Inundation Issue and Management in a Nepal Terai District

STUDY REPORT

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To:

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1.0 INTRODUCTION

The *Study on Inundation Issue and Management in a Nepal Terai District* has been initiated by the Jalsrot Vikas Sanstha (JVS) with an overall objective of facilitating water policy and strategy development at relevant levels. This Draft Final Report has been prepared according to the contract agreement made on 22 March 2005.

Department of Water Induced Disaster Prevention (DWIDP) has completed a study namely *Study of River Systems in Terai from Jhapa to Siraha Districts* (SRSJSD) in July 2004. The objectives of SRSJSD included: a) gather basic technical and social data and information on the rivers and drains that cross Indo-Nepal border in the study districts; b) assess the historical flood events and their impacts on both local communities and natural regimes of those rivers; c) gather information on the encroachment and human intervention into the natural regimes of those river systems on the Nepalese side and their observed effects in chronological order; and d) analyze and compile those data and information and present them in Geographical Information System (GIS).

As a study output of SRSJSD, inundation prone wards were delineated in GIS environment along with watershed area of the rivers crossing the Indo-Nepal border from Jhapa to Siraha Districts. The study showed that the total average area, which comes under regular submergence[1] due to monsoon flood, is 26,085 ha. Out of this, 10,395 ha in Jhapa, 6,705 ha in Morang, 2,900 ha in Sunsari[2], 3,035 ha in Saptari and 3,050 ha in Siraha come under submergence regularly. In terms of river, Biring, Kankai and Ratuwa in Jhapa district have been identified as the rivers with substantial risk of inundation.

As a next step to the study, suggestions were put forward by the DWIDP to delineate inundation demarcation area within those wards to come up with more accurate information in regard to inundation area. In addition, the SRSJSD has recommended that local level institutions should be strengthened and environmental aspects should be considered to manage the inundation problems in the study area effectively.

This study is a follow up of the SRSJSD and thus has been formulated in line with the suggestions provided by the DWIDP and the recommendations outlined by the SRSJSD. In this perspective, this study has worked out more precise inundation area in Jhapa district[3]. Within the district, the study has focused on three major rivers namely Biring, Kankai and Ratuwa as they were found causing significant inundation compared to other rivers. For better analysis and presentation, a GIS based thematic maps of inundation prone area has been prepared. Further, the study has also examined the strengths of the existing local level institutions and recommended measures for their enhancement to effectively deal with inundation problems within the study area. In addition, it has also identified general environmental impacts of inundation.

Analysis of such systematically gathered and compiled technical, social, institutional, and environmental data and information on the concerned rivers can contribute in timely and effective solutions to the inundation problems in the country and along the Indo-Nepal border.

The broad objective of this study is to contribute in operationalization of national water strategy, policy and plans with regard to water induced disasters (WID), especifically in

[1] *Regular submergence refers to case of inundation with frequency 1 in 1 to 3 years.*

[2] *The Koshi River was not included in the study.*

[3] *Jhapa district has been selected for the study because SRSJSD showed that it has bigger area susceptible to inundation compare to other districts .*

relation with inundation. It will also help further forge dialogue among the stakeholders on the WID and, subsequently, assist in informed decision making in realizing the efficiency objective.

This report comprises of two volumes. This main report (Volume-1) starts with the introductory part in Chapter 1 followed by Chapter 2 with the information on the existing national scenario, bilateral issues, policy and planning support, description of the study area etc. Chapter 3 describes objectives and scopes of the services followed by Chapter 4 consisting the adapted methodology. Chapter 5 covers the findings of the study in terms of technical, institutional, environmental and social description of the studied rivers and their inundation-affected area followed by Chapter 6 with conclusions and recommendations. The report also comprises of five annexes. Checklists and the questionnaires used for the study are presented in Annex-1. Annex-2 presents reference coordinates of the inundation prone area obtained from the field. Results of calculation regarding discharges of various return periods of those rivers are presented in Annex-3. Information from the field in relation to the action plans and constitutions of main committees in each of these rivers are presented in Annex-4. Photographs of important places are presented in Annex-5.

Volume-2 of the report comprises of relevant maps including ward level maps, topographical maps and GIS based maps with the inundation area delineated on them.

2.0 NATIONAL CONTEXT

2.1 General

Water and risk is a cross-cutting theme that encompasses many institutions as well as communities. Water, which is the most cherished boon of nature, can also be the cause of disastrous calamities to life and property. Therefore, the judicious harnessing, utilization and protection of this resource is of paramount importance for human survival, well being, and economic progress.

Nepal has many river systems stretching from the Himalayas to the Gangatic plains. The average density of 0.3 km per sq km of more than 6,000 river systems in Nepal expresses the closeness of these channels. The rivers from the territory of Nepal are drained to India. Such rivers include large snow-fed and medium sized rivers like; Bagmati, Kamala, Karnali, Gandaki, Sapta Koshi, West Rapti, etc. The average annual runoff from all the rivers is estimated to be over 220 billion m^3 (BCM). The dominant feature of Nepal's water resources is that though the country occupies only about 13 percent of the total drainage area of the Ganges River, it contributes as much as 70 percent in the lean season and some 45 percent of its average annual flow to the Ganges River.

This way, Nepal being rich in water resources offers a fertile opportunity to enhance the quality of life of numerous people by exploiting these resources. Despite lot of benefits, these river systems are often the cause of risks and vulnerabilities that apply to mountain communities as well as low land inhabitants in Nepal. Poverty and vulnerability to water induced hazards appear to be closely linked in the context of Nepal. Several water induced disasters including inundation, landslides, debris flows, droughts, Glacial Lake Outburst Flood (GLOF) and epidemics of water borne diseases are common phenomena in Nepal. Given the country's geo-climatic condition, such disasters may be expected to occur more often and at any time and in any place, in the light of Global Climate Change, especially the Global Warming.

2.1.1 Some Facts and Figures

Majority of the inundation affected communities in Nepal live in the marginalised river area. These rivers are generally rainfed, and originate from the southern face of the fragile mountain chain. The fragile geological structure of the terrain in combination with torrential monsoon rains and intense tectonic activity result in high sedimentation in the rivers. The shifting nature of the river courses in the plain areas due to large quantities of sediment deposition causes river bed aggradation and inundates farmland and settlements.

In the past, numerous people have lost their lives and many of them have been displaced. According to the available data, flood occurred during 30 July to 2 August 2003 alone killed 244 persons injuring 310 persons and badly affecting 9, 063 families throughout the country. Available data indicate that about 12,000 landslides/slope failures occur each year in Nepal. Similarly, catastrophic event of flood disaster including inundation occurred in 23 August 1993 left a mournful reminiscence in Nepalese heart killing 1,048 people and affecting total of 553,000 people throughout the country. Likewise, Available records from 1995 to 2000 reveal that, on an average, 250 people have lost their lives annually in such disasters.

Inundation in the Study Area

The Biring River

According to the SRSJSD, seven village development committees (VDC), namely Saranamati, Surunga, Dangibari, Ghailadubba, Chakchaki, Rajgadh and Gherabari, are regularly affected by inundation due to overflow in the Biring River. Event of inundation occurs once in two to three years. Each event is associated with 1 to 4 cases of submergence during June to August lasting for 12 to 24 hours. Total average area that comes under submergence regularly is about 2,585 ha. Total affected households and population comes to be 3,525 and 17,930 respectively (excluding the inundation area of Gherabari VDC, which was excluded due to security reasons)[4]

The Kankai River

The SRSJSD showed that seven VDCs, namely Mahabhara, Shivganj, Tagandubba, Kumarkhod, Surunga, Pancganchi and Saranamati, are regularly affected by inundation in the Kankai River's surroundings. Event of inundation occurs once in two years. Each event is associated with 1 to 3 cases of submergence during June to August lasting for 5 to 8 hours. Total average area that comes under submergence is about 2,100 ha with average submergence depth of 1.00-1.25 m. Total affected households and population comes to be 2,225 and 11,710 respectively[5].

The Ratuwa River

The findings of SRSJSD indicate that Kohabara and Khajurganchi in Jhapa and Sijuwa and Mahadeva in Morang district are regularly affected by inundation. Event of inundation occurs once in two to three years. Each event is associated with 1 to 3 cases of submergence during June to August lasting for 5 to 8 hours. Total average area, that comes under submergence is about 2,260 ha with average submergence depth of 0.75 m. Total affected households and population come to be 2,100 and 9,405 respectively[6].

Such inundation-induced tragedies are repeated each year. Therefore, effective and timely forecasting system coupled with a responsive preparedness mechanism could be one of the most cost-effective and reliable methods to reduce the negative impacts of inundation on the inhabitants and social, economic and ecological wealth.

Human Induced Factors

In Nepal, increasing population pressure, encroachment on marginal lands for subsistence, farming on high slopes, deforestation and unsustainable extraction of bio-mass for energy in the rural areas are blamed as the human induced factors leading to land degradation and natural resource depletion as well as increased risk of disasters. Deforestation in the upper catchment and hill slopes has resulted in degeneration of watersheds with a loss of surface cover unbalancing the hydrological cycles and depleting up of perennial flows and thereby increasing flash floods and sedimentation in downstream making the area vulnerable for erosion and inundation. Other malpractices include quarrying of stones, sand mining in the river bed and the poor engineering design and alignment of roads, canals etc. Further encroachment of the poor and marginalized people in the river channels in lower reaches for cultivation and settlement due to the high productivity of soils and relatively flat terrain is also a common scenario. Such practice generally blocks natural gully in its mouth. Finally, during heavy rainfall, the rain water collected in gully could not drain out through its channel leading to inundation in the surrounding area.

Bilateral Issues

[4] Source: SRSJSD
[5] Source: SRSJSD
[6] Source: SRSJSD

Irrigation and flood structural intervention by joint Indo-Nepal collabration and several such measures taken by India unilaterally in the form of weirs and embankments have rendered number of places in Nepal Terai inundated. Inundation has made flood prone areas of Terai extremely vulnerable to water induced disasters. For example, in Koshi Barrage Project, water logging has led to adverse impact on agricultural productivity. In another case, near Indo-Nepal border on the Indian side, the Government of India has constructed a ringbund to protect their Bargania town and some villages. This has resulted in continious submergence of Gaur town in Nepal side for the last many years making the affected areas unfavorable for human settlement and other gainful activities. The tendency of the Indian side to tie-up their side of the weirs and embankments to a higher ground elevation in Nepal territory for better protection and performance of their structures (e.g. Tanakpur Barrage) has further contributed to increase the area of inundaton and river bank erosion of Nepal's southern border areas.

Number of meetings of the standing committee on inundation problem between India and Nepal was already held. However, not much serious work is done as a follow up to the meeting decisions. The Indian side rarely agrees with Nepal's position that inundation in the Nepal side is the result of Indian intervention in the river waterways. These interventions have made direct adverse impact on the socio-economic stakes of the common Terai people. The unilateral Indian structural intervention for irrigation and flood control, if goes on unchecked, contains all the possibilties of turning the agricultural land of Nepal Terai into an area that will not be suitable for any human settlement.

Therefore, in view of the feudal structure of the society that is entrenched on either side of the border, it will be the local people who would be deprived of the right to livlihood through agricultural occupation in the inundated areas. Since no systematic quantitative and qualitative data are availabe on the extent of the inundated areas and its impact on the way of life of the local people, the effects of increasing extent of inundation in the border areas may lead to a break down in the local social order, which will have grave national ramification. Inundation due to such structural intervention, however, has not been observed as a case in the study area. Mosoon flood has been claimed as the major reason of the inundation in the study area.

2.1.2 Policy and Planning Support

The goal of water resource development in the country is to harness and utilize the water potential for gaining social benefits by ensuring the participation of the private sector and the concerned communities. In this context, mitigation of water-induced disasters is one of the key areas where the government has to focus on meeting its development goals and poverty reduction.

National Action Plan on Disaster Management

National Action Plan on Disaster Management (NAPDM), 1996 approved by HMGN contains, among others, measures related to geological, hydrological and meteorological hazard assessment, awareness raising programs including training/rehearsals/simulations, disaster management information system, national land use and land cover plan, formulation of policy on disaster reduction measures, promotion of regional and sub-regional cooperation among countries exposed to same natural hazards and establishment of a documentation center on disaster management. This is a sound document that has only been partially implemented owing to lack of resource allocation and coordinated planning amongst the relevant and responsible organizations.

Nepal Water Resources Strategy

Nepal Water Resources Strategy (NWRS) has envisaged to enhance the institutional capabilities for managing water induced disasters. In this regard, realization of integrated

planning for sustainable development of water resources has been reflected in the Tenth Five-Year (FY) Plan as it gives due consideration to these issues with an objective to control and manage the natural disaster caused due to erosion, flood, landslides and debris flow. In addition to preparations for emergency response, rescue and relief in the case of water induced catastrophic events; the NWRS also aims to establish WID prevention, warning, preparedness and mitigation measures in at least 20 priority districts by 2010, and the whole country by 2027. The NWRS has highlighted some strategic outputs to achieve its purposes. Some of the outputs relevant to this study include:

- Effective measures to manage and mitigate water induced disasters are functional;
- Appropriate institutional mechanism for water sector management are functional; and
- Sustainable management of watersheds and aquatic eco-systems achieved.

Some of the activities foreseen by the NWRS under the quoted outputs are:

- Prepare and implement a water induced disaster management policy and plan;
- Conduct risk/ vulnerability mapping and zoning;
- Strengthen the disaster networking and information system;
- Strengthen institutional set-up and capacity;
- Implement disaster reduction/ mitigation measures;
- Implement watershed and aquatic ecosystem protection, rehabilitation and management programs;
- Develop productive use of flood plains; and
- Enhance planning and implementation capacities of all stakeholders.

National Water Plan

National Water Plan (NWP) has been developed by Water and Energy Commission Secretariat (WECS) to operationalize the output objective of the NWRS. The Plan's objective is to contribute towards the fulfillment of the national goal through implementation of water related programs within a framework of good governance, equitable distribution and sustainable development, especially through the process of integration, coordination, decentralization and popular participation.

The focus of the WID management during the first five years of the Plan is to enhance institutional capabilities for managing water induced disasters. In the following ten years, effective measures will be adopted to better manage WID and mitigate their adverse effects. The long term goal of the plan is to make Nepal's water disaster system fully functional, effective and responsive to people's need. The total program is expected to directly address the needs of the poor and marginalized people, thereby contributing to improve living conditions of the poorest sector. One of the various action programs as set out by the NWP is the WID management program. Some of the key elements of this program are:

- Identify, prioritize and develop management plan for high risk areas;
- Develop plan for flood forecasting and warning system and disaster preparedness effective and functional;
- Implement non-structural measures such as afforestration with people participation involving CBOs/NGOs for watershed area conservation; and
- Develop and implement capacity development programs in all WID related institutions.

Tenth Five Year Plan

One of the various quantitative goals as set out by the Tenth Plan is to prepare the indicative and catagorized maps of WID prone areas. In this context, the working strategy set out by

the Plan also emphasizes invention, development and extension of location effective technology for minimizing water induced disasters.

Thus, the presently proposed study is one of the endevours towards attainment of objective set by the Tenth Plan and NWRS.

2.1.3 Institutional Attempts

Institutional attempts at mitigating water induced disasters in the country were initiated with the cooperation of the Government of Japan through the Japan International Cooperation Agency (JICA) with the establishment of the Water Induced Disaster Prevention Technical Centre (DPTC) in 1991 that was later changed to the Department of Water Induced Disaster Prevention under the Ministry of Water Resources. In order to overcome the risk to the implementation of the activities owing to lack of clear authority and co-ordination amongst organizations, the DWIDP has been identified as the lead agency to undertake enhanced co-ordination and co-operation with all the partners. Currently, DWIDP is implementing Disaster Mitigation Support Program (DMSP). The Department of Narcotics Control and Natural Disaster Management has also been recently established under the Ministry of Home Affairs for further coordination of efforts at disaster management.

Jalsrot Vikas Sanstha

Jalsrot Vikas Sanstha (JVS), established in 1999, aims to bring persons and organizations related to water resources development (WRD) together and forge knowledge-based understanding and distilled wisdom on this naturally transparent but politically complex matter. The objectives of JVS are as follows:

- Help formulate policies on Integrated Water Resources Management (IWRM);
- Help sustainable conservation, utilization and management of water resources;
- Analyze the prevailing differences among donor agencies and receiver countries and suggest remedial measures;
- Help develop methods for optimal utilization of water resources;
- Work for the development of integrated approach at the national, bilateral and regional level;
- Coordinate and work collaboratively with partner institutions; and
- Share experience, knowledge and information on the WRD sector.

This study has been formulated by the JVS under it's output program to operationalize national water strategy, policy and plans with regard to WID, especifically in relation with inundation and to help further forge dialogue among the stakeholders on the WID and subsequently assist in informed decision making in realizing the efficiency objective.

2.2 Study Area

The study area is the area prone to inundation in each of these three rivers. Most of the study area falls in the Terai plain of Jhapa district except a small area in Morang suseptible to inundation by the Ratuwa river. Most of the area is confined downstream of the East-West Highway except some area along the Biring river upstream of the E-W Highway, which is also prone to regular inundation. Indicative map of the study area is presented in **Figure 2-1.**

The study area has sub-tropical climate with hot temperate summer. The area is dominated by the caste/ethnic groups such as Yadhav, Tharu, Khatbe, Dhanuk, Shah, Telli, Rajpoot, Kayastha, Dom, Chamar, Newar, Brahmn/Chhetri, Haluwai, Mushar etc. Agriculture is the mainstay of the economy in the study area. Large percent of local people depend on agriculture for their livelihood and less on service, trade and others.

3.0 OBJECTIVES AND SCOPES

3.1 Objectives

The objectives of the study have been guided by the i) suggestions of the DWIDP and recommendations outlined in the SRSJSD; and ii) relevant strategic outputs, activities and the key elements envisioned by NWRS and NWP. In line with this, the specific objectives of the study are to:

- Prepare GIS based thematic maps of the identified inundation prone area;
- Assess present institutional set-up at the local level involved in the mitigation;
- Assess environmental implications created by inundation;
- Assess effective modes of mitigation of environmental problems; and
- Recommend measures that could contribute to resolve inundation issues and its effective management.

3.2 Study Scopes

The scope of the services are as follows:

- The study area is the adjoining area of the three rivers, namely Biring, Kankai and Ratuwa, susceptible to inundation.
- The data to be generated and analyzed contain:
  - information on the area, depth, duration of the regular cases of inundation; including extent of damages;
  - information on the most severe case of inundation in terms of area, depth, duration and extent of damages;
  - information on settlement pattern and agriculture practice in high risk areas;
  - information on the present institutional arrangement for flood mitigation in the community level including its working modality;
  - information on the existing methodology for emergency action in case of inundation;
  - information on existing evacuation procedures including location of temporary shelter, emergency storage, evacuation routes including transportation modes etc
  - information on the environmental implications created by inundation like submergence, water borne diseases, sedimentation and loss of flora and fauna.
  - socio-economic status of the affected community including number of households, cattle population, agricultural land, major economic activities, education, health, communication etc; and

4.0 METHODODLOGY

The study was carried out in three different phases - Desk Study, Field Survey, and Compilation and Analysis. These individual phases have been further divided into series of activities which in their turn represent the methodological framework for attainig the preset objectives.

4.1 Desk Study

A road map for the entire study was formulated with accomplishment of the desk study phase. Within the desk study, the following activities were ca rried out:

Team Mobilization, Information Collection, and Planning

The works undertaken under this activity include:

- Establishment of logistic arrangements required for the study and team mobilization;
- Conduction of consultative meeting and preliminary planning within the Team;
- Collection and review of relevant documents that included project reports, disaster review reports, government policies and regulations including NWRS, National Water Plan, and Tenth Plan; and
- Procurement of required topographical maps (1:25,000), Ward and VDCs maps and other relevant digital maps covering all the study districts from the Department of Survey (DOS).

Development of the Working Tools

Different data collecting tools were developed during the desk study phase. These tools were prepared based on the review of collected relevant information, specific requirement of the study, and professional judgement of the team to reveal all the expected information. The developed tools include:

- Checklist for Technical Observation and Mapping;
- Checklist for Preliminary Environmental Assessment;
- Questionnaire for Community Group Survey for Social Assessment; and
- Questionnaire for Assessment of Strength of Local Institutions.

Specific purposes of each of these tools are further elaborated in **Section 4.2**. The developed questionnaires are presented in **Annex-1** of this report.

Orientation Program

A series of orientation program was conducted at the end of the desk study. Brainstorming session was held to discuss all the aspects of formulated questionnaires, guidelines and checklists with the aim of increasing competence of each team members in terms of awareness and familiarization of the activities to be executed by them.

4.2 Field Survey

After completion of the desk study, the study team with required resources commenced field visit. Interactive meetings/discussions with DDC was the activity conducted primarily before starting the field works to acquire available information of the study area. The team met program officers and representative of DWIDP in DDC. Discussions were held on various relevant themes that among others include:

- location of inundation prone area;
- damages caused by flood disasters;
- list of all the VDCs along the river side including population, household numbers etc;
- social status of the affected communities;
- Working modality of DDC in terms of execution of WID related activities; and
- level of supports from DDC.

The team then visited the inundation prone area of each of these three rivers. All the activities as mentioned in the following sections were carried out based on rigorous community interaction accompained with credible professional judgements. Representatives from different walks of life including affected communities, local knowledgeable persons, key informants and representatives from community level institutions involved in WID management in the study area were approached. Different surveys were conducted in affected area of each of these three rivers to work out information on inundation issues in terms of technical features, social features, general environmental impacts and local insitutional arrangements for inundation management.

4.2.2 Technical Observation and Mapping

This activity was performed basically to demarcate inundation area in the topographical maps and as well as in the ward maps. The team first identified various spots in the left and right side of each of these rivers up to where the effect of inundation was observed. Rigorous community interaction and professional judgments were the basis to identify such spots. Such spots were identified in a regular interval at the both side of the rivers. Then the team made walkthrough throguh such spots. The spots were identified in terms of their longitude, latitude and altitude using GPS. This was followed by preliminary interpretation of each location in the topographical and ward maps right at the field. The coordinates of these spots are presented in **Table 1** to **Table 3** of **Annex–2**.

In addition, the team also made a walkthrough along the river course in the identified inudated areas and collected information on the water depth (during inundation) at various cross-sections of the river for regular and most severe case of inundation. For the regular case of inundation, the water depths were collected for the last three years viz: 2002; 2003 and 2004. These cross sections were then marked in the topographical maps with the help of GPS. To minimize the error, the cross-sections were tried to locate at some reference places e.g. roads and other infrastructures that are indicated in the topo map. The coordinates of these points are presented in **Table 4** to **Table 6** of **Annex–2**.

As outputs of technical observation, the following information were derived:

- Name of the VDCs along with respective wards regularly affected by the inundation;
- Area of inundation (ward level) for regular case;
- Depth and duration of inundation for regular and most severe case;
- Information on submergence depth along the river course for regular and most severe case;
- Information on the existing river training works to prevent inundation in terms of their location, functional status and adequacy etc; and
- Description of human encroachment/structural intervention, if any.

The outcome (riverwise) of such observations is presented in **Chapter 5**.

4.2.3 Preliminary Environmental Assessment

As outputs of environmental assessment, the following information were derived:

- Information about the impacts in the agriculture lands in terms of affected crops, area and severity of damages;

- Changes in soil fertility of the agriculture land due to inundation;
- Types of sediment deposited in the agriculture land after inundation including average layer and its harmfulness for agriculture purposes;
- Information on the lands that get completely unused for agriculture purposes after inundation;
- Outbreak of diseases, their types and number of people affected;
- Types of pollution brought about by the inundation including its impacts in social life;
- Information on the industries (if any) situated in the upstream and their contribution on spreading pollution during inundation;
- Impacts of inundation in drinking water supply;
- Impacts of inundation in flora and fauna in terms of appearance or disappearance of certain plants/animals due to inundation, impacts on habitat of acquatic animals, damages of shrub/forest areas in the vicinity etc; and
- Changes in the river regime and morphology due to inundation.

4.2.4 Survey to Assess Strength of Local Institutions

As outputs of this survey, the following information were derived:

- Information about the community level committees/groups involved in WID management;
- Information about the funding sources of such committees;
- Costraints for sustainability of such committee(s);
- Level of local people participation in the committees' activities;
- Roles/responsibilities and actions of such committees during the case of events in terms of providing pre-information about disaster, mode of communication for such information;
- Roles/activities for evacuation, temporary shelter/storage, grievance handling, supply of medicament, coordination with concerned organization for damage and compensation etc; and
- Information on the distrcit level institutions, (I)NGOs/Clubs involved in inundation mitigation/management including level of supports provided

4.2.5 Social Survey

As outputs of this survey, the following information were derived:

- Affected population, households, ethnic groups, occupation etc;
- Affected public facilities in the VDCs;
- Other cultural/historical/religious places affected by the inundation;
- Description of human encroachment in the river course;
- Information on the most severe case of inundation in terms of area, depth and duration; and
- Information on the damages brough about by the inundation in the regular as well as most severe events.

4.3 Compilation and Analysis

After completion of the field works, the study team commenced analysis and compilation of the gathered data and information. In addition to the rigorous analysis of collected technical, social, environmental and institutional data/information and their compilation in the form of report, other major activities accomplished during this phase are described as follows:

4.3.1 Finalization of topographical maps and ward maps

The spots (reference points) taken in the field (up to the point of inundation) were first incorporated in the topographical maps based on their longitude, latitude and altitude. These points were then joined together to form an area representing submergence. Similarly, ward maps were also finalized by incorporating all the necessary information/data collected from

the field to represent the inundation area. The topographical (1:25,000) and ward maps with the area of inundation delineated on them are presented in **Volume 2** of this report.

4.3.2 Application of GIS

Application of GIS covered two major activities viz; delineation of the inundation prone area of the studied rivers in the digital map, and incorporation/update of the database related to inundation in the study area. For delineation of inundation area in respective wards and incorporation of associated information in the GIS database, the following steps were carried out:

- Refining/recoding existing available data;
- Updating existing database by adding data/information gathered during field survey. Such data/information include affected ward area, affected population and households in the respective wards; and
- Final representation of affected wards in base maps by taking the reference boundary points from the topo-maps and their interpretation in the digital maps based on the latitude, longitude and altitude of those points. Manual digitization was performed to delineate the area.

The GIS based thematic maps in terms of the inundation area and the associated attribute tables are presented in **Volume 2** of this report.

4.3.3 Flood Frequency Analysis

Flood frequency analysis was carried out to determine peak flood events of each of the studied rivers at the Indo-Nepal border site. Determination of discharges of different return period viz, 2, 5, 10, 20, 25, 50, 100 and 500 of the rivers was carried out using Dicken's and WECS Regional methods. Catchment area of each of these rivers have been taken from the secondary sources. The results obtained have been presented in a tablular form in **Annex-3** of this report.

5.0 STUDY FINDINGS

The study findings have been derived in terms of the following major aspects of the studied rivers:

- Generel features of the studied rivers including their length, origination, major tributaries, elevation etc;
- Technical features in terms of area (VDC and ward level), frequency, depth and duration of regular and the most severe case of inundation;
- Social features of the affected communities including ward-wise number of affected households/population, ethnicity, occupation and extent of damages;
- A brief information on existing infrastructures for inundation prevention;
- Level of human encroachment and structural interventions;
- General environmental impacts brought about by the inundation;
- Existing local institutions and their effectiveness in inundation management; and
- Reasons of inundation.

Following section presents analytical descriptions on the study findings. The general, technical and social features are presented river-wise while environmental and institutional analyses are presented collectively for three rivers.

5.1 The Biring River

5.1.1 General Features

Biring is a perennial river. It originates from the Mahabharat range, cuts through the Churia range and flows through the Terai. Total length of the river is about 62.5 km out of which 44 km lies in Jhapa district. The river meets the Kali khola in Bhotetar (Budhabare VDC) at about 18 km downstream from its origin. From this confluence point, the river flows in Jhapa district. Elevation of the river at the place of its origin is about 2,000 m amsl, whereas the elevation at the E-W highway is 115.5 m and near Indo-Nepal border is 71.4 m amsl. Dahi, Sukhani, Tatin, Goyan, Rote, Sano Nete, Nete, Phulmati, Surunga, Ghagara, Kawali, Budhi Sukhani, Baghe, Juke are the tributaries of the Biring. It passes through Gherabari VDC near border and crosses the border at Kuttighat village. The river has steep gradient at the upper reach with boulders, cobbles and gravel as main deposition. The lower reach has flatter slope (average 1 in 1,000) and mainly consists of fine sand and silt. The lower reach is characterized by the irregular meandering pattern and has also shifting trend towards west.

Three VDCs namely Kudunabari, Surunga and Saranamati are situated in the right bank of the river. Budhabare, Chakchaki and Rajgadh VDCs are situated in the left bank of the river. Similarly, four VDCs namely Arjundhara, Ghailadubba, Dangibari and Gherabari are situated on the both bank of the river.

5.1.2 Inundation Issues

Technical Features

Out of the ten VDCs situated in the left and right banks of the river, seven VDCs namely Saranamati, Surunga, Dangibari, Ghailadubba, Chakchaki, Rajgadh and Gherabari are regularly affected by inundation. Inundation in general starts from Sukumabasi Tole in the left and Tollo Bhagedi Tole in the right of Ghailadubba VDC. It spreads down to the different wards of the mentioned VDCs and ends at upstream of a east west aligned road south of Seghubasti of Gherabari VDC near the border. In the east west direction, the width of inundation front vary in the range of 1.5 to 3.0 km. According to the survey, event of

inundation occurs once in two to three years. Each event is associated with 1 to 4 cases of submergence during June to August lasting for 12 to 24 hours. The total submergence area calculated after its delineation in the topographical and ward maps comes to be 4,059 ha. This area differs in magnitude of 1,474 ha from the total area indicated by the previous study SRSJSD, which was equal to 2,585 ha. This error is associated with the facts that SRSJSD had worked out the area (VDC level) merely based on local interview and not through intensive field investigation. In contrary, this study has determined ward-wise area based on the spot verification in each affected ward. Furthermore, inundation area in Gherabari VDC, which was left out by SRSJSD (due to the security reason), is also included in this study. Therefore, the area worked out by this study is more precise than the one estimated by SRSJSD.

The ward-wise area that comes under regular submergence, which has been derived from the ward maps, has been presented in **Table 5-1**.

Table 5-1: Ward-wise Area Affected by Inundation in Different VDCs

SN	Affected VDCs	Affected Wards	Affected Area (ha)	Duration (Hrs)
1.	Saranamati	Ward 1 Ward 2 Ward 3 Ward 5 Ward 6	152 115 200 166 130 **Total: 763**	12-24
2.	Surunga	Ward 6	110 **Total: 110**	12-24
3.	Dangibari	Ward 1 Ward 2 Ward 3 Ward 4 Ward 5	108 95 230 130 108 **Total: 671**	12-24
4.	Ghailadubba	Ward 1 Ward 3 Ward 4 Ward 7 Ward 8 Ward 9	67 114 140 200 90 210 **Total: 821**	12-24
5.	Chakchaki	Ward 1 Ward 2 Ward 3 Ward 4 Ward 5 Ward 9	157 60 90 85 135 6 **Total: 533**	12-24
6.	Rajgadh	Ward 1 Ward 2 Ward 4 Ward 7	97 319 206 88 **Total: 710**	12-24
7.	Gherabari	Ward 3 Ward 4 Ward 5	90 120 241 **Total: 451**	12-24

Note: The submergence area has been derived from the ward maps after total submergence area delineated in it.

The local responses and field verification confirm that the average submergence depth fluctuates from 1.20-1.30 m in immediate surroundings of the river. The submergence duration is in the range of 12 to 24 hrs. The average depth of submergence in several cross-sectional reference of the river for last three years viz; 2002, 2003 and 2004 and for the most severe case[7] of inundation collected through the local responses and reinforced with field verification is presented in **Table 4** of **Annex-2**. These reference points are also indicated in the topo-map with red color.

Local responses confirm that the most severe case of inundation has occurred in 2003 in the month of July, which lasted for about two days. The total area affected in this event was about 9,300 ha with the average depth of submergence of about 1.75 m (Refer **Table 4** of **Annex-2**).

Social Features of the Affected Communities

Ethnic composition of the people inhabiting in the riverside comprises of different castes. They are; Rajbansi, Sattar, Rai, Limbu, Magar, Tharu, Brahmin, chettri, Tajpuria, Dhimal, Kami, Miyan etc. Predominant castes in the upstream of E-W Highway are Brahmin, Chettri, Rai and Limbu. On the other hand, majority of ethnic composition of the affected area comprises of Satar, Rajbansi, Brahmin, Chettri, Kami etc. Total affected households and population come to be 3,342 and 16,285 respectively. General socio-economic features of the affected communities are presented in **Table 5-2**.

Table 5-2: General Socio-economic Features of the Affected Community

SN	Affected VDC	Extent of Effects			Major Ethnicity	Major Occupation
		Wards	Households	Population		
1.	Saranamati	Ward 1 Ward 2 Ward 3 Ward 5 Ward 6 **Total:**	200 100 250 250 100 **900**	1,075 750 1,250 1,500 675 **5,250**	Rajbansi, Musalman, Brahmin, Chettri, Rai, Limbu, Gurung, Kami	Agriculture, Livestock raising, Laboure
2.	Surunga	Ward 6 **Total:**	50 **50**	330 **330**	Chettri, Brhamin, Kami, Miya, Sattar	Agriculture, Livestock raising, Labour
3.	Dangibari	Ward 1 Ward 2 Ward 3 Ward 4 Ward 5 **Total:**	70 100 125 100 80 **475**	350 425 475 415 400 **2,065**	Brahmin, Chettri, Rajbansi, Sattar, Rai, Limbu	Agriculture, Labour
4.	Ghailadubba	Ward 1 Ward 3 Ward 4 Ward 7 Ward 8 Ward 9 **Total:**	50 75 100 225 75 150 **675**	225 375 480 1,200 380 820 **3,480**	Rai, Tamang, Bhujel, Brahmin, Chettri, Sattar, Mushar, Rajbansi, Chaudhari	Agriculture, Livestock raising, Labour
5.	Chakchaki	Ward 1 Ward 2 Ward 3 Ward 4 Ward 5 Ward 9 **Total:**	125 70 100 72 120 12 **502**	420 280 450 320 550 40 **2,060**	Musulman, Sattar, Rajbansi, Brahmin, Chettri, Damai, Kami, Rai, Limbu	Agriculture, Labour

[7] Most severe case of inundation refers to that historical event which has caused comparatively maximum impacts in terms of area, duration, depth, magnitude of damages, loss etc.

6.	Rajgadh	Ward 1 Ward 2 Ward 4 Ward 7 **Total:**	65 150 125 75 **415**	315 625 415 300 **1655**	Teli, Miya, Sattar, Brahmin, Chettri	Agriculture, Labour
7.	Gherabari	Ward 3 Ward 4 Ward 5 **Total:**	120 105 100 **325**	515 430 500 **1445**	Teli, Miya, Sattar, Brahmin, Chettri	Agriculture, Labour

The number of regularly affected infrastructures and public assets is presented in **Table 5-3**.

Table 5-3: Affected Public Infrastructures

Description	Nos.
Temple	2
Health Post	2
Post Office	2
School	6
Police Station	2
Rice Mill	2
Market Place	2

Damages caused by inundation in the regular case as well as in the most severe case have been presented in the **Table 5-4**.

Table 5-4: Average Magnitude of Severe Damages Caused by Inundation

Items	Regular Case	Most Severe Case
Agriculture land	25 -50 ha	500 ha
Houses (Nos)	4 -10	60 - 80
Crops (types)	Paddy	Paddy
Cowsheds (Nos.)	4 - 10	70
Road (km)	0.5	2.0
Culverts/bridges (Nos)	3	11
Irrigation Canal (k.m)	3	5

Existing Infrastructures for Inundation Prevention

The team has also gathered information on the existing infrastructures (e.g. embankments, spurs) built by different organizations for prevention of inundation and other WID. An embankment with some 600 m length was observed in the right side of the Biring River in Saranamati VDC. This embankment was built with support from DDC in 2002/03. However, a part of this embankment was destroyed by the flood of 2003 and the embankment could not serve its purpose. Similarly, about 300 m of embankment was also observed in the left bank of the river in Ghailadubba VDC. This earthen embankment (without protection) also got eroded in the flood of 2003 and a part of it was washed away. Likewise, for an immediate solution, people have constructed about 150 m embankment of bamboo filled with sand bags in left bank of the river in Ghailadubba – 7. A series of spurs with length varying from 10 to 15 m were observed in both the banks of the river in Ward 7 and 8 of Ghailadubba VDC. These spurs were constructed with support from Red Cross and VDC. They were observed intact and are well serving their purpose. Similarly, four spurs with length of about 10 m were observed in Rajgadh VDC.

Human Encroachments

Intensified agriculture practice prevails in both the sides of the river. Sukumbasi and other migrants have been blamed for encroaching the flood plain in Ward-1 (Bhagudubba) of Rajgadh VDC. Similarly, noticeable encroachment has also been observed in Ward 1, 2 and 3 of Chakchaki VDC. The present trend of encroachment, especially for occupancy of agriculture land, shows that in future it could be a reason of disastrous calamity. Structural intervention across the river causing inundation has not been observed so far.

5.2 The Kankai River

5.2.1 General Features

Kankai is a perennial river. It originates from the Mahabharat range at Deumaikhop village, Chamaita VDC of Ilam district and flow southwards through the Terai. At the place of origination, the river is called Deo Mai Khola. Total length of the river is about 108 km out of which 29 km lies in the Jhapa district. The river starts flowing through Jhapa district from Sukedangi village, Surunga VDC-8, where Birsinge Kholsi meets the Kankai river at the left bank. Elevation of the river at the place of its origin is about 1,820 m, whereas the elevation at the starting of Jhapa district is 120 m, at the E-W highway is 108 m and near Indo-Nepal border is about 70 m. The river crosses the Indo-Nepal border at Hukulbari village (Mahabhara VDC) in its right bank and Sadakbasti village (Kumarkhod VDC) in its left bank. Main tributaries of the Kankai are Jog Mai Khola, Mai Khola, Puwa Mai Khola and Deo Mai Khola. They all lie in Ilam district. Other small tributaries within Jhapa district are Hundrunge Khola, Bhalu Khola, Jharna Khola, Satasi Khola and Kamal Khola. The Kamal Khola meets the Kankai river right at the border. The river has steep gradient at the upper reach with boulders, cobbles and gravel as main deposition. The lower reach has flatter slope (average 1 in 1,000) and mainly consists of fine sand and silt. The lower reach is characterized by the irregular meandering pattern and has also shifting trend towards right. In the Mahabhara-9 (Rangiyathan village) and Panchgachhi-8 (Bhelamunitole), the local query divulged that the river shifts towards right side in the range of 100-200 m each year damaging about 17-27 ha of land.

Surunga, Saranamati Tagadubba and Kumarkhod are the VDCs along the left bank of the river. Similarly, Satisidham, Panchganchi and Mahabhara VDCs are situated in the right bank of the river. Shivganj VDC lies in the both bank of the river.

5.2.2 Inundation Issues

Technical Features

Seven VDCs namely Mahabhara, Shivganj, Tagandubba, Kumarkhod, Surunga, Pancganchi and Saranamati are regularly affected by inundation. Inundation in general starts near the border of Shivgunj and Satashidham VDC. In the downstream the inundation front reaches the border covering the entire Mai Bhangalo and extending almost up to the Baniyani River. It was noted that event of inundation occurs once in two years. Each event is associated with 1 to 3 cases of submergence during June to August lasting for 5 to 8 hours. The total submergence area calculated after its delineation in the topographical maps comes to be 2,983 ha. This area differs in magnitude of 883 ha from the total area indicated by the previous study SRSJSD, which was equal to 2,100 ha. The ward-wise area that comes under regular submergence, derived from the ward maps, has been presented in **Table 5-5**.

Table 5-5: Wards/Area Affected by Inundation in Different VDCs

SN	Affected VDC	Affected Wards	Affected Area (ha)	Duration (hrs)
1.	Mahabhara	Ward 5 Ward 6 Ward 7 Ward 9	195 175 165 125 **Total: 660**	5 - 8
2.	Shivganj	Ward 1 Ward 5 Ward 6 Ward 7 Ward 9	108 457 140 145 13 **Total: 863**	5 - 8
3.	Kumarkhod	Ward 4 Ward 6 Ward 7 Ward 8	140 125 67 185 **Total: 517**	5 - 8
4.	Surunga	Ward 4 Ward 6 Ward 7 Ward 9	200 36 43 18 **Total: 297**	5 - 8
5.	Saranamati	Ward 8 Ward 9	103 210 **Total: 313**	5 - 8
6.	Pancganchi	Ward 3 Ward 8 Ward 9	87 76 80 **Total: 243**	5 - 8
7.	Tagandubba	Ward 9	90 **Total: 90**	5 - 8

Note: The submergence area derived from the ward maps.

The local responses and the field verification confirm that the average submergence depth fluctuate from 1.00-1.30 m with duration of 5 to 8 hrs. The most severe case of inundation was occurred in July 2003, which lasted for about 24 hours. The total area affected in this event was about 11,000 ha with the average depth of submergence of about 1.80 m. The average depths of submergence in several cross-sectional references of the river for the last three years viz; 2002, 2003 and 2004 and for the most severe case of inundation are presented in **Table 5** of **Annex-2**.

Social Features of the Affected Communities

Ethnic composition of the people inhabiting in the riverside comprises of different castes. They are: Rai, Limbu, Brahmin, Chettri, Sattar, Rajbansi, Tajpuria etc. Predominant casts in the upstream of highway are Brahmin, Chettri, Rai and Limbu. On the other hand, in VDCs like Mahabhara, which is near the border, Rajbansi and Sattar are the predominant ethnic groups. Total affected households and population are 2,230 and 10,755 respectively. General socio-economic features of the affected communities are presented in **Table 5-6**.

Table 5-6: General Socio-economic Features of the Affected Communities

SN	Affected VDC	Extent of Effects			Major Ethnicity	Major Occupation
		Affected Wards	Households (Nos)	Population (Nos.)		
1.	Mahabhara	Ward 5 Ward 6 Ward 7 Ward 9 **Total:**	200 100 50 120 **470**	1010 560 205 415 **2190**	Rajbansi, Sattar, Brahmin, Chettri, Rai, Limbu, Mahatto, Kami	Agriculture, Livestock raising, Laboure
2.	Shivganj	Ward 1 Ward 5 Ward 6 Ward 7 Ward 9 **Total:**	75 175 125 80 20 **475**	300 1020 600 350 75 **2345**	Sattar, Rajbansi, Rai, Limbu, Chettri, Brhamin, Kami, Damai	Agriculture, Livestock raising, Labour
3.	Kumarkhod	Ward 4 Ward 6 Ward 7 Ward 8 **Total:**	120 95 50 175 **440**	600 420 215 950 **2185**	Brahmin, Chettri, Rajbansi, Sattar, Rai, Limbu, Kami, Damai	Agriculture, Labour
4.	Surunga	Ward 4 Ward 6 Ward 7 Ward 9 **Total:**	200 50 40 15 **305**	1020 175 175 60 **1430**	Brahmin, Chettri, Sattar, Rai, Limbu	Agriculture, Livestock raising, Labour, Service
5.	Saranamati	Ward 8 Ward 9 **Total:**	110 180 **290**	475 950 **1425**	Musulman, Rajbansi, Brahmin, Chettri, Kami, Rai, Limbu	Agriculture, Labour, Service
6.	Pancganchi	Ward 3 Ward 8 Ward 9 **Total:**	50 50 50 **150**	225 195 210 **630**	Musulman, Rajbansi, Brahmin, Chettri, Kami, Rai, Limbu	Agriculture, Labour, Service
7.	Tagandubba	Ward 9 **Total:**	100 **100**	550 **550**	Musulman, Rajbansi, Brahmin, Chettri, Kami, Rai, Limbu	Agriculture, Labour, Service

The number of regularly affected infrastructures and public assets is presented in **Table 5-7**.

Table 5-7: Affected Public Infrastructures

Description	Nos.
Temple	7
Health Post	1
School	4
Police Station	1
Rice Mill	2
Market Place	2

Damages caused by inundation in the regular case as well as in the most severe case has been presented in the **Table 5-8**.

Table 5-8: Average Magnitude of Severe Damages Caused by Inundation

Items	Magnitude of severe damages	
	Regular Case	Most Severe Case
Human life (Nos)	-	4

Agriculture land	20 -50 ha	450 ha
Houses (Nos)	2-4	25 - 40
Crops (types)	Paddy	Paddy
Cowsheds (Nos.)	2-4	30
Road (km)	0.1	0.5
culverts/bridges (Nos)	2	10
Irrigation Canal (km)	0.5	4

Note: The most severe case refers to the case of July, 2003.

Existing Infrastructures for Inundation Prevention

An embankment with about 200 m length was observed in the right side of the Kankai River in Shivgunj VDC. This earthen embankment was built with support from DDC in the fiscal year 2002/03 and is serving its purpose as it has been constructed with enough waterways for the monsoon flood. A series of spurs are located in Wards 7 and 8 of Kumarkhod VDC. They were built with support from Red Cross and VDC and are well serving. Spurs were also observed in Sugabathan village in Kumarkhod VDC, Shanti Tole, Lal Pani, Kankai Tole, Dhakal Tole, Jharbari and Shivganj Bajar in Shivganj VDC. About 1.0 km of embankment was observed in the right side of the river at Kankai Banth Tole in Satashidham VDC.

Human Encroachment

Human encroachment in the form of settlement and agriculture practice in the river flood plains is severe in Tapu, Chaurigaun, Tunubasti and Rangethan in Mahabhara VDC and Kulmu Basti in Kumarkhod VDC. Structural intervention across the river causing inundation has not been observed so far.

5.3 The Ratuwa River

5.3.1 General Features

Ratuwa is a perennial river originating from the Mahabharat range in Chisapani VDC of Ilam district and flow through Jhapa district. In the lower reach, it forms border between Jhapa and Morang districts. The river enters the Jhapa district in Beldangi village, Damak-1 nearby Refugee camp. Total length of the river is 78 km, of which about 49 km lies in the Jhapa and Morang districts. Elevation of the river at the place of its origin is about 1,800 amsl and at the Indo-Nepal border is about 70 m. The river crosses the Indo-Nepal border at Chalgachhi village, Mahadeva VDC-1. Main tributaries of the Ratuwa are Mawa, Chaju, Betani, Perunge, Lukkuwa, Majhuwa, Bukuwa, Bidhuwa etc. Mawa and Chaju are the major tributaries in Jhapa district. The river has steep gradient at the upper reaches with boulders, cobbles and gravel as main deposition. The lower reach of the river has flatter slope (average 1 in 1,000) and mainly consists of fine sand and silt. This reach is characterized by the irregular meandering pattern and has also shifting tendency towards right.

The river passes through nine VDCs and Damak Municipality. The VDCs in Morang district situated in the right bank of the river are Madhumalla, Urlabari, Rajghat, Itahara, Jhurkiya and Sijuwa. Similarly, VDCs in Jhapa district in the left bank of the river are Lakhanpur, Kohabara and Khajurgachhi. Damak Municipality and Mahadeva (Morang) Ie in the both bank of the river.

5.3.2 Inundation Issues

Technical Features

The VDCs regularly affected by inundation are Kohabara and Khajurganchi in Jhapa district, and Sijuwa, Jhurkiya, Itahara and Mahadeva in Morang district. The inundation starts from Indrajhoda village of Itahara VDC at the right and Dimmautha village of Kohabara VDC at the left. Field survey found that the event of inundation occurs once in two to three years. Each event is associated with 1 to 3 cases of submergence during June to August lasting for 5 to 8 hours. The total submergence area delineated in the topographical maps is about 2,560 ha. This area differs in magnitude of 300 ha from the total area of 2,260 ha indicated by the previous study SRSJSD. However, this study has included area of Itahara and Jhurkiya VDC, which were left out by the SRSJSD. The ward-wise area that comes under regular submergence, derived from the ward maps, has been presented in **Table 5-9**.

Table 5-9: Wards/Area Affected by Inundation in Different V DCs

SN	Affected VDC	Affected Wards	Affected Area (ha)	Duration (hrs)
1.	Kohabara	Ward - 1 Ward - 2 Ward - 3 Ward - 4 Ward - 5 Ward - 6 Ward - 8 Ward - 9	157 130 128 94 130 120 60 214 **Total: 1,033**	6 - 8
2.	Khajurganchi	Ward - 2 Ward - 3 Ward - 4 Ward - 9	28 162 87 100 **Total: 377**	6 - 8
3.	Mahadeva	Ward - 1 Ward – 2 Ward - 5 Ward - 6 Ward - 7 Ward - 8	138 80 94 90 203 15 **Total: 620**	6 – 8
4.	Sijuwa	Ward – 1 Ward – 2 Ward – 3	15 170 175 **Total: 360**	6 – 8
5.	Itahara	Ward – 8 Ward – 9	40 50 **Total: 90**	6 – 8
6.	Jhurkiya	Ward – 9	80 **Total: 80**	6 – 8

The local responses and the field verification confirm that the average submergence depth fluctuate from 1.00-1.30 m with duration of 6 to 8 hrs. The most severe case of inundation was occurred in July 2003, which lasted for about 24 hours. The total area affected in this event was about 7,000 ha with the average depth of submergence of about 1.60 m. The average depths of submergence in several cross-sectional references of the river for the last three years viz; 2002, 2003 and 2004 and for the most severe case of inundation are presented in **Table 6** of **Annex-2**.

Social Features of the Affected Communities

The ethnic composition inhabiting in the riverside comprises of different castes. They are: Brahmin, Chettri, Sattar, Rajbansi, Dhimal, Rai, Limbu, Tajpuria etc. Brahmin, Chettri, Rai, Limbu and Dhimal are dominant in the upstream part whereas Rajbansi, Sattar, Dhimal and Muslim are predominant in the area near Indo-Nepal border. Total affected households and population are 2,220 and 10,015 respectively. General socio-economic features of the affected communities are presented in **Table 5-10**. The number of regularly affected infrastructures and public assets is presented in **Table 5-11**.

Table 5-10: General Socio-economic Features of the Affected Communities

SN	Affected VDC	Extent of Effects			Major Ethnicity	Major Occupation
		Wards	Households (Nos.)	Population (Nos.)		
1.	Kohabara	Ward 1 Ward 2 Ward 3 Ward 4 Ward 5 Ward 6 Ward 8 Ward 9 **Total:**	140 120 125 80 135 77 50 150 **877**	700 375 520 300 440 300 210 800 **3,645**	Rajbansi, Tajpuria, Gangai, Rai, Limbu, Brahmin, Chettri, Satar	Agriculture, Livestock raising
2.	Khajurganchi	Ward 2 Ward 3 Ward 4 Ward 9 **Total:**	30 135 60 125 **350**	125 650 320 575 **1,670**	Rajbansi, Gangai, Tajpuria, Mushahar, Brahmin, Chettri	Agriculture, Labour
3.	Mahadeva	Ward 1 Ward 2 Ward 5 Ward 6 Ward 7 Ward 8 **Total:**	125 75 80 100 185 20 **585**	475 290 350 520 1,000 120 **2,755**	Tajpuria, Rajbansi, Gangai, Das, Sattar	Agricuture, Services, Labour
4.	Sijuwa	Ward 1 Ward 2 Ward 3 **Total:**	20 140 140 **300**	75 675 700 **1,450**	Rajbansi, Tajpuria, Singh, Brahmin, Chettri, Mochi, Haluwai, Sattar	Agriculture, Labour
5.	Itahara	Ward 8 Ward 9 **Total:**	30 40 **70**	150 175 **325**	Rajbansi, Tajpuria, Singh, Brahmin, Chettri, Mochi, Haluwai, Sattar	Agriculture, Labour
6.	Jhurkiya	Ward 9 **Total:**	40 **40**	170 **170**	Rajbansi, Tajpuria, Singh, Brahmin, Chettri, Mochi, Haluwai, Sattar	Agriculture, Labour

Table 5-11: Affected Public Infrastructures

Description	Nos.
Temple	2
Health Post	1
School	3
Rice Mill	1
Oil Mill	1
Market Place	2

During 2003 flood, a football ground in Khajurganchi VDC was washed away and a temple and a masjid in Kohabara VDC got severely damaged. Damages caused by inundation in the regular and the most severe cases have been presented in **Table 5-12**.

Table 5-12: Average Magnitude of Severe Damages Caused by Inundation

Items	Magnitude of severe damages	
	Regular Case	Most Severe Case
Agriculture land	10 - 20	150
Houses (Nos)	-	85
Crops (types)	Paddy, Jute	Paddy, Jute
Cowsheds (Nos.)	-	85
Road (km)	0.2	1.0
culverts/bridges (Nos)	1	7
Irrigation Canal (m)	0.3	2.0

Note: The most severe case refers to the case of July 2003.

Existing Infrastructures for Inundation Prevention

An 800 m long embankment has been observed in right side of Ratuwa in ward no 8 of Itahara VDC. A series of spurs bifurcate from this embankment. The starting point in the north (upstream) of this embankment coincide with the starting point of inundation in regular case. This embankment was constructed with support from DDC. Recently, DWIDP has also provided its supports to built embankment in the right side of the river in Jhulka Dubba Village (Sijuwa – 2). Both of these embankments have been recently constructed. There performance is still to be assessed. River training works in the form of spurs are provided at different places along the river course.

Human Encroachment

Noticeable encroachment in the riverside for settlement can be observed in Harira and Chimlara villages of Khajurganchi VDC and Sijuwa Tole of Sijuwa VDC. Similarly, Adibasi are blamed for encroaching river in Maharajthan of Lakhanpur VDC. Structural intervention across the river causing inundation has not been observed so far.

5.5 Environmental Impacts due to Inundation

The issue of bio-diversity conservation and environment protection is an ongoing global challenge that requires local efforts for its solution. There is vicious linkage between inundation, environment, health and poverty. Therefore, failure to act decisively on environmental issues brought about by inundation and other water induced disasters in the fertile land of the southern Terai is expected to undermine the livelihoods and physical well being of the people.

A preliminary survey has conducted to assess general environmental impacts of the inundation in each of these three rivers. Common features for each of these rivers are discussed below:

Impact on Agriculture Land and Soil Fertility

Out of the total inundated area, about 80 percent is the agriculture land that get affected each year due to inundation. Of this, almost 90 percent of the land covers paddy cultivation. The rest 10 percent covers sugarcane, jute, pulses etc. Inundation makes enormous damages to these crops. Due to deposition of sediments after inundation, the level of the agriculture land rises up. The depth of thus deposited sediment vary from 0.15 to 0.90 m in different locations. These sediments are generally alluvial in type consisting fine silt, sand or loose clay. Thus deposited sediments, on one hand, compel the local communities to bear a huge cost for rearrangements of their land, whereas, on the other hand, it brings a change in

soil fertility. Deposition of clay particles does not usually hamper the fertility of soils. However, sand deposition often turn their land almost in the desert. Therefore, maintenance of soil fertility has become prime concern in the area. Further, the stagnant water during inundation can percolate and supplement the ground water. This might cause raise in ground water and can also lead to salinity hazards.

Pollution, Diseases and Sanitation

The sanitation practice in the study area is not proper and is the main sourse of river water pollution. Disacharge of untreated sewage into a small area and dumping of solid waste into the river and on the river bank are the prominent features in the study area. Further, dead animals are also dumped into the river water. This causes pollution to surface as well as ground water. During inundation the polluted river water spread over the surrounding land and the entire submerged area get affected due to such pollution. This contribute in smell disorder in the vicinity.

Use of groundwater for drinking purpose is intensive in the study area. Surface water and ground water are interrealted. In the high flow season, river water recharges the ground water, river being the influent. On the other hand ground water may flow into a river in low flow season. In this case the river is called effluent. Therefore, degradation of quality of either of the water sources affect one another. It has been responded that during the inundation, the drinking water from the tube-well generaly changes into less transparent color and gives an unpleasant order.

The most significant impact of improper waste management and poor sanitation practices is thus also linked with the drinking water use and which, in turn, has significant impacts on the health status of the people. During and after the event of inundation, one of the prominent diseases is diarrhoea. The poor and low income groups that are habitated near the river bank are found to be more vulnerable to this problems. The middle and upper income groups are often placed in a better situation to afford variety of coping strategies. In an average, 1,000, 600 and 500 people suffer from diarrhoeal diseases each year in the inundation affected area of Biring, Knakai and Ratuwa rivers respectively. Out of this, the number of infants and childrens are quite significant.

Another problem associated with the polluted water is the eroded sediment from the upstream area. The eroded sediment from the upstream farm lands also carry pesticides, fertilizers, and other chemical observed into soil surfaces. These pesticides, fertilizers and chemicals spread over the land along with the submerged water. Fertilizers often contain compounds of nitrogen and phosphorus that can stimulate the growth of algae and other acquatic plants. Nitrates deposited in the farm land can percolate into ground water zones. High concentration of nitrates in ground water used for drinking has been linked to methemoglobinemia, a serious disease in infants. However, the local people are less aware in this regard. There is a lack of awareness and knowledge of safe handling and proper use of pesticides among the farmers.

Aquatic life, Flora and Fauna

Extensive fish habitat does not exist near the inundation affected area of each of these rivers. Therefore, disturbance to the fish and fish breeding habitat is minimal. However, it can be imagined that considerable impacts on migratory fish may result from the sudden rise and spread over of the river water into the surrounding land. Snails, snakes and the tortoise are some of the other animals, which usually get affected due to inundation. People often encounter dead animals in their agriculture field after the event of inundation. Habitat of such animals are affected by the inundation and, especially snake hazard reach apex after the case of inundation.

Local responses indicate that some peculiar types of plants get favorable condition for their growth after event of inundation. Such plants include Lahare Jhar, Kande Jhar and Lazzabati Jhar. Similarly, it has also been responded that in the vicinity of affected area of Biring River, the plants like Pater and Kora usually get dissapeared after the event of inundation. Appearance of any new plants due to inundation has not been noticed by the community yet. Forest or dense shrub land have not been observed so far in the vicinity of the affected area. Neither other prominent habitat for wild life has been found in the vicinity.

River Regime and Morphology

Bank failures, changes of thalweg due to local scours, changes of the entire river way are some of the features observed in the study area.

The river banks in the study area generally consist of non-cohesive sand and silt. The spread over water, generally, loosen the particle interaction of such non-cohesive soils and sliding of banks take place. Further, intensive rainfall and spread over water also contribute on rise of ground water. The river water get lower in a short span of time, while ground water may take a significant time to lower down. This creates imbalances of hydraulic pressure and may cause slip circle in the bank resulting in slope failures. Sliding of river banks are, therefore, now and then the case after the inundation in the each of these rivers, which then supplement the natural sediments in the river and also pose threat to the settlement and agriculture lands. Such impacts are occuring in most of the reaches in the affected area of the three rivers.

One of the reason of inundation is the insufficient channel geometry to pass the high flood discharge in a limited time. Due to this during high flow, the river always tend to find other way to flow with deeper bed level. Therefore in the places, where high sedementation occurs, there is a danger that the river changes its flow path. Such events can be seen in Surunga -6 , Ghailadubba and Saranamati – 5 along the Biring river. Similarly, in Satashidham, Shivganj and Mahabhara in the Kankai river and in few spots of Ratuwa as well.

Population Dispalcement

On one hand there is a trend of encroaching river banks for the human settlement by the migrants from the hills and Sukumbasi. On the other hand displacement of the population due to hazards created by WID including inundation is also a common scenario in the study area. Over 80 percent of the affected people are agriculturist. The inevitable physiological, pshycological and socio-cultural stresses that occurs each year due to inundation on those populace has been undermining their livelihoods. Due to this a trend of shifting to the safe place exist in the community. This is not only provoking the communities to encroach in the forests but also causing a breakdown of social harmony. In a long run this will have a great national ramification.

5.4 Local Institutions and their Effectiveness on Inundation Mangement

The three rivers Biring, Kankai and Ratuwa holds long and tragic story of disasters created by WID including inundation. Each year when monsoon starts, in an average 200-250 households get ready to be resettled. The shifting nature of the these rivers has increased threats among the local communities. In addition to the enormous damages each year, the affected communities are also compelled to spend thousands of rupees to manage their sediment deposited land after the events of inundation.

5.4.1 Community Level

Within the last few years number of sub-committes were formed in the VDC level to manage and mitigate water induced disaster including inundation in their respective VDC. These sub-committtees are responsible for planning and implementing activities for controling WID in their respective VDCs. The members and other officials of the sub-comittees are selected on consensus among the communities. Such sub-committes are active in each affected VDCs, situated in either banks of these three rivers. Unlike in Biring and Kankai, there are also committtes in the affected ward level in case of Ratuwa, which are responsible to coordinate the activities in their respective wards. The consitution of recently formed main committees at the river level (refer **Section 5.4.2**) has also defined duties and rights of these VDC level sub-committes and ward level committees (in case of Ratuwa).

Lack of resources and technological supports are the prominent features of these committes, which has resulted in erratic working modalid ities and inefficient management plan of these committees. The major activities of these committees are limited on identifying problems and constructing infrastructures to protect inundation in their VDCs with support from different organizations including VDC, DDC and DWIDP. According to the survey, Red Cross and Army often supports the communities and these sub-committes, especially during the post inundation events for rehabilitation. Red Cross has also supported the communities through these sub-committees to construct infrastructures for WID prevention in different places of each of these rivers. Rural Reconstruction Nepal, local clubs and mother community has now and then supported these sub-committees.

The sub-committees often collect cash and labour from the local communities to manage and mitigate the inundation problems, when the requirements seems prominent. These sub commitees coordinate with recently formed main committee at the river level (refer **Section 5.4.2**) to facilitate them to obtain requ ired resources, especially, construction materials from relvant organizations.

5.4.2 River Level

On the view of coordinating the entire activities related to WID and implementing river-wise integrated approach for WID management, main committees have be en formed in 2003 in each of these rivers with initiation from DWIDP. These main committees are:

- Biring River Control and Management Committee (BRCMC);
- Kankai River Control and Irrigation Management Main Committee (KRCIMMC); and
- Ratuwa/Mawa River Control and Irrigation Management Main Committee.

These committees have been established with an objective of overall management/ mitigation of WID in the three rivers. These committees are registered in District Adminsitrative Office of Jhapa and as well as in the DDC office. It is also noted that KRCIMMC and RMRCIMMC are formed as joint river control and irrigation management committee. These committees are basically responsible for identifying problems, making plan of action for WID prevention and coordinating with the respective VDC for their implementation. A brief description of each of these committees are presented below:

Biring River Control and Management Committee

The office of BRCMC is located at the Ward No – 6 of Surunga VDC. The executive committee of BRCMC consists of maximum two member representatives from each sub-committes and they have working duration of four years. The members and other officials of the sub-comittees as well as the BRCMC are selected on consensus among the

communities. Name and positions of the key officilas representing the executing committee are as follows:

Table 5.13: Name and position of the committee's officilas

S. No.	Name	Position	VDC representation
1	Kundan Bhattarai	Chairman	Arjundhara
2	Motilal Rajbansi	Vice Chairman	Chakchaki
3	Om Prasad Pathak	Member	Saranamati
4	Krishna Bahadur Rajbansi	Member	Gherabari
5	Rudra Prasad Oli	Member	Dangibari
6	Tika Prasad Prasai	Member	Ghailadubba
7	Kaji Shrestha	Member	Budhabare
8	Netra P. Chimaria	Member	Surunga

The BRCMC has considered the following important aspects in its working plans:

- Allow resources collection only from the certain safe parts within the flood plain to prevent shifting tendency of the river;
- Construct irrigation and other infrstuctures in well managed and scientific basis to prevent the disaster;
- Manage the upper catchment area to prevent erosion, landslides and inundation; and
- Coordinate activities and planning of the government's and non-government organizations to carry out integrated planning for river control and management therby support the master plan of the Government.

The BRCMC foresees the following activities to implement the above mentioned action plans:

- Conduct awareness campaign to enhance communities' level of understanding in river behaviour, disasters, usefulness and all other alied apsects;
- Conduct regular meetings and interaction among the affected communities;
- Conduct regular field visit, inspection and studies to gain knowledge on physical conditions of the river;
- Conduct inteaction to divert attention of administrative sector; and
- Coduct visit to observe river training works and other activities for river control and disaster prevention in different rivers and places and share experience.

In addition to the BRCMC and other sub-committes, a NGO namely Community Protection Forum (CPF) is recently registered (in 2003) to work in WID related activities in the Biring area. The office of the CPF is situated in Surunga VDC, Ward No – 6. This NGO holds objective to increase awareness among the communities towards WID mitigation and prevention; implement relevant activities for WID mitigation; conduct activities to rescue the WID affected communities. The Forum has provision of its own fund to be supported by the membership fee and donation. Despite this, significant activities of the Forum has not been observed in the study area so far.

Kankai River Control and Irrigation Management Main Committee

The KRCIMMC was established in 2003 with initiation from DWIDP. The office of KRCIMMC is located at the Ward No – 8 of Satashidham VDC. The committee comprises of 13 members. Chirman and Secretary of each VDC level sub-committee are the members of executing body of this committee. The key positions of the executing body of this committee

have been selected in consensus among the members. The working duration of this executing body is 3 years. Name and positions of the officilas representing this executing committee are follows:

Table5.14: Name and position of the committee's officilas

S. No.	Name	Position	VDC representation
1	Karna Bahadur Thapa	Chairman	Satashidham – 8
2	Ambika Adhikari	Vice Chairman	Shivgunj – 6
3.	Laxmi Prasad Pathak	Secretary	Surunga – 4
4.	Tek Prasad Dahal		Mahabhara
5.	Bharat Sitaula	Treasurer	Panchganchi – 8
6.	Brihaspati Upreti	Member	Mahabhara
7.	Ghanshyam Mainali	Member	Shivgunj – 1
8.	Dilli Sitaula	Member	Surunga – 4
9.	Amrit Karki	Member	Satashidham – 8
10.	Mohan Kumar Rajbansi	Member	Kumarkhod
11.	Chandra Bahadur Acharya	Member	Kumarkhod
12.	Lok Kumari Chauhan	Member	Satashidahma – 8
13.	Devimaya Dahal	Member	Surunga - 4

In addition to this, represent from affected household or landowner of the affected land with age more than 16 years are also entitled to have general membership in the committee. For this one should pay appropriate fee as determined by the executing body.

The KRCIMMC holds following objectives:

- construct, conduct O&M, and mange river control/training systems to prevent villages, households, agriculture lands, irrigation canals and other public places from WID including inundation;
- mobilize government budget and resources from affected communities for new construction and rehabilitation of the river control/training systems;
- form and mobilize required sub-committees to maintain livelihoods among the affected communities;
- initiate activities toward environmental conservation;
- implement bio-engineering works in close coordination/consultation with concerned organization for making the efforts towards WID prevention sustainable and effective; and
- conduct awareness raising campaign among the communities.

The committee is expected to manage its financial resource through membership fee; amount paid as fine; amount received as donation from individuals and organizations; and loan from different financing institutions.

The committee has provision of helding meeting once in a three month. However, in a rainy season when the need seems prominent meeting is held even thrice a month.

Ratuwa/Mawa River Control and Irrigation Management Main Committee

RMRCIMMC was established in 2003 B.S. with aims to mobilize different biological and physical technologies with close consultation/coordination with DWIDP for sustainable management/mitigation of WID in the Ratuwa and Mawa Rivers. The office of RMRCIMMC is located within the Damak Municipality Office. The executing body of this committee

comprises of 9 members including 2 members from three VDC level sub-committees (Lakhanpur, Kohabara and Khajurganchi) and 3 members from Damak Municipality. The working duration of this executing body is 2 years. Name and positions of the officilas representing this executing committee are follows:

Table 5.15: Name and position of the committee's officilas

S. No.	Name	Position	VDC representation
1	Bodh Raj Neupane	Chairman	Damak
2	Harka Bahdur Bhandari	Vice Chairman	Lakhanpur
3.	Madan Adhikari	Secretary	Kohabara
4.	Santosh Kumar Singh		Khajurganchi
5.	Dhanendra Yonga	Treasurer	Damak
6.	Bhim Prasad Bhandari	Member	Kohabara
7.	Ganga Prasad Rajbansi	Member	Khajurganchi
8.	Karna Bahadur Bhandari	Member	Lakhanpur
9.	Jhas Raj Dhakal	Member	Damak

In addition to this, represent from affected household or landowner of the affected land with age more than 16 years, represent from Rama Community Forest, Damk - 19; Hamse Dumse Community Forest, Damak – 3; Rajarani Community Forest, Damak – 1; Balubthan Jharka Community Forest Development and Users Committee, Lakhanpur/Kohabara are also entitled to have general membership in the committee. For this one should pay appropriate fee as determined by the executing body.

Unfortunately, there is no representation from the VDCs like Mahadewa, Jhurkiya, Itahara, Sijuwa in the RMRCIMMC, though these VDCs are identified as regularly inundation affected VDC.

The financial resources of the RMRCIMMC comprises of membership fee; annual levy from the members; amount collected as fine; and donation from individuals and organizations.

The KRCIMMC holds following objectives:

- manage/mitigate water induced disaster thorugh biological and physical technologies;
- raise community awareness on mobilization of local resources for WID prevention and management;
- give continuation for development and O&M to support the sustainable planning
- mobilize resources from government and non-govemment organization for activities related to river control
- form and mobilize required sub-committees to maintain livelihoods among the affected communities;

The committtee has also set its working strategy to achieve the quaoted objectives.

The committee has provision of helding meeting once in a six month. However, on the emergency requirements it can held its meetings out of the schedule.

District Level

DDC and DWIDP are the institutions that supports WID related activities in the district. DWIDP, however, functions at regional level with its office situated in Biratnagar for the eastern region. To oversee the WID activities in the Jhapa district, it has its representative in the DDC office, who is responsible for coordinating WID related activities among

communities, DDC and DWIDP. While in DDC, there is a program officer responsible for such coordination. In terms of support, major activities of DDC and DWIDP is concentrated on building infrastructures (embankment, spurs, revetments) and providing gabion boxes and sand bags as per the community demand for immediate solution of localized problems. Some of the activities of DDC and DWIDP in terms of infrastructure building in each of these three rivers is described in **Section 5.1.2, 5.2.2** and **5.3.2**.

Generally, after each monsoon a bunch of applications from the affected communities reach the DDC and DWIDP offices, asking for supports, especially in terms of gabion boxes, sand bags and construction of required infrastructures. The level of supports from DDC and DWIDP are not sheduled and depends upon availability of the budgets. Both of these institutions do not play any roles in pre information and evacuation in the case of inundation. A well managed database regarding affected areas, population and extent of damages for different types of WID is not in the place.

DWIDP has recently initiated formation of main committee in the river level (please refer **Section 5.4.2**) with the aim of coordinating the entire activities related to WID management/mitigation. However, representation from some of the inundation affected VDCs is still missing in the main committee in case of Ratuwa river. A training programme has recently been imparted by DWIDP for the committee's members and users of Biring, Kaknkai and Ratu wa River on the theme ethical behavours of committe's members and users.

In the fiscal year 2003/04, NRs 6 million, 4 million and 2 million have been allocated by HMGN for activities related to WID prevention in Biring, Kankai and Ratuwa respectively. DWIDP is authorized to mobilize this budget, while the committes are responsible merely for identification of problamatic spots. In the Biring River, the BRCMC identified 84 vulnerable sites for preventive activities along the river, out of which it suggested 20 spots for immediate consideration for this year. Out of these 20 suggeted spots, the DWIDP has prioritized 10 spots, where it is constructing 15 spurs, 711 m of embankment and bank revetments in 3 spots. Similarly, bio-engineering works and plantation activities have also been considered. Similarly a few spurs, embankments and bank revetments have been planned in the Kankai. In the Ratuwa, DWIDP has planned to construct four spurs, and a embankment in Lakhanpur and Kohabara VDC.

Common Constraints

Though the objectives and action plans of the main committes in the river level demonstrate commitments towards efficient management and mitigation of inundation in the three Rivers, yet due to the possession of inadequate technical as well as financial resources, the committee is almost passive in terms of implementation of its action plans. Provided that they are newly formed, all they have done during their one year of formation is identification of problematic spots and coordination with relevant organization, especially DDC and DWIDP for facilitating the sub-committees in obtaining gabion wires, meshes etc.

Despite the provision of scheduled meetings in their constitutions, the committees held their meeting to discuss the issues related to water induced disaster only when requirement seems prominent. No participation of communities takes place in such meetings.

The main as well as other sub-committes neither have any roles nor possess relevant technologies or resources to pre-disseminate the information about the happenings of inundation. These committes generally do not play any roles in evacuation, management of temporary shelter and storages during the inundation event. An effective coordination and communication mechanism for this is lacking. People do not have any fix place for temporary shelter or storage. During event, they act haphazardly to leave the affected area.

Nevertheless, the survey indicates that sub-committes in Ratuwa Rivers (Kohabara and Khajurganchi) have often palyed roles in managing the evacuation during inundation. However, none representation of Mahadewa, Jhurkiya, Itahara and Sijuwa VDCs in RMRCIMMC indicates that inundation mitigation/management aspects of these VDCs are completely neglected.

In the post inundation events, the sub-committees in each of these rivers, however, shows initiation on grievance handling, damage record keeping and requesting donors, DDC, DWIDP and other relevant organizations for the rehabilitation works. According to the responses, the damaged public properties are quite often rehabilitated. But, as far as damage of private properties are considered, they never have been compensiated. It is always the local affected communities, who have to bear cost of their private damages each year.

The main committees, though, possess their funds to be supported by membership fees, annual levy, amount received from fine and donation/contribution from individuals and organizations. However, the committes claims that their financial status could not be achieved to the satisfactory extent to drive them for efficient work and consistent planning. Despite expectation, they never have been supported by any NGOs/INGOs or other donor agencies. Due to this, the committes are not in the position of preparing its anuual budget to support the inundation management activities. Each of these main committes have sugestsed that the policy supports should be concentrated towards mobilizing financial resources allocated for water induced disaster including inundation in these rivers through this committee. They suggest that DWIDP should play active role to make them financially, technologically and institutionally capable to manage inundation problems in their area.

5.6 Reasons of Inundation

Main reasons of the inundation in the area have been identified as follows:

- concentration of the most of the rainfall in short time;
- shallow and undefined bank in the most of the reaches;
- insufficient channel geometry to pass the high flood discharge;
- rise in bed level each year due to sediment deposition; and
- bank/embankment erosion.

Inundation due to across the river structural intervention has not been observed so far. The monsoon flood has been claimed as only the reason of inundation.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

6.1.1 General

This study has supplemented further quality data and information regarding average area, depth and duration of inundation in the study area due to monsoon flood. The information derived regarding area of submergence in the previous study SRSJSD was merely based on the query from local people. Further, submergence area were determined only to the VDC level by SRSJSD. Unlike this, this study has worked out submergence area in ward level based on rigorous spot checking and technical observation accompained with credible cross verification. Therefore, in terms of accuracy of the data regarding area, this study is more precise compare to SRSJSD.

Based on the outcomes of the study, the following general conclusions have been derived:

- The total average area of inundation due to the monsoon flood in the studied three rivers comes to be 9,602 ha. This area makes 6 percent of the total area of Jhapa (160,600 ha[8]). Out of this, 4,059; 2,983; and 2,560 ha of lands are in average being inundated by the Biring, Kankai and Ratuwa rivers respectively.

- Twenty VDCs are affected by the inundation each year due to overflow in the Biring, Kankai and Ratuwa rivers. Out of this four VDCs lie in the Morang district. Sixteen affected number of VDCs in Jhapa makes 34 % of total number of VDCs (47[9]) in Jhapa.

- Average number of regularly affected population due to monsoon overflow in the studied rivers comes to be 37,855. This number makes 6 % of total population of Jhapa (688,109[10]). Out of these, 16,285; 10,755; and 10,015 people are affected by Biring, Kankai and Ratuwa respectively.

- Average number of regularly affected households due to monsoon overflow in the studied rivers comes to be 7,832. Out of these, 3,342; 2,230; and 2,260 households are affected by Biring, Kankai and Ratuwa respectively.

- The current trend of infrastructure development for inundation prevention is random and as per the immediate local needs. This trend has been leading to solutions at localized places shifting the problems to some other places. Morphological consequences in the river after their implementation are generally neglected.

- Ethnic composition of the affected communities comprises of different casts, majority of which include Brahmin, Chettri, Yadav, Satar, Rajbansi, Mandal, Musahar (Sada), Sah, Musalman, Chamar etc.

- Agriculture, livestock raising and laboure are the major occupational catagories of the affected community.

- The most common identified reasons of the inundation include:

[8] Source: District Demographic Profile of Nepal, 2002
[9] Source: District Demographic Profile of Nepal, 2002
[10] Source: District Demographic Profile of Nepal, 2002

- concentration of the most of the rainfall in short time;
- shallow, weak and undefined banks in the most of the
- reaches;
- insufficient channel geometry to pass the high flood discharge;
- rise in bed level each year due to sediment deposition; and
- erosion of existing bank/embankments.

Inundation due to across the river structural intervention is not the case for the studies rivers.

- Forms of the human encroachment found in the vicinity of the border area include:

  - practice of having winter crops right in the course of small non-perennial rivers with shallow and undefined banks;
  - practice of occupying river course for agriculture practice of the perennial rivers with shallow and undefined banks after the thalweg chnges its course;
  - practice of cutting river banks and beds for collection of soils for local use;
  - unplined mining of the river bed for construction;
  - settlement in the flood plain of the river. Especially migrants from hills and sukumbasi have been blamed for this; and
  - practice of conducting funeral procession establishing tombstones in the river banks.

6.1.2 Environme nt

- More than 80 percent of the affected area covers agricuture land that comes under inundation each year making a enormous damages to paddy and other crops. Deposition of sediments of 0.15 to 0.90 m depth in the agriculture land changes the soil fertility.

- Smell disorder in the agriculture land and the settlement area due to spread over polluted water is associated with almost all cases of inundation. The major source of such pollution is improper sanitation practice.

- Due to the pollution of groundwater, the drinking water from the tubewells, especially, during and after a few days of inundation generaly changes its color becoming less transparent and gives an unpleasant odour.

- One of the prominent diseases that occurs immediately after inundation in the study is diarrhoea. In an average 500 – 1000 people get affected from diarrhoea each year, out of which number of children and infants are quite significant.

- Due to absence of extensive fish habitat in the nearby vicinity, only migratory fishes get affected due to inundation. Snails, snakes and tortoise are the other animals that get affected due to inundation.

- Lahare Jhar, Kande Jhar and Lazzabati Jhar are some of the plants that grow more intensively after inundation. Where as plants like Pater and Kora usually get dissapeared. Apperance of new plants is not the case after the inundation in the study area.

- Inundation is bringing about the changes in the river regime and morphology each year. Bank failures, changes of thalweg due to local scours, changes of the entire river way are some of the features observed in the study area.

- The cyclic physiological, pshycological and socio-cultural stresses due to inundation has causing a serious impacts in the livelihoods and social harmony. Trend of shifting to the safe place is the obvious phenomenon.

6.1.3 Strength of Local Institutions

- Sub-committes are functional for last few years at the affected VDC level for WID related works. The efforts of such committees are rather concentrated towards short term solution of the problems in a particular spots creating problems in some another spots. Due to inadequacy of appropriate technical, financial and institutional supports, such sub-committes are charectirized by erratic working modalidities and inefficient management plan. Donation from few organizations, cash and labor colleted from the affected communities and supports from DDC and DWIDP (unsheduled) are the major sources of such communities.

- Recently, DWIDP has initiated formation of Main Committee in the river to coordinate and implement entire activities related to WID including inundation. Though these commitees have committed action plans, yet required financial, technological and institutional strengths are the major constraints for their sustainability. The committees are of the openion that in addition to the technological enhancement, the allocated budgets for WID related activities in each of these rivers should be mobilized through them. Regular finace flow, appropriate technological trainings and institutional supports are highly desired by the committees.

- Neither these committees, nor any other organizations play roles in pre-dissemination of information about inundation events, evacuation and management of shelter during inundation. These part of responsibilities are also missing in the constitutions of the main committes. However, some of the sub-committees, especially, in Ratuwa now and then play roles in grivience handling and private damage record keeping after the event. All these committees generally keeps public damage records and request donors, DDC and other relevant organizations for rehabilitation of public assets.

- The nature of supports from the DWIDP, DDC and other concerned organizations are unsheduled. The level of supports generally consists of distribution of gabion wires and meshes upon requests of the communities, construction of embankments, spurs and revetment for prevention/rehabilitation of particular spots.

6.2 Recommendation

6.2.1 General

- This study has gathered more precise data on the area that comes under inundation regualarly. Furthermore, it has prepared a users friendly GIS based thematic maps of the identified area of inundation. These data and maps has to be taken as the base for decision support in relation to planning an integrated approach for riverwise inundation management plan.

- The study presents inundation issues brought about by the major rivers in Jhapa. It is highly recommended to conduct a similar nature of study for other major rivers in different districts of Nepal to ultimately come up with precise figures about the inundated area and their impacts in the country. Use of such data would also support concerned agencies on planning at local, national and bilateral level.

6.2.2 Environment

The complexity of environmental processes associated with inundation is such that accurate prediction of the full spectrum of the changes brought about needs an in-depth study. However, provided limited time and resources, this study has identified basic environmental impacts due to inundation and recommended some measures for effective management/mitigation of environmental impacts brought about by inundation.

- Deposition of sediments in the agriculture land, changes in soil fertility, changes in river morphology are some of the prominent environmental features brought about by the inundation in the study area. Therefore, a growing sensitivity to such effects will be needed to secure sustainable food production, land reclamation and flood protection in the future. For this, integration of environmental concerns brought about by inundation into mainstream of Terai planning is required.

- Current trend of infrastructure development for inundation preventention is as per the immediate local needs. Such developments often neglect the environmental concerns, especially the morphological consequences in the river. Therefore, any of the development planning towards inundation management/mitigation including the construction of isolated small infrastructures should also be oriented from the beginning toward environmental improvement. For this integration of environmental awareness program with any development process in a participatory approach and mutually supporting manner is vital.

- Unawareness towards environmental issues brought about by inundation is the persisting problem among the local communities. Therefore, public information, education and training program to increase the environmental awareness among the communities should be effectively implemented in the study area. Such programme must be implemented at local level as an action oriented program and should be easy to introduce and implement.

- This study has indicated a number of environmental impacts brought about by inundation. Based on these findings, it is recommended that inundation management/mitigation plan should be established based on critical environmental review criteria, that among others, should include:

    - Loss of irreplaceable resources;
    - Accelerated use of resources for short term gain;
    - Endangering of species (flora and fauna);
    - undesirable displacement and rural to urban migration; and
    - Increase in affluent/poor income gap.

6.2.3 Strength of Local Institutions

- Local Institutions still needs to be strengthened for effective inundation management/mitigation in the study area. The goal of WRS to establish water induced disaster prevention, warning, preparedness and mitigation measures in at least 20 priority districts by 2010, and the whole country by 2027 indicates that there is an urgent need for appropriate institutional plalning and linkage to achieve this goal. In this context, it is recommended to make these three rivers as pilot shemes for implementation of prevention, warning, preparedness and mitigation measures. The implementation modality then can be updated based on result derived from the pilot schemes and can be replicated in another rivers.

- Financial, technological and institutional strengths are the major constraints for the sustainability of the main committes at the river level and the sub committes as well. Therefore, a clear-cut responsibilities and adequate financial, technological and other resources supports towards managing/mitigating inundation problems should be established among the community level institutions. DWIDP has to play an active roles to make the community level institutions more effective on assuming their identified roles and responsibilities. They should be capacitated to mobilize the allocated budgets through themselves.

- None of the institutions were found responsible for disseminating pre information about inundation and evacuation during the event. People do not have any fix place for temporary shelter or storage. During event, they act haphazardly to leave the affected area. In this context, a research towards feasibile pre-alarming system and evacuation management plan would be more beneficial.

6.2.4 Next Step

In addition to conduction of similar studies for other rivers in different districts, it is also recommended to conduct studies in the following particular areas in these three rivers:

- In depth study on damaged assessment and respective asset valuation;
- Study on loss of production and its valuation;
- Exploration of behaviour change of ground water due to inundation and its impacts;