due to poor drainage. People reported that the road situation during monsoon is very poor due to continuous flooding, erosion and sedimentation. It is estimated that the flood damaged roughly 28 km road in the study area in 2007. The same situation is of marketing centers, gabion embankments, spurs, hand pumps, schools and sub-health post. The physical condition of hand pumps (the sources of drinking water) and many other infrastructures is badly affected due to floods.

b) Damage of social assets

Similar to damage of physical assets, the flood has also eroded the social assets like: neighborhood, brotherhood, *Parma*[3] system, and strong bondage of kinship. The rate of erosion of social assets is continuing in the recent years. It was shared that when a community is hit by flood, many families are forced to evacuate in safe places for some period of time - some days to several weeks. As a result, all of the social institutions are likely to be affected during this period. Indeed, the entire social fabric that defines a population as a community is seriously weakened. People are compelled to relocate, some permanently, hence neighborhoods are destroyed, friendships are severed, support networks are broken and domestic relationships come under greater stress. Schools, social groups and families are apt to never be the same after the flood. After big flood, family roles and responsibilities undergo considerable change with worsened economic hardship and living conditions. It was also found that during the relocation, people are unable to adopt Parma system to ease the situation in the study area. The flood-affected families were reported to be living with relatives, some as welcomed and some as unwanted guests hence creating some crack in social milieu of kinship.

The careful analysis of time line and trend analysis of the study area revealed that the effects of flood are on increase. The flood damage is contributing in pulling the poor farmers in the vicious circle of poverty. Before 1985, there was only the problem of flood but now there is a problem of droughts and erratic rainfall even in inappropriate season. It has caused the damage of crops that is ready to harvest, or sometimes there is complete crop failure or low production. The rainfall in inappropriate season has caused sometimes the delay in cultivation and reduction of winter crop production. The resource of water borne disease was the common phenomenon in the recent years. The timeline of the disaster (mainly water induced) in the cluster-1 is given below. The timeline of other clusters are given in Annex VI-6.

[3] *Exchange of group labour*

Table 2.3: Timelines of Flood and Drought in the Study Area (Cluster-1)

1985	Paddy land inundated-heavy loss of crop production; seasonal migration outside the village for the first time.
1987	Problem of inundation during the paddy plantation (July-August); loss of 20-quintal paddy; failure in crop production; people were unable to transplant the paddy again due to scarcity of seedlings.
1989	Problem of inundation during the harvesting time of wheat; 16 houses were inundated where water level rose to above three feet; losses of 30-40 quintals paddy; people were unable to sow winter crops like maize, wheat, mustard and lentil in time; farmers were in immense debt and some were compelled to sale their land; livestock were attacked by unidentified diseases.
1991- 1995	Longer drought before the paddy plantation and flooding during the plantation decreased farm production; two HHs migrated outside the village due to severe problems of inundation during monsoon and continuous crop failure; increase in hunger and famine.
1996	An eight years old girl died due to the flood; 3 goats died; inundation during flowering period of paddy and crop failure by above 60%.
1997	Flood damaged the paddy ready to harvest (about 60-70 quintals); heavy seasonal migration to India and other cities of Nepal.
2001	Construction of Bagauda Road obstructed the flow due to poor drainage system and caused more flooding problems.
2002	Flood damaged the paddy ready to harvest (about 50-60 quintals); increased seasonal migration.
2003, 2004, 2005	Drought in Shrawan and Bhadra (August and September) and flooding on Kartik(November); damage of crop that was ready to harvest; outbreak of water borne disease like pneumonia, fever and diarrhoea.
2006	Drought in July; heavy rainfall in mid August and losses in the production of paddy; dispute among the farmers; many of them lost wooden poles, *halo* (plough) and *juwa* (instrument during ploughing) used for traditional ploughing; theft cases of livestock were reported; permanent out migration to Bardia (3 families) and Dang (1 family). About 122 HHs temporary migrated to *Chaubis bigha* side.
2007	Three houses completely collapsed and 250 quintal paddy lost; people were affected from water borne disease like diarrhoea, dysentery; flood killed large number of cattles; 12 houses were inundated and families were shifted to school compound for three days. About 18 HHs migrated to Chaubis bigha side.

Source: Discussion with Farmers, cross checked with the responses of FGDs

2.2.7 Involving Agencies /Local Organizations and their Role on Poverty Alleviation

District Development Committee (DDC) is the major line agency of the government entrusted with development work in all the VDCs of the district. In addition, a number of sectoral programs of government are run through other line agencies. Domestic conflict, budgetary constraint and problem of resource allocation have been major causes of difficulties for launching effective programs aimed at poverty alleviation. Activities of NGOs and INGOs were severely affected during conflict. Even after initiation of peace building process, the involvement of NGOs and INGOs in the study area is limited due to poor accessibility.

In terms of flood management, mostly the activities conducted in the study area are related to response, recovery and relief. A number of NGOs/INGOs have been involved on distribution of relief materials and support repair and reconstruction of houses and schools. The details of involving agencies working in the district are made in Section 2.4.6.

There are many local community level organizations and institutions which aim to improve livelihood, help poverty alleviation and manage flood disaster. They support range of activities from physical construction to improving agriculture and managing easy loan to the flood affected people. Apart from these, others supported activities are related to managing relief and rescue materials and improving awareness on flood preparedness. The number of these local organizations and institutions in the study area (disaggregated into 4 clusters) is shown in Fig. 2.7. Clearly, cluster 1 has more local initiatives as reflected by greater number of the organizations.

Saving and credit groups

- These groups by their nature make monthly savings and mobilize this amount in to credit among the group members in cheaper interest rate (1.5 to 2% per annum). The main objectives of these institutions are to ease the situation during the flood by providing immediate loan so that they can use it either in procuring the grain or repair the damaged house. Majority of such groups are formed by farmers' initiatives whereas some are under the Local Development Fund program of DDC. These groups are also linked with cooperatives to boost their transactions.

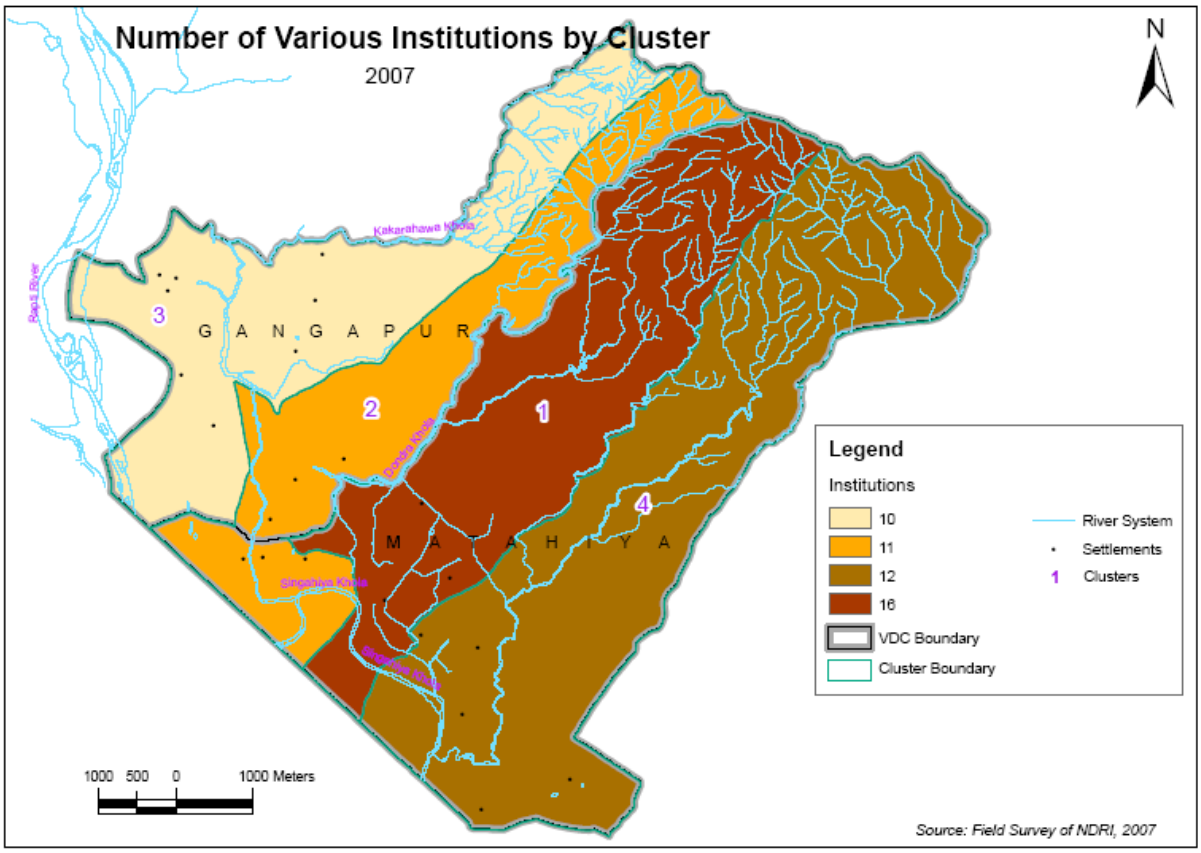


Figure 2.7 Number of Various Institutions in the four Clusters of the Study Area

Farmers groups

- These groups are formed by Agriculture Sub-service Centre(ASSC) to enhance the farmer's knowledge on the modern agriculture tools and techniques. It includes the selection of seeds, initiation for hybrid varieties of crops, and other agriculture inputs. The main motto of these groups is to produce more crops even from the small chunk of land. Technicians from ASSC with help of these groups sometimes facilitate the mass of farmers about the techniques of cropping even in the flood prone area suggesting appropriate seasons, cropping patterns, etc.

Local Community Based Organizations (CBOs)/Non-Governmental Organizations (NGOs)

- The main role of these social institutions is to raise the awareness of people in the flood preparedness, manage relief and rescue materials and flood disaster management. Bheri Environmental Excellence Group (BEE Group), a district based NGO, is working in Matehiya and Gangapur VDCs for raising awareness through school based disaster mitigation program with the support of Action Aid Nepal. It has been helping in the formulation of

DMC (Disaster Management Committee) to enhance their skills and knowledge on search and rescue, primary health care and flood disaster preparedness.

- Apart from these activities, NGOs and CBOs are also helping on establishing temporary flood shelters and relief camps, manage training to local teachers, students, youths, volunteers and NGO personnel, distribute relief and rescue materials, ensure the transparency in resource distribution, etc. These institutions are closely working with Nepal Red Cross Sub Branch, VDC office and police station.

Aama Samuha (Mothers' groups)

- Similar to saving and credit group, they are also involved in providing easy loan at the time of need within the group. Apart from these, they also support to manage the immediate food for the flood affected households. They work on a volunteer basis.
- They run the program at local level to strengthen the neighbourhood and brotherhood. They encourage people to adopt the parma system for the agricultures works and other household chorus. They encourage exchanging their foods to each other as per their household needs.

Health related organizations

- Immediately after the flooding, in coordination with District Public Health Office, Sub-health posts assess the situation and request for immediate heath camps to organize.
- They provide free check-up and distribute necessary medicine for flood victims.

VDC and schools

- These Institutions are mostly constructed with cement mortar and have concrete roof. Therefore, in many places, they were used as evacuation centers during the flooding. In addition, these institutions manage the food and other necessary materials immediately after the flooding in coordination with Nepal Red Cross. The role of school is to provide the space by closing the school for some days.
- VDCs also coordinate for the river training work; spur construction, culvert construction, weir construction, etc. with the support of divisional office of Department of Water Induced Disaster Prevention.

Community Forest Users Groups

- They are resourceful organizations at local level. They help the flood affected families with by providing timber for the construction of houses.

In a nutshell, all these organizations have been offering their services directly or indirectly to the flood affected people during the flooding season. The more the organizations in the village, the more services will be received by the flood affected people. It was observed that strong coordination and cooperation seems lacking among these institutions. As a result, sometimes there is service lacking or sometimes duplication of the services.

2.3 Flood Problems in the Banke District and the Study Area

2.3.1 General

Flood has remained a unique problem of the WR River for years. As learnt from the discussions with the locals in the study area and other riverine VDCs such as Holiya and Bethani floods of heavy magnitudes have created big destruction in the distant past also. However, in the last ten years the floods of 1999, 2006 and 2007 have been more destructive. These floods have been reported to be more destructive to the VDCs mainly bordering India.

While fire, snakebites, droughts, epidemics are also prevalent in the lower basin, flood induced inundation, sedimentation and bank cutting are the major problems of the lower basin including the study area. The deposition of sands in the farmland by the torrents originating from the Chure/Shiwalik range, inundation due to flooding, blockage of natural flow of natural *nalas* by the afflux bund on the Indian side, and bank cutting at various locations along the WR River are affecting lives and livelihoods of the people living on the Lower West Rapti Basin. The municipality and the other urbanizing villages have been suffering from drainage congestion and inundation problem due to the unplanned growth, faulty design and poor waste disposal practices. The participants of stakeholder consultation workshop (See Annex-1) held at Nepalgunj identified the following factors contributing to the flood disaster.

Table: 2.4 Factors Contributing to the Flood Disaster in Banke District as Perceived by Stakeholders

A. Natural	**B. Anthropogenic**
• High rainfall intensity in recent years	• Construction of Laxmanpur barrage and Kalkaluwa bandh (afflux bund) in India
• High rainfall in traditionally low rainfall zone	• Lack of proper waste management system in the city->blockage of drainage system
• Intense and concentrated rainfall over a short period	• Deforestation
• Loose soil condition and flat topography	• Poor planning, design of roads, and construction practices
• Debris flows in associated tributaries	• Cutting of the highway at 8 different places for transferring flood water to downstream areas affecting crops downstream
• River channel migration	• Massive increase of households along east-west highways and haphazard settlements
C. Institutional	**D. Socio-political**
• Lack of accountability of government to the people	
• Conduction of flood control activities including construction of structures during rainy season	• Lack of public sensitivity and awareness with flood; attitude of people
• Lack of participation of local people due to lack of practice of soliciting their advices on the construction of river embankments	• Lack of political will power and strength to take up the flood issue with India
• Lack of long-term plans and vision	
• Lack of comprehensive of the flood management plan covering whole flood prone areas	
• Lack of periodic updating of research data	

2.3.2 Major Structures and Projects in the River Basin

There are a few projects in the basin. The notable are, Jhimruk hydropower project (located in the upper basin), Sikta and Praganna Irrigation Projects (located in the lower basin). Similarly structures such as a barrage (named Laxmanpur Barrage) and a dyke (named Kalkaluwa bund) exist on the Indian part of the basin. Besides these, there are a few number of flood control structures such as spurs, and dykes constructed in the Nepalese territory.

Jhimruk Hydroelectric Project (Installed capacity 12.5 MW), a run-off-river (ROR) project, is in operation in the Jhimruk Khola, a tributary of the West Rapti River. The design discharge of the project is 7.05 m3/s and the minimum downstream flow released is 1 m^3/s. The tailrace of the hydroelectric plant discharges the flow in the Mari River (Please refer section 2.6.3) by passing the lower Jhimruk stretch of the river. It has negligible influence in the flood in the lower part of the basin.

Praganna irrigation system (5,230 ha) and Sikta irrigation project (36,000 ha) are two projects under implementation. Currently, the rehabilitation of Praganna Farmer Managed Irrigation System (FMIS) is under execution, and the headworks of the Sikta Irrigation project is under construction. The gross and cultivable command areas of these projects are 36000 and 33766 hectares respectively. The maximum diversion requirement of Sikta project h 5 m of weir height is 65 m^3/s. The project has 46 km of main canal length. Although the sole purpose of Sikta Irrigation Project is to provide irrigation facilities in Banke District, it might have some indirect benefit as a flood control measure. Diversion of some flood water in the command area during rainy season might be helpful for detaining some flood water.
A brief overview of the Laxmanpur Barrage and the Kalkaluwa dyke (afflux bund as per Indian authority) which are perceived in Nepal as major causes of the flooding in the bordering VDCs of Nepal is given below.
Laxmanpur Barrage: It was constructed by the Government of India during 1981-1985. The barrage consists of 14 bays each of 18 m clear span separated by piers of 2.5 m width. The crest level of the barrage is kept at original bed level of the river (125 m amsl). The pond level of the barrage is 127.7 m amsl and the design high flood is 130.4 m amsl. The barrage is constructed only for allowing non-monsoon water from *Saryu Canal* to pass through (Press Release Issued by Indian Embassy at Kathmandu on 2000,NO.KAT/23/2000). There is an argument in Nepalese media[4] terming barrage as a component of a grand project called “River Linking Project” of India. While the barrage is 16.5 km from the WR River in Nepal, it is just about 4.5 km from the nearest inundation point on Nepal.

Kalkaluwa dyke: The government of India completed the construction of 13 km long Kalkaluwa dyke in 1999. The distance of dyke from nearest part of Nepal varies from 0.3 to 0.65 km. It has been constructed from Ch 10.000 to Ch 22.25 km upstream of the barrage. The remaining portion is closed by a road joining the dyke and the left bank of the feeder canal from *Saryu*. The dyke closes the concentrated monsoonal flow of two natural drains namely Sotaihaiya and Gandheli and closes the sheet flow of Rapti flood across the right bank of the river. Before the construction of the dyke, the Rapti

[4] SPOTLIGHT Vol. 24, No. 24. Jan07-Jan-13,2005

flood used to overtop the low lying areas on the right bank on the Indo-Nepal boundary and flow over 13-14 km width.

2.3.3 Characteristics of Most Recent Floods in the Study Area

The increased frequency of flooding in 2006 and 2007 together with disturbed institutional set up in the region due to domestic political conflict has severely affected people in the region. The marginalized group having less education, fatalistic attitude and lacking development infrastructures have been most affected by the flood disasters. Although the flood of 1999 has affected some 159 and 272 households of Gangapur and Matehiya VDC respectively (Source: District Natural Disaster Relief Committee,DNDRC, Banke), only the most recent flood events of 2006 and 2007 are described here below together with triggering factors.

2006 Flood:

a) Rainfall characteristics

While the year 2006 was in general dry year for Nepal with most part of the country receiving less monsoonal rain, some areas in WR River Basin received much rain triggering flood. Baidya and Shrestha (2006) report that Nepalgunj received a record high 336.9 mm of rainfall on 27th August (the highest 24 hour rainfall ever recorded in Nepalgunj so far). While on an annual basis the rainfall is below normal annual for Nepalgunj, Kusum and Dang on the seasonal (monsoon) basis, it was above the normal for Nepalgunj (106.5 % of monsoon normal),moderately below the normal at Kusum (96.5 % of monsoon normal), and well below the normal at Dang (78 % of monsoon normal). Thus the flood in the lower WR River Basin and the study area was mainly due to the heavy downpour in the areas near to the foothills of mountains on 25-27 August. The instantaneous maximum flood of the Bagasoti station in this year was 1730 cumecs which is almost equal to the instantaneous flood discharge of 1740 cumecs in the normal year 2005. This shows that the flood was mainly due to the heavy rainfall in the lower WR Basin.

b) Associated Damage

The effect of flood was mainly on Bethani, Holiya, Phattepur, Matehiya and Gangapur of Banke district. The record of the damage is given in the Table 2.5

Table 2.5 Flood Damage in Banke District in the Year 2006
(Source: DNDRC,2006)

VDC	Population Affected	HH affected	*Pakki* Ghar	*Kachhi* Ghar	Agricultural Land (ha)	Loss due to Physical Damage (USD)*
Matehiya	1643	373	22	57	0.8	80361
Gangapur	4063	745	116	437	180.0	766902
Holiya	5159	1349	75	1200	639.8	1437097
Bethani	5793	1963	19	55	39.1	166405
Phattepur	3758	544	19	234	144.7	577806

* 1USD=63 NRs., Pakki Ghar: Houses made of cement/lime mortar, wood etc., Kachhi Ghar: Houses made of earthen material

The information collected during Focus Group Discussion (FGD) with the community suggests that in Newaji Gaun , Bhagawanpur and Bhojpur water level rose up to 2.4m in 2006 flood.

2007 Flood:

a) Rainfall characteristics

The rainfall data of the monsoon period (Jun-Sept) of the three stations in the lower WR River Basin is shown in Table 2.6 The table shows that the rainfall is quite high in Nepalgunj from July to September. The total monsoon rainfall in the year was about 180 % higher than the normal monsoon rainfall in the station. The comparison of normal accumulative rainfall and accumulative rainfall of 2007 monsoon period is shown in Fig. 2.8. As can be seen in the table, the other two rain gauge stations also showed higher rainfall particularly in the month of July. The instantaneous maximum flood of the Bagasoti station in this year was 1900 cumecs which is not very high as compared to the instantaneous flood discharge of 1740 cumecs in the normal year 2005 (unofficial data obtained from personal communication with DHM official). This shows that the flood was mainly due to rainfall in the lowland (lower WR Basin) areas.

Table 2.6 Rainfall of few Stations in 2007 Monsoon period

(Source: Preliminary Weather Summary of Nepal, DHM 2007)

Station	Month	Total Rainfall (mm)	%ge of Monthly Normal
Nepalgunj	June	181.9	84
	July	1083.9	235.3
	Aug	698.2	213.1
	Sept	351.8	173.5
Dang	June	282	104.4
	July	645.6	166.3
	Aug	417.7	95.9
	Sept	194.3	78.3
Kusum	June	167.7	86.5
	July	903.2	256.4
	Aug	267.9	82.6
	Sept	212.3	83.3

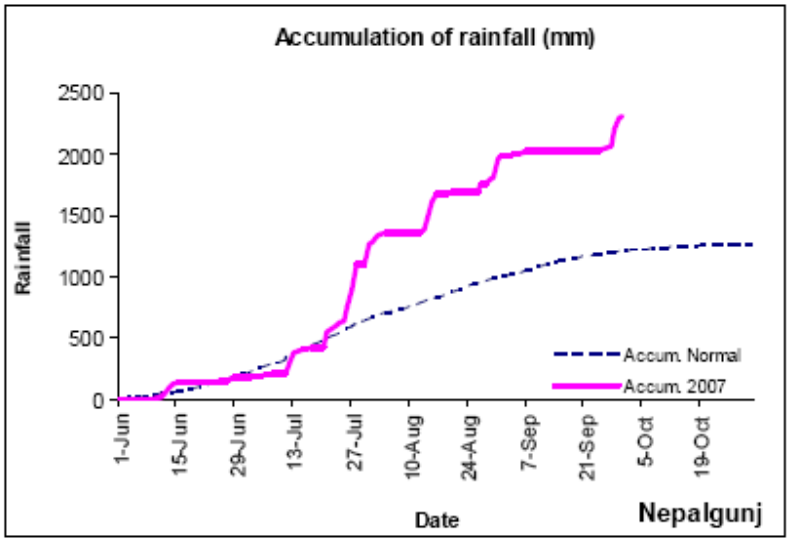


Fig. 2.8 Comparison of Accumulated Monsoon Rainfall in 2007 and Normal Rainfall of Nepalgunj

(Source: Preliminary Weather Summary of Nepal, DHM 2007)

b) Associated Damage

In terms of flood, Banke became the second most affected district in the country in 2007. Similarly Bethani, Holiya, Phattepur, Matehiya and Gangapur were most affected VDCs of Banke district. The detailed information about the damage is given in the section 2.2.6 and the flood affected areas are mapped in the Fig. 2.9. The information collected during FGD with the community suggests that in Gangapur in 2007, water level increased up to 1 meter. At that time, the flood inundated the area for 3-4 days. The same year Dondra River (torrent) made katan (bank cutting) of 500 meter length of 1 meter to 3 meter width. In Newajigaun, Bhagawanpur and Bhojpur water level rose up to 2.3m in 2007. The area was inundated up to 6-7 days. In Sonbarsha, people were suffering from inundation for 24 hours to 3 days caused by the high water level of about 1.7m. Similarly, in Jamuni, with raised water level of 0.5 m, the village was inundated for up to 24 hours.

During social survey, information was collected from the community regarding the destruction of crop land due to flood hazard. The information is given in the Table 2.7 and is mapped as shown in the Fig. 2.9.

Table 2.7: Destruction of crop land by Cluster by 2007 Flood
Source: SSI, FGDs, 2007

Cluster	***Destruction of crop land (in Bigha*)***			**Total**
	Duban	***Katan***	***Patan***	
1	110	230	450	830
2	2300	550	800	3650
3	3200	780	945	4925
4	142	0	85	227

*1 Bigha=0.67772 ha

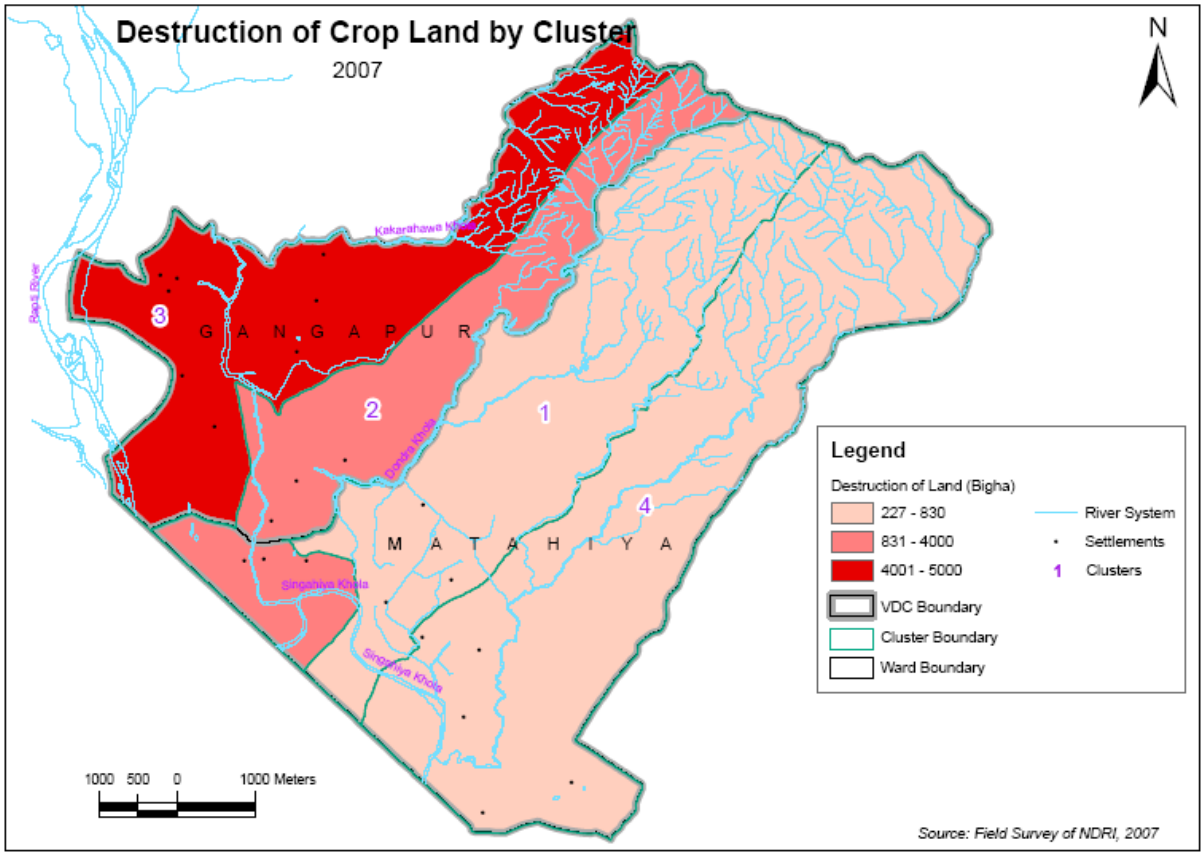


Fig. 2.9 Destruction of Crop Land by Cluster, 2007

2.3.4 Causes and Effects of Flood Disaster in the Study Area

The causes and effects of floods in the study area were also identified during socio-economic survey using PRA tools. These are summarised in the Table 2.8 below (for detailed discussions please refer to the supporting report). Poor land, forest and other resource management of upland areas, inadequate design and provision of drainage facilities, construction of Laxmanpur Barrage on the downstream, increased population and dense pattern of settlements were cited as some of the factors for increased flood disaster in the study area. The effect of flood has been reported not only of causing increased threat to human life but also to the source of livelihood through damage of productive farmland, reduction in crop and vegetable production, losses of livestock and damage of stored grain.

Table 2.8 Causes and Effects of Floods in the Study Area as Shared by the Community

Causes	Effects
Poor drainage system in the area Construction of infrastructure without assessing the monsoon flood Narrow drainage of the flashy rivers Construction of Laxmanpur barrage Extraction of boulders, sand from the upland haphazardly Expansion of Jalkumbhi (water hyacinth) and Besarm on both banks of torrents Absence of good irrigation facilities prompting haphazard, risky local initiatives for irrigation. Densely populated settlements inducing inundation Over grazing in the Churia area Slash and burn practices in the upper catchments Increased population and encroachment of marginal land and forest Continuous forest depletion and associated erosion and gully formation	Difficulty in mobility Damage of houses Increased risk to live at house Increased trends of fear and trauma Out-break of water-borne diseases Increased psycho-social problems Losses of livestock Reduction in crop and vegetables production Damage of productive land Damage of the stored grain

Based on the degree of affectedness and their indicators described in Table 2.9, the effect of flood disaster in the study area has been mapped and presented in Figure 2.10. The details of the number of HHs affected by floods in each clusters are given in the supporting report (Annex VI-8).

Table 2.9: Degree of Affectedness and Their Indicators

Degree of affectedness	Indicators
Highly affected	House completely or partially collapsed, loss of lives and livestock, inundation for longer period, people suffering from water borne diseases, flood depth up to 70 cm, flood standing for more than 3 days
Moderately affected	Cracking of the wall of houses, falling down of wall, damage of stored food, sedimentation in the crop land, flood depth up to 30-70 cm, flood standing between 1-3 days
Less affected	Minor destruction, minimal damage of grain, damage of standing crops, damage of newly planted crop, flood depth less than 30 cm, flood standing for less than 1 day

Source: FGD, 2007

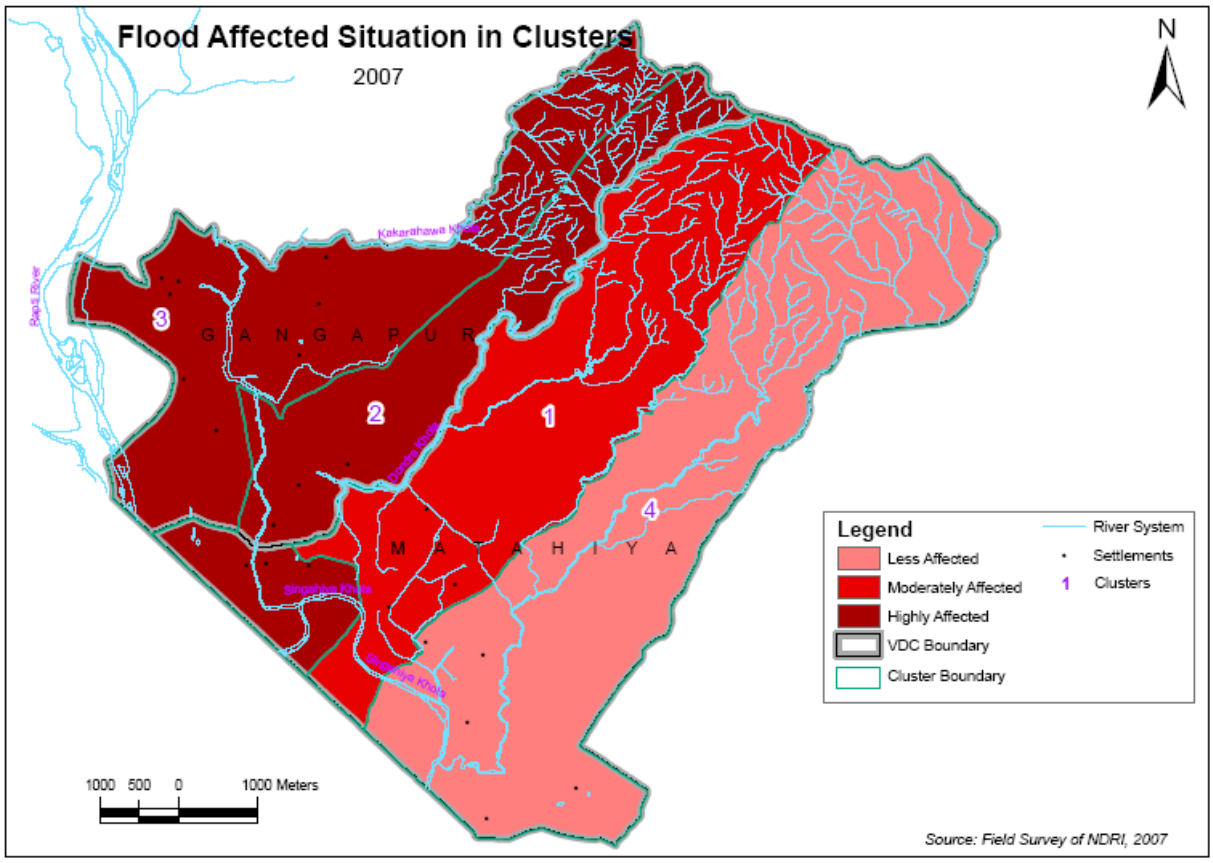


Fig. 2.10 Flood Affected Situation in the Study Area due to 2007 Flood

2.4 Institutional Aspects of Flood Disaster Management and Current Activities

2.4.1 Legal and Institutional Framework

Nepalese periodic national plans and water policy have put high emphasis on disaster risk reduction. The 9th 5-year plan (1998-2002), recently completed 10th 5-year plan (2002-2007), ongoing interim plan (2008-2011) all have given emphasis on the reduction of water induced disaster. The National Water Plan (NWP, 2005) has set up action and target programs to achieve the strategy setup by 25-year Water Resources Strategy (National Water Resources Strategy, 2002). Similarly in the framework of Integrated Water Resources management (IWRM) and river basin-approach, Water Induced Disaster Management Policy, 2006 has also been formulated and approved. In addition, National Policy and Strategy for Disaster Risk Management, 2007, which is based on the Hyogo Framework of Action has been finalized and awaits government's final endorsement.

However, Natural Calamity Relief Act (1982) is the sole legal instrument to define disaster and reduce disaster risk. It has specified a set up for different institutions for disaster response. It outlines four different hierarchies namely central, regional and district and local (Figure 2.11).

The Central Natural Disaster Relief Committee is under the Chairpersonship of Home Minister and comprises of related ministries and security agencies along with voluntary organization like Red Cross. To support the functioning of Central Committee, there are Working Committee, Relief and Treatment Sub-committee and Supply, Shelter and Rehabilitation Sub-committee. The Regional Natural Disaster Relief committee is under the Chairpersonship of Regional Administrator and comprises of related regional government agencies and security agencies along with voluntary organization like Red Cross. Similarly, the District Natural Disaster Relief Committee is under the chairpersonship of the chief district officer and comprises of related district government agencies and security agencies along with voluntary organization like Red Cross. To facilitate rescue and relief operations at international levels, Nepal has ratified the conventions namely, Privileges and Immunities of the United Nations, and Privileges and Immunities to Specialized Agencies.

In Nepal, various stakeholders contribute to the risk reduction and disaster management. These include governmental organizations, media, professional societies, non-governmental organizations, local political bodies, community based organizations, international agencies, voluntary organizations and citizen groups in large.

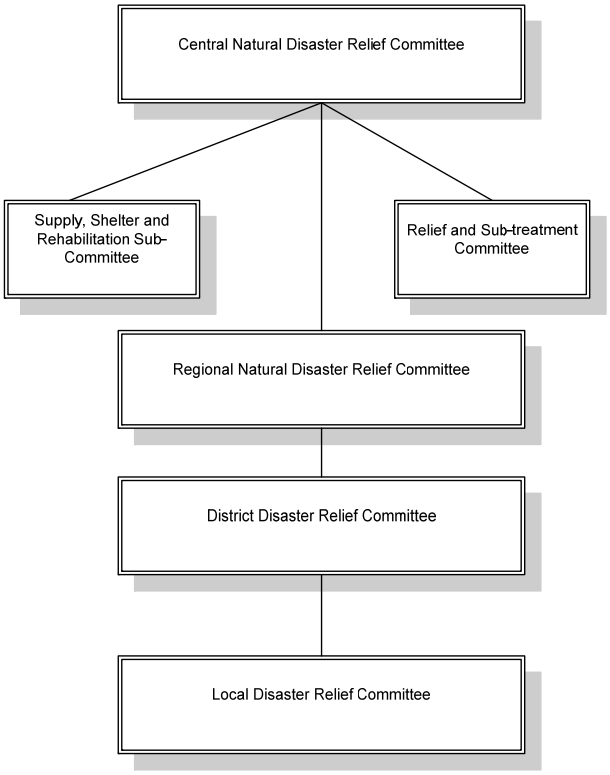


Figure 2.11 Organizational Structures of Disaster Response Bodies

2.4.2 Stakeholder Analysis and Flood disaster management Activities in the District

The group discussion and information collection during the local consultation meeting was later supplemented with informal interviews with the District Administration Office (DAO) officers and other relevant stakeholders. From the discussion, it is learnt that there is an active District Natural Disaster Relief Committee (DNDRC) in the Banke district which meets before monsoon for general planning and preparedness, and obviously after the floods for rescue and relief activities. Under the coordination of the district administration office, the committee has focused on three main areas namely: immediate rescue and relief operation, general relief works, and epidemic and other health risk control. In the immediate rescue operation institutes such as DAO, District Police Office (DPO), Armed Police Forces (APF), Nepal Army Units, and United Nation's Mission to Nepal (UNMIN) have been actively involved in the last years. For relief operations such as providing food, clothes, water and other utilities, there have been coordinated efforts under the coordination of the district Red-Cross office. Similarly, District Public Health Office (DPHO) has coordinated post disaster health risk and epidemic controls in the flood prone VDCs. In the pre-disaster preparedness phase, a number of survey and training works have been also conducted by the DPHO. A number of other government and non-government organizations have been actively involved in these three sub-committees.

A high level committee of Indian and Nepalese government also exists for resolving the problems caused by the construction of afflux bunds and barrage. The committee has, however, not been effective on resolving the issues due to differences of opinions.

While local level stakeholders were identified during the social survey in the study area (reported in section2.2.7), some district level stakeholders were identified during the consultation workshop and later through discussion with DAO and DDC officers. These are reported below:

i. DAO and DNDRC: The DNDRC is the main stakeholder involved in disaster management in the district. It is chaired by the chief district officer and comprises of a number of organizations such as DPO, DPHO, Red Cross, APF, Irrigation Development Division Office (IDDO), Divisional Office Department of Water Induced Disaster Prevention (DWIDP), District Forest Office, District Agriculture Office etc.

ii. DDC, Banke and VDCs: DDC is the elected body at district level (at present there is no elected local body in Nepal) and is responsible for the overall development activities in the district including disaster management. The DDC, Banke has spent mainly on relief activities, followed by preventive measures such as construction of dykes and check-dams. VDC is an elected lowest administrative unit and is responsible for overall development in its territories including flood management. Like DDC, the VDCs in Nepal do not have elected body at present. The VDC receives very small fund from DDC and the government, and raises some tax from within its areas. But these are not sufficient for major development and Disaster management activities.

iii. Nepal Red Cross Society (NRCS): The NRCS is another main actor in the field of disaster management in the district. Although they focus mainly on providing relief materials, they also undertake disaster preparedness activities.

iv. DWIDP: The DWIDP is a major actor in the engineering study, and flood mitigation activities. It is learnt that DWIDP has undertaken a number of structural measures for reducing the flood risk in the West Rapti River. Unfortunately, lack of budget and resulting peace-meal approach has constrained the activities of the organization. Moreover, the peace-meal approach has limited the effectiveness of the measures taken by the organization.

v. District Police Office and its branches: The institutional role of the organizations such as police and armed forces in reducing the flood damages and casualties was evident from the general discussion with the locals in Gangapur and Matehiya VDCs. It was learnt that in 2005 when there was no police posts and other institutions in these VDCs due to domestic armed conflict, the damage due to flood was quite high. In contrast, after the peace process when these institutes were reinstalled in 2006, the disaster management was said to be quite effective. These institutions not only helped on timely (forced) rescue of the households but also coordinated with Indian side to ensure that the gates of Laxmanpur Barrage are not lowered by any reasons.

vi. Agriculture, irrigation, forest and watershed management organizations: Although, not very active at present for the flood management, agriculture, Irrigation and forest sector organizations can have important role in any comprehensive flood management program. Their role could be quite important for better watershed management and reduced erosion, improved livelihood opportunities through effective agricultural extension.

vii. Divisional Water Supply and Sanitation Office: The office has important role in the post disaster phase to provide potable water and sanitation facilities in the flood affected areas. It was observed that it was involved in distributing some relief materials in the study area.

viii. DPHO and health posts: These organizations are important for preparedness and relief operations. Before flood, they are involved on preparing for anticipated flood and enhancing community's preparedness. Similarly after the flood they are involved in the distribution of medicine and in the treatment. It was learnt that the DPHO has conducted health risk assessment of flood affected areas, distributed medicine and treated the flood affected population.

ix. International development/donor agencies (DFID, Save the Children US, WFP, UNICEF, GTZ, WHO): These organizations are mainly involved in relief focused program in the districts. Some of these agencies like Save the Children US, work through the local Red Cross Society.

x. NGOs: A number of NGOs like CARE Nepal, CARITAS Nepal, ActionAid Nepal are working in the district. These organizations also mainly work on the relief and rehabilitation focused program. Very recently, Practical Action Nepal under the aid of European Commission is engaged in establishing a flood early warning system in the West Rapti River for the benefit of communities of mainly Holiya, Bethani and Phattepur VDCs of Banke district. The warning system comprises of telephonic conveying of water level data at upstream (Bhaluwang bridge site in Dang District) to the downstream reaches and operation of sirens.

xi. Local NGOs: A number of right based local NGOs operate in the Banke District. In the study area, however, an NGO called Bheri Environmental Excellence Group (BEE-group) was found actively involved in mobilizing relief materials and rehabilitation of schools under some national level NGOs such as Action Aid Nepal, Care Nepal etc.

2.5 Topography, River Geomorphology and Geology of the Study Area

2.5.1. DEM, Slope and Aspect Maps of the Basin

Digital Elevation Model of the West Rapti River basin and the topographic map of the study area are shown in the Fig. 2.12 and 2.13 respectively. As shown in the Fig.2.15, most of the settlements in the study area are situated in the flat, relatively lower elevation range. The Slope and aspect maps for downstream side from Sikta are shown in the Fig. 2.16 and 2.17 respectively.

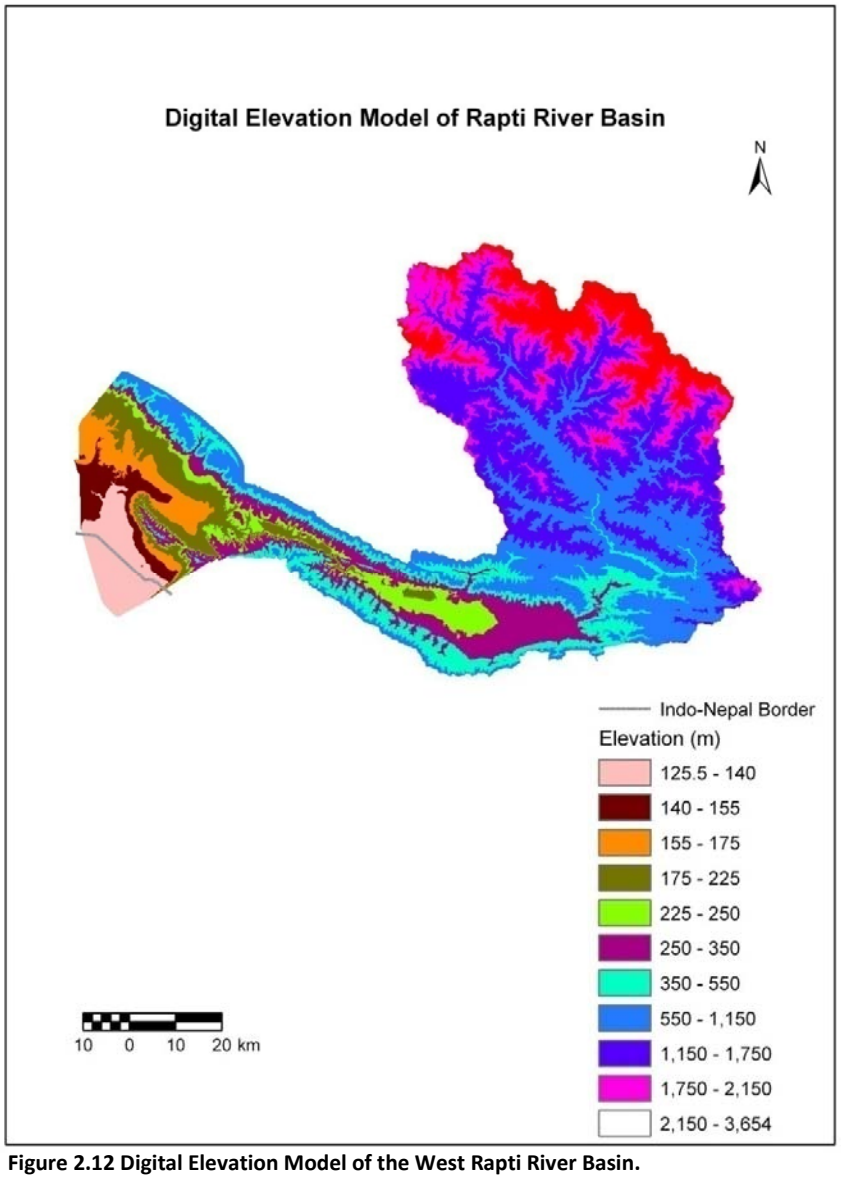


Figure 2.12 Digital Elevation Model of the West Rapti River Basin.

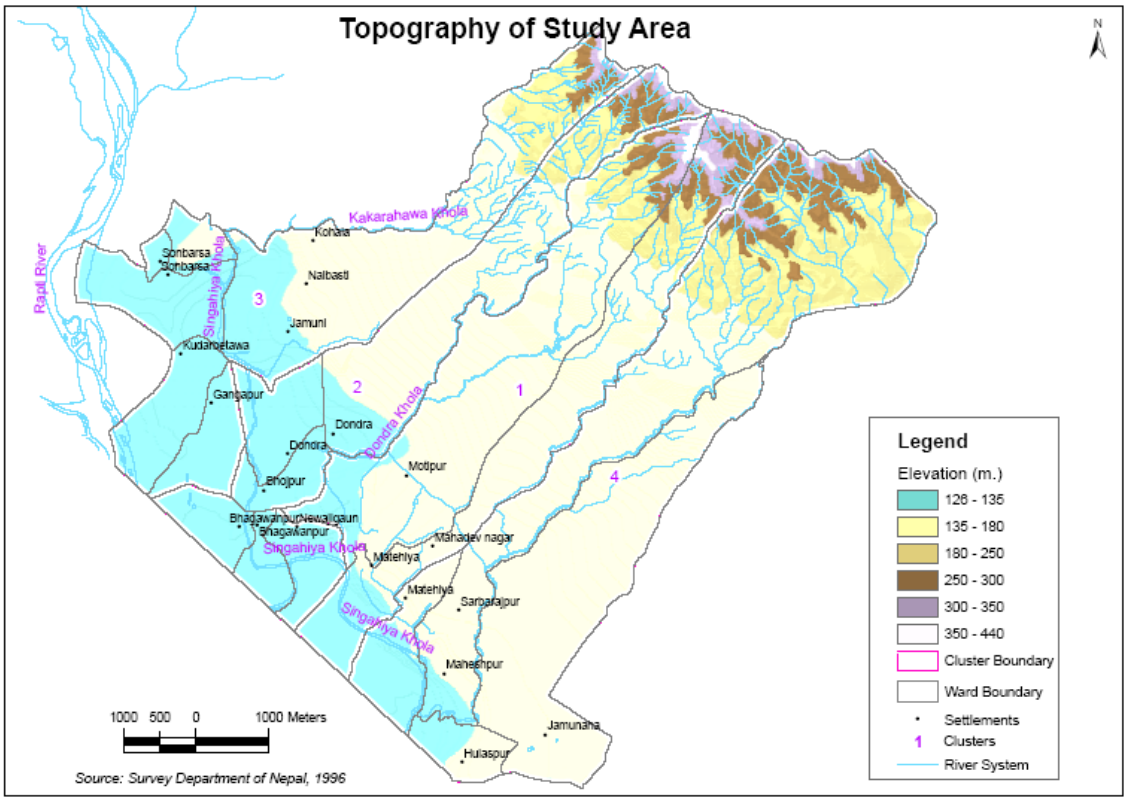


Fig.2.13 Topography map of the study area

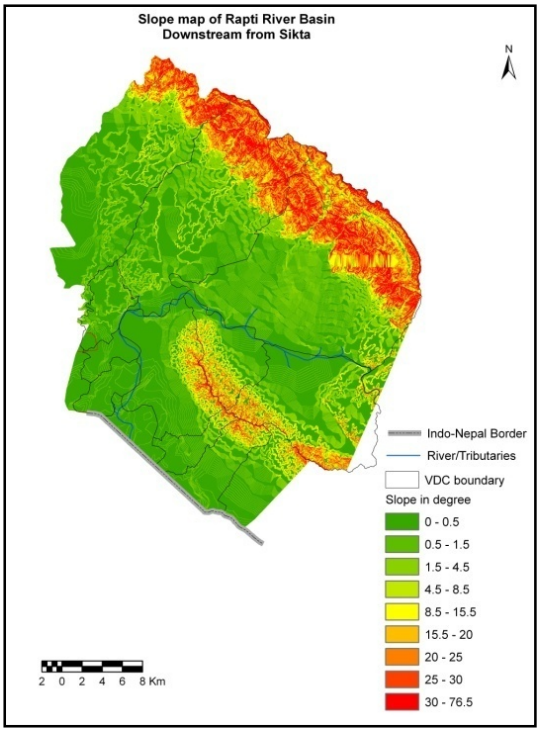


Figure 2.14 Slope map of the study area

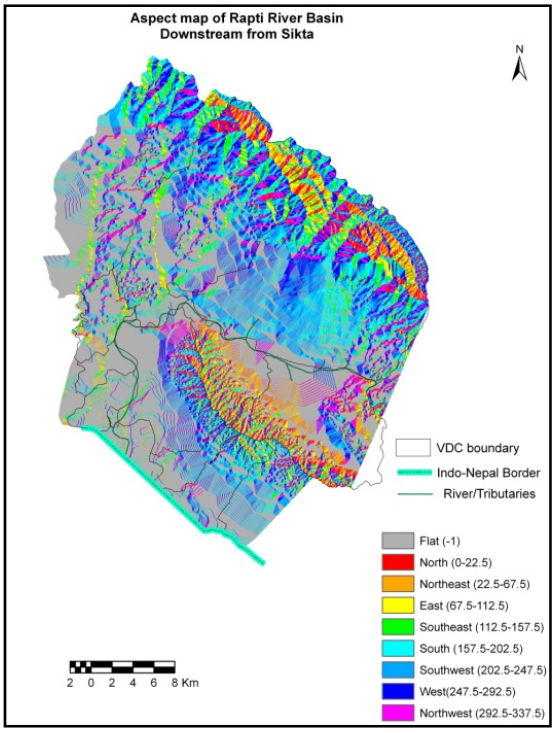


Figure 2.15 Aspect map of the study area.

2.5.2 River Geomorphology

a) River Bank Condition

Field survey of the WR river banks (left and right banks), and cross-sectional data measurements at 23 locations (Annex-2) were performed on November 2007. The result of the river transect survey is summarized in Fig. 2.16. The study identified the river channel migration, presence of flood control structures in the West Rapti River downstream of Sikta, and general soil condition etc. which is reported in Table 2.1 in Annex 2. Based on the field observation of river bank cutting and efficacy of flood control structures present, crude geomorphic flood hazard information was prepared (Fig.2.16). Locations of a number of photographs of river bank side, flood control structures etc. taken during the field investigation have been marked in the figure and the photographs are shown in Annex 5.

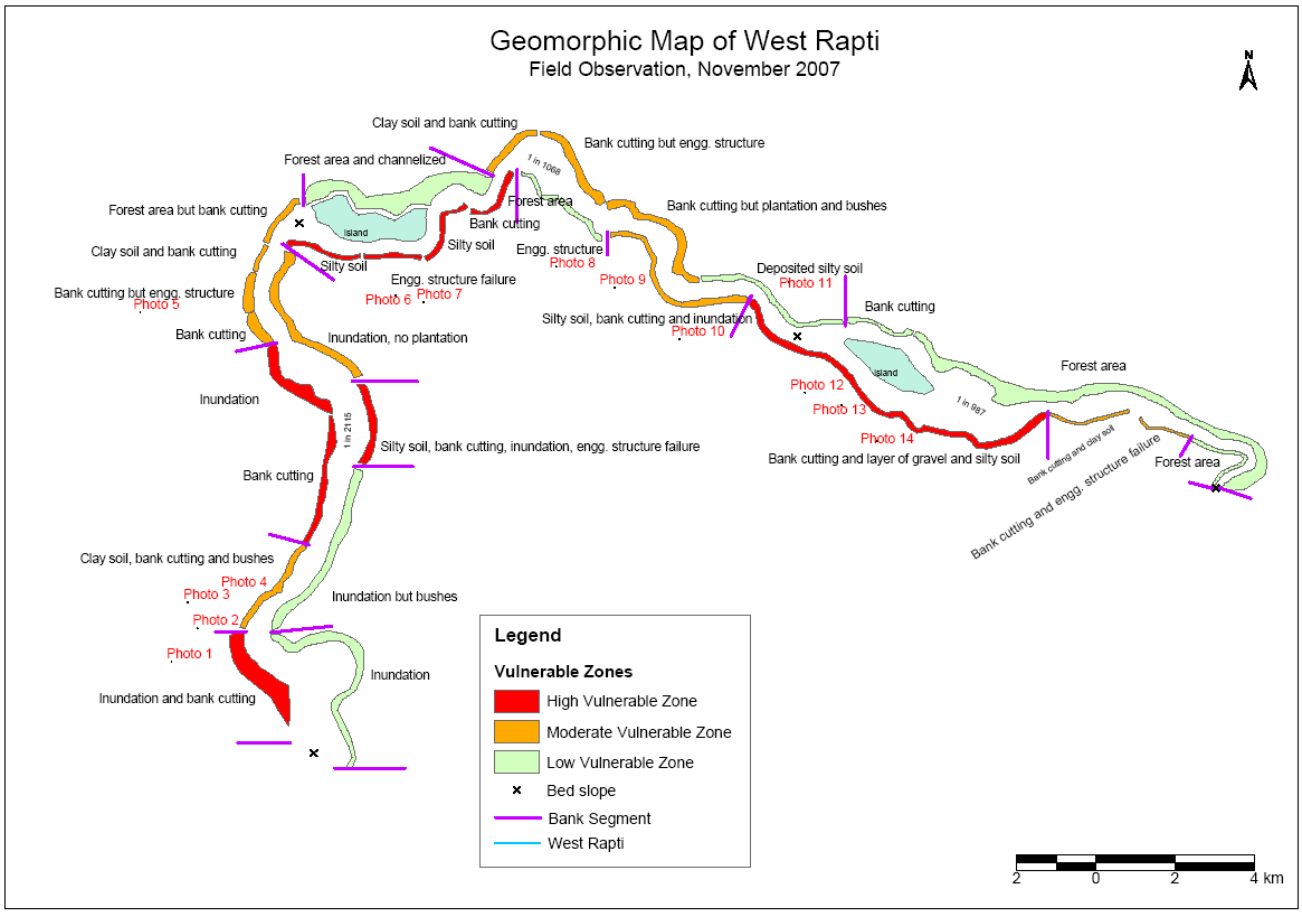


Figure 2.16 Geomorphic Map and Bank Cutting Hazard Zones along the WR River from Indo-Nepal Boarder to Sikta

b) River Channel Width, and Slope

The aerial photo of the WR River was collected for analysis from Google Earth and is shown in the Fig. 2.17. The width of the river (outer banks) at various chainages from the Laxmanpur Barrage measured on the aerial photo is shown in the Table 2.10. The high resolution aerial photographs at various chainages marked in the figure are shown in the Annex 5. As can be seen, the river shows meandering as well as braiding at various reaches. The reach downstream of Jhuri River and upstream of Muguwa River and a reach upstream of Jhijhari River through Samshergunj village are highly braided.

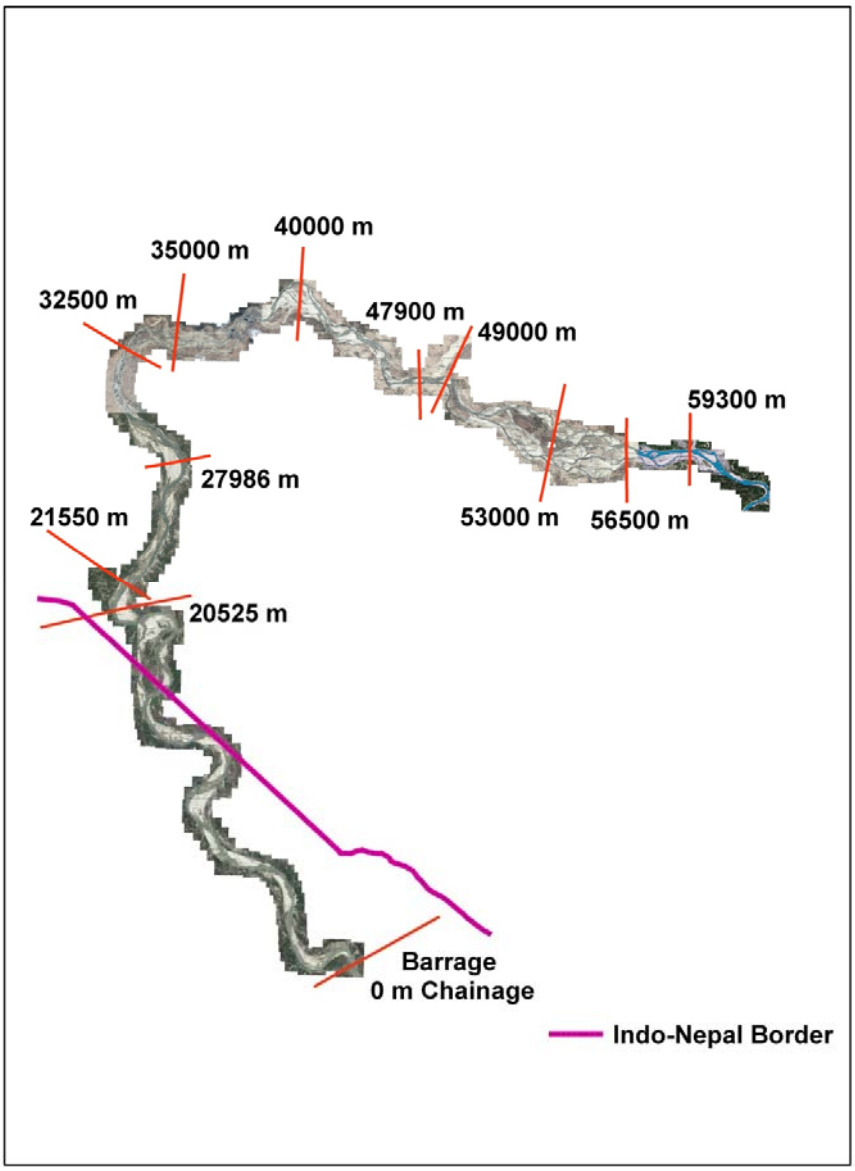


Fig. 2.17 River Width at Various Locations Source : Goole Earth 20 April 2008

Table 2.10 River Width at Various Locations Upstream of the Laxmanpur Barrage

S.N	Chainage, m	location	River Width, m	Date of Aerial Photos taken	Remarks
1	0	Barrage	203.00	March 6,2007	
2	20525	Downtream of Dundwa River	606.32	March 6,2007	
3	21550	Upstream of Dundwa river	343.87	March 6,2007	
4	27986	Sidhanawa, Phatepur	781.04	March 6,2007	
5	32500	Downstream of Jhijari	287.45	Jun,2003	Flow channelized in two channels
6	35000	Upstream of jijhari	1011.15	Jun,2003	Highly Braided
7	40000	Shamsergunj	895.78	May 27,2003	Highly Braided
8	47900	Upstream of Muguwa	277.76	May 27,2003	Flow channelized in two channels
9	49000	Downstream of Muguwa	526.19	May 27,2003	Flow channelized in two channels
10	53000	Moranga	1654.73	May 27,2003	Highly Braided
11	56500	Khairi	631.02	May 27,2003	Flow channelized in two channels
12	59300	Shukhar	343.19	May 27,2004	

Source: Google Earth, 20 April, 2008

The slope of the WR River is very small in the lower reaches of the river, particularly downstream of the location from where the river has taken U-turn and flowed southward. The L-section of the WR River downstream of Sikta based on the DEM derived from the contour map of the lower WR Basin and river cross-section survey is shown in the Fig. 2.18. The slopes along different reaches as directly computed in ArcGIS are shown in the Table 2.11. The flatter slope in the reach near the Indo- Nepal boarder has implication for the safe passage of flood.

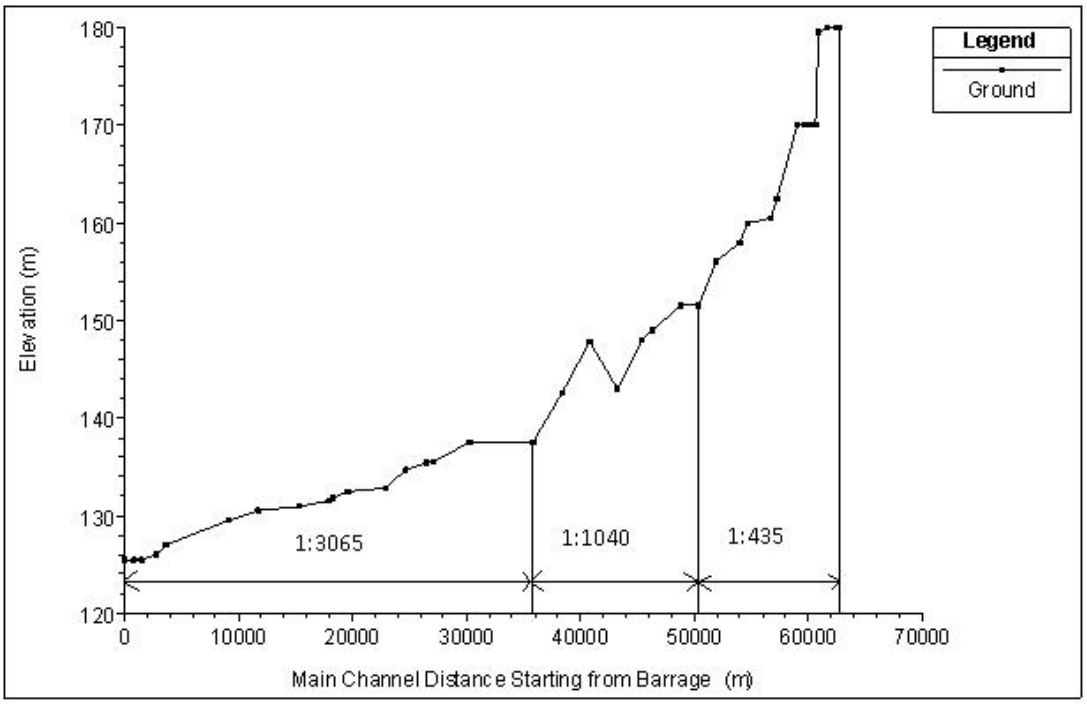


Fig 2.18 L-section of the WR River Downstream from Sikta

Table 2.11 Slope of the River Channel at Different Reaches

S.N	chainage, m		Location		Slope
	From	To	From	To	
1	0	36776.56	Barrage	Dhalia, Phatepur VDC	1 in 3065
2	36776.56	51332.19	Dhalia, Phatepur VDC	Lalahi, Binauna VDC	1 in 1040
3	51332.19	63695.28	Lalahi, Binauna VDC	Sikta, Khaskusma, VDC	1 in 435

2.5.3 Land Use/ Land Cover

The land use map of the Lower West Rapti Basin is shown in Fig . 2.19. As shown, the area is mostly covered with forest and grass. However, as can be seen, the floodplains and low lying areas are mostly used for cultivation.

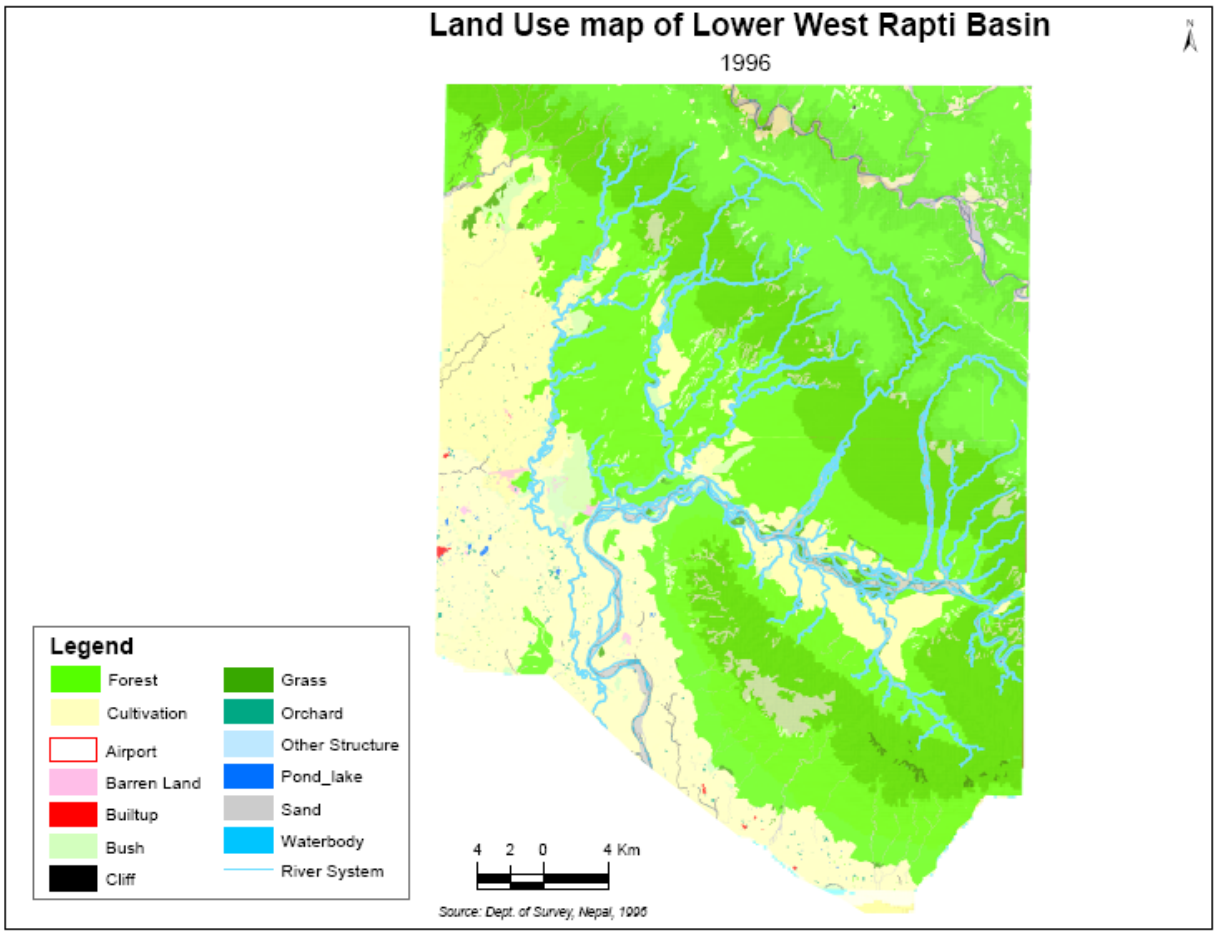


Figure 2.19 Land Use Map of Lower West Rapti Basin

2.5.4 Geology of the study site

The lower WR River Basin, under investigation, belongs to the Terai zone.

Lying on the southern most part of Nepal, the Terai Zone depicts three distinct geomorphologic units from south to north, namely Southern Terai, Middle Terai and Bhabar Zone. The grain size of the sediments in the Terai Zone decreases from north to south having coarser sediments like gravel, cobbles and boulders in the Bhabar Zone and finer sediments such as silt and clay in the Southern Terai. In the

Middle Terai, the sediments are of intermediate nature consisting of gravel and sand intermixed with silts and clays. The sediment in the Terai is about 1500 m thick and the underlying bedrock consists of sedimentary rock of Siwalik range.

Bhaber Zone:

The northern most part of the study site belongs to Bhaber Zone and is situated at the foothill of the Churia range. The Bhaber zone at this place is composed of ill-sorted deposits of sub-angular to sub-rounded boulders, gravels, cobbles and pebbles of quartzite, sandstone and gneiss derived from the Siwalik and Lesser Himalayan mountains and intermixed with sand and silt. The surface humus soil is brownish gray in color and is less than one meter thick.

Middle Terai:

The central part of the study site belongs to the Middle Terai. The bulk of the surface and subsurface sediment in the Middle Terai consists of sand followed by silt and clay derived from Siwalik and Lesser Himalayan mountains. Deposited by rivers, these sediments are rounded to sub-rounded and are loosely packed. Some waterlogged sites are also found in this unit.

Southern Terai:

The southernmost part of the study area belongs to Southern Terai. The surface and subsurface sediments in the area are composed of rounded to sub-rounded sand intermixed with silts and clays derived from the Siwalik and Lesser Himalayan mountains. Bulk of the sediments is of silt and clay size followed by fine sand.

2.6 Hydrology and Meteorology of the Study Area

2.6.1 General Climate

While the upper WR basin has deciduous climate, the lower basin including Banke district has tropical to subtropical climate. In the study area, the period from March to June is hot and dry, July to August is hot and humid, September to October is pleasant, and November to February is cool and dry. The temperature goes very high up to 46^{o}celcious in the summer and falls below 2^{o} during winter. The hot wave during the summer and cold wave during the winter reflects harshness of the climate here.

i) Rainfall: The study area receives southeast monsoon rainfall extending from June to September. There is no rain gauge station in the study area (Gangapur and Matehiya VDCs). However, the mean annual rainfall of the nearest station in Nepalgunj (districts headquarter of Banke) is 1435 mm (1996 - 2005) and the monsoonal precipitation in the four months accounts about 80% of the total annual. Based on Thiessen polygon

method using 14 stations, the average rainfall for WR River Basin is calculated to be 1507 mm.

ii) Temperature: The temperature of the study area is similar to that of Nepalgunj area. The temperature rises from March to June-July and decreases from October to January. The coldest month is in January and the hottest month falls in between May and August. Based on the 1987-2005 data of Nepalgunj, Khajura and Sikta, the mean maximum and minimum temperature of the area is estimated as 42.7 and 3.8 degree Celsius.

iii) Relative Humidity: The study area falls in the class of 80-85% annual average RH. The RH goes as low as about 60 % in May to above 90 % in January. Compared to the study area, the upper basin has relatively higher annual RH (85-90% class).

iv) Sunshine: While the average Sunshine hour for almost 8 months of a year is about 80%, this goes down to below 50% during monsoon.

2.6.2 Hydrometerological network

There are altogether nine hydrometric stations in the basin as shown in Table 2.12. Four of which, namely St. No. 339.5 in Jhimruk Khola at Tigra gaon, St. No. 330 in Mari Khola at Nayagaon, St. No. 350 in the main stream of the river at Bagasoti and St. No. 360 in the main stream of the river at Jalkundi have long term data. The other five stations are stations newly established (1999-2000) within the "Institutional Development of the Department of Hydrology Meteorology (DHM)" project under the Nepal Irrigation Sector Project. There are a number of rainfall stations within and in the vicinity of the basin with long term rainfall data. Rainfall data of fifteen rainfall stations (Table 2.13, Fig. 2.20) have been collected for the study.

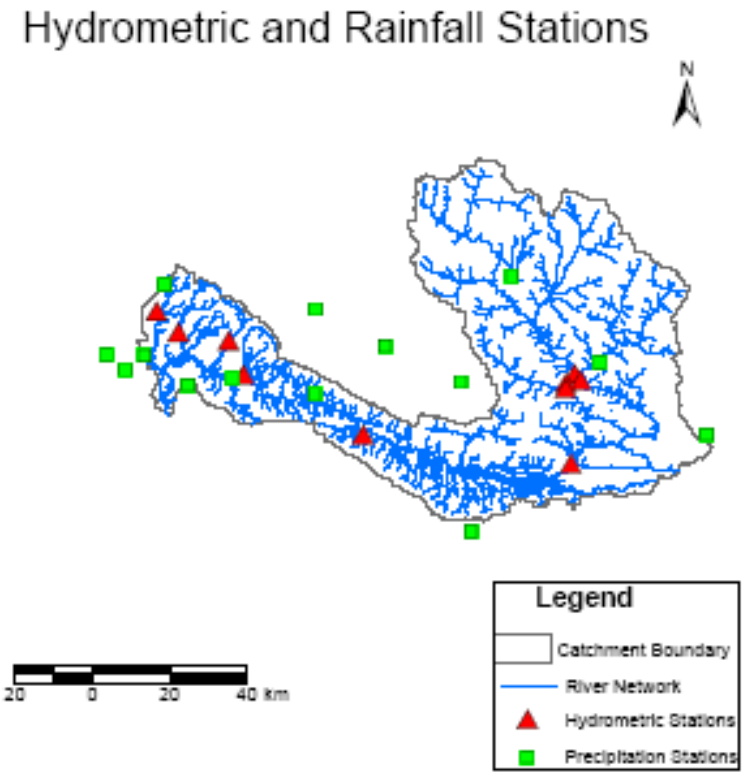


Figure 2.20 West Rapti River Basin with Drainage Network, Rainfall and Hydrometric stations

Table – 2.12 Hydrometric Stations in the West Rapti Basin

S.N.	St. No.	River	Location	Latitude (deg-min-s)	Longitude (deg-min-s)	Elevation (m)	Est. Date
1	330	Mari	Nayagaon	28^{0}04’20”	82^{0}48’00”	536	Jan-1964
2a	339.3	Jhimruk	Chernata	28^{0}03’24”	82^{0}48’59”	738	Dec-1999
2b	339.5	Jhimruk	Tigra	28^{0}03’00”	82^{0}46’40”	709	May-1971
3	350	W. Rapti	Bagasoti	27^{0}51’41”	82^0 47’33”	317	May-1975
4	360	W. Rapti	Jalkundi	27^{0}55’26”	82^0 14’42”	220	Apr-1964
5	333	Arung	Devisthan	28^{0}02’16”	82^0 46’35”	575	Apr-2000
6	361	Khairi	Agaiya	28^{0}03’36”	81^{0}55’36”	173	Jul-2000
7	362	Mungwa	Thuria	28^{0}08’18”	81^{0}53’12”	222	Oct-1999
8	363	Jhanjari	Dhakeri	28^{0}09’22”	81^{0}45’13”	159	Nov-1999
9	364	Dundawa	Masurikhet	28^{0}12’15”	81^{0}41’44”	162	Nov-2000

Source: Tahal et al (2002)

Table 2.13 Rainfall Stations in the West Rapti River Basin

S.N.	Station name	Index No.	District	Latitude	Longitude	Elevation	Established	
						meter	Date	
1	Kusum	0407	Banke	28^{0}01’	82^{0}07’	235	Nov	73
2	Khajura	0409	Banke	28^0 06’	81^{0}34’	190	Jan	68
3	Naubasta	0412	Banke	28^{0}16’	81^{0}43’	135	Feb	71
4	Baijapur	0414	Banke	28^{0}03’	81^{0}54’	226	Feb	71
5	Nepalgunj	0416	Banke	28^{0}04’	81^{0}37’	144	Feb	73
6	Sikta	0419	Banke	28^{0}02’	81^{0}47’	195	May	78
7	Nepalgunj Airport	0420	Banke	28^{0}06’	81^{0}40’	165	May	96
8	Libang Gaun	0504	Rolpa	28^{0}18’	82^{0}38’	1270	Mar	73
9	Bijuwa Tar	0505	Pyuthan	28^{0}06’	82^{0}52’	823	Mar	73
10	Nayabasti	0507	Dang	28^{0}13’	82^{0}07’	698	Dec	70
11	Tulsipur	0508	Dang	28^{0}08’	82^{0}18’	725	Dec	70
12	Ghorahi (Masina)	0509	Dang	28^{0}03’	82^{0}30’	725	Dec	70
13	Koilabas	0510	Dang	27^{0}42’	82^{0}32’	320	Feb	71
14	Ghorai (Dang)	0515	Dang	28^{0}03’	82^{0}30’	634	Jul	89
15	Khanchikot	0715	Arghakhanchi	27^{0}56’	83^{0}09’	1760	Nov	70

Source: DHM

2.6.3 Hydrological Characteristics of West Rapti Basin

The West Rapti River is a class II river. It has several tributaries. The drainage map showing major rivers is shown in Figure 2.20 and the river network showing major tributaries downstream of Sikta is shown in Fig.2.21. The brief description of the major tributaries and important natural *nalas* (drains) with respect to flooding problems is given below (DWIDP, 2006).

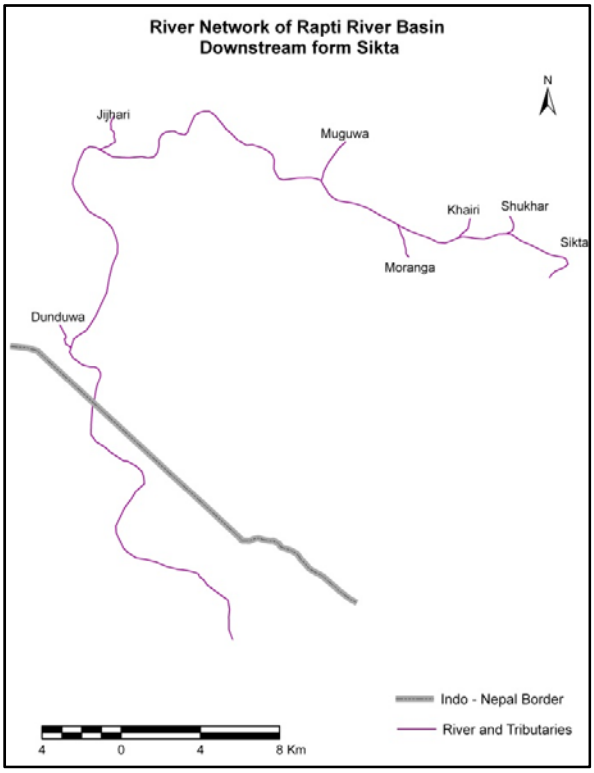


Figure 2.21 Plan View of River Network of W. Rapti River showing Major Tributaries.

a) Major Tributaries of WR River

Jhimruk River: Jhimruk River originates at an altitude of 3000 m, flows southward and joins the Mari River at Airawati Village of Pyuthan District. The river has a catchment area of about 961 at Airawati

Mari Khola: Mari Khola originates at an altitude of 2880 m, flows northeast and joins Jhimruk River and flows as West Rapti River afterwards. The river has a catchment area of about 1,920 km^2, at Nayagaon.

Arung Khola: Arung river has a catchment area of about 230 sq. kilometers and joins Mari river in the upper hills.

Lungri Khola: It originates at an altitude of 2880 m and drains an area of about 580 sq. Kilometers. The river drains into the West Rapti River.

Sit Khola: It flows in the east-west direction and drains into the Rapti River. The Sit Khola entirely flows through the Siwalik Range.

Dunduwa Khola: Dunduwa khola orginates at xxx and flows through Nepalgunj. The khola used to meet the West Rapti river on Indian side, but the westward movement of the river in Nepalese side has made the West Rapti River meet the Dunduwa khola in Nepal.

Sotiya and Gandhali Nala: These natural *nalas* originate in the lower flat areas of the river basin. The natural flow of these nalas has been blocked by the Kalkaluwa Aflux bund constructed on Indian site.

b) Rainfall-Runoff relationship

Figure 2.22 shows a typical mean monthly hydrograph of Bagasoti Gaon and Jalkundi stations for the year 2000. The rainfall of the same year recorded at Sikta station is also shown in the same figure. As can be seen, the discharge increases rapidly from May and reaches maximum at August and September

respectively at Bagasoti and Jalkundi. It can be seen that the catchment shows quick response to the rainfall particularly in station 350 compared to 360. The correlation between monthly rainfall and runoff relationship is higher in Bagastoi than in Jalkundi (See Fig. 2.23).

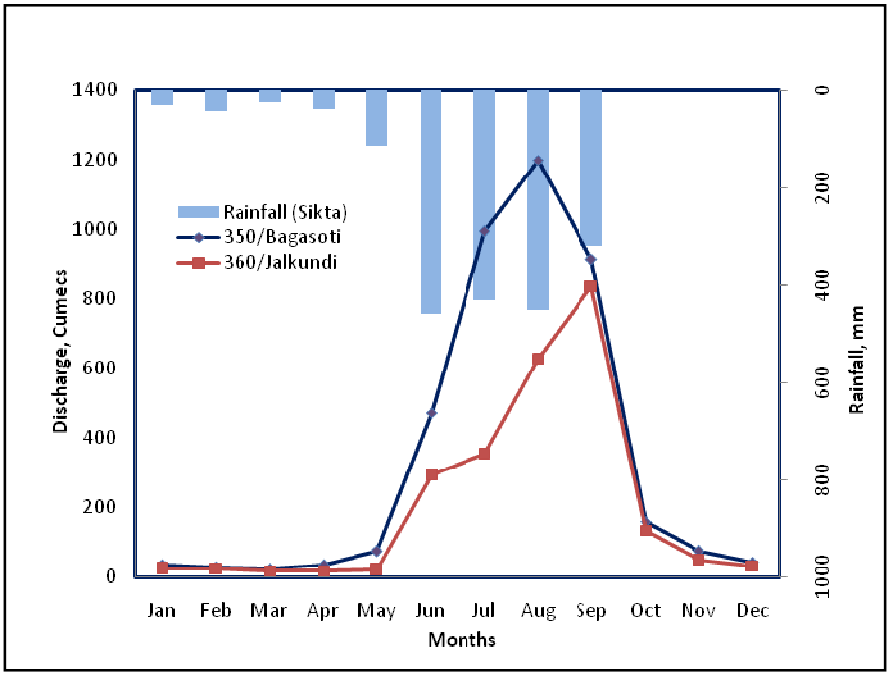


Figure 2.22 Comparison of Monthly Hydrograph of Hydrometric Stations 350 and 360

The daily flood hydrograph for the same year in these two stations is shown in the Fig. 2.24. With the exception of few flood events, the data shows that the magnitude of flood is higher in the Bagasoti, the upstream gauging station compared to the Jalkundi, the downstream station.

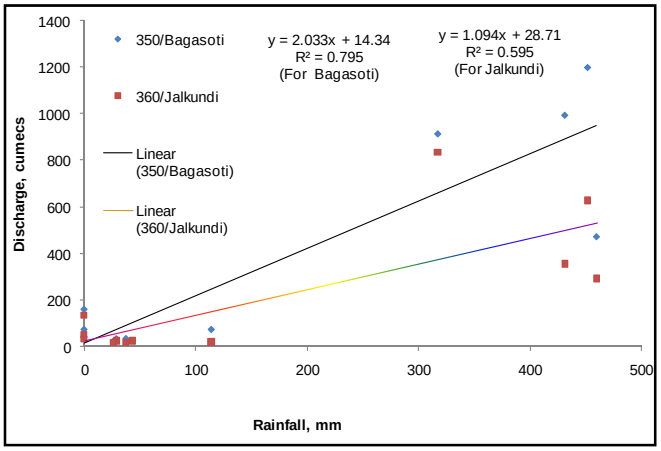


Figure 2.23 Monthly Rainfall-Runoff Relationships at Jalkundi and Bagasoti

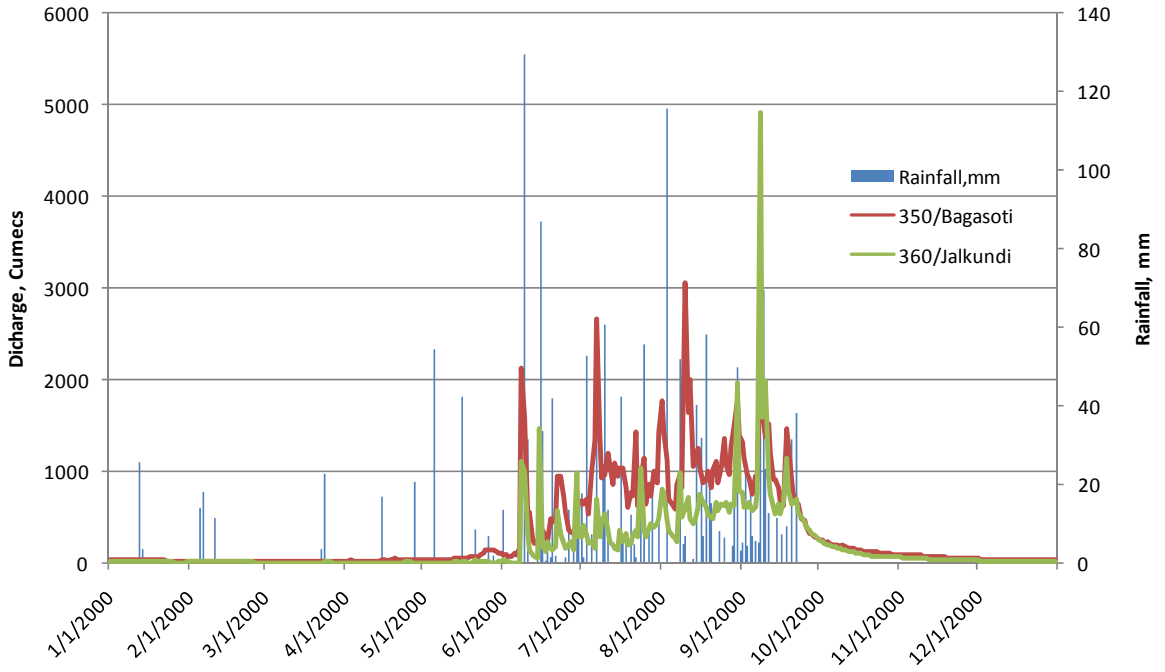


Figure 2.24 Comparison of Daily Runoff of Response of Jalkundi and Bagasoti Gaon Hydrometic Stations to Rainfall at Sikta

2.6.4 Observation Techniques, Quality and Quantity

The observation of the precipitation is usually made with ordinary bucket type gauges (Fig. 2.25). The precipitation gauging stations owned by DHM are housed in some governmental or semi-governmental premises. The data is recorded once or twice a day by the staffs paid by DHM. These data are then transmitted to the office at regional headquarter, Surkhet. Most of the precipitation stations in the basin are located in the Terai. The precipitation station in Nepalgunj Airport is automatic and seems more reliable.

Based on statistical analysis of available data of most recent year 2005, with 5 % allowable degree of error in the estimate of the mean rainfall, the number of the rain gauge stations required in the WR River Basin comes out to be 14, which is satisfied in the WR River Basin with the inclusion of the rainfall stations in the areas nearby. Similarly the requirement of Meteorological Station Density of 600 – 900 km^2 per station (in plain/Terai areas) and 100 – 250 km^2 per station (Hills and mountains) based on the recommendation of World Meteorological Organization (WMO) is also satisfied.

The discharge measurement in different hydrometric stations is being done through the water level monitoring with the staffs paid by DHM. These data are transmitted to the office at regional headquarter, Surkhet or directly to the central office, Kathmandu through VHF set. It is reported that the observation is made twice a day. Some low-cost simple, rough technique to measure instantaneous peak flood water mark is being practiced at Jalkundi (Fig. 2.26) and other stations. As common everywhere, high floods are, difficult to monitor and this is not the exception here as well. It is felt that a

careful scrutiny of the discharge measurement activities at least in one monsoon period is required in order to be confident in the monitored data. The hydrograph shown in Figure 2.22 also raise some question as the upstream flow is higher than the downstream. While there could be some valid reasons such as presence of geological structures or leakage of streamflow through underground, there could also have reasons related with measurement uncertainty. The accuracy of flood measurement at these stations is necessary for estimation of flood of various return periods, for flood forecasting and warning purpose.

Figure 2.25 Non-recording bucket type rain gauge at Jalkundi (Station 360, DHM)

Figure 2.26 Water Level gauge staffs at Jalkundi (Station 360) with simple device for recording instantaneous maximum flood

2.7 Hydrological and Morphological Analysis

2.7.1 Flood Frequency Analysis

Flood frequency analysis is required to calculate different return period floods at different catchments or sub-catchments. The magnitude of different return period floods are required as inputs for the design of many hydraulic structures or for developing different scenarios of flood inundation/hazard.

Flood frequency analysis was performed on discharges provided by DHM (based on observed instantaneous maximum water level data) on three stations and the results are reported in the Table 2.14. Three different methods namely Log Pearson III (LPIII), Gumbel and Log Normal (LN) methods were applied on these data series.

Table 2.14 Flood Estimates at Various Return Periods using Different Methods

	LPIII				Gumbel				LN				Remark
Station	2	10	25	50	2	10	25	50	2	10	25	50	
339.5	335	984	1582	2198	424	1212	278	1903	366	947	1341	1679	Jhimruk
350	1571	3201	4433	5582	1739	3777	4804	5565	1688	3114	3897	4504	Bagasoti
360	2595	4568	4888	5006	2239	6466	8594	10172	1961	6484	10043	13325	Jal Kundi

Most of the tributaries of the WR River area ungauged; however, as said earlier, gauging of a few tributaries has been started since early years of this decade. For recently gauged tributaries or ungauged tributaries and river reaches regionalized flood frequency analysis methods such as WECS-DHM (Sharma and Adhikari, 2004), Modified Dicken's and Catchment Area Ratio (CAR) methods which are commonly employed in Nepal, are used. The details of these methods are given in Annex 3 and the results are given in Table 2.15, 2.16 and 2.17. The catchment areas for these tributaries are computed based on the ArcGIS. The flood estimate for various return year periods given by WECS-DHM method showed higher values compared to the other methods. Since a detailed Rainfall-Runoff modeling and subsequent flood frequency analysis is being carried out in phase 1(b) of the study, the conservative values given by WECS-DHM equation was adopted in this study.

Table 2.15 Flood Estimates of Tributaries and the West Rapti River Reaches by WECS Method

S.N	River	Reach	Discharge in m^3/sec for different return periods (T)					
			2 years	5 years	10 years	20 years	50 years	100 years
1	Jalkundi to Sikta		333	515	647	781	965	1111
2	Shukhar	2	100	166	217	270	345	407
3	Khairi	4	17	31	43	55	75	91
4	Moranga	6	75	127	168	210	271	321
5	Muguwa	8	96	160	209	260	333	393
6	Jijhari	10	247	389	494	600	748	866
7	Dundwa	12	27	48	65	83	111	134

Table 2.16 Flood Estimates of Tributaries and the West Rapti River Reaches by Modified Dicken's Method

S.N	River/Tributaries	Reach	Discharge in m^3/sec for different return periods (T)					
			2 years	5 years	10 years	20 years	50 years	100 years
1	Jalkundi to Sikta		230	366	468	571	706	808
2	Shukhar	2	90	133	165	197	240	272
3	Khairi	4	21	27	32	37	43	48
4	Moranga	6	72	104	128	153	185	209
5	Muguwa	8	87	128	159	190	231	262
6	Jijhari	10	183	285	362	440	542	620
7	Dundwa	12	31	42	50	58	68	76

Table 2.17 Estimate of Flood of Tributaries and the West Rapti River Reaches by Catchment Area Ratio Method

S.N	River/Tributaries	Reach	Discharge in m3/sec for different return periods (T)					
			2 years	5 years	10 years	20 years	50 years	100 years
1	Jalkundi to Sikta		176	300	382	461	563	639
2	Shukhar	2	44	76	96	116	142	161
3	Khairi	4	5	9	12	14	17	19
4	Moranga	6	32	55	70	84	102	116
5	Muguwa	8	42	72	92	111	135	154
6	Jijhari	10	125	213	272	328	401	455
7	Dundwa	12	9	16	20	25	30	34

2.7.2 Trend Analysis of the Rainfall and Temperature

Trend analysis was performed on rainfall and temperature data in the study area to check if it contains any signature of the climate change. This is useful to distinguish the cause of the floods i.e. whether the floods are as a result of climate change or some other recent anthropological interventions. Non-parametric tests namely Mann-Kendall Test (Hipel and McLEOD, 1994) was applied to the available rainfall and temperature time series data recorded at 15 stations in and around WR Basin and 3 in the periphery of Nepalgunj respectively.

a) Test for trend in rainfall data

The Mann-Kendall Test for annual rainfall for the stations in and around WR Basin suggests that there is no consistent trend in the whole basin. As shown in Table 2.18, while 5 stations shows positive z-value implying increasing trend, the smallest significance level with which the test shows that the null hypothesis of no trend should be rejected is greater than 10 % except stations 0507. Rest other stations shows negative Z-value implying decreasing (downward) trend. However, none of these stations with the exception of station 0420 have their trend significant within 10% level. Sen's slope for 0507 and 0420 are 16.17 and -49.86 respectively whose value at 95 % confidence level are 5.443 (min), 32.588 (max) and -89.38 and 3.98 respectively. The annual and seasonal trends of rainfall at station 507 are shown in Figure 2.27.

Table 2.18 Mann-Kendall Test and Sen's Slope (For Annual Precipitation)

Station	Annual Rainfall Data	Z-statistic	Sen's Slope	Remarks
0407	1971-2005	1.39	11.72	>10 % significance level
0409	1971-2005	-0.91	-5.07	>10 % significance level
0412	1971-2005	-0.09	-0.85	>10 % significance level
0414	1971-2005	-0.67	-4.04	>10 % significance level
0504	1971-2005	0.77	6.22	>10 % significance level
0505	1971-2005	-0.14	-0.38	>10 % significance level
0507	1971-2005	2.40*	16.17	*5 % level significance
0508	1971-2005	-0.68	-4.72	>10 % significance level
0509	1971-2005	-1.36	-11.92	>10 % significance level
0510	1971-2005	0.00	-0.16	>10 % significance level
0715	1971-2005	-0.51	-3.99	>10 % significance level
0416	1973-2005	0.33	5.69	>10 % significance level
0419	1978-2005	-0.10	-1.03	>10 % significance level
0420	1996-2005	-1.79**	-49.86	**10 % level significance
0515	1989-2005	0.37	5.61	>10 % significance level

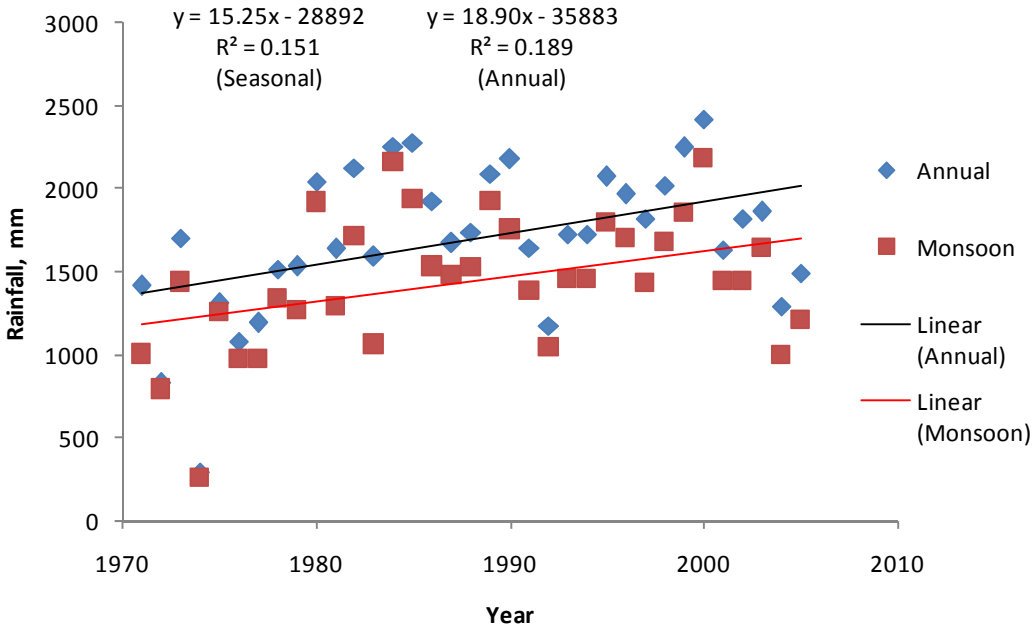


Figure 2.27 Annual and Seasonal Trend of Rainfall at Station 507

In order to investigate further if there is any trend in the rainy period, similar analysis was performed using seasonal (monsoon) data. The result is displayed in Table 2.19. It is observed that there is not much change in the result as from the annual data. From both tables it may be inferred that the station 507 has an upward trend in precipitation. Also it may be concluded that there is no significant and consistent trend of rainfall in the basin.

Table 2.19 : Mann-Kendall Test and Sen's Slope (For May-September)

Station	Annual Rainfall Data	Z-statistic	Sen's Slope	Remarks
0407	1971-2005	1.14	7.94	>10 % significance level
0409	1971-2005	-1.14	-5.46	>10 % significance level
0412	1971-2005	-0.28	-1.48	>10 % significance level
0414	1971-2005	-1.09	-6.86	>10 % significance level
0504	1971-2005	0.77	5.59	>10 % significance level
0505	1971-2005	0.28	1.25	>10 % significance level
0507	1971-2005	2.00*	13.16	*5 % level significance
0508	1971-2005	-0.94	-4.38	>10 % significance level
0509	1971-2005	-1.68**	-10.78	**10 % significance level
0510	1971-2005	0.26	1.69	>10 % significance level
0715	1971-2005	-0.26	-1.51	>10 % significance level
0416	1973-2005	0.48	5.41	>10 % significance level
0419	1978-2005	-0.18	-0.76	>10 % significance level
0420	1996-2005	-1.61	-48.07	>10 % level significance
0515	1989-2005	-0.31	-11.30	>10 % significance level

b) Test for trend in temperature data

The Mann-Kendall Test for annual instantaneous daily maximum temperature data for the stations in and around Nepalgunj (Please Refer Table 2.20) suggests that there is no consistent trend in the area. While 2 stations (Nepalgunj and Sikta) show positive Z-value implying increasing (upward) trend, the smallest significance level with which the test shows that the null hypothesis of no trend should be rejected is greater than 10 %. The data of Khajura shows negative Z-value implying decreasing (downward) trend. However, none of these stations have their trend significant within 10% level. Sen's slope for 0409(Khajura), 0416 (Nepalgunj) and 0419 (Sikta) are -0.015, 0.06 and 0.017 respectively whose value at 95 % confidence level are -0.1 (min), 0.129 (max); -0.062(min) and 0.239 (max), and -0.062(min) and 0.133(max) respectively. Similar to the rainfall data the temperature data also does not show significant and consistent trend in the lower WR Basin.

Table 2.20 Mann-Kendall Test and Sen's Slope for Instantaneous Maximum Temperature

Station	Annual Temperature Data	Z-statistic	Sen's Slope	Remarks
0409	1987-2005	-0.07	-0.015	>10 % significance level
0416	1987-2005	0.88	0.060	>10 % significance level
0419	1987-2005	0.56	0.017	>10 % significance level

2.7.3 River Channel Migration

The WR River channel is learnt to be frequently migrating particularly in the southern region. Such migration clearly poses a risk to the settlements and farmland in the vicinity of the river. Figure 2.27 shows comparison of WR river channel pathways in 1975, 1996 and 2007. The figure clearly shows the westward movement of the river in recent years. Over last 10 years, the channel has migrated over 1.8 Km near the southern boarder. A detailed analysis on this matter is being carried out in the next phase (Phase 1.b) of the study.

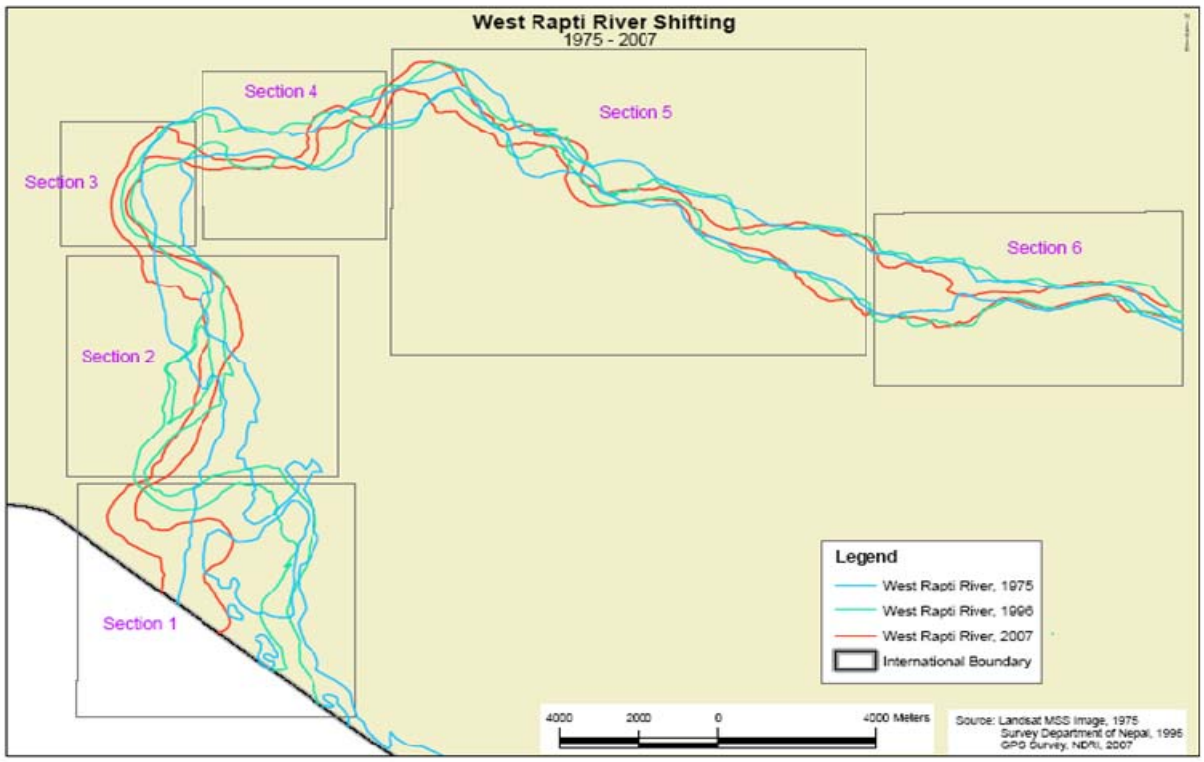


Fig 2.28 Migration of the West Rapti River Channel from 1975-2007

2.7.4 Upstream/Downstream and Upland/Lowland Linkages

Recent floodings in the Lower West Rapti River Basin and the study area has shown that the upstream/downstream and upland/lowland linkages have great significance on designing any comprehensive flood management plan. Consideration of such linkages will help address the root causes of flooding.

In the study area, there is a common perception among Nepali administrators, researchers and local people in general that the extent of flooding has increased since the construction of Laxmanpur Barrage and Kalkaluwa Bandh in India. The blockage of flow of natural drains namely Sotiya and Gandhali Nalas due to Kalkaluwa bandh is one of the reasons for such increased inundation. This is also observed in the present study based on hydraulic modeling using HEC-RAS and is reported in Chapter 5. Similarly, in the study area (Gangapur and Matehiya VDCs), the backwater effect of the increased flood discharge in the WR River has been reported by the locals, affecting the drainage of inundated area. Moreover, based on the general hydraulic principle, it can be said that the construction of Laxmanpur barrage and the Kalkaluwa bund is expected to cause aggradations upstream of these structures. Such aggradation reduces the conveyance capacity of the river channel resulting into inundation due to bank overtopping (Bhusal, 2004).

The upstream catchments contribute significantly to the WR River dry and wet period flow. The determination of time of concentration of several sub-catchments and flow routing in the main channel are necessary for the proper design of any flood forecasting system. Such study has implication for proposing specific watershed management activities in the sub-catchments with rapid rainfall-runoff response. The hydrological linkage between upstream and downstream is aimed through the HEC-HMS modeling in the sub-phase of this phase research.

The upland and lowland linkage is clearly observed in the study area. A number of rivers originating from the Churia range carry huge amount of sediments which get deposited in the farm land reducing the productivity of the land. While harnessing these rivulets is necessary for water security for irrigation purposes in the study area, their proper management is necessary to reduce the flood and associated hazards (inundation, bank cutting, and sedimentation). This upland and lowland linkage is true in the whole WR River also. It is widely believed that, the increased erosion in the upland areas and debris flow has caused increased sediment in the WR River resulting into reduced conveyance capacity of the river channel and thus causing flooding and bank cutting problems.

Chapter 3: Participatory Assessment of Flood Hazard, Vulnerability and Risk, and Capacity of the Community

3.1 Hazards, Vulnerability, Risks and Capacity

While in general there is less ambiguity and divergence on defining hazard, there are competing and widely divergent views on vulnerability and risk. In this participatory assessment work these terms are defined in the following way:

Hazard: Hazard is a potentially damaging natural or manmade phenomenon that may cause physical damage, economic loss and threaten human life and wellbeing.

Vulnerability: Vulnerability is defined as an underlying condition, distinguished from the risky events that may trigger the outcome (Webb, 1993 in Jeffrey et. al. 2001). While detailing vulnerabilities in the study area, physical, social and attitudinal aspects were considered, but while mapping, vulnerability is taken as settlements, and structures that are vulnerable to damages from flood.

Risk: Following Blakie, et. al. (1994), risk is defined as the probability of exposure to events and outcomes. In this regard, while mapping, risk is considered for settlements, and structures that are under imminent threat of exposure and damage from flood.

Capacity: The capacity includes strengths and resources available within a community such as the relevant institutions, social infrastructures, and skilled manpower useful for disaster management.

The participatory vulnerability analysis (PVA) was used as the guiding tool for the fieldwork. PVA is a systematic process that involves communities and other stakeholders in an in-depth examination of their vulnerability, and at the same time empowers or motivates them to take appropriate actions (Gautam, 2006). The overall aim of PVA is to link disaster preparedness and response to long-term development (AA International: 2000).

In order to know the real situation of flood hazard and associated vulnerabilities and risks, maps were prepared in each cluster keeping the flood affected people at the centre of the process. People were asked to identify different features such as flood prone area, public land, public utilities, high land, roads, *duban*[1], *katan*[2] and patan[3], evacuation centres, route in the map. Similarly, capacity which includes relevant institutions and social infrastructures are also identified for each cluster.

The hazard map prepared by the community for all the clusters (1-4) are aggregated and shown in Figure 3.1. The map also shows the potential evacuation route and shelters which they have also used in the past floods. Similarly physical vulnerability map of the study area which shows the physical infrastructures under threat in last 20 years is shown in Fig. 3.2. These include a number of settlements, schools, bridges, culverts etc.

[1] Inundated area
[2] River cutting area
[3] Sedimented area

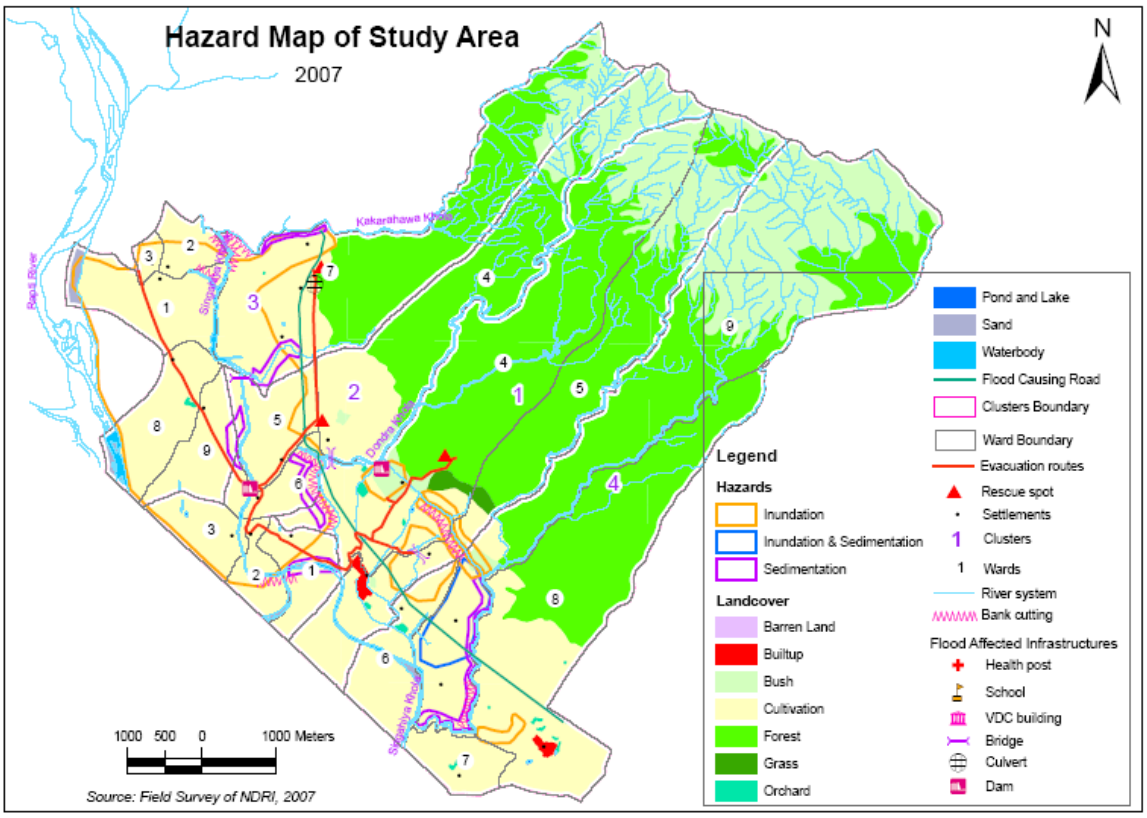


Figure 3.1 Community Based Flood Hazard Map of the Study Area with the Rescue Spots Shown

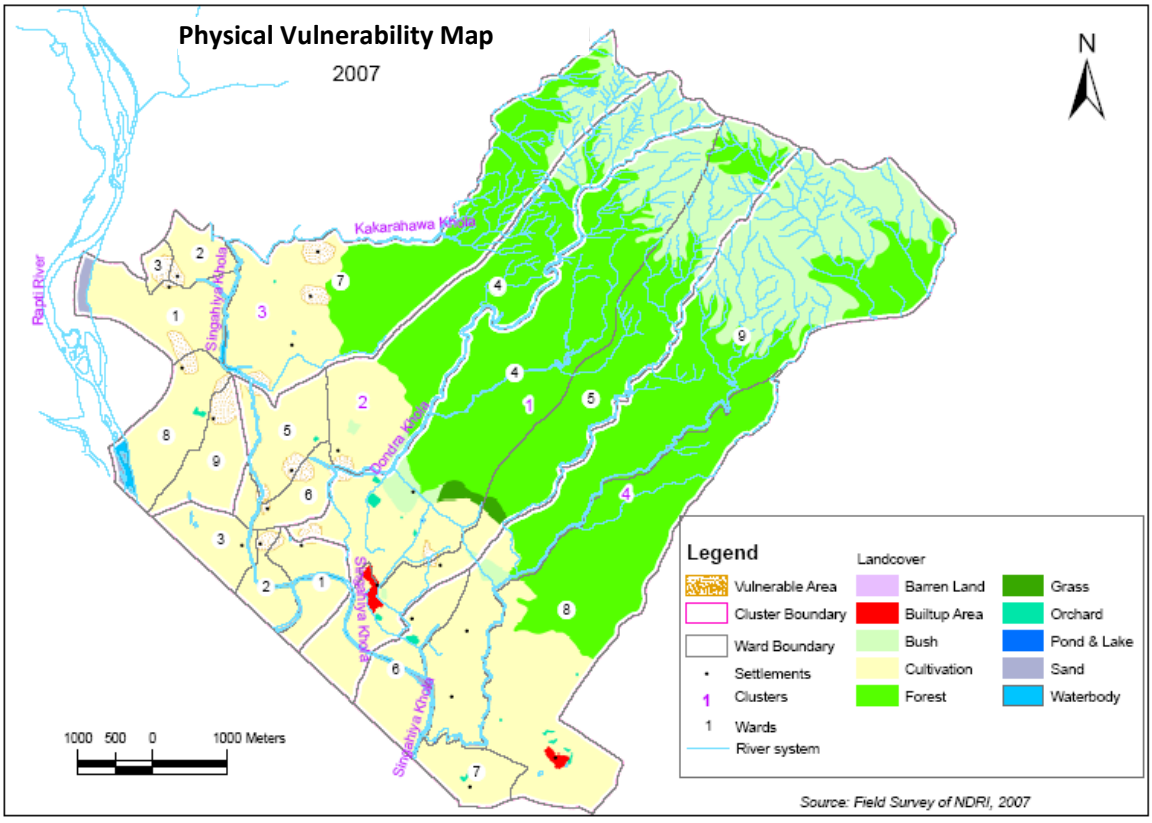


Figure 3.2 Community Based Physical Vulnerability Map of the Study Area

The community were also involved on identifying the physical infrastructures, and settlements on imminent threat of flood (termed as risk in this study). The information provided by the community is displayed as a map in Fig 3.3.

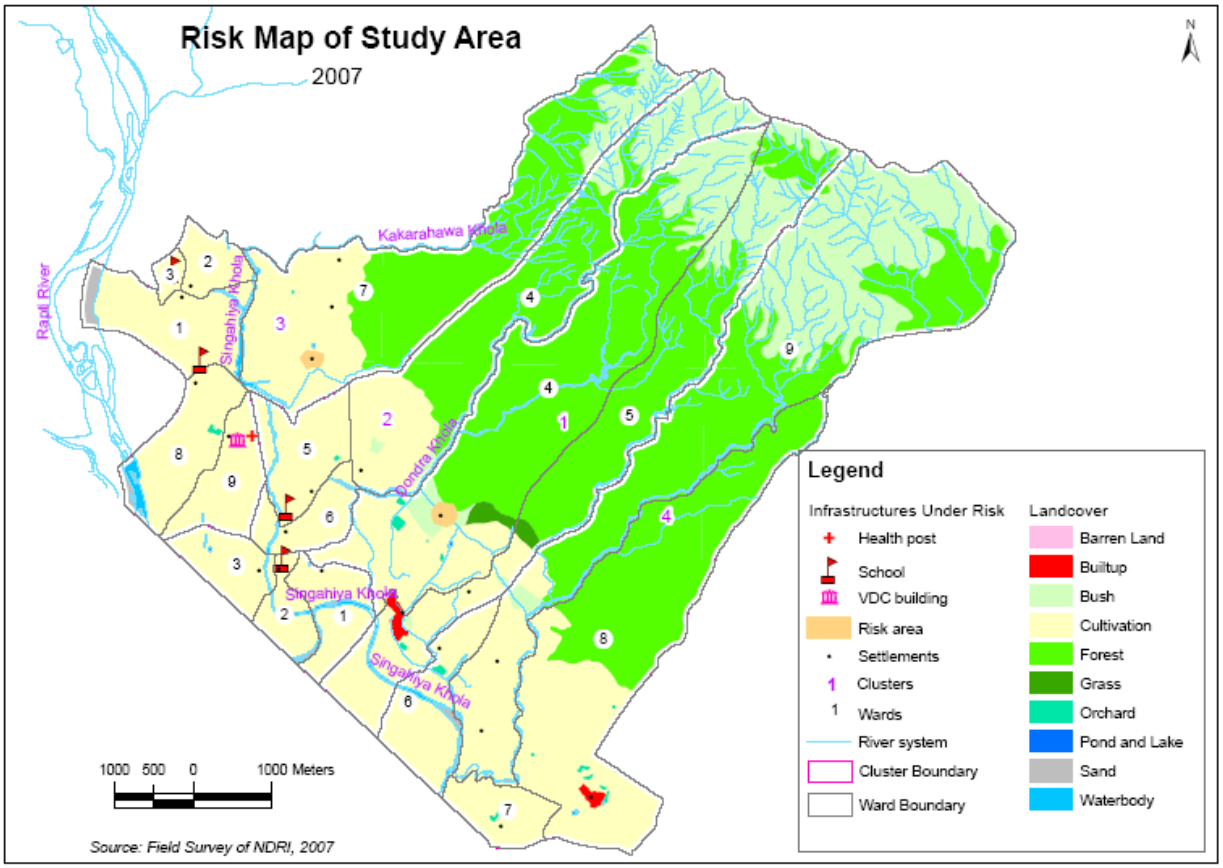


Figure 3.3 Community Identified Infrastructures, and settlements under Risk in the Study Area

The details of hazard, physical vulnerability, settlements and infrastructures under risk in the first three clusters of the study area are given in the supporting report (Annex VI-9); such detailed information is needed to plan any countermeasures for disaster mitigation and management in the study area. The capacities in the form of available institutions and infrastructures useful for flood disaster management in the study area are listed below.

- Community Forest Users Groups in Matehiya for support and increasing resilience.
- School of *Naibasti* on the southern part of *Bagauda road* for shelter.
- Shelter of Chaubis Bigaha on the north side of causeway.
- Shelter on the high land of forest area on the western part of Dondra River and north side of Bagauda road.
- Lower Secondary School near the road in Bhojpur for shelter.
- Madarsa (Muslim School) in Bhojpur near the Dondra River for shelter.
- Gangapur VDC office.
- Sub-health Post and Police Post of Gangapur.
- Lower Secondary School, Bhojpur.
- Primary School , Sonbarsha.

- Prilmary School , Kodarbetwa.
- Prilmary School , Jamuni.

Similarly available human capital in the study area, in terms of skill of the people useful during flood, was also documented for all the clusters. The details are given in the Table 4.1.

Table 3.1: Types and Number of Skilled Person by Cluster

Cluster	Location	Types of skilled persons	No. of skilled persons
1	Matehiya VDC: Motipur and Mahadev Nagar Gangapur: Kohala and Naibasti	Health personnel	1
		Women Health Worker	3
		Professional swimmer	5
		Search and rescue facilitators	5
		Boat operator	17
2	Gangapur VDC: Dondra and Bhojpur Matehiya VDC: Newajigaun, Bhagawanpur	Health personnel	1
		Women Health Worker	7
		Local healer	15
		Tent repair technicians	1
		Professional swimmer	20
		Search and rescue facilitators	5
		Boat operator	24
3	Gangapur VDC: Sonbarsa, Jamuni, Kudarbetwa, Gangapur	Health personnel	5
		Women Health Worker	6
		Professional swimmer	4
		Boat operator	35
4	Matehiya VDC: Matehiya, Hulaspur, Jamunaha, Sarbarajpurwa and Maheshpur	Health personnel	0
		Women Health Worker	6
		Professional swimmer	0
		Search and rescue facilitators	5
		Boat operator	6

Source: Discussion with farmers, FGDs and KIIs

3.2 The Communities and Groups Affected from Flood Hazards in the Study area

All communities living in the low lying area and along the river bank are affected from flood disaster. But not all people are vulnerable equally. Based on the discussion with the people during the fieldwork, the following groups of people were identified as vulnerable:

- The people living in the low lying area and along the banks of West Rapti River.
- The people living in the clusters along both banks of rivers flowing from the *Churia.*
- Terai dalit communities because of their poverty, marginalisation and deprivation.
- Landless because flood disaster reduces the opportunities of off-farm labour work within the village.
- Low income source groups like landless, bonded labour.
- Pregnant women, children and elderly people because the breadwinner of the houses are mostly living outside for seasonal labour work.
- Livestock herders because flooding reduces the grazing land and feed of livestock.
- Marginal landholders who completely rely on agriculture and livestock.
- The sharecroppers whose scope of taking others land as sharecropping and on rental basis is reduced due to the continuous flooding and crop failure.

3.3 Factors Contributing Vulnerabilities of People to Flood Disaster

There are many reasons embedded for the vulnerabilities of people due to flood disaster. People's vulnerabilities depend upon their coping capacities. Those who are able to cope with the effects of flood disaster immediately are less vulnerable compared to others. Through careful analysis, the following main issues were identified as factors contributing to the vulnerabilities of flood affected people.

- As the settlements are in the low lying area, even small flood affects the settlements.
- About 70% houses are of thatched roof type. These houses by their nature get easily damped with the first flood if stagnant for 2-3 days.
- Dense settlements are more vulnerable as the closeness of the houses affects the drainage and promotes the problem of water logging.
- The degree of landlessness also promotes the vulnerabilities. About 20% people in the study area are landless.
- The continuous flooding reduces the crop production and it again reduces the on and off farm activities within the village. It also promotes the vulnerabilities of poor people further.
- The heavy practice of seasonal migration leaves only children, elderly and women at home. This also creates the vulnerabilities due to their poor coping capacities to fight against the flood.
- The crop failure and losses of livestock create extra burden in the family and create vulnerabilities. It also creates negative attitude, behaviour, and thinking, which are very harmful to secure the livelihood.
- The damage of seeds creates extra burden to people and compels them to procure new seed on higher price. This financial burden makes people more vulnerable to next flood.
- The livelihood of the people mainly depends on agriculture and livestock. The failure in these two sectors directly hampers their livelihood and people become vulnerable.

- The failure in crop and losses of livestock often make people indebted and people have no alternative other than selling of land. Those who have no land get migrated seasonally for longer period.
- The continuous flooding cause dropping out of students. Often, otherwise school going children get involved in child labour, as cow boys and domestic helpers to pay the loan.

3.4 Local Knowledge on Flood Issues

Flood forecasting, early warning system and community based flood management can save many lives and properties during and after the flood. During the field work, community in the study areas shared their local knowledge on flood forecasting, early warning and flood management practices. This knowledge is mainly of experimental nature acquired over years of struggling with flood disasters and in some instances the transmitted ones through poems and songs (Box 3.1). It is necessary that any comprehensive flood management plan should take into account the existing local knowledge of flood affected communities on local physical condition, history and trends of the flood, local flood forecasting and warning approaches, and various other aspects of flood management (Dekens, 2007). This is necessary as people know the local context, the physical set up, the problems of floods and possible solutions better than the outsiders (Osti, 2005; Osti et al., 2008). While it is important to study existing local beliefs and practices for forecasting, early warning, and for flood management, in the operational phase it is equally important to ascertain that they are useful and appropriate, and can be integrated in the disaster management plan.

There are diverse ethnic groups and subgroups within the study area including groups of hill and Terai origins. Thus the local knowledge is not same every where in all communities. Nevertheless, the study tried to cover the whole area for documenting the local knowledge for various aspects which is described below.

3.4.1 Forecasting of Heavy Storms

While listening of weather forecast report from radio stations are practised by some people for getting information about forecast of heavy storms, many still practised their own ways for forecasting heavy storms. Some of the indicators for the people for forecasting heavy storms as shared by them during the field study are:

- Position of the cloud in the sky.
- The extent of rainfall in upper catchments and Churia area
- Mobility of ants
- Abnormality in fly bite
- Abnormal crying/voices of animals and birds
- The intensity of sound of thunderstorm
- Direction of wind
- Position of stars
- Degree of hotness

Box 3.1: *'Tij Kai Barsat'*

"Badar Barase Musharan Dhar, Shiv Ke Mahima Aparampar!

Dondra Sota Badhai Lag, Gharma Pani Paithai Lag!!

Pahile Pani Aangan Ma Paitha, Kothari Ma Khatiyap Chadhi Baitha!

Bartan Bhanda Utraya Chale, Lari Ke Bachche Chillay Uthe!!

Dasani Kathari Dihis Bhijay, Lakadi Kanda Dihis Bahay!

Ganw Ma Machiga Ha Ha Kar, Koi Koik Na Sunai Pukar!!

Ek To Andhiyari Rat, Sujhi Parai Na Aapan Hath!

Dhunde Milai Na Diya Salai, Dhebari Batti Kaise Jalai!!

Nanda, Bhainsa, Ladiha Bahiga, Tatiya, Chhapara, Palla Bahiga!

Gay, Bhains, Chhagadi Kai Chhuti, Aanna, Pat , Kapada Ga Luti!!

Mr. Kamta Prasad Maurya, Gangapur-5, Dondra (Date: 2063/5/14)

(MEANING: There is a heavy rainfall, the divine act of the Lord Shiva! When water level increases in the Dondra River, water starts to come within the courtyard. Slowly water enters into the house. Then people reside on khatiya. The flood sweeps the utensils, woods and livestock, damages the grains and clothes. There is total confusion and crisis in the village and nobody listen each other. In the dark night, they are unable to burn the light as they cannot find the matches. ...)

3.4.2 Early Warning Practices

There is no formal early warning system in the study area. But people try to assume and correlate their proven knowledge to mark for early warning. There is a general practice that people living in the areas along or near the river banks get voluntarily involved in the monitoring of flood and warning others especially during the daytime in the monsoon season. Some of the examples of local knowledge on early warnings documented during the field study are given below:

- **Strange sounds from rivers:** Community people assess the strange sound (rumbling sounds) from the WR and other small rivers. They identify the sound of heavy flood upstream, based on their prior experiences. Once confirmed that there is a flood upstream, there is a general practice of shouting in loud voice to notify other people. Accordingly, people decide either to stay inside the house taking some precautions, or to go to safer places for staying.
- **Muddy smell of the water of the river**: Muddy smell in the water is considered as another indicator of the flood. Generally big flood carry fresh soil/mud along with water and its smell is different than the normal flood. According to the local people, colour of river water is also another indicator of flood.
- **Presence of dry leaves, mud and other materials in river water:** When the water level increases, flood carries dry leaves, mud and other materials along the river course. These are taken as an indication of increasing water level. It is also reported that if number of fishes in rivers suddenly starts increasing, then this is considered as an indication of possible flooding in the immediate future. If there is a big flood coming nearby, dead bodies of animal and snake can be seen flowing at the surface of the water.

3.4.3 Management Before, During and After the Flood

People in the study area demonstrated some knowledge and skills for flood preparedness and management during and after flood. The flood management practices adopted by the community as shared by them during the field study and as observed at the real ground shows that people have good understanding and knowledge about flood and its nature. They are familiar with the possible damage and destruction. The flood management practices of the community in the study area as grouped into three categories namely flood management before, during and after the flood are reported below.

a) Before Flood

- **Management of basic materials in advance:** It was observed that wherever possible, people tried to manage basic materials that are needed during the flood situation at their house. It is found that people keep plastic sheets, tents, ropes, rubber tubes, empty drums, torchlight, etc. especially during monsoon in *aatiya.* At the same time, those unable to manage the materials in advance adopt 'wait and see' strategy. As a result, the people of latter groups are found more vulnerable during the flood because of the poor preparedness.
- **Psychological preparedness for flood:** It was found that majority of people take the events of flood as a part of life. They are aware of the possible magnitude and frequency of flood and its possible destruction. Thus, they are mentally prepared to face and struggle with the possible flood disaster and prepare accordingly at individual and family level. People express that living with the flood should be the lasting alternative in the absence of support from external agencies.
- **Protection against cough and cold:** During the flooding period, children mostly suffer from many diseases, cough and cold being the major one. People are found sensitive to save the life of children from cough and cold. People use local spices such as *marich, harro, barro* and *kala jira* in the food and take *tulasi tea* to prevent cough and cold. They also collect *neem* as they use leaves of *neem* during the fever and to treat the skin disease.
- **Use of NTFP as medicine to treat livestock:** A number of *gharelu* (domestic) treatment practices for livestock are common in the study area as people cannot afford for western medicines and do not have access to the services of veterinary technicians particularly during floods. It was shared that people usually make pest of karaunda root (a forest plant) and use in the injured legs of the livestock that is suffering from *Khoret(foot and mouth)* disease. This disease is common during flooding period. Similarly, pest of *lahara beli* is especially used for goats suffering from diarrhoea and dysentery. Pieces of *gurjo* are mixed with grass and feeds if the livestock are suffering from cold and cough. Garlic and *bojo* is widely used during the stomach problem of livestock. Therefore, before the floods, communities ensure that these NFTP are available.
- **Creation of drainage outlet in each plot of land**: Poor drainage system compounds the flooding and inundation problem in the study area. In order to protect paddy land from the possible flood, people try to make *savah* (drainage outlet) in each plot of land. This is very common practice in the flood affected area.
- **Storage of the valuable materials in aati*/Attaiya*[4]*:*** People usually keep the important documents and utensils in the safe places either in their own house or in safer houses of close neighbours or kins. People living in the low lying flood prone areas who have thatched houses

[4] The upstairs used to storage materials in order to save from flood.

and have no close neighbours with *pakka* house cannot usually save their documents and the assets.

- **Preparation of the *khatiya/palang of bigger height***: *Khatiya* made from *babio* rope is very common in the Terai. Due to risk of snakebite, every family member tries to sleep on *Khatiya*. As the number of death with snakebites after flooding is on rise, people have started to make *khatiya* of bigger height. *Khatiya* are especially useful to keep the children outside the house during flood if the flood level inside the house is high. For instance, in 1995, some people of Mahadevnagar, Matehiya had saved the lives of their children by hanging the *khatiya* on the *Mauwa* tree and keeping their children on it throughout the night.
- ***Weaving doko*:** Some settlements in the study area weave *doko* (a large sized basket made of bamboo) in advance for protecting poultry during the flood. It is a common practice of putting chicken in the *dokos* and hanging the *dokos* on the safer places. Usually people try to sell chicken before flood season.
- **Storage of grains and dry foods:** There is a general practice of milling sufficient grain in advance for monsoon season. People usually prepare and keep dry food and vegetables such as beaten rice, salt, sugar, *bheli*, noodles, gundruk (dried green leafy vegetables), potato chips, pulses etc. Besides, people also prepare dry food of *satuwa (roasted and powdered gram)*, *bhuja(made from rice),* biscuits, especially for their kids. Sidra (dry fish, see Fig. 3.4), mango pickles, titaura (dried daal and mustard) and dried pumpkin are also prepared for the monsoon period.

Figure 3.4 Sun Drying of Fish

Figure 3.5 Construction of Pihan

- **Preparation of Informal self plan for evacuation:** During peak monsoon, evacuation in the safer place is common. People prepare informal plan in advance for possible evacuation to safer areas. For example, the people of Dondra and Gangapur used to go to *Chaubis Bigha* (comparatively on higher elevation) because of safety and proximity. In the last monsoon (2007), eight HHs of Gangapur-7, Kudarbetwa and five HHs of the Sonbarsha moved to *Panchayati Ban*(Forest) of Gangapur-7, Kohala. Similarly, people from about 50% HHs of Dondra and about 110 HHs residing near the Sub-health Post of Gangapur moved to *Chaubis Bigaha* area.
- **Arrangement of evacuation place and plan:** Before monsoon, people within the community discuss for evacuation plan and management of evacuation places. The plan consists of renovation of possible evacuation centres and administrative arrangement with school management committee to close the school for some days among others.

- **Management of livestock in advance:** People take their livestock to safer places if they perceive that flooding problem will become severe. It is, however, very difficult to evacuate livestock before evacuating people due to security reasons. People of *Gangapur* use to take their livestock to *Jamuni,* a place relatively safer from flood.
- **Making of temporary aatiya/taad:** In the study area, people use to construct temporary *aatiya/taad* to place the *deheri* (grain storage bin made up of mud) for storing grass and feed of livestock.
- **Procurement of essential drugs in advance**: It was learnt that people usually drink contaminated water, eat dead fishes and contaminated food as they are forced by the situation during flood. As the surrounding is also contaminated due to dead animals, the quality of water becomes worse. As a result, common cough and cold, water borne diseases, fever, skin disease, and worm infestation are very common in the villages during floods. As a precautionary measure, some people procure essential drugs like Amzit, Cetamol, ORS, etc in advance.
- **Management of firewood:** In the study area, especially in the northern village, there is no problem of firewood due to proximity of forest area. People in the southern village use cow dung apart from firewood. Usually, people manage sufficient quantity of firewood and cow dung for monsoon period as it is very difficult to manage firewood during the flooding season. In order to store the firewood and cow dung safely, they make *aatiya* and *taad*.
- **Storage of dry food for livestock:** Livestock grazing during monsoon is not possible in flooded and inundated areas in majority of the villages. In order to cope with the situation, people usually store the straw, *khar* (hay), dry grass and chopped grass in advance. They also store bran to feed their livestock during flooding.
- **Making of *pihan.*** During flood, it is very difficult to cook food due to wet surrounding which makes it difficult to burn firewood. For handling such situation, people make *Pihan*[5]*(Fig.3.5)* in advance to keep stoves or other traditional cooking stoves on it.
- **Improvement of drainage:** Poor drainage is one of the root causes of inundation in the study area. In some villages such as Motipur, clearance of silts from canal and culvert is usually carried out before the flooding period.
- **Homestead raising:** In order to be safe from the flood, there is an increasing trend of homestead raising before the construction of house over it. People prefer to raise homestead with stone machinery.
- **Raising the height of hand pumps:** With scarcity of water during flooding period and contamination of water due to open defecation, height of the newly installed hand pumps are being raised by the people.

b) During Flood

- **Caring of children and elderly with priority:** The primary task during this phase is to care the children and elderly first as they are the first victims from the flood. Kids are rescued in the *taad/aatiya* or in the *khatiya* to save from the flood. Those who have two-storey houses go upstairs to live.
- **Keeping of valuable goods safely:** Those who still keep the valuable goods at home try to keep them carefully so that those will not be damaged by flood. Those goods are generally kept at safer place or in the neighbour's houses which are safer.

[5] A kind of cooking stand made up of mud.

- **Making of double *khatiya* with increased height**: In order to raise the height of the *khatiya*, there is a practice of stacking one *khatiya* over another. People keep children, elderly people and pregnant women on them. Sometimes, khatiya is also used to keep the grains (Fig. 3.6)
- **Evacuating pregnant women:** When people start evacuation during flood, they were reported to give priority to pregnant women. People shared that pregnant women suffered a lot during the floods.
- **Monitoring flood during night:** Many communities are found to monitor flood during night time. For this purpose, usually youths from the same *tole (*neighbourhood) are assigned on a rotational basis.

Figure 3.6 Use of *Khatiya* for Keeping Grains

- **Using rescue and relief materials:** People shared that some of them use vehicle tubes and family fishing boats for rescue purpose. As people perceive that floodwater level has reached the danger level, those having such rescue and relief materials start using them.
- **Mobilisation of youths:** Role of youths (particularly school students) is very important during evacuation of the people towards comparatively safer place. Schools are closed for some days and youths are involved in rescuing people affected from the flood. The rescue and relief activities include carrying people towards the safer places, management of valuable goods arrangement of food, and treatment of people.
- **Informing Red Cross and other stakeholders:** Local volunteers inform relevant stakeholders about the situation of flood through CDMA phone and seek immediate relief materials. The Red Cross and security personnel are first notified than other stakeholders including District Administration Office.
- **Taking shelter at appropriate place:** Families whose houses are completely damaged or destroyed take shelter at school, health post and neighbouring houses. Those few households who have multi-storey cemented buildings stay in the upper floors.
- **Using of tents and plastics to stay:** At the initial stage when flood has just started, those having tents and plastic sheets start using them. But as the flood water level increases further, they also move towards the safer places.
- **Managing Livestock:** Generally livestock are kept at uplands to protect them from the flood. In the extreme condition, livestock are freed from rope so that they can swim and go to safer places on their own. In high flood situation, management of livestock may not be a priority for people.
- **Filling sand bags to divert the flood:** During floods, on the basis of their proven knowledge, experiences and practices, people sometimes try to divert flood from their area. It is done by excavating new canal and constructing dykes of sandbags.

c) After the flood

When water level recedes, people return to their houses. Some of the measures taken by people after the flood are as follows:

- **Informal Damage assessment:** When they return home once the flood is out of risk level, they assess the damage caused by flood informally so that immediate plan could be made for action on the priority basis. The damage assessment is also done to receive relief materials from government and for preparedness for next year flood.
- **Drying of wet seed, grains and clothes:** Sun drying of wet seed, grains and clothes is one of the main tasks people perform after the flood. Elderly and women are mostly involved to separate good grains from the damaged ones.
- **Construction/repairing of houses:** Not all houses are damaged by the flood. The extent of damage depends on the magnitude of flood, condition of houses and physical set up of the villages. The partially damaged houses are repaired and made liveable. People with completely collapsed houses, collect construction materials like bamboo, rope, hay and wood from nearby forest. The role of CFUG is important for providing such materials. Community often show solidarity and cooperation during such disaster events. People stay in their neighbour's or kin's home for some time until the house is ready to live. Some community leaders also provide assistance to the affected families during this period.
- **Management of food and clothes:** If stored grain is damaged by food, people seek grain from others on credit. Taking loan from private moneylender is common during these days for purchasing food for survival. In most of the conditions, to manage warm clothes for family members and to procure additional food to eat people take loan or get support of big landowners in exchange of providing their services during cultivation and sending their kids as domestic helps in future. People also receive relief materials from various relief and humanitarian organizations.
- **Management of temporary set up for children and elderly:** After returning from evacuation centre, people set up places for children and elderly people to stay and sleep. This is a kind of temporary set up until the house is reconstructed or repaired.
- **Maintenance of tube well for drinking water:** Managing drinking water is another prime task for families after the flood. Hand pumps and traditional wells in many locations get completely defunct because of the flood. People repair their hand pumps so that they start getting water again.
- **Use of *Pihan* to cook food:** As the ground is wet after flood, burning firewood or cow dung for cooking becomes difficult. People use already prepared *pihan* for cooking until the ground is completely dry.
- **Use of local treatments to manage water borne diseases:** There is usually outbreak of water borne diseases after the floods. The common diseases are diarrhoea, cholera, dysentery, pneumonia, skin and eye infections, worm infestation, etc. Livestock also equally suffer from many diseases. In such situation, people usually apply local treatment methods until they receive good treatments.

3.5 Coping and Adaptation Strategies

People have lived with floods for years and thus have devised their own way to cope (short term strategy) or adapt (long term strategy) with them. Various flood management strategies taken by the local communities have been already in Section 3.4. These are further succinctly put here under coping and adaptation strategies.

Coping strategies are short term in nature. In order to reduce the effects of flood, people living in the flood prone area have demonstrated certain coping mechanisms as mentioned below:

- Preferring cheaper food at times of food shortage.
- Borrowing food on a barter system or buying on credit.
- Spending savings on food, clothes and treatments.
- Reducing the frequency and amount of food consumption by youth family members.
- Selling household assets like livestock, utensils, land and gold at the time of extreme need.
- Migrating to the nearby cities during monsoon by handing over the assets to close relatives.
- Changing food composition and practices, (in general, people take green vegetables, *daal* (lentil soup) with rice or *roti*).
- Preparing temporary *machan (elevated place)* to stay.
- Preparing seed beds of paddy not at once but at instalments with certain interval of time.

Adaptation strategies are for longer term and are more sustainable to manage the effect of flood. Examples include:

- Cultivating water melon and *sakarkhanda(sweet potato)*, peanuts, etc. in the area where the land is covered with sand as means of securing alternative livelihood.
- Increasing the height of goat-shed as goats are considered highly vulnerable to be swept by flood.
- Raising homesteads above the flood level of last ten years.
- Shifting from mud made *deheri* (Fig. 3.7) to wooden *bhakari* (Fig.3.8) for grain storage.
- Constructing channel in the villages to divert flood water.
- Raising height of newly installed hand pumps.

Figure 3.7 Mud Made Deheri for Food Grain Storage

Figure 3.8 Wooden Bhakari for Grain Storage

A further example for adaptation comes from the case of women members of saving and credit groups. They have collectively taken 7 *bigha* land of Jilla Panchayat Lower Secondary School, Bhojpur for 4 years and distributed 5 to 7 *kattha* land to each member. They deposit 50 percent production from the land to their committee. This is a new initiative for alternative income.

CHAPTER 4: Flood and Livelihood Aspects in the Study Area

4.1 Sustainable Livelihood Strategy of People Living with Food and the Need

People's vulnerability and coping capacity to flood and other hazards depend on their livelihood strategy. In the Sustainable Livelihood Framework (DFID, 1999), a livelihood is defined as the capabilities, assets (both material and social resources) and activities required for a means of living. A livelihood is considered as sustainable when it can cope with and recover from stresses and shocks (e.g. natural disasters, conflicts, epidemics etc.). The framework expresses strengths and capacities of people in terms of their livelihood assets namely Human, Natural, Financial, Social, Physical and Natural Capitals. In the following, the livelihood assets of the people in the study area are described with suggestions for enhancement.

4.1.1 Social capital

The social capital of the people is judged by many factors including the level of strong social bondage, mutual cooperation among the community people, practice of *parma* system, involvement in communal work such as group farming, etc. Similarly, the existence of strong community level institutions with membership base and practices of local knowledge and skills, practices for the betterments, good networks and connections, and relationship of trust, reciprocity and exchange are other characteristics of social capital.

Through careful analysis of the social capital of the area, it was found that some part of the study area is very strong on bondage, mutual cooperation and practice of *parma* system and existence of strong community level institutions. People have good local knowledge and practices for flood management. Strong rituals and customs in relation to flood also encourage people to involve actively in the management of flood. There are no major ethnic disputes in relation to flood management.

However, because of the people living with fear and trauma from flood disaster, the social networks are deteriorating, and social insurance and solidarity that make them cheerful are becoming weaker. To make the situation better, there is a need of organising psycho-social counselling with input support to the flood affected people to raise the ray of hopes. It is also necessary to share the knowledge and information on how the people from other flood affected communities cope with similar flood related problems. Gautam (2006) in his study in eastern Nepal observed that in the flood affected area, people suffer from many psycho-socio problems. This is due to relocation, poor social closure, collective action and community safety.

4.1.2 Human capital

Human capital of the community can be assessed by skills and knowledge, level of literacy, exposure, awareness, ability to labour, good health, etc.

In the study area, people have good skills and knowledge on how to manage the flood effectively. People have different capacities that directly or indirectly support the flood management (please refer Table 3.1). However, low level of literacy, poor income source, traditional practice of animal husbandry, poor health facilities at the area, poor knowledge on modified tools and techniques, and inadequate community's emergency fund make their human capital always at risk. The low level of awareness and exposure about the new initiatives undertaken by the people from others areas make people to continue whatever they know in terms of flood management.

Hence, there is a need of assisting the flood affected most vulnerable people in alternative income generation, increase level of awareness and exposure especially for skill promotion. People shared during the discussion that bicycle repairing, mason, carpentry seem most feasible in the area. For improved animal husbandry, there is a need to promote stall feeding with proper vaccination services and de-worming schemes immediately before and after flood. Farmers have to be trained on proper feed management. Health education is urgent need of the area before, during the post flood situation. It will help to reduce the effects of water borne diseases. The staff and volunteers should be trained and facilities pre-positioned along with the first aid kits support. The capacity building on search and rescue is very crucial for saving lives of people. The emergency fund, if established, can be used to provide the rescue, relief and rehabilitation materials and distribute the flood affected people during the emergency situation. It is necessary to train farmers to adopt low cost seed preservation techniques.

4.1.3 Financial capital

Strong financial capital of the community is based on the availability of the good services of financial groups and institutions in terms of resource mobilisation and management in free or minimal collateral and manage easy loan to the flood affected people. In terms of financial institution in the study area, there are 18 saving and credit groups and *Ama Samuha*. These institutions promote the saving practices and mobilise the saving fund in credit programs.

However, all poor and marginal people are not included in these groups. The mandatory rule of the monthly savings hinders them to be a member of these groups. Only middle income group of people are involved in saving and credit practices. As result, wherever there is a need, poor and marginal people often have to visit the private moneylender to take loan in high interest rate.

It is identified during the consultation with local people that providing collateral free credit facilities and agriculture inputs in subsidy rates through the establishment of agriculture cooperatives is effective means. Poor, Dalits, marginalized, flood affected people and at-risk group should be provided first preference for the credit facilities to strengthen their financial capital.

4.1.4 Natural capital

The proper management of natural resources like: water, forest and land and their proper utilization reflects the level of natural capital. In terms of utilizations of these resources, the study area is poor. In spite of abundance water resources, people have to rely on rain-fed irrigation as there are inadequate irrigation facilities. The people along the lap of churia use water from the flashy rivers for the purpose of irrigation through earthen canals.

People from all three clusters are also affiliated with CFUGs. Though these groups have developed several rule and regulations to protect and manage community forests for greenery promotion, fulfil the basic needs for firewood, fodder and timber and minimise the soil erosion but in practice, the forest resources are used haphazardly and the rules of CFUG have not worked properly.

Particularly in cluster 2 and 3, the land management is also poor. The continuous encroachments along the riverbank and towards the forest area make the situation further vulnerable. The sand, boulders and stone from the lap of churia are continuously being extracted despite several efforts to control.

In order to optimize these resources, there is need of permanent evacuation centre to save the forest and land resources. The temporary shelters/ camps in the forest area created negative impact on forest resources and communal land. Some bio-engineering techniques which are socially acceptable, economically viable and environmentally sound should be initiated to mitigate the effects of flood. For this, plantation of babio, *khar* (hay) and *kass* (a kind of grass grown along the river bank) would be more beneficial as expressed by local people. Gautam (2007a) has found that people in the eastern region of Nepal have adequate knowledge, skills and information about the bioengineering techniques like bamboo spur since generation. This is the reason that, for instance in Jhapa district of Nepal, people advocate to grow kass along the river bank and this initiative is very much successful to save the rive bank from erosion.

Construction of structures like gabion check dams, loose stone check dams and spurs are also needed with plantation of seedlings of different soil retaining and fast growing species. Plantation of water-resistant trees such as bamboo and banana, next to the homestead can protect the house from erosion and people can also earn extra income. Along the river and bank of torrent (flashy river), Amrisho, NB-21, Napier, Bankas, Kass, Khar and bamboo could be planted. This initiative also supports for the animal husbandry by fulfilling the fodders.

Promotion of agro-forestry initiatives, plantation of fast growing fodder including bamboo in private land is other schemes to reduce the effects of flood and generate additional income. Promotions of flood friendly agricultural practices are equally important to mitigate floods and to reduce risk. Hence, it is necessary to adopt agricultural coping measure which includes selection of appropriate variety of paddy and other crops, depending on the timing and water level as well as type of soil.

4.1.5 Physical capital

The availability of the physical infrastructures and their effectiveness determine the position of physical capital. It includes roads, irrigation related infrastructures and flood control measures, etc.

In the study area, the road network is inadequate and poor. The drainage system of the road network is very poor. The culverts are not functioning well and the Bagauda road itself has created additional inundation problem. The absence of bridge in the WR River has made people isolated from external support and more vulnerable particularly during the monsoon.

The infrastructure of schools/Sub-health Post (SHP) is also poor. There are minimal initiatives undertaken for the river training and other flood protection measures. The facility of boat is

available in few locations to cross the Rapti River which is sometimes risky. Last year, 15 people died once the boat drowned in the WR River.

In terms of irrigation and flood control related infrastructures, the area is poor. Considering the severity of the river bank erosion and sedimentation, the existing infrastructures seems inadequate. A decade long armed conflict also discouraged development organisation for the investments in these sectors.

In order to improve the physical capital, first, there is a need to support boats to the community in group approach. Boats are the only means to cross the rivers as there is absence of bridge facilities in the rivers. Within the village, in order to cross the small torrents, temporary wooden bridges should be repaired immediately in coordination with CFUGs. Second, replacement of small sized hume pipes with big ones is urgent as majority of the people opined that this is the major reason for the inundation at local level. Small hume pipes are not sufficient to allow flood water to pass. It is equally necessary to periodically remove soil deposited inside the hume pipe because soil often blocks the water. It is necessary to raise the height of village road with sufficient hume pipes for proper drainage. Third, the feasible and cost effective flood resistant housing options for the poor would be essential by analyzing the flood trends of 20-30 years. Moreover, housing techniques are to be adopted according to the risk posed by floods. Houses can be built on raised lands or earthen platforms so water cannot reach the plinth in normal floods. Fourth, the heights of majority of hand pumps are low so that they get submerged during flood. Hence it is necessary to raise their height. Construction of raised toilets is also necessary in flood inundated areas.

4.1.6 Political capital

The extent of mutual cooperation among the political parties and groups for the internal and external resource mobilisation and management for flood control determine the level of political capital of the area. In terms of cooperation, all major political parties were found united and have single voice for the flood related issues. They made many positive decisions but the level of enforcement is very poor. There is no political culture to generate the external resources to work on flood management. Though all parties are united, there are still some internal issues among them that hinder the proper mobilisation of the external resources.

There is a need of making issue based action plan with clear division of roles and responsibilities among the parties to pressurise the duty bearers in securing the external resources to support in flood management. The resources available in the VDC should also be used part of flood management. There is a need of technical assessment for the extent of flooding caused by Laxmanpur Barrage and take steps in the mutual cooperation of both countries viz. Nepal and India.

4.2 Impact of flood in livelihood of farmers

There are number of impacts of flood in the peoples' live and livelihood as shared by the local people during the discussion. Some of the important impacts are discussed below.

- ***Increased heath hazards on vulnerable groups:*** The workload of women, children and elderly is increased as young force leaves the village in search of employment for several months to years. It has created negative implication on the women's health and social status.

- ***Increased expenses in treatment:*** The flood occasionally has disrupted the education and health services at local level. The disruption of educational and health services have resulted into poor educational and health performance. The high percentage of drop out in the schools and increased number of patients suffering from flood related diseases are its evidences. Weak health status, malnutrition and other health hazards are likely to increase where poor have to spend more in treatments. For this, they need more money in treatment.
- ***Increased Expenses in Farming:*** Taking other's land as sharecropping and on rental basis (to cultivate on annual basis) are the common practices in the study area. It is estimated that about one-forth population of the flood affected areas are landless who mostly earn their livelihood either by cultivating other's land or by daily wage labour. In order to invest on farming they take loan from local moneylenders on an exorbitantly high rate. The consecutive flooding like that of 2006 and 2007 put them in trouble.
- ***High price of seed:*** Floods also damage stored seeds and grains of cereals and vegetables. The price rate is higher for the seeds and is mostly procured from India. The poor farmers are obliged to use the wet seed which results in less germination.
- ***Less return from animal husbandry:*** High mortality rates of livestock are reported due to sudden attack of diseases in pre- and post- flood situation. Also, due to poor fodder management, it is difficult to keep the livestock healthy and manage their appropriate feed during this time.
- ***Poor performance of social institutions:*** The social networks and institutions, which are considered community's assets, are eroded as people have no time to discuss and promote these networks and institutions. People become more individualistic to run their livelihood. With poor social networks, they are not able to secure the resources from outside. In fact, the social institutions have poor performance which results in poor resource mobilization.
- ***Changes in cropping pattern:*** Flood also impacted cropping patterns. Due to flooding and inundation, in majority of the cases, farmers were unable to transplant paddy in time. This delayed the harvesting of paddy as well as plantation of winter season crops. The increased dampness is also responsible for change in the cropping pattern. The change in cropping pattern often reduces the total crop production.

Chapter 5: Participatory Planning for Flood Control and Mitigation

In order to minimize the flood hazards, the community have recommended various sets of actions in priority order. The study team facilitated to prepare the action plan for the three clusters(The fourth cluster was later added in the study for the purpose of collecting socio-economic and flood related information in the study area and action plan was not prepared). These action plans reflect community's ideas, priority and could be viewed as providing information about communities' ideas for flood control and mitigation and could be useful starting point for any future comprehensive flood management plan. The action plans are presented below in Table 4.1 through 4.3. These plans manifest that community has identified the root causes of hazards and vulnerabilities and they have ideas to control and mitigate flood. Further these plans show their commitments towards resource management and interest in the community based flood disaster management works.

Table 5.1: Community's Action Plan for Flood Control and Mitigation in Cluster-1 of the Study Area

Priority Ranking	What (Activities)	Where (Location)	When (Time Frame)	Who (Responsible Authorities)	Resource Management
1	Clearance of the routes of flashy river channels to W.Rapti River	Shinhayiya and Dondra Rivers, Matehiya and Gangapur VDCs	April 2008 to June 2008 and January 2009 to April 2009	Water Induced Disaster Management Office / DDC/ VDCs/ local representatives of political parties	Water Induced Disaster Management Office/ Donor Organizations/ DDC/ VDCs
2	Construction of Culvert on the Sinhayiya torrent	In the centre of Phattepur VDC and Gangapur VDC	April 2008 to March 2009	DDC/ VDC/ other Donor Organizations / Local Users	Non-local materials support by the DDC/ Donor Organizations and local materials collection and partial labour contribution by local users
3	Construction of Bridge	On the location of existing damaged culvert in Gangapur VDC-7, Naibasti	December 2008 to November 2010	DDC/ VDC/ other Donor Organizations and Local Users	Non-local materials support by the Donor Organizations, supports in management activities by local communities
4	Prevention of deforestation	Matehiya VDC, Ward No.1-9	From March 2008	Local Community Forest User Groups,/ VDC/ local representatives of political parties/ Community based local organizations	Local Community Forest User Groups, VDCs/ Community based local organizations
5	Tree Plantation in the CFUG area	Matehiya VDC, Ward No.1-9	From March 2008	Local Community Forest User Groups,/ Community based local organizations	District Forest Office/ Local Community Forest User Groups/ Community based local organizations
6	Prevention of boulder extraction	Matehiya and Gangapur VDCs	From March 2008	VDC/ local representatives of political parties/ Community based local organizations/ local users	VDCs/ Community based local organizations

Priority Ranking	What (Activities)	Where (Location)	When (Time Frame)	Who (Responsible Authorities)	Resource Management
7	Provision of Health Services including regular services and camps	Matehiya and Gangapur VDCs	From June 2008	District Health Office/ Sub-Health Post of the VDCs/ Donor Organizations	District Health Office/ Sub-Health Post of the VDCs/ Donor Organizations
9	Veterinary Services	Matehiya and Gangapur VDCs	From June 2008	District Livestock Office/ ,Area Agriculture and Livestock Service Centre/ Local Organizations	District Livestock Office/ VDCs/ Donor Organizations
10	Agriculture Renovation Program	Matehiya and Gangapur VDCs	From April 2008	District Agriculture Office/ Area Agriculture and Livestock Service Centre/ Donor Organizations/ District Cooperative Office/ Local Community Based Organizations	District Agriculture Office/ Donor Organizations/ District Cooperative Office/ Local Community Based Organizations/ Local Farmers
11	Construction of Canal	Matehiya and Gangapur VDCs	November 2008- April 2010	Irrigation Department,/ Donor Organizations	Irrigation Department/ Donor Organizations/ VDCs

Table 5.2: Community's Action Plan for Flood Control and Mitigation in Cluster-2 of the Study Area

Priority Ranking	What (Activities)	Where (Location)	When (Time Frame)	Who (Responsible Authorities)	Resource Management
1	Clearance of the torrent routes to Rapti River	Shinhayiya and Dondra Streams at Matehiya and Gangapur VDCs	April 2008 to June 2008 and January 2009 to May 2009	Water Induced Disaster Management Office /DDC/ VDC / other Donor Organizations/ Local Users	Technical and non-local materials support by the Water Induced Disaster Management Office / Donor Organizations and partially labour contribution by local users
2	River Bank Protection measures in the Streams	Shinhayiya and Dondra Streams at Matehiya and Gangapur VDCs	April 2008 to June 2008 and January 2009 to June 2009	Water Induced Disaster Management Office/ DDC / VDC/ other Donor Organizations	Non-local materials support by the Water Induced Disaster Management Office/ DDC/ Donor Organizations, partially labour contribution by local users
3	River Bank Protection	Along the bank of W. Rapti River	April 2008 to June 2008 and January 2009 to June 2009	Water Induced Disaster Management Office DDC / VDC/ Donor Organizations	Non local materials support by the Water Induced Disaster Management Office/ DDC/ Donor Organizations, partially labour contribution by local users
4	Prevention of deforestation	Matehiya VDC, Ward No.1-9	From March 2008	Local Community Forest User Groups/ VDCs/ local representatives of political parties/ Community based	Local Community Forest User Groups/ VDCs/ Community based local organizations

Priority Ranking	What (Activities)	Where (Location)	When (Time Frame)	Who (Responsible Authorities)	Resource Management
				local organizations/ local users	
5	Community plantation	Matehiya VDC, Ward No.1-9	From March 2008	Local Community Forest User Groups/ Community based local organizations/ local users	District Forest Office/ Local Community Forest User Groups/ Community based local organizations
6	Prevention of haphazard extraction of boulders	Shinhayiya and Dondra streams at Matehiya and Gangapur VDCs	From March 2008	VDC/ local representatives of political parties/ Community based local organizations/ local people	VDCs/ Community based local organizations
7	Construction of Canal	Improve the existing canal from the side of Shinhayiya stream to Kakarhawa	November 2008- June 2010	Irrigation Department/ Donor Organizations	Irrigation Department/ Donor Organizations/ VDCs
8	Plantation of *Besharma* (hedge plant)	Gangapur VDC-4, Dondra to Ghawaiya Ghat	From March 2008	VDC/ Community Forest Users Group/ Community based local organizations/ local people	VDCs/ Community Forest Users Groups/ local farmers
9	Construction of dyke on the route of Bagauda road	Gangapur VDC	From Nov. 2008 to Dec. 2009	Water Induced Disaster Mgmt. Office/DDC/Other Donor Organizations	Water Induced Disaster Management Office/ DDC/ VDC/ Donor Organizations
10	Management of Shelter	Matehiya VDC, Ward No. 4, Badi Butti	From March 2008 to June 2008 and From January 2009 to June 2009	DDC/ VDCs/ District Administration Office/ local representatives of political parties	DDC/ VDCs/ District Administration Office/ Donor Organization/ local people
11	Health Service Centre	Shelter of Chaubis Bigaha area in Gangapur VDC-4, 5	From June 2008	District Health Office/ Sub-Health Post of the VDCs/ Donor Organizations	District Health Office/ Sub-Health Post of the VDCs/ Donor Organizations/ local organizations
12	Improvement in the capacity of existing Sub-Health Post	Gangapur VDC	From March 2008 to December 2008	District Health Office/ Sub-Health Post of the VDC/ Donor Organizations	District Health Office/ Sub-Health Post of the VDC/ Donor Organizations/ local organizations
13	Veterinary Services	Matehiya and Gangapur VDCs	From June 2008	District Livestock Office/ Area Agriculture and Livestock Service Centre/ Local Organizations	District Livestock Office/ VDCs/ Donor Organizations/ Local Organizations
14	Agriculture Renovation Program	Matehiya and Gangapur VDCs	From April 2008	District Agriculture Office/ Area Agriculture and Livestock Service Centre/ Donor	District Agriculture Office/ Donor Organizations/ District Cooperative Office/ Local Community Based Organizations/ Local Farmers

Priority Ranking	What (Activities)	Where (Location)	When (Time Frame)	Who (Responsible Authorities)	Resource Management
				Organizations/ District Cooperative Office/ Local Community Based Organizations	

Table 5.3: Community's Action Plan for Flood Control and Mitigation in Cluster-3 of the Study Area

Priority Ranking	What (Activities)	Where (Location)	When (Time Frame)	Who (Responsible Authorities)	Resource Management
1	Clearance of the torrent route to Rapti River	Shinhayiya Stream at Matehiya and Gangapur VDCs	April 2008 to June 2008 and March 2009 to June 2009	Water Induced Disaster Management Office / DDC/ VDC / Donor Organizations/ Local Users	Non local materials support by the Water Induced Disaster Management Office / DDC/ Donor Organizations and partially labour contribution by local users
2	River Bank Protection measures in the Stream	Dondra Stream at Matehiya and Gangapur VDCs	April 2008 to June 2008 and January 2009 to June 2009	Water Induced Disaster Management Office DDC / VDC/ Donor Organizations	Non local materials support by the Water Induced Disaster Management Office/ DDC/ Donor Organizations, partially labour contribution by local users
3	River Bank Protection measures	Along the bank of Rapti River	April 2008 to June 2008 and January 2009 to June 2009	Water Induced Disaster Management Office DDC / VDC/ Donor Organizations	Non local materials support by the Water Induced Disaster Management Office/ DDC/ Donor Organizations, partially labour contribution by local users
4	Control of Deforestation	Matehiya VDC, Ward No.1-9	From March 2008	Local Community Forest User Groups/ VDCs/ local representatives of political parties/ Community based local organizations/ local users	Local Community Forest User Groups/ VDCs/ Community based local organizations
5	Community plantation	Matehiya VDC, Ward No.1-9	From March 2008	Local Community Forest User Groups/ Community based local organizations/ local users	District Forest Office/ Local Community Forest User Groups/ Community based local organizations
6	Prevention of extraction of boulders	Shinhayiya and Dondra streams at Matehiya and Gangapur VDCs	From March 2008	VDC/ local representatives of political parties/ Community based local organizations/ local people	VDCs/ Community based local organizations
7	Construction of Canal	Improve the existing canal from the side of Shinhayiya stream to Kakarhawa VDC	November 2008- July 2010	Irrigation Department/ Donor Organizations	Irrigation Department/ Donor Organizations/ VDCs
8	Plantation of *Besharma* (hedge plant)	Gangapur VDC-4, Dondra to Ghawaiya Ghat	From March 2008	VDC/ Community Forest Users Group/ Community based	VDCs/ Community Forest Users Groups/ local farmers

Priority Ranking	What (Activities)	Where (Location)	When (Time Frame)	Who (Responsible Authorities)	Resource Management
				local organizations/ local people	
9	Construction of dyke	Sonbarsha-Bhojpur to Bagauda road, Gangapur VDC	From November 2008 to December 2009	Water Induced Disaster Management Office/ DDC/ other Donor Organizations	Water Induced Disaster Management Office/ DDC/ VDC/ Donor Organizations
10	Provide Health Services including regular services and camps	Matehiya and Gangapur VDCs	From June 2008	District Health Office/ Sub-Health Post of the VDCs/ Donor Organizations	District Health Office/ Sub-Health Post of the VDCs/ Donor Organizations/ local organizations
11	Veterinary Services	Matehiya and Gangapur VDCs	From June 2008	District Livestock Office/ Area Agriculture and Livestock Service Centre/ Local Organizations	District Livestock Office/ VDCs/ Donor Organizations/ Local Organizations
12	Agriculture Renovation Program	Matehiya and Gangapur VDCs	From April 2008	District Agriculture Office/ Area Agriculture and Livestock Service Centre/ Donor Organizations/ District Cooperative Organization/ Local Community Based Organizations	District Agriculture Office/ Donor Organizations/ District Cooperative Organization/ Local Community Based Organizations/ Local Farmers

Chapter 6: Flood Inundation Mapping Using Hydraulic Model

Flood inundation mapping was performed to assess the flooding situation under different steady state flooding scenarios and to assess the impact of the construction of dykes/levees on Indian side. The HEC-RAS 4.0 Beta Version was used for hydraulic analysis using standard step method for gradually varied flow condition. HEC GeoRAS Version 3.1 was used for pre- and post-processing of the data. The model requires river cross-section data which is extracted from DEM and supplemented by measurements in the field (23 number of cross-sectional data were collected) and from the contour map of low lying areas near India-Nepal boarder prepared by Indo-Nepal Joint team. The Manning's coefficient was derived using the land use/land cover data obtained from the Department of Survey, Nepal and assigning value for each category based on standard text (Chow, 1973). Due to lack of precise cross-section data upstream of *Sikta Ghat*, HEC-RAS model was run downstream of this location with the input boundary condition of known discharge considered at this location. The flood estimates at this station for various return periods were calculated by various approaches such as: catchment area ratio method, WECS-DHM method, Modified Dicken's method, and/or combination of them. Since more accurate method of flood frequency analysis based on the discharge data generated using hydrological model is planned for phase 1(b) study, in this study more conservative values obtained by WECS-DHM method were selected. The downstream boundary was considered at the Laxmanpur barrage with calculated normal depth as boundary condition. The flood estimates for tributaries were also calculated with the similar approaches.

The local topography of the area was derived from digital elevation model (DEM) developed from a 1:25,000-scale topographical map made by the Survey Department of Nepal after the accomplishment of an airborne survey in 1996. The spatial resolution of the data from Nepal is about 20 m with a permissible error of 6.25 m, i.e. a horizontal distance error in the contour. In the pre-processing phase, a Digital Terrain Model (DTM) of the Lower WR River Basin in the form of triangulated irregular network (TIN) was prepared. A series of line themes pertinent to developing geometrical data for HEC-RAS, namely stream centre line, flow path centre line, main channel banks, and cross-sectional cut lines, were created in HEC-GeoRAS. Similarly polygon theme of land use/land cover information was also created based on the land use/land cover data of the region. Additional theme such as levee alignment was also created to extract additional geometric data for import in HEC-RAS. An overview of the HEC-GeoRAS process is shown Fig. 6.1. These Pre-RAS themes comprising of geometric data were exported from HEC-GeoRAS and imported into the HEC-RAS and extracted. The plan of the West Rapti River downstream of Sikta generated by ArcView GIS is shown in Fig. 6.2

Hydraulic data including flow data and associated boundary condition were supplied directly into HEC-RAS. In the next step, water surface profile calculation for the flood of 2, 5, 10, 20, 50 and 100 year return periods were performed with a subcritical flow regime. Once the water surface profiles were calculated, the results were exported to GIS format for post processing.

In the post-processing phase, HEC-RAS results were imported into the ArcView GIS system and a floodplain map for each profile was developed. Post-Processing (postRAS) in GIS facilitates the floodplain delineation with the data contained in the RAS GIS output file and the original terrain TIN.

The longitudinal profile of the WR River is presented in Fig. 6.3 whereas a few typical cross-sections of the WR River are shown in Fig. 6.4 and 6.5 (the water surface shown in the figures are calculated values for 2 and 20 years return period with the consideration of levee)

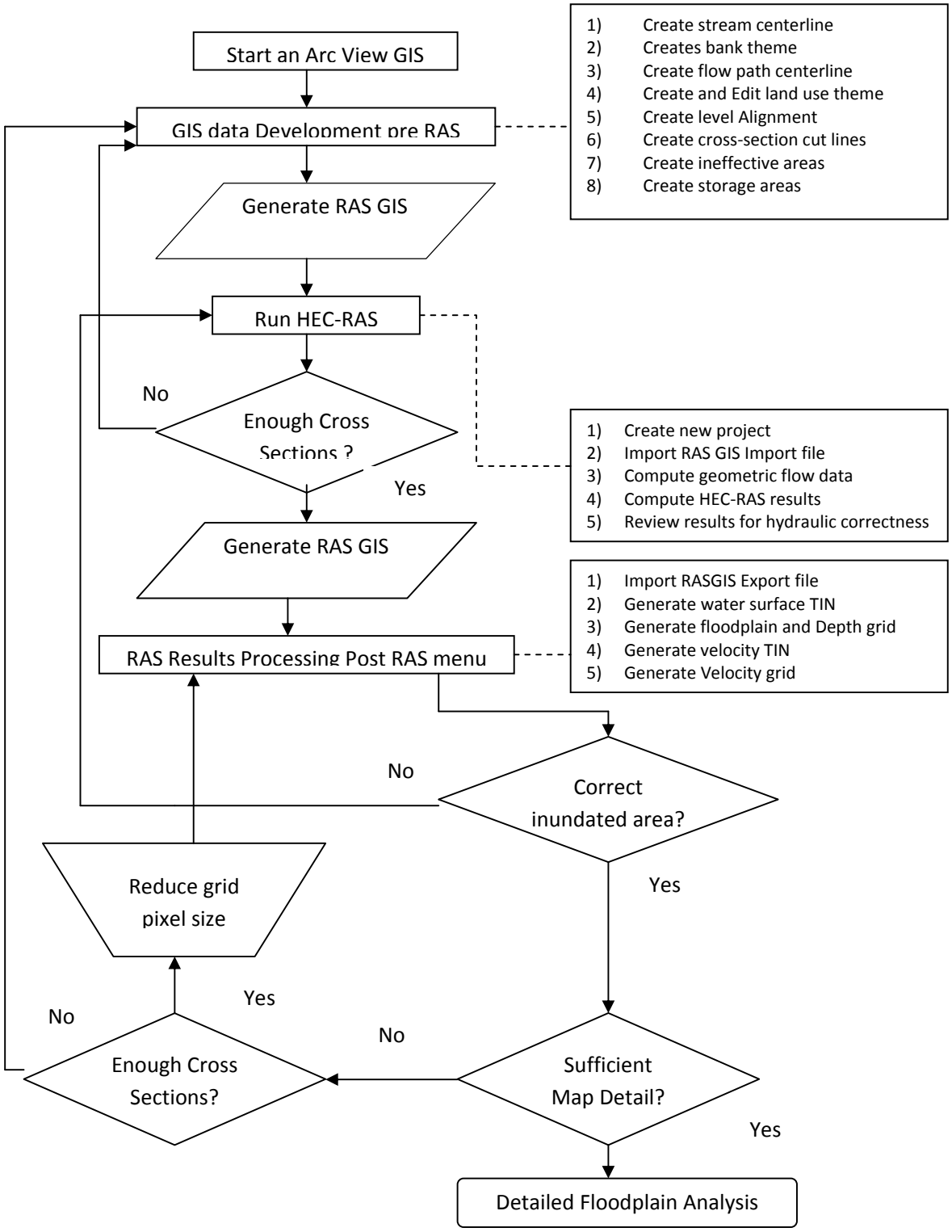


Figure 6.1 Process Flow Diagram for using HEC-GeoRAS
(Source: HEC-GeoRAS manual)

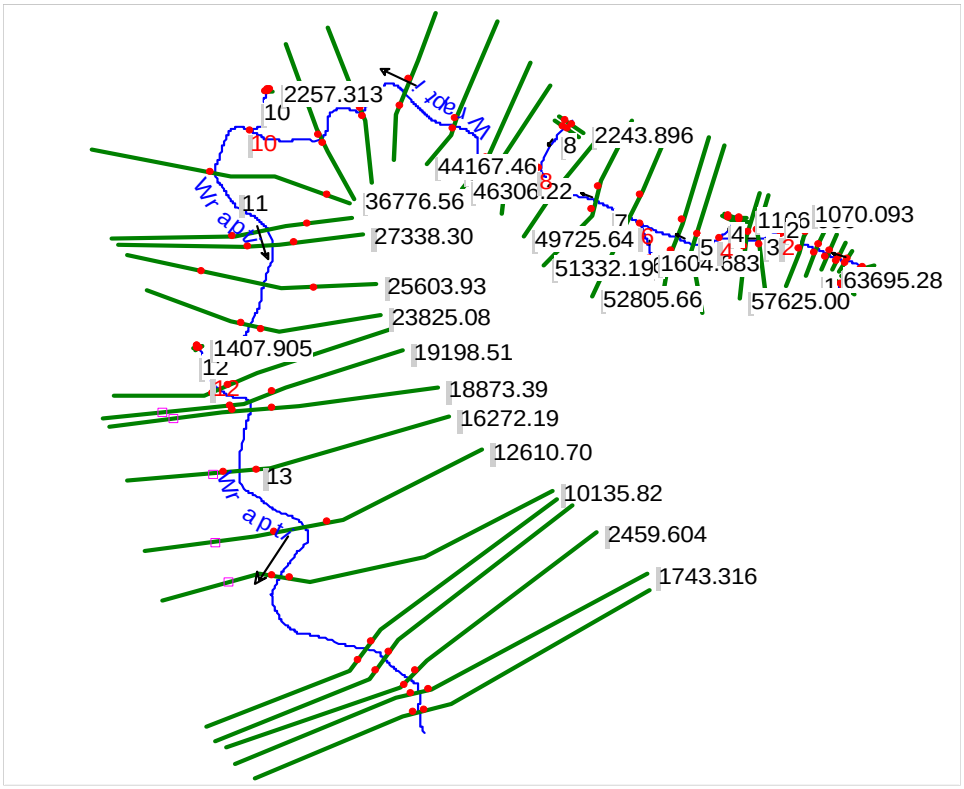


Figure 6.2 Plan of the West Rapti River showing river center line, cross-sectional lines

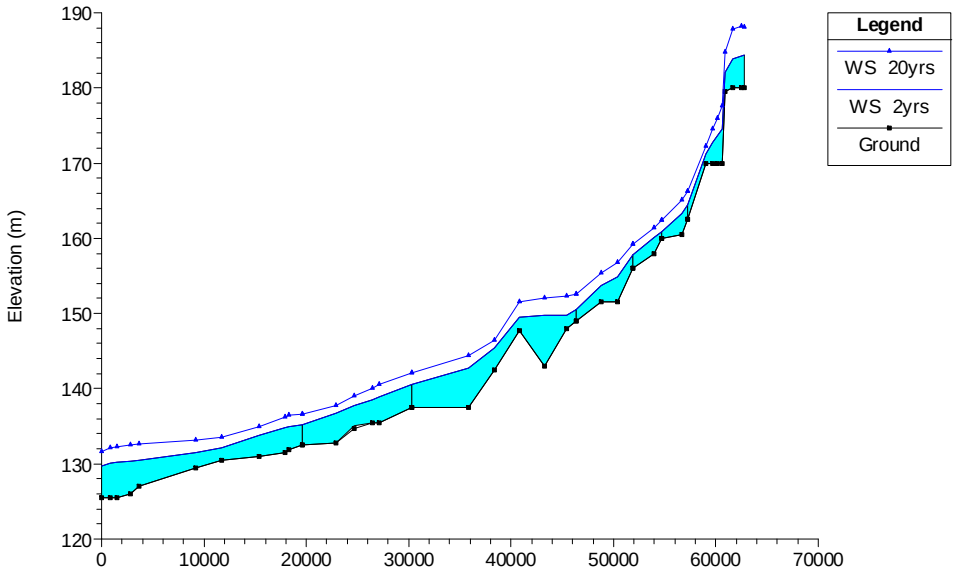


Figure 6.3 Longitudinal Profile of the West Rapti River (water surfaces shown are based on calculated values for 2 and 20 years return periods in the presence of Levee)

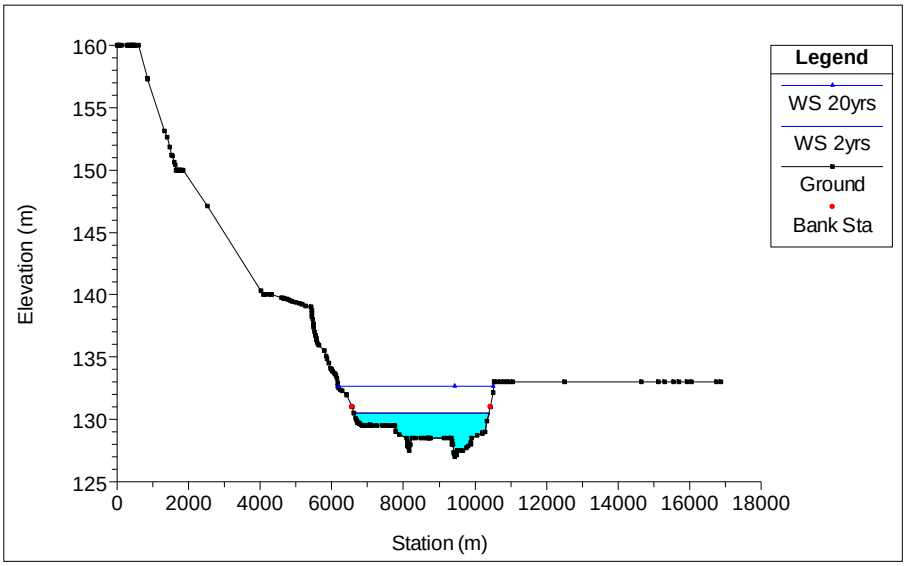


Figure 6.4 Typical Cross-Section of the West Rapti River at Chainage 4600m from Barrage

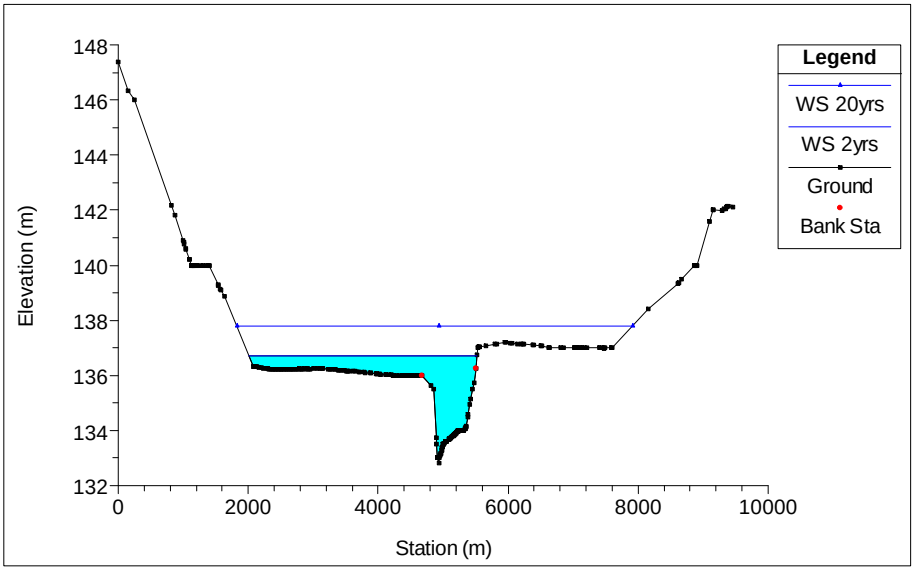


Figure 6.5 Typical Cross-Section of the West Rapti River at Chainage 23825m from Barrage

A number of inundation maps were prepared for the considered return periods (2, 5, 20, and 100 years) with and without the presence of Kalkaluwa bandh. The inundation maps for 2 and 20 year return period (with and without dyke) are shown in Fig. 6.6, 6.7 and 6.8 and 6.9 respectively. Other maps are shown in the Annex 4. It is evident from the model results (with and without scenarios of Kalkaluwa dyke) that there is decreased flood extent in the Indian Territory due to the construction of the dyke. While the increase on the extent of flood in the Nepalese Territory is not high, the increase in flooding depth is quite evident. Figure 6.10(a) and 6.10(b) clearly show the increase on depth of flow for the floods of 2 and 20 years return periods (please see Annex 4 for results of other return period floods) on the Nepalese side (including the study area) due to construction of dykes on Indian side. As evident from

these figures, a large tract of riparian areas and settlements have been affected by increased depth of flood due to the construction of dykes. The GIS overlay of settlement map over the inundation map could give a picture of degree of hazard to the people living in those settlements. For 2-year return period flood with levee, considering flood depth less than 30 cm, 30-70 cm, and greater than 70 cm as low, medium and high hazard, the result obtained by GIS overlaying is shown in Table 6.1.

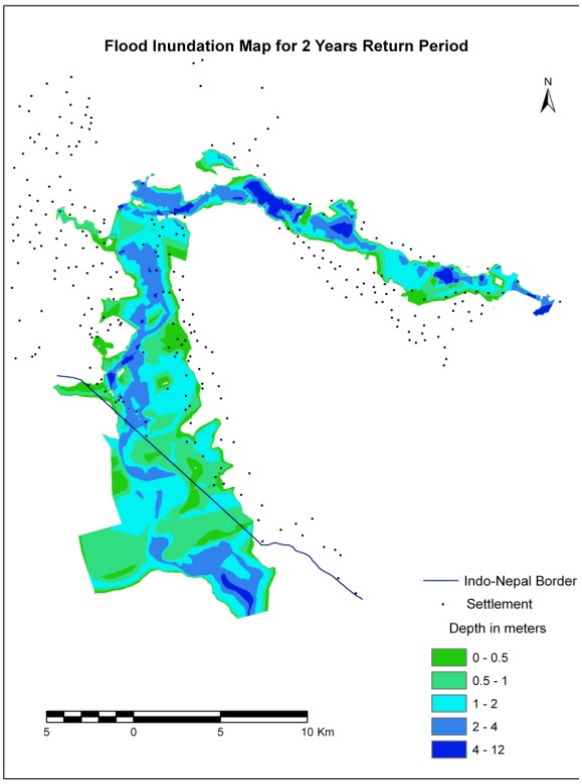


Figure 6.6 Flood Inundation map due to 2-year Return Period Flood (With Levee)

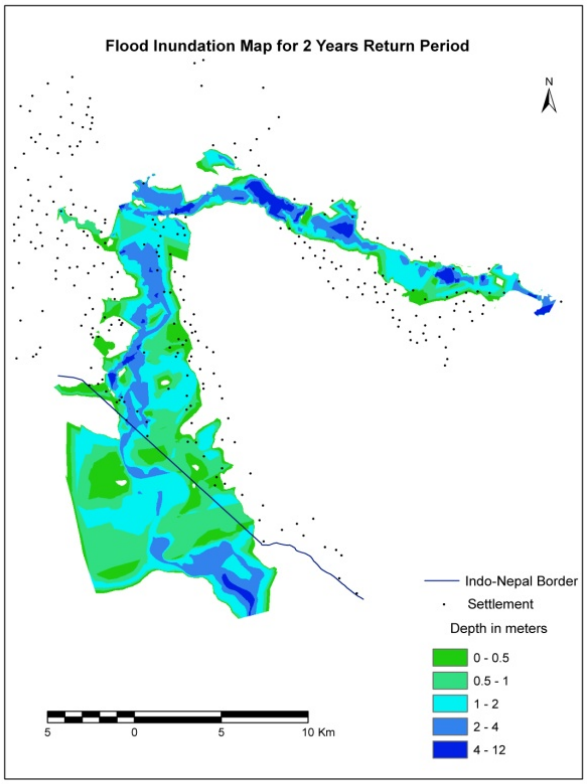


Figure 6.7 Flood Inundation map due to 2-year Return Period Flood (Without Levee)

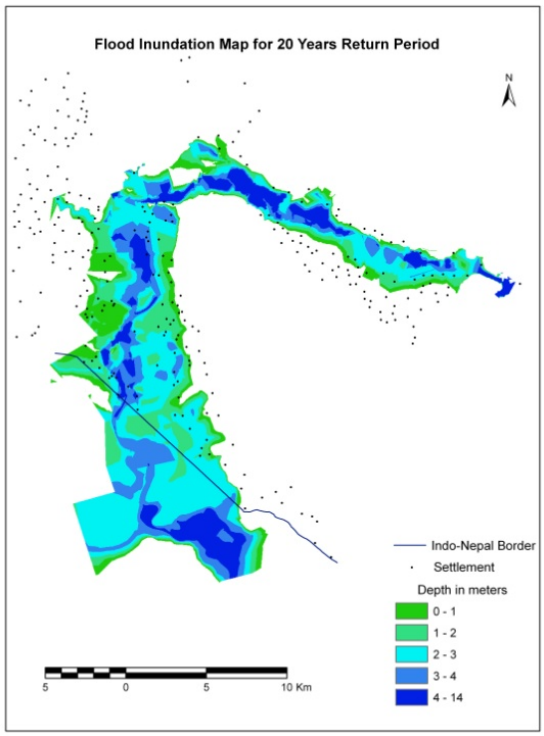
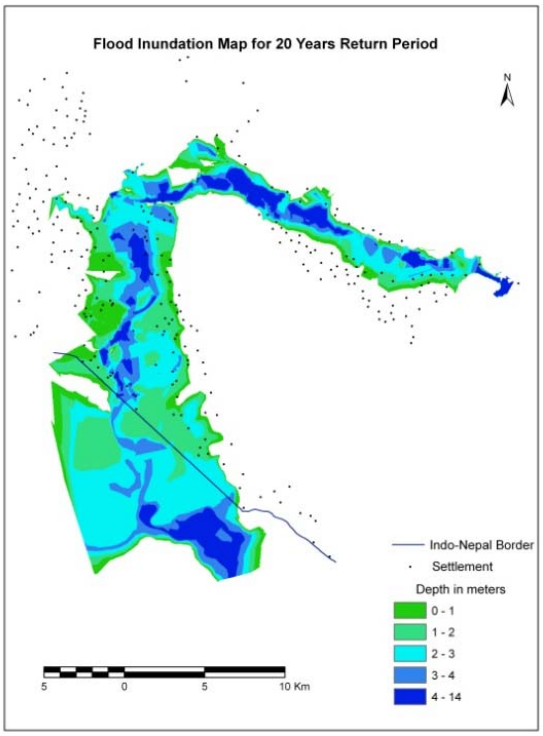
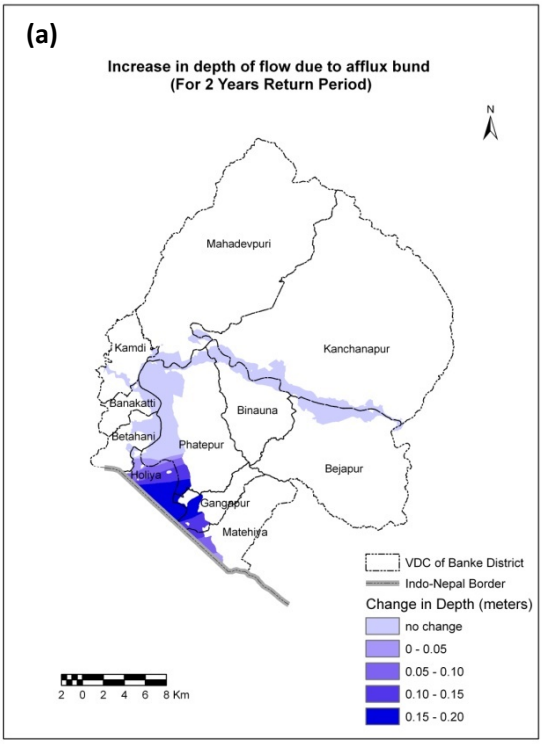


Figure 6.8 Flood Inundation map due to 20-year Return Period Flood (With Levee)



6.9 Flood Inundation map due to 20-year Return Period Flood (Without Levee)



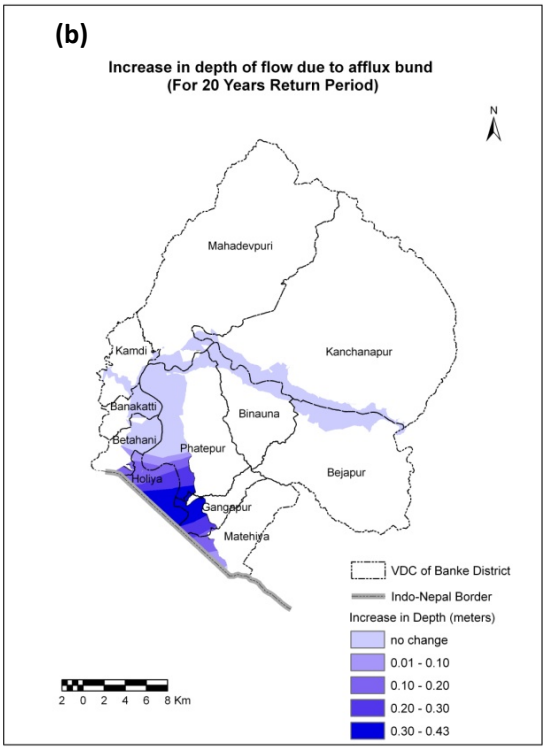


Fig. 6.10 Increase in Depth of Flow in Nepalese Territory Due to the Construction of Dyke For (a) 2-year Return Period Flood (b)20-year Return Period Flood

Table 6.1 Inundation Hazard due to WR River Floods in Gangapur and Matehiya VDCs

Return Period	High (>0.7m) VDC(Settlements)	Medium (0.3-0.7 m) VDC(Settlements)	Low (<0.3 m) VDC(Settlements)
2 years	Gangapur VDC (Settlements: Gangapur, Kudarbetawa)	Gangapur VDC (Settlements: Dondra, Bhojpur) Matehiya VDC (SettBhagawanpur)	No settlement
5 years	Gangapur VDC (Settlements: Gangapur, Kudarbetawa, Dondra, Bhojpur) Matehiya VDC (Bhagawanpur)	Matehiya VDC (Settlement: Newajigaun)	No settlement
20 years	Gangapur VDC (Gangapur, Kudarbetawa, Dondra, Bhojpur) Matehiya VDC (Bhagawanpur, Newajigaun)	Gangapur VDC (Sonbarsa)	No settlement

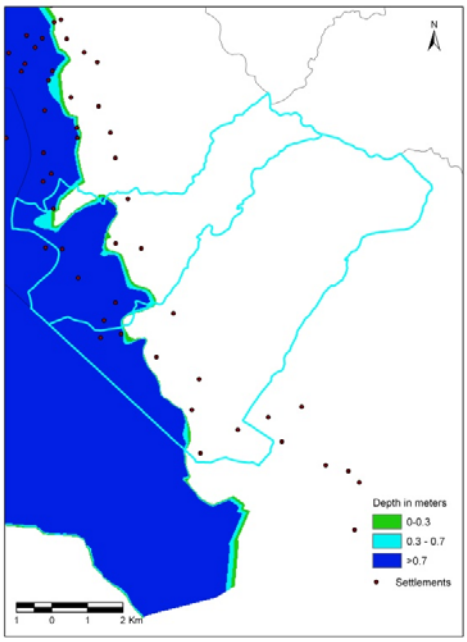


Figure 6.11 Flood Hazard Map of Study Area for 20-Year Return Period Flood (With Levee)

Comparison of these inundation maps with the community based flood hazard map (CBFHM) prepared with the community's participation shows agreements particularly for high hazard settlements. But for medium and low hazard zones there are some differences. The CBFHM was prepared based on 2007 flood for which the exact return period is still to be explored based on rainfall-runoff modeling. Also, while preparing the CBFHM, the effects of torrents coming from Churia was also considered. In addition, the CBFHM, as reported in Chapter 3, is a composite flood hazard map taking care of flood related hazards such as bank cutting, sediment deposition and inundation. However, the result of hydraulic model shows the inundated villages due to flooding in the WR River only and does not account any effect from the flash floods from rivers like Dondra, Saujhawa etc in the study area. In the phases 1(b) and 2, these issues and shortcomings of hydraulic modeling will be taken care of and a more reasonable comparison of technical flood hazard map with the CBFHM is expected. Nevertheless, the present hydraulic modeling could clearly identify the extent of flooding due to the flood water in the WR River.

CHAPTER 7. Outline of the Next Phase Study Based on the Feedback from the First Phase

There is growing realization among development workers, disaster managers, engineers and policy makers alike that structural measures alone cannot give the total security against disasters. In many cases, structural measures transfer the problems from upstream to downstream or vice-versa. The construction of Kalkaluwa dyke by India is just an example how the problem in the downstream (Indian side) has been transferred to the upstream (Nepalese side). There is yet another realization that in the developing countries like Nepal where majority of the population are poor and struggle for their basic livelihood, poverty explains the increasing impact of disasters. Amidst massive poverty, people knowingly ignore the hazards and take more vulnerable positions for basic needs of life. The implication of such realizations is that disaster management program should not be framed in any model that fails to address the root cause of disaster-the poverty. Rather it should simultaneously target minimization of both hazards and vulnerability under the poverty alleviation framework. Mainstreaming disaster risk issues in any development activities in the community and consideration of livelihood and poverty issues in any disaster management activities can be argued to be more effective than any stand alone disaster management program (even if it is community based/participatory).

The phase 1.(a) of the research has identified some of the upstream-downstream and upland-lowland linkages in relation to flood management. It is expected that the research on phase 1(b) will make this linkages more explicit with rainfall-runoff modeling of WR River. Similarly the phase 1(a) has also assessed various types of flood hazards such as bank cutting, sedimentation and inundation, and root causes of the vulnerability. The study has made in depth search for various capacities namely social, physical, financial, natural, human, political existing in the community and recommended means to improve upon these capacity bases. Assessment of vulnerabilities and capacities and the local knowledge existing in the community helps to formulate a comprehensive flood management plan within any livelihood centered/poverty alleviation framework.

Based on the findings of first phase, the next phase of study should formulate such a framework and devise countermeasures for flood comprising of a mix of both structural and non-structural approaches. Such proposal of countermeasures necessitates a thorough understanding of the types of flood, and the river channel dynamics among others. The study should not only look into the science behind the bank cutting, but also see whether economic engineering means are available to check such phenomenon. Planning of flood forecasting and warning system based on rainfall-runoff modeling and channel routing could be another aspect of the second phase. Awareness building, networking and lobbying for the implementation of proposed framework is also needed for the benefit of the people of the flood prone areas.

The present study area whose source of flood hazards are the rivers starting from churia hills as well as the WR River and which hosts population far behind the mainstream population in terms of development and HDI, could provide an excellent avenue to prove the merit of the framework to be proposed in the next phase. Given the availability of fund, there is yet another possibility to upscale the

study area to include two more poverty stricken VDCs (Binauna and Baijapur) hosting indigenous *Tharu* Communities suffering from flood, erosion and loss of lands due to bank cutting.

The outline of the proposed next phase study is shown in the Figure 7.1.

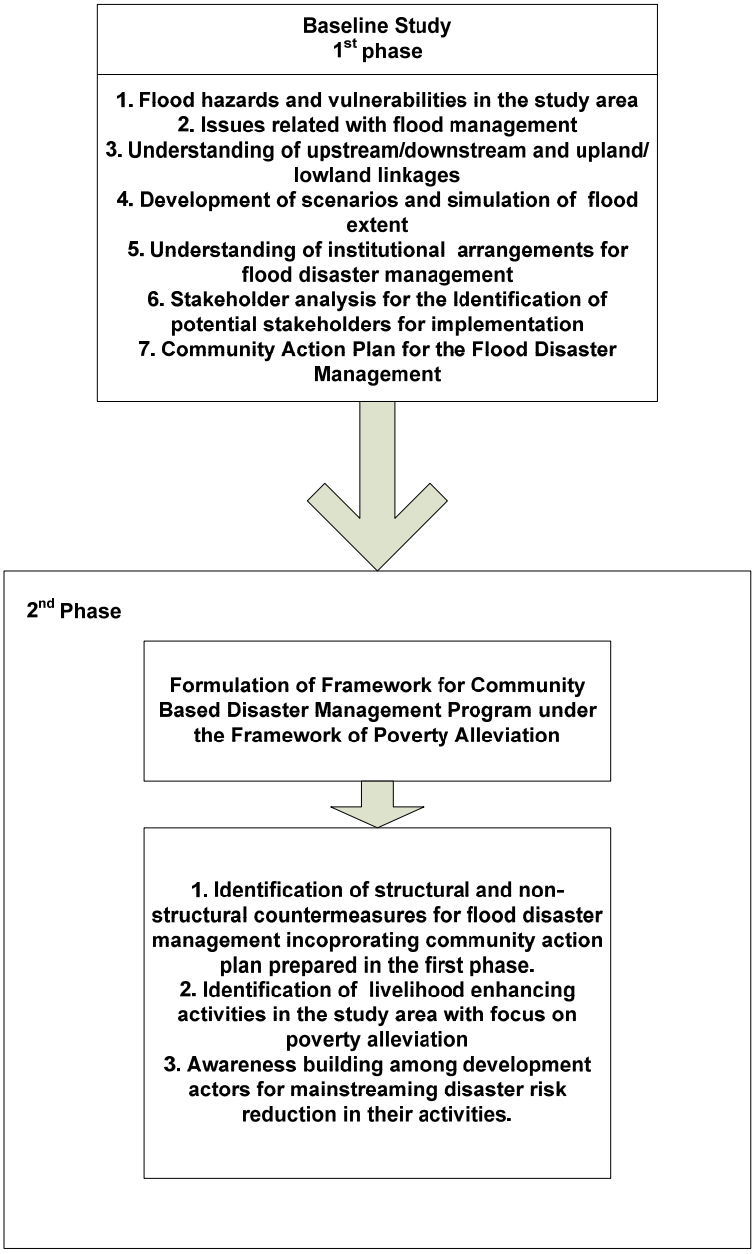


Figure 7.1 Outlines of the Proposed Activities in the Next Phase with Inputs from the First Phase

CHAPTER 8: Conclusions and Recommendations

Based on the findings of the study and subsequent discussions over the key issues, the study is able to draw a number of conclusions and recommendations. Some recommendations have been also made in the specific chapters itself.

1) Besides natural factors, the anthropogenic factors like construction of poorly designed infrastructures, river training works on an ad-hoc basis, and control of river flow through construction of barrage, levees etc are the culprits for the flooding in the study area. Flood inundation analysis based on HEC-RAS (US Army Corps of Engineer, HEC, 2007) showed that the effect of kalkaluwa bandh was to increase the depth of flood water in the Nepalese side and decreased flood extent in India.

2) In many flood-affected areas adjacent to the rivers, families have been rendered homeless and land has become uncultivable due to deposition of sand after the floods. The affected families in such areas need special attention in terms of provision of shelter, resettlement along with improvement in human lives and livelihood. Therefore, it is a need to go for livelihood improvements programs. Access to easy and soft credit is also important for the poor and flood affected people.

3) The nexus between poverty and the increased flood risk in the study area is clearly seen. Thus In order to reduce disaster risk, improvement in the resilience of the community within the broader framework of enhancing livelihood options and poverty alleviation should be targeted. The diversified technical mitigation options as well as skills development, awareness and capacity building of flood affected communities are also required in addition to the programs for improved livelihood opportunities. This will help to improve the flood resistance capacities of people living in the flood prone area and help them to live with floods in a better way.

4) The people in the study area showed various capacity bases (livelihood assets); but there is a need to improve all these assets as part of improved sustainable livelihood strategy for better flood disaster management. In the study area where the poverty level is high and the food sufficiency level is rather dismal, there is no alternative to launching flood disaster management programs with consideration of improved livelihood opportunities to the people.

5) The people of the study area were learnt to have their beliefs, local knowledge and practices for forecasting of heavy storms, early warning and flood management. These are accrued in the community mostly by experience of over years of dealing with flood. Their knowledge of local surroundings and events is the most valuable asset for any flood management planning. All these local knowledge should be the base on which any disaster management plan and activities must stand. Some beliefs and practices of the community might not be scientific or worth of integration into the comprehensive plan, but these may give an insight into the attitude and mindset of the community.

6) The flood hazard map prepared by the community shows the evacuation route, possible shelters and the hazard prone areas. This is a very useful tool for local organization to base their preparedness as well as other flood management plan. There is possibility of either

supplementing such CBFHM with technical FHM or vice-versa for practical use (Osti et al, 2008). The technical FHM has advantage of providing various scenarios which is very useful for planning purpose.

7) In the study area community with their knowledge of their area, their experiences of living with floods, prepared their own plan for management of flood and disaster. This might not be the best or adequate in true technical or economic sense, but this reflects the local capacity and points towards need to base intervention activities to strengthen this local capacity to deal with flood and disaster.

8) The institutional and legal arrangements and mindset of policy makers have been more aligned to the reactive approach ('relief-focused') to deal with floods and disaster in Nepal. There is undisputable need of rescue and relief operation; but there is more need on mitigation and preparedness. The institutional arrangement must be reframed into new paradigm of proactive flood risk management aimed at reducing the vulnerability and building the resilience of the community. There should be clear institutional mechanism with matching fund at district and local level for such proactive disaster management. Also, there should be clear defined roles of the institutions and better coordination mechanism. Moreover, the practices of construction of structures without evaluating its possible effects and consequences for flood and inundation should be avoided. In short, disaster must be mainstreamed into any development activities.

9) Precautionary measures are required to prevent massive damage from the flood. The downstream construction of levees on Indian site blocking the passage of some natural drains has reduced flood hazard to Indian side, but has transferred the hazard upstream to Nepalese site. Similarly the high rate of soil erosion, land slide and debris flow at upland are often considered as contributing to increase in flooding at lowland. Moreover, like the study area where there are numerous torrents originating from the fragile Churia (the upland), the deforestation and lack of watershed management practices have been manifested as 'sorrow' for the lowland in terms of increased flash flood. The upland-lowland and upstream-downstream linkages are important for understanding and finding solution to flood problems. Acknowledging such linkages holistic approach on scientific investigation and planning at a river-basin scale are recommended. However, action at local scale of community level is still the most appropriate approach as this matches the institutional and financial capacity of the country.

10) The GPS survey provided data of present river bank situation which when overlayed with 1997 showed a clear trend of river channel migration towards west. The river channel migration has created havoc to a number of settlements in Nepal on western part of the WR River near Indo-Nepal boarder. The river channel migration should be studied in detail by also considering geological aspects of the river bank.

11) The hydraulic and hydrological modelling on which technical FHM are based need to be improved upon based on the availability of data, model and prior experience of dealing. As new data and technique become available there is always scope for improvement. The improvement on DEM, hydrometeorological data and river cross-section data can bring more confidence in the results obtained. Moreover, there is always a trade-off between the model cost and the result. It must be weighed upon for dealing with practical problems.

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