

# **INFRASTRUCTURE DEVELOPMENT AND WATER INUNDATION IN RAUTAHAT DISTRICT**



**A Thesis Submitted to the  
APF Command and Staff College  
Faculty of Humanities and Social Sciences,  
Tribhuvan University in Partial Fulfillment of Master Degree  
in Security, Development and Peace Studies**

**Submitted by**

**Mohan Bahadur Chhetri**

**Sixth Batch (2078-2079)**

**Roll No: 4006**

**TU Registration No: 19425-95**

**APF Command and Staff College**

**Sanogaucharan, Kathmandu, Nepal**

**September 2022**

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## DECLARATION

I hereby declare that this research paper entitled “**Infrastructure Development and Water Inundation in Rautahat District**” submitted to APF Command and Staff College, is entirely my original work.

I have made due acknowledgments to all ideas and information cited and extracted from different sources in course of preparing this research. The result of this research paper has not been presented or submitted anywhere else for the award of any degree or any other purpose. I assure that no part of the content of this research paper has been published in any form before. I shall be solely responsible if any evidences found against my research paper.

This thesis is being submitted to Armed Police Force Command and Staff College, Faculty of Humanities and Social Sciences, Tribhuvan University in Partial Fulfillment of Master Degree in Security, Development and Peace Studies.

Signature:

Name: Mohan Bahadur Chhetri

Date: September 04, 2022

## LETTER OF RECOMMENDATION

I certify that this thesis entitled **Infrastructure Development and Water Inundation in Rautahat District** was prepared by Mohan Bahadur Chhetri under my supervision. The researcher has fulfilled the criteria prescribed by Faculty of Humanities and social Sciences, Tribhuvan University. I hereby recommend the thesis for the final evaluation and approval.

.....

Dr. Naresh Rimal

Thesis Supervisor

Date: September 04, 2022



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### LETTER OF APPROVAL

This thesis entitle **Infrastructure Development and Water Inundation in Rautahat District** submitted by Mohan Bahadur Chhetri to APF Command and Staff College, Faculty of Humanities and Social Sciences, Tribhuvan University in partial fulfillment of Master Degree in Security, Development and Peace Studies has been approved by the undersigned members of the Evaluation Committee.

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Mohan Bahadur Chhetri

Date: September 04, 2022

## ABSTRACT

Historically flooding and inundation were received as boon and over time population growth and chaotic urbanization brings serious challenges to the communities overall livelihood. Infrastructure such as road, embankments, dams, bridges, railway track along with degradation of the Chure Ecological Region has escalated the impact of flooding and inundation in the area. This research has been developed with the objective to understand the disaster phenomenon of Rautahat District with reference to inundation.

The qualitative research offers key understanding via collection of primary data gathered through open-ended interview questions, focus group discussions, key-informant interaction and stakeholders meeting. The data analysis and interpretation indicate, although Rautahat District is often affected by flooding and disaster for a longer period of time, contemporarily increased urbanization and infrastructural growth is key to recurrence of inundation. Among the various infrastructure, the absence of strategic infrastructure such as road, dam, embankment, railway tracks and the urbanization pattern proves to be the factor for contributing to increased disaster events. The study indicates the need for effective adaptive measures for protection of communities' health and well-being.

**Keywords:** Flooding, Inundation, Infrastructural Development, Dams, Embankment, Chure Ecological Region

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## LIST OF ABBREVIATION AND ACRONYMS

AD	Anno Domini
ADB	Asian Development Bank
APF	Armed Police Force
BC	Before Christ
BS	Bikram Sambat
CBS	Central of Bureau Statistics
CER	Chure Ecological Region
DAO	District Administration Office
DEOC	District Emergency Operating Center
DHO	District Health Office
Dr.	Doctor
DRR	Disaster Risk Reduction
EIA	Environmental Impact Assessment
FGD	Focused Group Discussion
GDP	Gross Domestic Product
GLOF	Glacier Lake Outburst Flood
HFF	Himalayan Frontal Faults
ICRC	International Community Red Cross
INGO	International Non-Governmental Organization
KII	Key Informant Interview
MBT	Main Boundary Thrust
MCT	Main Central Thrust
MOEWR	Ministry of Energy, Water Resources and Irrigation
MOF	Ministry of Finance

MOFAGA	Ministry of Federal Affairs and General Administration
MOHA	Ministry of Home Affairs
MOUD	Ministry of Urban Development
NEOC	National Emergency Operating Center
NGO	Non-Governmental Organization
NPC	National Planning Commission
NRA	National Reconstruction Authority
OXFAM	Oxford Committee for Famine Relief
UNICEF	United Nations Children's Fund
USD	United States Dollar
VDC	Village Development Committee

# CHAPTER I

## INTRODUCTION

### 1.1 Background of the Study

Nepal is prone to various disasters given its geological and geographical reasons. Such disasters are compounded by the neglect of the impact generated by infrastructural development. The threat of flooding in Nepal can be characterized often by impacts generated or triggered during the monsoonal period (Rieux et al., 2012). However, such factors are becoming a cause of concern due to climate change and chaotic development patterns that escalates the threat of floods in Nepal.

Flood, overflow of water beyond the river channel, is one of the major natural hazards that cause enormous loss of lives and properties worldwide every year. Floods become more severe once they pass through built-up areas and arable lands as in the case of 1993 flood in Nepal, 2008 Koshi flood in eastern Nepal, and the 2017 central Nepal water flood (Yogacharya & Gautam, 2008). Several historical flood events show that the major losses are incurred across the river and rivulet channels. After the 2017 floods in eastern and central Nepal, flood damage to the structures and infrastructures and associated losses are more pronounced as frequent floods are inevitable in Nepal.

In the case of Terai, during the monsoon months from June to September, all the rivers are in spate with bank-full discharges and cause flooding and inundation. The problems of flooding and inundation in the Terai are more critical due to change in climate in general and change in rainfall pattern/intensity in particular (Adhikari, 2013). Further, Drainage congestion is also the other of the reasons causing flooding and inundation in the Terai. Among the drainage congestion, east-west highway, bridges and culverts, urban settlements, Hulaki sadak and Dams have a huge contribution in the inundation in the Terai region.

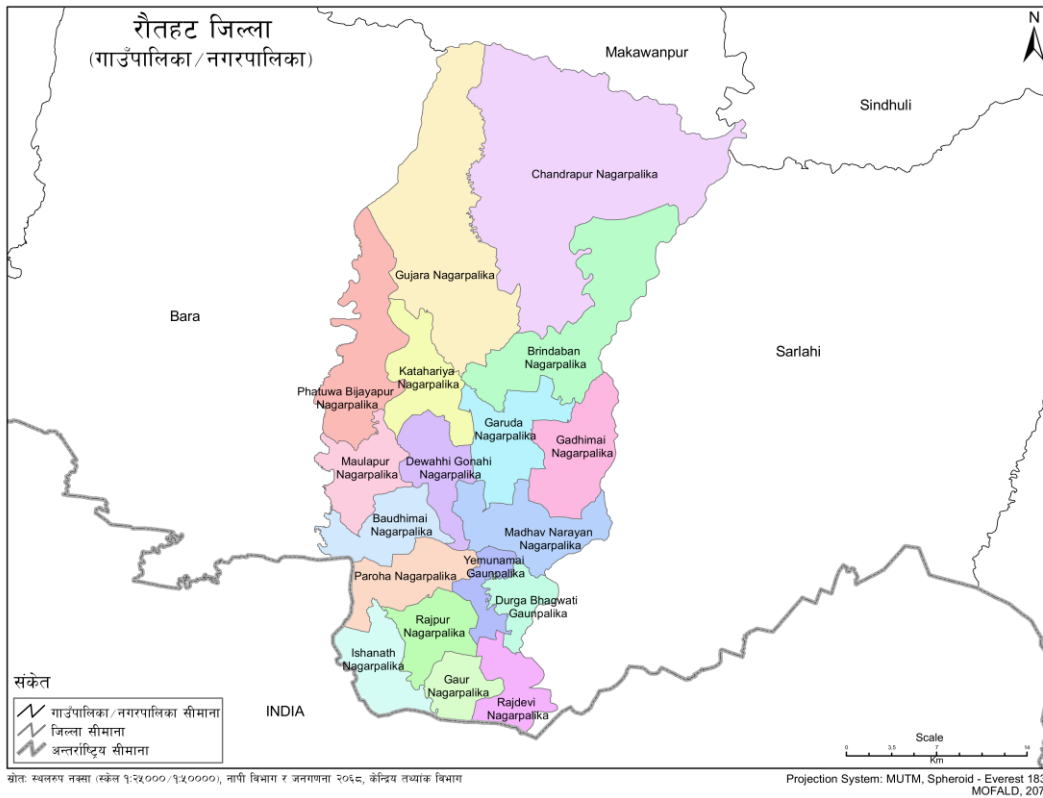
#### 1.1.1 Introduction to Rautahat District

Rautahat District is the district located almost southern-mid, Terai province of Nepal, which an area of 1,126 sq.km (435 sq.mil) and has a population of 686,722 within 106,668 households (CBS, 2011). The district comprises of 16 municipalities and 2 rural

municipalities. Among them, Gaur Municipality and Chandrapur Municipality are the most populous municipality. The livelihood of the district mostly depends on an agriculture-based economy, however, some industries and small-scale factories are also running especially in the town area. Hindus, Muslims, Buddhists, Christians religious peoples are celebrating their cultures and festivals as per religion. The following map shows the Rautahat District with its Municipalities/ Rural Municipalities.

**Figure 1:**

*Political Map of Rautahat District*



*Note:* Figure 1 shows the political map of the district, the municipalities structure is divided into 16 Municipality and 2 Rural Municipality. Among them Baudhimai, Paroha, Ishanath, Gaur and Rajdevi Municipality has shared border with India. Bara, Sarlahi, Makwanpur and Sindhuli are the neighboring districts of Rautahat.

Source: Nepalmap, 2013

**Table 1.***Flooding and its impact on the various places of Rautahat District*

VDC/Municipality	Incident Number	Death	Injured	Affected Family	Estimated Loss (NRs.)
Jayanagar	1	1	0	1	0
Basantapatti	1	0	0	0	0
Mithuawa	1				500,000
Banjaraha	1	1	1	0	0
Bariya	1	0	0	0	0
Jokaha	1	1	0	0	0
Dewathi	2	0	0	81	0
Gaur	10	8	0	9	0
Hajminiya	1	0	0	7	0
Durgabhagawati	1	1	0	0	0
Brindaban	1	1	0	0	0
Gadhimai	1	1	0	2	0
Garuda	1	0	0	23	0
Ishnath	1	1	0	1	0
Katahariya	1	1	0	0	0
Madhavnarayan	1	1	0	1	0
Other (Municipality are not defined)	33	20	2	298	733300
Total	59	37	3	423	1233300

*Note:* The table 1 shows the number of flood in that has occurred in the Rautahat District within the period of 10 years. As, per the report of MoHA published in DRR portal, disaster related to flood in the district has seen 59 flood since 2011 to till date. It has killed 37 people and affected 423 families.

Source: DRR Portal, 2022

### **1.1.2 Development Activities and Flood Inundation**

Whenever humans modify the landscape in any way changes are to be expected in the way water drains from the land. Unless careful consideration is given to the possible drainage consequences, such landscape modifications can result in higher incidence of flooding. Development on floodplains should therefore be undertaken only with great care (Nelson, 2015). Existing developments that have enhanced flooding problems are often costly to fix.

The changes made to an area by construction of a concentration of buildings have a direct effect on its surface hydrology. The covering of the land surface by a large proportion of impervious material means that a much larger proportion of any rainfall forms immediate runoff and any slope of the land also greatly enhances the runoff response of a paved area (Ferreira, et al., 2019). This results in higher possibility of flood and inundation in such area.

### **1.1.3 Development Activities and Flood Inundation in Rautahat District**

The development activities such as road construction, development of dams, and change in the use of land patterns are causing the floods in all three ecological zones of Nepal (High hills, Midhills, and Terai). The District of Rautahat with two major Lalbakeya and Bagmati Rivers share the international border with India (Poudel et al. 2018). The embankment of the river and construction of a dykes as per the need and security of the Indian community along the Nepal India border has resulted in yearly flooding in the Rautahat District. Additionally, in some extent the excessive use of earth materials in brick manufacturing is causing land depression supporting to inundation. The recent railway track construction in the district is likely to increase the number of flooding during and after the construction in absence of proper environmental and social compliance.

The flooding in the Rautahat District, which has been now frequent inundates several areas that negatively impact agriculture, and infrastructure, and displaces locals affecting their livelihood for a long time to recover. These issues are of direct and indirect concern to the Armed Police of Nepal given its mandate to engage during a disaster and sliding livelihoods of communities resorting to hopelessness and helplessness.

The present research for thesis requirement fulfillment develops an understanding of the current inundation pattern, the role of different development activities in the flooding, and ways to mitigate such threats.

## **1.2 Statement of the Problem**

Flood damage to structures and lifelines and losses to lives and property prompt crucial planning in terms of flood hazard mapping and mitigation strategies. The problem of floods in many urban and rural areas of Nepal is still severe as floods would generally affect Nepal in almost every monsoon. Further, the infrastructural development is important for the development of the human society. There has been seen a growing population in the Rautahat District and development of various infrastructure both through national and local level planning has been conducted. At the same time the pattern of the inundation at the district has also changed.

There are different stakeholders which play a key role, before, during, and after the disaster in the Rautahat district, especially the vulnerable community themselves and the local government. There has been a lack of cooperation and coordination among different stakeholders for building a disaster resilience infrastructure, which has resulted in an increment in the impact of flooding and inundation in the Rautahat district each year.

Hence this research has conducted to understand the link between the infrastructure and the pattern of inundation in Rautahat District and is focused to address following research questions.

1.2.1 How is the risk of inundation in various areas linked to infrastructure development activities in the district?

1.2.2 What are the efforts of stakeholders to understand the cause of threats and actions to mitigate them?

## **1.3 Objectives of the Study**

1.3.1 Identify how inundation risk in various areas are linked to infrastructure development activities in the district.

1.3.2 To examine efforts of stakeholders to understand the cause of threats and actions to mitigate the disaster.

#### **1.4 Rationale of the Study**

This study examines the flood inundation at the Terai region, with reference to Rautahat District by analyzing the impact of infrastructural development in the district. This analysis will help in understanding the role of infrastructure in causing the flood/inundation and its impact on the study area. The study will help address social, economic, environmental, political and cultural development of the community. It helps address people in poverty through enhanced livelihood via improved and appropriate intervention by rural and urban municipalities in the district. It will also support sustainable future of communities through effective communication and development intervention.

#### **1.5 Delimitation of the Study**

The research has been conducted through the field visit and interview with the Key Informant Interview (KII) and through Focus Group Discussion (FGD). The research is limited to disaster risk and management and engineering details are not included. The research covers the inundation in the Rautahat District and is mainly focused on the inundation due to the infrastructure development.

## **CHAPTER II**

### **LITERATURE REVIEW**

To complete this thesis paper, various literatures and previous research findings were reviewed as theoretical background to the concept of flood, climate change and its impacts, river basin, types of flooding in Terai region and infrastructural development and its impact in the following sections:

#### **2.1 Flood**

ADB (2019), assessed the flood disaster in Nepal. Despite being a small country, the landscape of Nepal is diverse; it ranges from the humid plains in the south to the lofty Himalayas in the north with varied geographies, climates and flood risks. Thus, Nepal can be divided into three different geographical regions and each region extends from east to west across the country. The principal and most destructive type of flooding is from rivers (fluvial) located within the Terai region. Apart from fluvial flooding during the monsoon, other flood risks include flash flooding from heavy rainfall in mountainous areas, Glacial Lake Outburst Flooding (GLOF), landslide induced flooding, and infrastructural flooding (such as embankment failure). On average, floods cause over 175 deaths each year and average annual economic losses exceeding USD 140 Million. Without comprehensive flood protection or appropriate risk-sensitive urban planning, increased ongoing economic and development activity in the floodplains will likely increase the economic damage associated with floods in the coming years.

Chapagain (2017) examined the Terai flood of 2017, which affected 35 districts of Nepal resulting death of more than one hundred people. It impacted on the delivery of the services that were provided. The impact of the flood had been on the economic sector making vulnerable group more vulnerable of economic threat. The case study was prepared based on the study area of Gaur Municipality and data were collected through interview and interaction with the local people. The author stated that the Gaur is the oldest municipality and as well as the headquarters of the districts, which resulted in rapid urbanization, high population growth resulting in social stratification based on economy, followed by the political instability. Lack of political stability has made it more

prone to the impact of disaster. Further the recent development activities, urbanization has resulted in such higher impact. It was concluded that the flood has impacted on development activities economy and services to the people.

## 2.2 River Basin and Types of Flooding in Nepal

JICA (2021) identified three distinct types of rivers in Nepal. The first type includes three big perennial rivers – Koshi, Narayani, and Karnali – originating from the high Himalayas, with some of their tributaries entering from Tibet. These rivers are fed by the glaciers, snowmelt, and rainfall in the Himalayas and flow down to India through the lower hills and Terai plains of Nepal. The second category rivers are also perennial but originate from the middle mountains of Nepal that flow down to the lower plains of Nepal and India. The third category of rivers, often referred to as torrents or streams, originate from the Chure hills and Siwalik Hills.

**Table 2.**

*Types of Flooding in Nepal and its reasons*

Types of Flood	Source	Significant Flooding
River (fluvial) flooding during the Monsoon	Rain	1926 Bagmati Flooding; 1987 Eastern Terai; 2007 Terai Flooding; 2008 Kailali Flood; 2017 and 2019 Terai Flooding.
Flash Flooding	Intense rain in short period of time	1993 Central Nepal; 2021 Melamchi Flooding
GLOF	Bursting of Glacier lake	1980 Tamor; 1981 Bhote Koshi; 1977, 1985 and 1998 Dudh Koshi; 2011 Kaski
Landslide induced flooding	Landslides	1978, Butwal; 2012 Seti; 2014 Jure
Infrastructural Flooding	Embankment or blockage; Urban	2008 Kushaha; 2020 Kathmandu Flooding; 2021 Manang Flooding

*Note:* The table 2 shows that the major threat has been from the River (Fluvial) Flooding during the monsoon season. Similarly, the GLOF event has also occurred many times. It was found that there has already been experienced of the infrastructural flooding.

Source: ADB, 2019

Thapa et al. (2020), examined the flood vulnerability of the Khando River. The flood had been more vulnerable to residential buildings. The river had resulted in the inundation and the return of flood was calculated to 20 year, with the variation in the maximum inundation depth is not so wide between 20 and 200 years return periods for the Khando River catchment. The analysis of residential houses along the riverbank of the Khando River highlighted that the wattle and daub construction system is highly vulnerable even for 20 years return period flood.

Kafle et al. (2017) analyzed the Koshi flood and stated that around 2.64 million people in India and Nepal were impacted by the Koshi flood in August 2008. It was determined that 25percent of the impacted agricultural area in the Sunsari district's Shreepur, Hariपुर, and western Kushaha villages is still uncultivated and still contains flood material ranging in size from clay to sand after eight years. It was found that the agricultural land were lands hampered for a longer period of time, based on the sediments.

### **2.3 Chure Ecological Region**

CSRC (2005), defined the Chure Ecological Region (CER) and its significance to the different ecology of the Nepal. From the east to the west of Nepal, 36 of the country's 77 districts make up the continuous Chure area. It has low hogback ridges that range in width from 10 to 50 kilometers and are arranged in a sinuous form. Its height ranges from 120 meters to about 2,000 meters. It is the first and lowest ridge in the Himalayan mountain system and is strategically situated between the Terai plains in the south and the Mahabharat range of Mid-hills in the north. Geologically speaking, it is young and made out of loose, unconsolidated components that came from soft rocks (e.g., mudstone, sandstone, silt stone and shale). Most soils have a coarse texture, are shallow, and were produced on sedimentary rocks.

Singh (2017) analyzed the conservation in Chure Ecological Region. The Chure region, which makes up 13 percent of Nepal's total land area, is a fragile, sensitive, and environmentally vulnerable area. As a result, the Nepalese government designated the area as a Chure ecological Region to monitor conservation efforts there. The boundaries of the Chure Environmental Protection Area is disputed since there are considerable human settlements nearby, especially following the government's unilateral declaration;

questions still persist over the rights to use forest resources. The upstream village, in particular, have overused the resources as a result of these circumstances and has resulted in larger impact on the downstream ecosystems.

## **2.4 Terai Region**

World Bank (2020) explained the features of Terai region in its report. The Terai region of Nepal occupies about 17 percent of the land area (25,000 km<sup>2</sup>) and forms the northern edge of the Indo-Gangetic plain.

With a similar view, Bhujju et al. (2007) further explained that the Terai area is popularly known as the granary of the nation. The topography of the Terai is almost flat with gentle slope towards the south. The elevation of the Terai ranges from 65m to 300m from mean sea level with varying width of 20 km to 45 km. The climate of the Terai is subtropical with average temperature of 28<sup>0</sup>C.

Bhusal et al. (2008) examined the rainfall of the Terai which varies from 1,200 mm to 3,000 mm per annum with occasional showers and cloudbursts. All the rivers of Nepal exit into the Terai plain at the foot hills of the Chure and Siwalik ranges and provide water for livelihood of the Terai. During the monsoon months from June to September, all these rivers are in spate with bank-full discharges and cause flooding and inundation in several parts of the Terai. The problems of flooding and inundation in the Terai are more critical due to change in climate in general and change in the rainfall pattern in particular. This article tries to highlight the issues and concerns of flooding and inundation in the Terai and suggests measures to mitigate these issues in light of climate change adaptation.

Adhikari (2013) examined the flooding and Inundation in the Terai. The Terai has been the bread basket of the country, and due to that it needs to be protected from the flood and inundation. The constant flood is a threat to the food security of the country. The major reason for the flood and inundation in the terai region has been due to the ongoing climate change, inducing change in rainfall pattern. Further the development activities, without providing adequate waterways for the river had also contributed towards floods and inundation. The sedimentation of the rocks, sand and other materials in the Terai region has also contributed in the increase of impact of the flood and inundation. Further

the development of infrastructure that are blocking the waterways has been another factor for the flood and inundation.

Shreevastav et al. (2021) stated that among the various risk in Terai, the main risks in Nepal's Terai area is flooding. People who live along a river's bank are more at risk of flooding. In order to compare the elements of flood risk from livelihood perspectives, collected data were processed to determine the indexed value and vulnerability index. According to the findings, downstream/lower belt had the greatest, followed by middle belt where flood risk was higher and the top belt is the least exposed. Vulnerability, contributing factors-exposure, sensitivity, and adaptive capability were shown to be significantly correlated. Flood susceptibility was found to vary greatly by grade.

## **2.5 Climate Change impact**

Riaz and Ali (2014) studied the increased risk of the Glacier Lake Outburst Flood (GLOF) in Nepal due to Climate change. Climate change is likely to have a significant impact on the frequency and intensity of extreme flood event. Increases in air temperature will make GLOF flooding more likely as glacier melting increases and large volume pro-glacial lakes form more quickly.

Further the report of ADB (2019) pointed out that increase in extreme precipitation will make flash flooding more frequent; increase soil erosion potentially leading to more landslide induced flooding; and increase the frequency of events where urban flooding occurs due to infrastructure being overwhelmed compared to its design.

## **2.6 Infrastructure Development and Inundation**

Matondo et al. (2012) described the effects of development activities in the occurrence of the flood. Urbanization and expansion of structural developments are challenges that require a rapid response in terms of flood-damage mitigation measures. There have been several cases of flash floods resulting from heavy downpour and a poor drainage system, thus causing in loss of property and goods. In the study, the effects of development activities on the occurrence of floods were investigated. Impervious areas were computed and quantified to determine the hydrological response of the catchment due to development activities. The result indicated that increasing development activities were responsible for the occurrence of flash floods and primarily due to percent increase of

imperviousness which had increased. It was also determined that the generated amount of volume in modern days than previous days. In the end the author recommended that the drainage system to be upgraded, properly re-routed and cleaned regularly.

Bhusal (2004) stated that the overland runoff from Nepal enters into India. This article examines the consequences on Nepalese lands due to construction of Laxmanpur barrage and afflux bunds. A vast India (of India near) Indo-Nepal border is vulnerable to inundation every year due to monsoon floods. Non-monsoon flows of Nepalese rivers are extensively used for irrigation in India, where as monsoon floods are delayed over Nepalese territory due to constructions of afflux bunds and dykes in Indian soil near Indo-Nepal border. Afflux bunds blocks overland flows as well creates runoff retarding ponds.

Dhungana et al. (2016) stated that unplanned construction and growth along the Tinau River as a contributing factor to flooding. Rivers have a natural cycle of high and low water flow, and when these patterns are considerably disrupted by the construction of buildings, roads, and other infrastructure, flooding and damage are very certain to result. Similar to how inhabitants in India and Nepal perceive the construction of dams across the Danav River directly south of the Nepal-India border as a danger to flooding. Outside of the Tinau River, the impacts of building on inundation are also apparent. Red Cross survey respondents in Bhairahawa, for instance, claimed that the Bazaar itself floods because building dwellings obstructs the flow of water underneath and above ground, and because of poor drainage, the regions experience flooding for several days per year. The strain on the exploitation of natural resources, such as the usage of water and the mining of river bed materials, increases as a result of the growing urbanization in the area surrounding Butwal bazaar and along the route from Butwal to Bhairahawa. The building of homes also increases the need for sand, gravel, and cement, which puts pressure on mining in Tinau and on the removal of rocks from the Tinau watershed in Palpa district for cement. In fact, the ongoing construction of the Bhairahawa Butwal section of the Siddhartha highway and the upgrading of Bhairahawa Airport to the level of a regional international airport have already increased the demand for gravel and sand, with imports from nearby districts providing a portion of the material's supply (especially Nawalparasi in the east).

Terai region which covers only 17 percent of the total land of the Nepal, is significant for its production of the granary. However, due to the geographical features of the Nepal, and the types of the river that flows to the Terai through Chure region has been a reason for flooding and inundation along with the climate change and seasonal rainfall.

## **2.7 Research Gap**

The existing literature discusses the various reasons for the flooding in the Terai region. Majority of such flooding has been attributed to the types of the river, chure region, climate change. However, there has been little focus given on the impact of the development activities in accelerating the disaster. Majority of the literature associating to development and flooding has been focused on the urbanized area. However, this research focuses on the impact of the infrastructure development on the overall flooding in the Terai region, which has been barely studied.

## **CHAPTER III**

### **RESEARCH METHODOLOGY**

The research relies on the qualitative methodological approach because this work is primarily focused to discover and gain an in-depth understanding of individual experiences, thoughts, opinions, and digging deeper into the problem. Along with that qualitative approach was applied to quantify attitudes.

The insider's account or perspective is referred to as emic, and it is often thought to be more subjective and culturally distinctive (Pike, 1967). The researcher adopted the emic approach to interact with the people as an active participant, and has been facing the issue of flooding and inundation. The goal of this method was to get a deeper understanding of the people's perspective and experience.

#### **3.1 Research Design**

A qualitative research design was applied in this study where inductive reasoning, primary and secondary sources of data play vital roles for interpretation. The researcher focused the study to understand situations, and consequences of inundation in the Rautahat District, along with adaptive approach and preventive measures. For the collection of data primary data was deployed. The primary data were collected from the primary sources such as KII and FGD was conducted. For the KII, ward chairperson, Ex-Mayor, District Commander of Nepali Army, APF Nepal and Nepal Police, while for the FGD, local people of the Rautahat were conducted.

#### **3.2 Techniques & Tools of Data Collection**

Content analysis, sample selection, the computerized database were considered as techniques of data collection. Data were collected from both primary and secondary sources. For primary data FGD and KII was conducted. Similarly, for the secondary sources, the data were collected from various units, and published articles and journals.

Data and information were systematically analyzed and presented in various ways of data analysis methods. After processing of collected information, analysis and interpretation of data were done to fulfill the objectives of the study. Analysis and interpretation of the

collected information were reported in the form of findings and conclusions. Descriptive, analytical, explanatory, and comparative methods were employed for the analysis and interpretation of information.

### **3.2.1 Focus Group Discussion**

Focus group Discussion was carried out Banjaraha village with 10 participant. The participant included the chairperson of the Ward, and 9 other villagers. The interview question asked to the FGD which is shown in Appendix 'A'.

### **3.2.2 Key Informant Interview**

For the KII, different stakeholders for disaster response and management were identified and based on it KII interview was conducted. CDO office, Commander of Nepali Army units, APF Nepal units and Nepal Police units were interviewed regarding their disaster management plans and their experience on handling the previous disaster which are mentioned in Appendix 'B' to 'F'.

Similarly, the interview was also conducted among the Ex-Mayor of Gaur Municipality and other political representative of the Rautahat District to analyze the overall disaster response, question format is shown in Appendix 'G'.

## **3.3 Ethical Consideration**

The ten principles of ethical considerations were followed by the researcher according to the ethical guidelines developed by (Bryman & Bell, 2007) as the following.

- 3.3.1 Participants in the study did not experience any damage of any kind.
- 3.3.2 Priority was given to upholding the dignity of research participants.
- 3.3.3 Before the interview and group discussion began, the respondent gave their full permission.
- 3.3.4 It was made sure that research participants' privacy was protected.
- 3.3.5 The research data's confidentiality was maintained at an appropriate degree.

- 3.3.6 The research was conducted with the participants' anonymity protected.
- 3.3.7 The researcher avoided lying or exaggerating the goals or objectives of the research.
- 3.3.8 Honest and open communication regarding the research was conducted.
- 3.3.9 It was avoided to offer any false information of any kind or to portray the results of primary data in a biased manner.
- 3.3.10 Each responder was given thorough information about the study during data collection, and their informed permission was obtained. They had the right to cease responding to questions if they were humiliated, even though they had consented to provide the answers. The respondents provided anonymous replies. The data gathering form was, however, identified using an identifying code. The responder had the complete right to take part in or leave the interview at any point throughout the research period. The responses were all kept completely private. To ensure that only the researcher could access the data, all the questionnaires were stored securely. Any information that may be used to identify the respondents was not included in any report publications. The researcher protected the people, communities, and environments engaged in the studies from any kind of injury, deception, or malpractice by doing this study while being conscious of ethical and data protection concerns. For the citation and referencing APA 7<sup>th</sup> edition guidelines were followed as well.

## CHAPTER IV

### INUNDATION AND INFRASTRUCTURE

The Terai region of Nepal is an extension of the Gangetic plain. Together they are home to millions of people who practice agriculture-based livelihoods. In the last five decades, the region has witnessed tremendous growth in infrastructure development. Roads, irrigation canals, railway lines, flood control embankments and urbanization have all constrained drainage and thereby further exacerbated the impact of flooding and inundation.

#### 4.1 Natural Causes of Flood

Nepal is the part of the Ganges/Brahmaputra River Basin, which is one of the most disaster-prone regions in the world. The Terai region amounting to only 17 percent of the total area and river valleys in the mountainous region of the country regarded as the granary of Nepal is continuously suffering from flooding. The rivers in this area become wide and braided with wide spread damages to agricultural lands. The damages are further characterized by erosion of banks and deposition of infertile coarse material on the cultivated land. The channel capacity of the rivers in this regime is said to be decreasing due to increased sediment coming from increased erosion rate at upland, thus making these rivers unable to accommodate large floods; as a result the adjoining area suffers from inundation (Bhusal, 2004).

The issue of the flooding and inundation in the Rautahat District has been a major problem since a longer period of time. KII remembered the incident of the floods and its usefulness for agriculture.

*Before 35 years (during his childhood), the flood and inundation within the Rautahat District used to occur in the yearly basis. The inundation at that period were taken as a boon for the agriculture. As, the floods and inundation would bring fertile soil from the chure region and deposit in their lands.*

Further he added that the pattern of inundation used to be different as well. The inundation were more like floods, and within the few hour or days, the water will automatically escape back to the river.

So, according to the KII, the inundation process in the Rautahat District was not a new phenomenon, but the pattern had definitely changed. To understand it more we need to understand the river system that exist and the geographical condition of the area, climate and along with the population demographic.

#### 4.1.1 Major River system of Rautahat District

Major rivers flowing within Rautahat District include Bagmati, Lalbakeya, Chandi and Jhanjh. Bagmati is located in the eastern part and 51 kilometer of its length lies in the district. Irrigation facilities are developed from Bagmati and Lalbakeya, these rivers create danger to life and property during high flood due to bank cutting near settlement and cultivated areas. In addition to this, land submergence due to flood is more problematic. Other three rivers are less dangerous and are also being used for irrigation purposes (Adhikari, 2013).

**Figure 2:**

*River System in Rautahat District*



Source: Dixit et al., 2007

The river morphology in the Terai depends upon the origin, flow magnitude and sediment load of the river. The rivers originating from the Chure hills are characterized as flashy with negligible or low flow during the dry season. In addition, the large rivers also change their morphology as they debouch into the Terai plain with flatter slopes and wide widths (Adhikari, 2013).

Most of the Chure Rivers have relatively narrow width at the Nepal-India border. During heavy rainfall these rivers spill over the banks and flooding and inundation occur for some time depending on the topography, slope of the river and the waterway.

#### 4.1.1.1 Bagmati River

The Bagmati River flows through Chandrapur, Brindaban, Gadhimai, Mahav Narayan and Rajdevi Municipality including Durga Bhagwati Rural Municipality in the district. Poudel et al. (2018) examined the overall features of the Bagmati River, the overall details of the river is tabulated below:

**Table 3.**

*Basic Features of Bagmati River*

<b>Origin</b>	Shivapur Range
<b>Total Catchment</b>	13400 km <sup>2</sup> (7000 km <sup>2</sup> ) lies in Nepal
<b>Division of the River</b>	
Origin to Terai	154 km
Bairia to Karmaiya	22.5 km
Karmaiya to Gaur	41 km
<b>Bed slopes</b>	1.44 and 0.53 m/km

Source: Poudel et al., 2018

From the above analysis, the Bagmati is generally braided in Nepal Terai up to Nepal-India border and below that the river is of meandering type with constantly shifting courses. The high concentration of silt together with the flat terrain is the main cause of the shifting of the river and the inundation of villages and agricultural land along the riverbanks. The geology of the catchment is unstable and susceptible to heavy wear and tear, bringing increasingly large sediment loads. The embankment on the both banks

extends from India to all along the affected Nepalese territory. This has subjected to flood inundation due to river spills.

To analyze the impact of the flooding by the Bagmati river, analysis of impact of Bagmati river flooding 1993 is conducted. It was found that during the floods, about 1,300 people died nation-wide with about 111 from Rautahat District. In all, 73,606 families were affected among which 14,644 houses were affected in the district. There were 89,146 who were affected by the disaster, among them 111 people lost their lives. It caused a loss of total worth Rs 899,680,261. The table is shown in Appendix 'H'.

#### 4.1.1.2 Lalbakaiya

According to the Poudel, et al. (2018) the Lalbakeya River is one of the perennial rivers is terai region of Nepal. Further they described the overall features of the river which is as follow:

**Table 4.**

*Basic Features of Lalbakaiya River*

Origin	Chure
Total Catchment	896 km <sup>2</sup>
Total length	109 km (80 km in Nepal)
Maximum Discharge	500 m <sup>3</sup> /s

Source: Poudel, et al., 2018

There are many tributaries contributing to the Lalbakeya River. The Chure range consists of alternate sand and clay beds, the river basically passes through this area. It carries much sediment and depth of the bed is very shallow. Lalbakeya has much smaller catchments. Its complexity lies in its tributaries, which are liable to change its course to drain into another river in the region. Although the river carries smaller discharge, but causes a lot of damages. The embankments along both the banks extend from Indian Territory to several km north to affected area

Chure range, being geologically fragile, adds large volumes of sediment into the river system. The sediment is carried out downstream and deposited in the relatively flatter

area when it passes through the study area. The river becomes wide and often changes its course damaging the adjacent agricultural land. It also spills its bank causing inundation.

#### 4.1.2.3 Jhanjha River

The Jhanjha River is one of the river which flows within the district and joins the Bagmati River.

**Figure 3:**

*Jhanjha River of Rautahat District*



Source: Google Maps, 2022

This river has been one of the major reason for inundation. Despite having embankment of the Bagmati River, the Jhanjha River has not been embanked. This has resulted in the flooding through the reverse flowing of the water of Bagmati through the Jhanjha River. The KII specifically stated that rather than Bagmati River, it is Jhanjha River which is the major reason for the inundation.

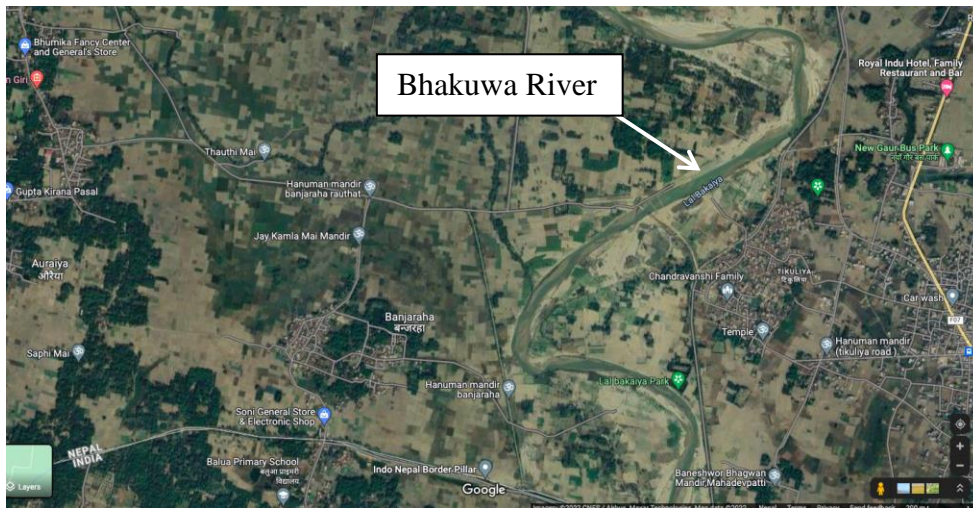
Further Jhanjha River also accumulates all the rain water from upper part of the district. Thus, during the monsoon season sometimes light rain also create inundation in Gaur bazar area.

#### 4.1.2.4 Bhakuwa River

The Bhakuwa River is one of the river which flows within the district and joins the Lalbkaiya River. This river has been one of the major reason for inundation in the Isanath Municipality.

#### Figure 4:

*Bhakuwa River of Rautahat District*



Source: Google Maps, 2022

Despite having embankment of the Lalbakaiya River, the Bhakuwa River has not been embanked. This has resulted in the flooding through the reverse flowing of the water of Lalbakaiya through the Bhakuwa River. The KII specifically stated that rather than Lalbakaiya river as it accumulates all the rain water within the district and also the threat of reverse flow of the water from the Lalbakaiya river, which enters the residential area.

#### 4.1.2.5 Chandi River

Chandi River flows in the uppermost part of the Rautahat District. The Water then mixes with the Bagmati River. During the flooding of the 2017, this river had inundated the area of the Santapur along with the East-West Highway.

During the inundation one of the village, i.e. Khaira was displaced. The KII stated that a total of 150 family were displaced from the village who re-settled at Chidiyadaha and Chandranigapur. Further he added that there has been ongoing construction of the dam and embankment project within the river with a motive to reuse the land that were

inundated during flooding of 2017. Similarly, another local respondent stated that during the flooding of 2050 BS, the floods interred into Mardhar village located at bankside of the Chandi River and create inundation for several hours. Though, human casualties and property loss were not recorded.

**Figure 5:**

*Chandi River of Rautahat District*



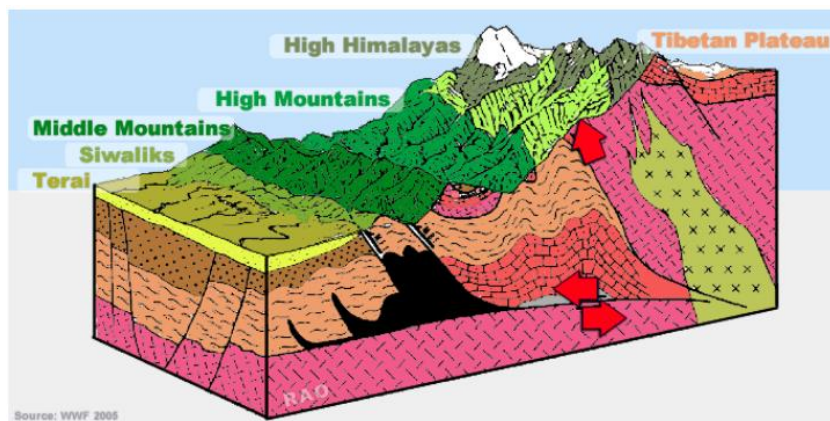
Source: Google Maps, 2022

#### 4.1.2 Geology

Nepal has diverse physical structure in limit territory, generally it is classified in three geographic structure such as Himalaya, Hilly and Terai (plain) area.

**Figure 6.**

*Geological Formation of Nepal*



Source: Gautam, 2008

However, it may be classified into five main tectonic zones based on its geology. The higher Himalayas are always covered in snow. The Siwalik range is located between the MBT and Himalayan Frontal Faults (HFF), while the Terai plain is located under the HFF. Sandstones, mudstones, siltstones, shales, sandy beds, and conglomerates make up the majority of the mollase formation found in the Siwaliks. The Terai is made up of thick alluvium that was deposited by Nepalese Ganges tributaries (Dahal, 2017).

Extreme rainfall events (such as cloud burst, monsoon depressions, and tropical cyclones) can trigger a variety of geodynamic processes, including landslides (including land slips, slumps, creeps, and wedge failures), pluvial processes (including debris flows, debris slides, debris torrents, mud flows, mud torrents with mud), and erosional processes in mountain ranges due to the presence of major fault systems like MBT and HFF (Dahal, 2017). These mechanisms provide a major contribution to the flood and sediment load of Nepalese rivers. During the monsoon, these rivers dump huge amounts of suspended and bed load. Since they are unable to stay inside of their channels, flooding results.

#### **4.1.4 Climate**

Nepal's climate, influenced by elevation as well as by its location in a subtropical latitude, ranges from subtropical monsoon conditions in the Terai, through a warm temperate climate between 4,000 and 7,000 feet in the mid-mountain region, to cool temperate conditions in the higher parts of mountains between 7,000 and 11,000 feet, and to an Alpine climate at altitudes between 14,000 and 16,000 feet along the lower slopes of the Himalaya mountains (Yogacharya & Gautam, 2008).

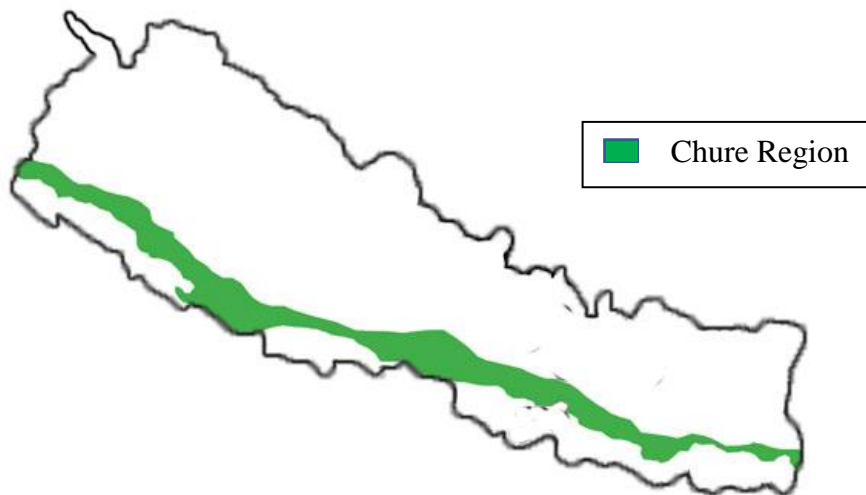
During the summer monsoon season, a belt of low atmospheric pressure known as 'monsoon trough' is normally established over the northern plains of India. Sometimes, it moves northward to the foothills of the Himalayas and stays there for a couple of days before retreating back. Because of the lowest pressure, it creates most unstable weather conditions in and around this area, the severity of which depends mainly upon the moisture content in the air. During this period, a heavy down-pour of rain occurs, triggering severe floods and landslides (Gautam, 2008). The climate change has a successive impact on the livelihood ranging from the hills to the Terai. The higher intensity of the rainfall, melting of snows/glaciers, has domino effect on the water induced disaster.

#### 4.1.5 Chure Ecological Region

The heavy rainfall over the CER has been causing unexpected high flood. Similarly, the lack of monitoring and early warning system has been resulting in high economic losses due to flood in the terai region of Nepal. The flood due to heavy rainfall on 24-28 July, 1954 and followed by another heavy rainfall one month later had created havoc situation in the eastern and central Terai of Nepal that resulted the death of hundreds as well as huge economic loss. Similarly, the highest daily maximum rainfall was recorded in Nepal, which measured 540mm in 19th July, 1993 at the Station of Tistung Makawanpur. Over sixty thousand hectares of agricultural lands was inundated and 67 irrigation systems were washed away. A part of Bagmati Barrage was damaged and had resulted in inundation in Sarlahi and Rautahat Districts (Sharma, 2018).

#### Figure 7.

*Map Showing the Chure Region of Nepal*



*Note:* Above demonstrate map shows the CER, just below the Chure region Terai area cover the fertile land of the country.

Source: Bhujju et al., 2007

The Chure range is geologically younger and fragile. The degrading forest in the range has increased erosion and consequent increase in the sediment in the river. The sediment is carried by the rivers and is deposited in the stretch where the study area lies. The result

is bed rise and instability of the river system. The rivers are observed to be changing their courses eroding banks. One of Key- informant participant accused to local government near the Chure region for over exploitation of natural resources without proper any study.

*“Chure Dohan (exploitations) has been the major reason for the recent increase in the flooding in the Rautahat District. Misusing of natural resources in upper area directly impacting in low land area especially during the monsoon period.”*

#### 4.1.6 Population Increment

In Terai, devastation due to flood is also increasing due to rapid increase in population and human activities. The flood plains are being increasingly crowded to meet ever-increasing demands of food and fiber, and consequently the flood problem is exacerbated. The Rautahat had seen increased number of people in each population census. The growth in the population has been due to the internal migration of the people from Hilly region and at the same time migration of the people from the India (which might not be reflected on the population census). The data of each affected Municipality and their population are represented in the table below:

**Table 5.**

*Population Growth in Rautahat District*

<b>Year</b>	<b>Population</b>	<b>±percent p.a.</b>
<b>1981</b>	332,526	—
<b>1991</b>	414,005	+2.22percent
<b>2001</b>	545,132	+2.79percent
<b>2011</b>	686,722	+2.34percent
<b>2021</b>	825,623	+1.86percent

Note: The table shows that there has been population increment of 2.22, 2.79, 2.34 and 1.86 percent in each census. The data however, does not include the temporary resident of the Rautahat District.

Source: CBS, 1981,1991,2001,2011, 2021

The people of the Gaur Municipality are the most affected municipality followed by Rajpur Municipality. The total affected family due to inundation was found to be 154,783

within the Rautahat District, which is 18.74 percent of the total population of the district, the figure is shown in Appendix 'I'

#### **4.1.7 Sedimentation**

Sedimentation is a natural process for balancing on subsiding sedimentary basin by distributing sediments over an area (Richards et al., 1993). The short term sedimentation covers around the local area along the channel and the accumulated sediments force the river to form of braided system and the river frequently enters nearby areas, especially in low lands, in an aggressive way during the monsoon seasons in the Terai (low land) region of Nepal. Deforestation, soil erosion, landslides, siltation etc., the results of excessive resource exploitation in the head reaches of the basin, have posed serious threats to the stability and sustainable use of downstream infrastructures (Paudel, 2015). In the case of the rivers at the Rautahat, three rivers reach Terai through CER and hence accumulate various sediments at the Terai region.

#### **4.2 Infrastructural Development and Flood/Inundation**

Increased flooding and disasters are also caused by the encroachment of floodplains, restriction of Natural River and sheet flow, poor drainage systems, and river training projects (Parajuli, 2010). Without a detailed analysis of the hydraulics of the river, danger and susceptibility are increased during the design and construction of water development and river training structures, which causes extensive flooding in upstream locations.

Rautahat area has seen number of infrastructural development in the recent years. Majority of the recent development has been based on without any proper planning. One of Key- informant participant called development in Rautahat as a curse than a boon articulated as the following.

*Prior to the infrastructural development, Rautahat has seen number of flooding each year, however, during such flooding and inundation, it was celebrated. The flood carried more fertilized soil and hence such inundation will help in agriculture.*

But according to the KII, the infrastructural development changed the impact of the flooding and inundation at the same time it impacted the general people by impacting the overall agriculture and even pointed it had negative impact on the lives of the people.

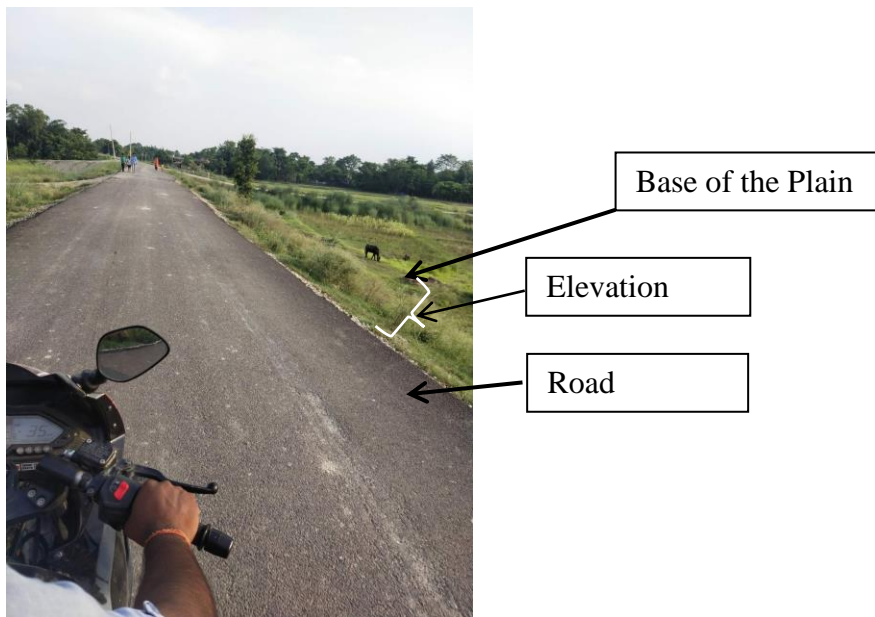
The development of roads, railroad tracks, bridges, culverts, embankments, and dams on the Indian side has operated to restrict water flow and hamper the movement of flood water. Many of these structures appear to have been poorly constructed with respect to flood risk. Due to this, flood waters in the southern Terai have backed up severely, flooding the area, which has been further elaborated below:

#### 4.2.1 Road Network

Hulaki Rajmarg (Postal Highway) is the lowest tip of the Terai region in South and Mahendra Highway runs above it. Chapur to Gaur Highway connect these two Hulaki and Mahendra Highway as shown in the figure 10. All the roads and highways are constructed with certain elevation from the land as shown figure 8.

**Figure 8:**

*Road infrastructure within Rautahat district*



Source: Field Visit, 2022

It is because of these highways, Terai region has been converted into a rectangular pond. And, there are many more such rectangular ponds in the Terai region. Roads are higher than the Terai lands. Only limited apertures have been left open for clearance of rainwater on these roads and there are chances they get blocked in absence of regular supervision by the public works department.

**Figure 9:**

*Water Outlet (Lachka) at the East-West Highway*

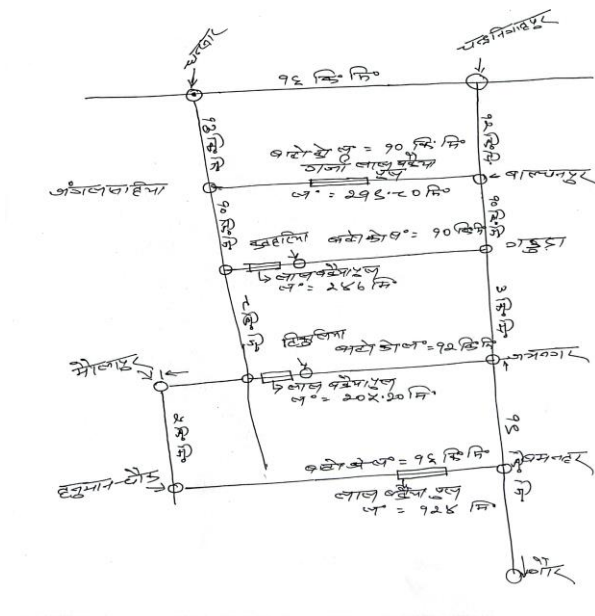


Source: Jha, 2019 and Field Visit, 2022

Figure 9 depicts that the water outlet constructed with the purpose of passing the water flow without impacting the road structure were inundated during the heavy rain flow. The picture of the inundation was taken during the inundation by the Chandi River.

**Figure 10.**

*Road development in Rautahat*



Note: Figure 10 shows the road (black topped) network of the district where the KII mentioned about the bridges along with its length.

Source: KII Road Division Office, Chandrapur, 2022

Along the highway there are number of feeder roads, most of the roads were found to be concrete road. The KII stated, that the "the reason for adopting the concrete road approach has been mostly due to local government and lack of the resources." However, on visiting number of roads, it was found that there did not exist any drainage system to manage the overflow of water. Hence the road network itself existed as a barrier for the drainage during the overflow causing the inundation.

The local level government has resulted in a rapid construction the road in different ward level. And majority of such construction has been concrete and hence such concrete development has decreased the possibility of water absorption. Such construction is rampant in the Rautahat District. Further such construction has been not properly designed for water outlet.

Arun Kumar Subedi who had been raising the voices against the development process in Nepal, in context with the disaster stated that the development process in Nepal has been more rampant in the context of Nepal. In his interview he stated that:

*Nepal is still following the traditional pattern of development work which is not environment-friendly and goes against the parameter of sustainable development... We never object to and bother about when link roads connecting two houses are put under spade and a bulldozer levels up the land by breaking the mounds around us. This kind of unscientific and non-sustainable development work for erecting physical infrastructure in Nepal has led to a massive level of soil erosion and landslides all across the country (Subedi, 2019).*

The view of Subedi (2019) is even supported by the KII, who stated that majority of the local development works (especially road construction) is done without any proper planning. Majority of the roads constructed within the local level has been locally and politically motivated. The KII stated that:

*The road construction within the local level are mostly politically motivated. The people who had supported local leaders in the election are the one who gets the tender of such construction. Despite lack of experience and equipment, they are given such tender with a sole motive to make them happy. The result could be easily seen in the construction pattern within the district, i.e. mostly concrete and without EIA.*

#### 4.2.2 Bridge

The district have 42 bridges altogether. Similarly, the bridge has also been a major challenges and one of the reason for the flooding and inundation. One of the KII stated that:

*Especially, while constructing the bridge in the road, the government often tend to construct the bridge as short as possible, and while doing so, the rivers are often narrowed where there are bridge. This results in flooding and the river tends to develop the pattern such as reverse flowing and inundating the area.*

This could be easily viewed in the Bridge of Chandi River. The river bottle neck has not been given due consideration while building the bridge. The bottle necks are within a very short span wider and narrower width of the river.

**Figure 11:**

*Bridge at the Chandi River and flow pattern of river*



Source: Google Maps, 2022

The map shows the width of the river at two different points. As, the river approaches the bridge area, river is embanked and hence passed through the narrow bridge width. Without any training the river has grown a width of 260 meter, and then as the bridges

has approached and river was trained, it has narrowed by 42 percentage and is 110 meter of width. This practice has been followed in the other river as well.

### **4.2.3 Urbanization**

Rautahat has seen a rapid urbanization in the recent years. With growing number of the people (CBS, 2011) as well as growing number of infrastructure such as road network, housing patterns and even other infrastructure has led to urbanization. However, the urbanization in the district has not been managed properly. It was found that majority of the houses that were developed within the highly affected flooding area have adopted the measures of constructing the houses by uplifting in a higher ground, through the means of adding soil to make it more height or making the construction through the uplifted first floor. Either way, the people of the Rautahat District, did not move away rather they adapted themselves for each year flood and increased the rapid urbanization process.

### **4.2.4 Water Embankment**

Water embankment has been taken as measures to control the river flow in the area. However, in the context of the Rautahat District it has been one of the measure challenges and cause for the inundation.

One of the KII stated:

*The government has embanked the both the river, i.e. Lalbaikaya and Bagmati, however the subsidiary river which joins these two river are not properly embanked. This has led to the inundation during the high flow of river through reverse flow of the river. The proper embankment of the river at the Jhanjha River and Bakuwa River could reduce the inundation in the area.*

Even during the monsoon, the embankment within these two rivers were not well developed. During the year 2020, the Lalbakaiya and Bagmati rivers had breached their levees at 13 places and inundated more than two-thirds of the district (Puri, 2020). The Lalbakaiya embankment had suffered nine breaches while the Bagmati embankment was damaged at four places. Similarly in the year 2019, the rivers breached their embankments at 31 different places.

It is further found that the embankments within the rivers are not timely managed and repaired which make it more vulnerable each year. The embankments along the flood-prone Bagmati and Lalbakaiya rivers were constructed around 20 years ago with the support of the Indian government. The embankments are often breached during the monsoon season (Puri, 2020).

#### **4.2.4.1 Dam Construction in Lalbaikya River**

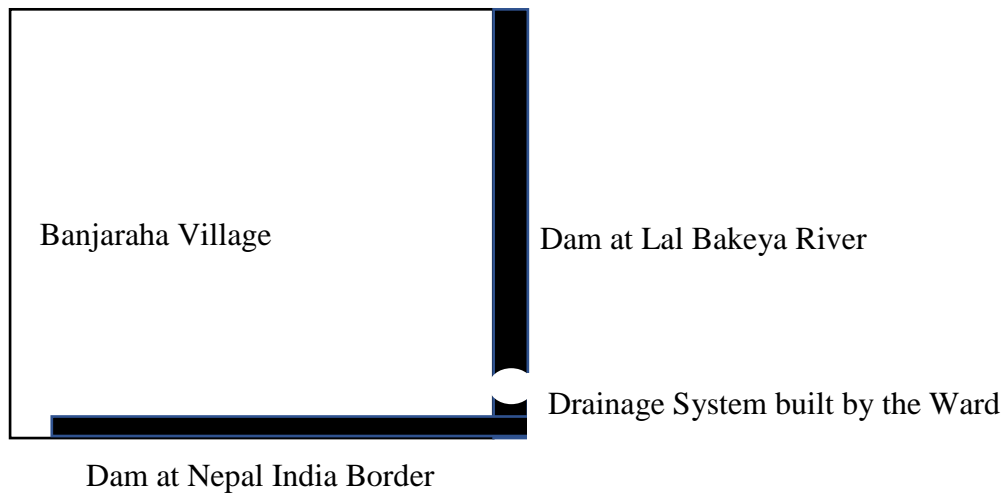
The dam constructed in the individual river at the Lalbaikya River has been one of the river for inundation. The KII stated that the river generally flows reverse and enters to the villages during the higher water flow. The discharge system of flooding water is not established properly, drainages are constructed in very few in number which are inadequate to discharge the water.

#### **4.2.4.2 Absence of Dam at Bakuwa River**

The rivers like Bakuwa and Jhanjha are not properly managed. The reason had mostly been due to their small size. Especially during the rainy season, they tend to reverse back to the village carrying huge water that are discharged from the river like Bagmati and Lalbaikya. One of the KII supported it by saying that, they do not have any fear of the Bagmati and Lalbaikya, however they fear most from the river such as Jhanjha and Bakuwa River which has been causing the major inundation in the district. The reverse flow of the water when two river Bagmati and Lalbaikya overflows through these rivers causing the inundation and flooding. Another KII also supported the view and stated that the dam that are built within the river of Bagmati and Lalbaikya has increased the impact as it blocked the natural drainage mechanism that existed before.

The embankment of Lalbakaiya River has created cracks in various places due to the water flow of the river, while the embankment of Bagmati River is also in a similar state. People living in riverside area are at high risk of flood and inundation from the Lalbakaiya and Bagmati River.

The following figure shows the impact of dam construction from both side in Banjaraha village which is creating more vulnerable to the local people of Banjaraha.

**Figure 12:***Dams in the Banjaraha Village*

Source: Field Visit, 2022

One of the local respondent presented a view that the lack of the embankment mechanism within the Jhanjha and Bakuwa River has been the major issue and the embankment process might reduce the impact of such river in the community. But KII was reluctant to support this idea, and stated that the existence of the Dam at the Nepal India Border has resulted in inundation of the area. The area that the KII was talking could be described in the figure above and photograph below

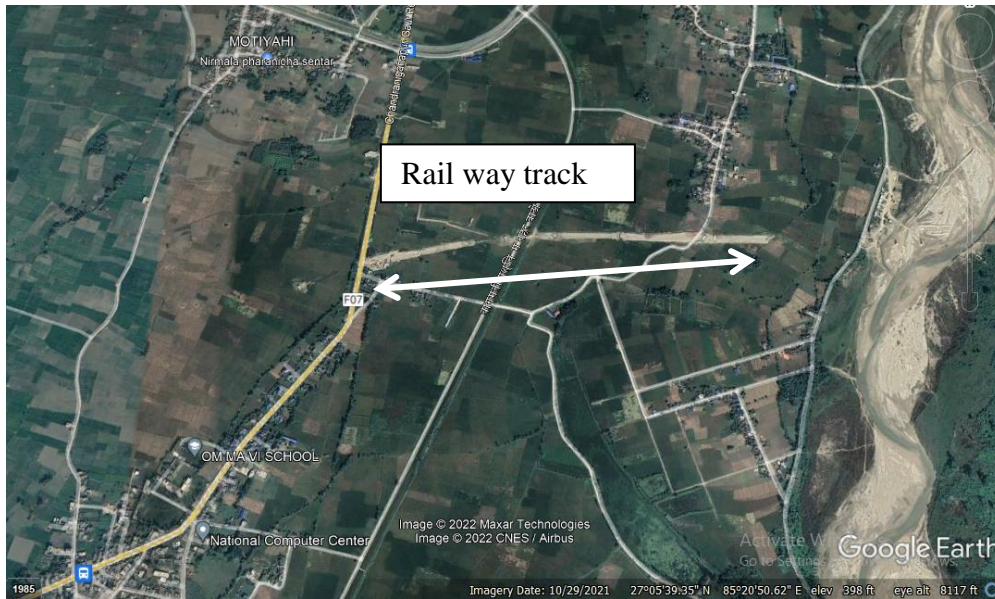
The figure shown in the Appendix 'J' the area where the dam constructed was destroyed by the high river flow, making a natural culvert in the area. From this point there were not seen any dam within the India Nepal border. KII stated that during 2019, the dam was destroyed by the high river flow. Since then local had obstructed the construction of the dam in the border area.

#### **4.2.5 Railway Development**

The 945-km East-West Railway, also called the Mechi-Mahakali Railway, passes from Bagmati to Laxminiya via Chandrapur in Rautahat District (Puri, 2021). However, local residents are worried that the construction of the railway track in Chandrapur might raise the risk of inundation in the area.

**Figure 13:**

*Map of Constructing Railway track in Chandrapur, Rautahat*



Source: Google Maps, 2022

As, per the data provided by the Rail Department, the railway track of 21 km has been under construction which includes a total 65 culvert placed at different part of the tracks. Similarly, the dam filling height and width of the track will be of 3-6 meter and 50 to 100 meter respectively. Railway track is interred from north-east to south-west direction in the district, which helps to reduce water discharge and might create disaster such as inundation in the future.

The figure in the Appendix 'K' shows the concrete culverts which helps to discharge the water system, one of the respondent had stated that,

*A platform around fifteen-feet high and culverts are being constructed for the railway track. We are worried about possible inundation during monsoon. The culverts are small and cannot hold floodwaters during monsoon.*

This view has been in align with view of the ward Chairman of Chandrapur Ward 06, Khadka Kushawar during his interview with Kathmandu Post in 2019 had stated that

*"The culverts are too small and limited in number so they might not be able to hold or direct floodwaters during the monsoon season. Authorities should think about a possible inundation threat to the settlements in the area" (Puri, 2021).*

Based on the KII information, in the case of heavy rainfall, the area of Santapur, Mothiyahi, Belti and Betauna will be more affected by the flood and inundation.

#### **4.2.6 Housing Structure and Pattern**

Most of the houses in the affected areas were made of poor structural materials, such as unbaked brick and bamboo, which were not capable of withstanding floods. Rural and riverside area of the district covered with small huts and cottages which are more vulnerable during the flood and inundation. The people in those area lacking of permanent property however, they are struggling hard for hand to mouth.

Figure in the Appendix 'L' the housing pattern in rural area and river embankment area of the district, the livelihood of affected area is more vulnerable due to health issues.

#### **4.2.7 Dykes of Southern Border**

All the rivers of Nepal drain to the Ganges basin crossing the Nepal- India border in the Terai plain. The total length of the border with India is estimated as 1,808 km, of which rivers act as the border between Nepal and India for about 595 km of length (Shrestha, 2007). The infrastructures constructed just downstream of the border across the contour have congested the drainage passage of the natural water bodies and have caused inundation in upstream areas adjacent to the border. India has constructed dozens of the embankments, dam water control structures just at the boarder inundating Nepalese territory/farmland. Nepal's request to alleviate the problems have not been considered by India. Local communities of Nepal gradually involved in to build dyke in border by estimating that the overflow water will go through the Bagmati and Lalbakaiya River and reduce the inundation in their area.

According to the United Nations Convention on the Law of the Non-navigational Uses of International Water courses defines that:

*“Watercourse States shall, in utilizing an international watercourse in their territories, take all appropriate measures to prevent the causing of significant harm to other watercourse States.*

While keeping in mind the provisions of articles 5 and 6 of United Nations Convention on the Law of the Non-navigational Uses of International Water, if significant harm is

nonetheless caused to another watercourse State, the States whose use of that resource results in that harm shall take all appropriate measures in consultation with the affected State to eliminate or mitigate that harm.

Similarly, the principles of notification, consultation and negotiation states that

*When a basin State proposes to undertake, or to permit the undertaking of, a project that may substantially affect the interests of any co-basin State, it shall give such State or States notice of the project. The notice shall include information, data and specifications adequate for assessment of the effects of the project (Manner & Mestsalampi, 1988, p. 364)*

### **4.3 Impact of the Inundation in Livelihood Context**

In the year, 2021 the inundation damaged crops that had just been planted. As the farmlands were logged with rainwater, the efforts and investment of farmers have gone in vain in the district where close to 90percent residents are farmers (Jha, 2021).

#### **Figure 14:**

*A Girl pointing the level of inundation during 2019*



Source: Shrestha, 2019

The figure above shows the level of inundation impact in affected area, as per the ground variation the water level goes up to six feet. The inundation in Rautahat also impacted various sectors which are further described below.

#### **4.3.1 Drinking Water**

The major source of water is the ground water. Most number of houses use tube well for the purpose of drinking water (Rural Development Center, 2021). Hence during the inundation tube well also filled up with flooding water and sometimes it is difficult to locate tap due to inundation the availability of drinking water is also impacted. One of the respondent stated that the difficulty of the drinking water is more critical while providing safe drinking water to their family and cattle as well. Lack of availability of other alternatives for safe drinking water has caused illness among the cattle.

#### **4.3.2 Road and Transportation**

The flooding and inundation severely interrupted road and transportation services almost across the district which impacted whole lines of communication. Flood also damaged the culvert and drainage system including village connection roads and Chapur- Gaur highway which link to district headquarters. One of Key- informant participant informed about road interruption during the Terai flood in 2017.

*“From the Garuda bazar to Gaur, linking road to district headquarters, the vehicles were stocked several hours due to inundation. High flow of water started scouring and badly affected the gravel and ward linking roads. Flood also damaged some sections of the Hulaki Rajmarga.”*

Similarly one of the respondent stated that due to flooding and inundation, movement was totally restricted because no roads or pavement can observe, the event became more painful while any family members got sick and they need medicine or foods.

#### **4.3.3 Health and Sanitation**

The health facilities of the district almost rely on DHO as a government agency though there are some private hospitals and clinic centers which can found in market area. In the village area there are some health posts, however they are far from the villagers and always suffering from adequate basic medicine. Water borne infections in ground,

garbage management, nutrient and hygiene were the major impacts in such places. One of Key- informant participant from Banjarah village described about poor health facility during the disaster.

*The health facility provided by the government agency was very poor during the inundation. My family members were affected by water borne diarrheal diseases and I didn't get medicine in time.*

Similarly another respondent stated that:

*During the inundation they were not able to reach the health service, as majority of the connecting roads were inundated. There were not any possibilities of calling for the ambulance.*

#### **4.3.4 Impact to Education**

Local schools and colleges are completely closed during the inundation because most of the affected people used local schools for their safety and temporarily residence. They choose to reside in multi-storied school buildings. According the school principal, "disaster affected people come with their cattle in school area and reside with their cattle and pets which is seriously impacted to health condition". They also make litter in school area, waste management is most challenging job during the inundation. One of the respondent stated that threat of the inundation during the rainy season has led to disturbance in the education. One of the Key respondent had stated that schools and colleges like Gauri Shankar Yadav Rautahat Campus, Mitra Memorial Awasiya School, Adharbhoot Pra. Bi, Banjaraha and other local schools were used for the purpose of shelter.

#### **4.3.5 Fear of Snakes and Insects**

During the flood and inundation reptiles and poisonous creatures also search for safety places so usually they come to houses, schools, temples and even a big tress. Mostly poisonous snakes, scorpions, monitors, lizards, wild rats were shown in inundation area. They become more aggressive during disaster because losing of their adapted environment and habitant.

#### **4.3.6 Agriculture**

Rural area of the district, people are engaged in agriculture and farming and almost in a house they have a cow/ buffalo, goats and chicken as economic supporting elements. One of the respondent stated that the inundation affected village were only able to produce crops once in a year however neighboring (Indian) farmer cultivating lands twice in a year easily.

Flood and inundation are the major environmental challenges in the study area. The threat to environment is higher during the disaster. The intense problem of sedimentation of the river in the low land is frequent and the sedimentation hazards are always seen particularly in the settlements adjoining the river banks (Kafle et al., 2017). The people in these settlements are heavily dependent on agricultural resources. However, the agricultural resources and its production potentials are always in threat due to frequent high sediment floods.

#### **4.4 Preventive Measures**

As per the discussion with the community in Rautahat District the floods in the study area are usually flashy in nature lasting hardly for one or two days in the past. But as there has been various intervention through the infrastructure development, such as embankment within the river, which has blocked the drainage pattern of the river immediately after the inundation. One of the KII who had been in the administrative position had identified the issue and developed a drainage system within his area, however he stated that the development of such drainage system has not been effective due to their size and number. The drainage system due to its size to discharge the water was not sufficient enough. This problem has further increased due to the existence of river embankment at the two river i.e. Bagmati and Lal Bakeya and the existence of the dam within the Nepal and India Border.

Flood is the inevitable part of the life of the community and the minor flood is considered beneficial. The community is not aware of flood forecasting and warning system. However, those frequently fighting with the floods are often more competent and knowledgeable as flood managers than highly trained professionals from outside. The local flood affected community has extensive knowledge on the exact local physical

conditions and history of the flood. Existing traditional know-how can be enhanced for the forecasting and warning system. During interaction it was found that the community is familiar with the recurrence and intensity of the floods. Also they were conscious and aware that if heavy rainfall occurred in the Kathmandu Valley (catchment) their area also could be flooded. Hence, some of the elite families of the community listened to the weather forecasting of the Radio Nepal and disseminated information to others. They reported that Gaur Municipality was warned through mike of the impending flood during the last 2002 flood.

#### 4.4.1 Housing Pattern Adapted for Flooding

The people of the Rautahat District has already begun adapting their housing development project through various initiative. During the field visit, the researcher had found various houses being elevated at the certain height, to prevent any water inundation during the rainy season. Similarly, raising the land itself, in the highway of Gaur to Chandranigapur could be easily seen.

#### Figure 15:

*Photos of house in the area*



Source: Field visit, 2022

The house were seen built in an elevation in the area. The first floor is constructed through a certain elevation from the normal ground.

#### 4.4.2 Drainage System

**Figure 16:**

*Drainage System*



*Note:* Above figure demonstrate differentiate of the drainage system, proper drainage system helps to reduce the vulnerability of inundation.

Source: Dixit et al., 2007

There has been the practice of development of the drainage system within the area, however, it was not found enough. The following picture shows drainage management at Lalbakaiya dam in Banjaraha village, ward no 1 of Ishanath municipality which was constructed by the ward level initiative. According to local people this system is not enough to discharge water in inundation period. The KII had proudly stated that he had constructed the drainage system under his own initiative. However, he further stated that the drainage system has not been enough to discharge during the inundation period and additional drainage system should be developed.

**Figure 17:***Drainage system developed*

Source: Field Visit, 2022

The challenge remains mostly during the construction of such drainage, as majority of the community members do not find it beneficial for their agriculture. The diversion of the water from such outlet will only destroy their crops and hence are reluctant to establish any.

#### **4.4.3 River Embankment**

There is an urgent requirement for the maintenance of the embankment that are established. All the embankment should be timely maintained and additional embankment should be established at the location which are more vulnerable to the flood. The image of inundated houses are shown in Appendix 'L'.

#### **4.4.4 National Level in Disaster Management**

National Government does not have a management practice regarding the inundation, however it comes within the flood risk management.

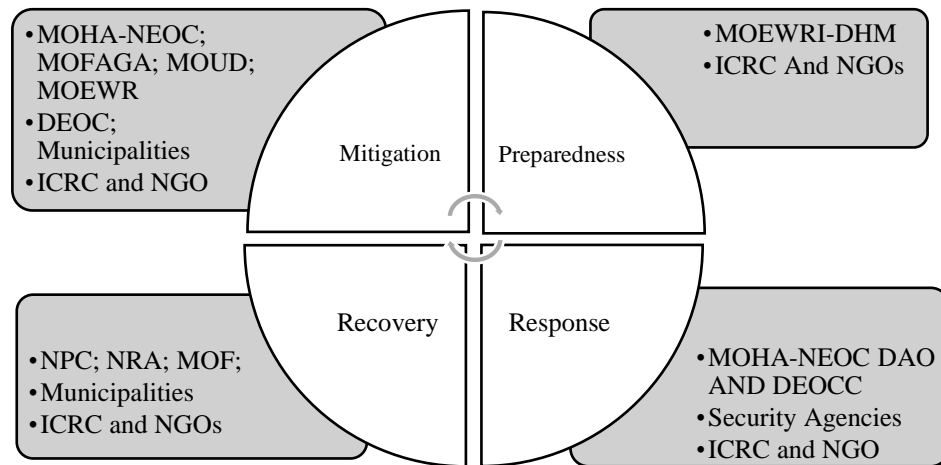
**Table 6.***Flood Risk Management*

Structural Measures			Catchment-wide interventions (agriculture and forestry actions and water control works)
			River training interventions
			Other flood control interventions (passive control, water retention basins and river corridor enhancement, rehabilitation and restoration)
Non Structural Measures	Risk Acceptance	Tolerance strategies	Toleration
			Emergency response system
			Insurance
	Risk Reduction	Prevention Strategies	Watershed management
			Delimitation of flood areas and securing flood plains
			Implementation of flood area regulations
			Application of financial measures
		Mitigation strategies	Reduction of discharge through natural retention
			Forecasting and early warning
			Emergency action based on monitoring, warning, and response systems (MWRS)
		Public information and education	

*Note:* The table shows the two measures, i.e. Structural and Non-structural to mitigate the risk of flooding. The structural measures include various measures such as river training, river control intervention and other. Similarly, the non-structural measures include the acceptance and risk reduction method.

Source: Shrestha, 2008

The role of the different stakeholder in the flood risk management are as follow:

**Figure 7.***Stakeholder in Disaster Management*

*Note:* Figure 7 summarizes the government involved in Flood risk management in Nepal and highlights the “crowded” institutional space and overlapping horizontal (i.e. Ministries) and vertical (National to Local) responsibilities.

Source: ADB, 2019

#### 4.4.5 Community Level in Disaster Management

Based on the analysis of the KII, it was found that many people in the community store some of their food grain on the first floor of those having multistory and permanent building. Some have built small temporary sheds in elevated places from which they can watch the crops against birds which is also used for taking refuge during flood. Some people have made wooden benches on which they stay above water while the inundation goes on beneath the benches. Some people have made provision of plastic for use during flood. Many people keep provision of dried and precooked food for about two days. This includes beaten rice and noodles. The plinths of permanent houses are kept high above the ground. Most of the affluent people in the flood-prone areas arrange for the temporary migration of their children, pregnant woman, old and sick people to their relatives’ houses in the flood-free areas. The community has no organized institution for flood fighting and the above-mentioned flood-response-strategy is practiced on individual basis, not in the collective form.

#### **4.4.6 Municipality and Rural Municipality**

The Municipality and Rural Municipality within the Rautahat District has been facing the inundation from a longer period of time. Hence, the head of the municipality and rural municipality are developing their own strategy to address the issues. Majority of such preparation has been towards managing the disaster.

According to the annual plans of Gaur Municipality Office, there were several initiatives of the municipality in the past as well as there are some more in the future. Municipality has the specific programs for special target groups, some of which are capacity building, income generation, construction of safe houses, etc.

#### **4.4.7 Sand Bags Placement**

During the each flooding and inundation season, sand bags are placed along the bank of the river. During the visit it is observed, the affected Municipalities and Rural Municipalities were engaged to fill up sand bags. India has also placed the sandbags within its border and it was found that such sandbags are prepared prior to the disaster in contrast to the practice in Nepal as shown in the Appendix 'M'.

#### **4.4.8 Security Agencies**

The security forces of the district are more conscious to respond any type of disaster. A sound co-ordination and co-operation between inter agency organizations and stake holders are most vital to counter the disaster. Though, different security organization have their own responsibilities however, during the disaster they perform jointly to save the affected people and their property. The preparedness conditions of each security forces are describe below:

##### **4.4.8.1 Nepal Army**

Nepali Army has been deployed in various disaster within the country. In the context of disaster in Rautahat, Nepali Army has established a unit for the disaster. During each flood and inundation season, Nepali Army deploys a small unit within the two major river with the riverine capacity for the flood risk management.

Nepali Army has made the disaster plan based on the previous inundation. According to the KII of NA, the practice of shifting equipment and weapons into the top floor of the barrack building before the rainy season and also pointed out their preparation for inundation with riverine capacity. KII further pointed that there had been conducted recent disaster management preparedness training/exercise to their personnel.

#### **4.4.8.2 Nepal Police**

District Police Office regularly circulate message regarding disaster impact in the district to its sub units and make aware to support affected local people to coup disaster. Nepal Police are deploying their personnel during any type of disaster however they are facing lack of adequate manpower and proper equipment. They are mostly deployed during the response period rather than preparedness and mitigation phase. During the flood and inundation in the district, the police units fully used their limited resources to save the life and property of local people. Furthermore, collecting instant information from affected area was appreciable.

#### **4.4.8.3 APF, Nepal**

Despite being one of the major stakeholders in managing the disaster in the area, APF Nepal themselves are being impacted by the inundation issue. Most of the APF units are constructed with single roof pattern buildings which are being badly impacted during the flood and inundation, the image is shown in Appendix 'N'.

There has been trained manpower deployed in the each unit to respond the disaster. APF personnel of the units were provided with equipment and training on disaster preparedness and risk reduction. During the field visit, the official records of local APF units shows the data of participants local community and clubs in disaster management awareness training. Flood disaster related equipment were kept as ready to use in the verandah of barrack building. The APF units in affected area is also seem vulnerable oneself. One of KII shared his past experience stating that:

*During the inundation of 2020, APF Base Camp at Gaur Customs area. The swollen Jhanjha khola gushed into APF 11 Bn at midnight. APF personnel from the APF base Camp at Gaur Customs area have been shifted to Gaur Eye Hospital.*

Available human and material resources of APF units were utilized in full fledge during the flood and inundation across the district. The KII further explained that the force is engaged in preparedness and response period of disaster and even during the recovery phase as per necessity.

However, the preparation to encounter any type of disaster in the district is creating obstruction by the unavailability of adequate disaster related equipment. He emphasized that some out board motor, rafts, life jackets, personal floating equipment, search lights are very few in number in the unit which should be increased.

#### **4.4.9 Government and Non-government Agency**

There have been several initiatives for flood disaster preparedness in Terai region of Nepal including the Gaur Municipality in the recent time. Nepal Red Cross Society, Junior Red Cross, Nepal Scout, UNICEF, Rural Development Center (RDC)-Nepal, Poverty Alleviation Fund, Government Agencies (Women and Children Development Office, Municipality Office, Health and Education Sectors) Mission for Better Life, OXFAM, Rural Education Development Center, etc. are some agencies working in disaster preparedness activities. Among the various NGO's NRCS have been providing relief in various disaster. According to the member of NRCS Gaur, in the case of flood and inundation it has provided non-food items to 1250 families on 2076 BS, food and non-food items were distributed to 1149 families in 2074 BS.

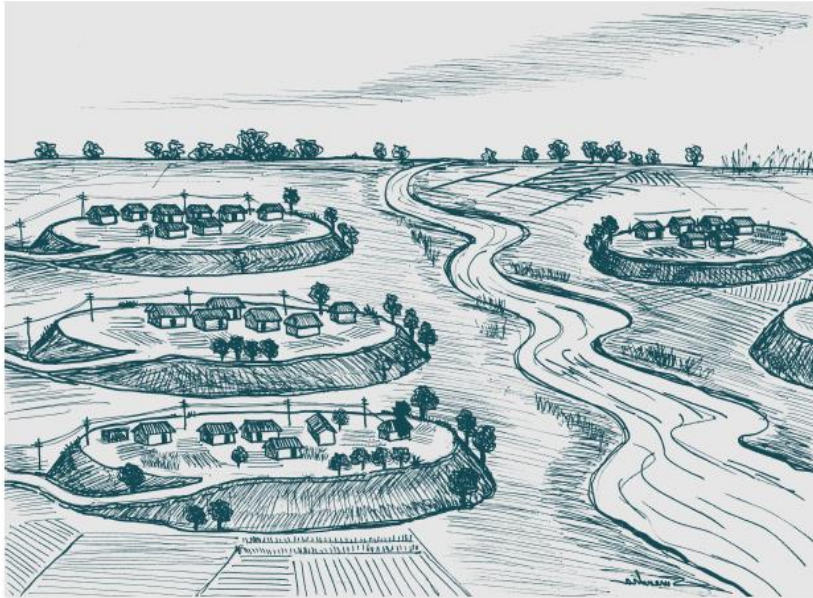
#### **4.5 Adaptive Approach**

Practical methods for minimizing the negative social impacts of floods and inundation can often be found by building on the actions that families already take and by designing interventions which can accommodate changing situations. Such interventions need to address the challenges that a flood hazard poses as well as its impacts. In the case of floods, for example, local people often seek safety from rising floodwater by moving to higher ground, planting flood resistant or early ripening variety crops, and stockpiling some food and emergency supplies including basic medicines, though such examples are very few. Poor access to basic drinking water, sanitation, basic health services and food stuff, however, continue be a major problem for the millions marooned. It is clear that these services must be made available, but the how question remains unanswered. We

need to continue institutional innovations to help improve access to safe drinking water during floods.

**Figure 8.**

*Elevated housing pattern for inundation*



Source: Dixit et al., 2007

Strategies that assist people in developing alternative and less vulnerable livelihoods and reducing their susceptibility to flood hazards may be a more effective response than focusing exclusively on structural measures to control floods. An appropriate strategy might be, as people have traditionally done, to build houses on stilts or on high points ('islands') for respite during flooding. Such an approach would allow flood water to drain quickly and thus remain standing for a shorter period; it also would not interfere with the beneficial deposition of fertile silt on agricultural land. Community forestry activities can help promoting biological shield as buffer zones along the flood plains.

A control-focused approach based on embankment building, in contrast, separates rivers from their flood plains and nullifies the benefit of flood spreading. Overall, approaches that attempt to reduce the vulnerability of people to flood hazards by enhancing capacity and by building on existing mitigation actions may be more effective. An added local benefit is that people can implement these measures in their localities without major institutional restructuring. Some strategies are already being employed while others were identified in course of the study.

In the long term, building transport and informational infrastructures that do not impede drainage may prove to be effective in mitigating flood disasters. It is worth repeating that roads must be designed so they do not hinder drainage. Managing drainage is a challenge for the community of civil engineers in South Asia; national engineering codes will need revision and new insights incorporated in water education stream. We need to focus on the formulation and implementation of appropriate laws and on compliance with municipal codes. This is an arena for continued thinking and investigation. Improving preventive health care facilities and diversifying livelihoods are other challenges. These are elements of governance which need to evolve in any given geographical, social and political context.

#### **4.5.1 Extension of Embankments and Indian Cooperation**

Local government from both side should response rather than central government. Realizing the seriousness of the flooding and inundation problems in the vicinity of the Nepal- India border, it was agreed to extend the embankments from the border along both banks of the vulnerable rivers. Since 2002, embankment constructions are being carried out in the Bagmati, Lalbakeya and Kamala rivers with grant assistance from the Government of India. Adjoining areas of these rivers in Rautahat, Sarlahi, Dhanusha and Siraha districts have been protected from the recurrent floods and inundations. However, many trans-boundary rivers are awaiting a positive response from the Indian side towards mitigating floods and inundation along the southern border. Apart from the Governmental initiatives, there are several Non-Governmental Organizations (NGOs) working in the field of floods and inundation in the Terai.

Further, the construction of dams along the Nepal India border should be discussed between the government and local level. A comprehensive understanding and agreement should be developed to address the issue of inundation among the both community. Various cordial co-operation should be developed among the community. The issue of the dams along the border has to be resolved by the discussion among the local government between two the countries.

#### **4.5.2 Discourage the Tendency to Encroach Upon Marginal Lands at the River Banks**

Many poor people take shelter at the banks of the river due to the availability of jobs and free fertile land in the river valley. Many marginal people are maintaining their livelihoods through cultivation of steep sloppy lands and river banks which are susceptible to flooding and inundation. This tendency is increasing day by day. The case of settlements along the Tinau River is an example.

#### **4.5.3 Enforce Land Use Rules and Regulations**

Proper land use based on topographic and agronomic considerations is key to a planned development approach. The settlement area should be at a higher elevation than the cultivation area. Due to absence of land use regulations, several houses are constructed in the most fertile lands of the Terai. Hence, proper land use regulation and its enforcement are essential to reduce the vulnerability to flooding and inundation in Rautahat District.

#### **4.5.4 Provide Adequate Drainage Passage in Road and Embankment Construction**

As mentioned earlier, development activities, mainly construction of physical infrastructure, are the major barriers to the passage of flood water. Roads in urban areas have less drainage passage way to allow the escape of incoming sheet flow. In addition, due to lack of sufficient information on hydrology, several bridges and culverts are constructed with constricted waterways. It is necessary to provide adequate drainage passage to safely allow the flood flows to pass.

#### **4.5.5 Conserve the Chure Ecology Region**

The Chure hills are the major source of sediments in the Terai Rivers. Due to degraded catchment, these hills are susceptible to erosion, landslides and mass wasting. The Chure conservation activities are being implemented on project basis since the last three decades. However, the process of degradation of catchment is not prevented. Hence, emphasis must be given to conserve the Chure hills in the long term with watershed management and local people participation is most essential.

#### **4.5.6 Use of Early Warning System**

Establishment and use of early warning system for preparedness and evacuation should be done. One of the local respondent had stated that he had been witness of one of such inundation at Gaur Municipality however he was able to quickly escape and reach a higher ground through the highway. Early warning systems should be established in the community of mostly affected area. The system should be devised so that the rise in the river especially Jhanjha and Bhakuwa River should provide with early warning for the community to prepare.

The use of social media could also have a huge impact on the training for the preparedness and response. Further the use of different media could also be done in disaster preparedness, response and rescue.

As per the discussion with the community in Gaur and its vicinity the floods in the study area are usually flashy in nature lasting hardly for one or two days. Flood is the inevitable part of the life of the community and the minor flood is considered beneficial. The community is not aware of flood forecasting and warning system. However, those frequently fighting with the floods are often more competent and knowledgeable as flood managers than highly trained professionals from outside. The local flood affected community has extensive knowledge on the exact local physical conditions and history of the flood. Existing traditional know-how can be enhanced for the forecasting and warning system. During interaction it was found that the community is familiar with the recurrence and intensity of the floods.

## CHAPTER V

### SUMMARY AND CONCLUSION

#### 5.1 Summary

Over time, population increase and haphazard development pose major threats to the general well-being of the communities, who historically welcomed flooding and inundation as a blessing. The effects of floods and inundation in the area have worsened due to infrastructure including roads, embankments, dams, bridges, and railway tracks as well as the deterioration of the Chure Ecological Region. With reference to flooding, the goal of this research is to comprehend the catastrophic phenomena in Rautahat District.

Key insight is provided by the qualitative research's gathering of primary data, which was done so through open-ended interview questions, focus group talks, key informant interaction, and stakeholder meetings. The data analysis and interpretation show that, although though Rautahat District experiences flooding and disasters more frequently and for longer periods of time, there is currently growing urbanization and infrastructure expansion.

The development work in the Rautahat district had extended the impact of the inundation. The impact were mostly on the socio-economic structure of the area. There has been number of preventive measures that the people living in the area has adopted and role of different stakeholders were also analyzed. To tackle the issue of inundation in the district, it is required that various adaptive approaches should be taken, which includes, extension of embankments, establishment of adequate drainage, installation of early warning system and conserving the CER.

#### 5.2 Conclusion

Rautahat District has been facing the challenges of flooding and inundation and will continue to face it for a longer period of time until the effective adaptation measures are implemented.

While inundation helped accumulate more nutrients for increased production and thus celebrated by the farmers. The causes of the flooding and inundation were based river

geomorphology and hydrology. There has been change in the pattern of the disaster in the recent days and there has been number of incidents of the flooding in the Rautahat District.

Infrastructural development has a huge impact on the flooding and inundation in the Rautahat District. It was found that two major infrastructure embankments of the river and the building of dam were the major contributing factor for the flooding and inundation. However road construction, human settlement and urbanization, development of dams at southern border, embankments on different river, development of bridge and railway development program were also identified as an infrastructure that has caused flood and inundation.

There are various stakeholders that are responding prior, during and after the disaster. However, the effort of the local level government has not been adequate enough to have an effective management. Every stakeholder are aware about the situation, but despite that lack of coherent response has resulted in high impact on the people and lack of any short and long term plans.

The issue of the inundation and flooding in the Rautahat District is the result of both natural and due to the human intervention. Hence the preventive measures should focus on both infrastructural intervention and preservation of natural resources, ie. CER. The infrastructural development program should be further reviewed based on the possible impact on the nature as well as disaster in future.

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**Appendix 'A'**

(Refer to Page No.15)

**INTERVIEW QUESTIONS TO GENERAL PUBLIC**

Gender:

Current Address:

Previous Address:

- What are the changes that you have seen within the some years with respect to flood and inundation?
- Can you point a year where there has been high inundation?
- According to you, what are the cause of the floods and Inundation in your area?
- What are the changes that you have found due to the inundation?
- What are the assistance that Governmental and concerning stakeholder had been providing during and after flood and inundation?
- Have you found any link between infrastructure development and disaster?
- If yes, please provide example.
- What are the changes that has occurred due to the inundation in your traditional economic activities?
- Have you ever been experienced the inundation in the recent year?
- What are the impacts that you felt?
- How did you respond/survive?
- Has your migration linked with the inundation and flooding?
- Do you think activities of the government could help reduce the inundation in your area? How?

**Appendix 'B'**

(Refer to Page No.15)

**INTERVIEW QUESTIONS TO LOCAL  
GOVERNMENT/REPRESENTATIVES**

Contact Number:

Tenure of Representation:

Current Address:

Previous Address:

- What are the changes that you have seen within some years with respect to flood and inundation during your tenure?
- Did you face the situation of inundation during your tenure?
- If yes, did you find any reason for the inundation?
- How did you respond to address the causes?
- What are the challenges that you faced during your disaster management/reduction?
- What are the preparation plan you have developed during your tenure?
- What are the changes that you have found due to the inundation, mostly migration and agriculture?
- Did you develop any infrastructure development program in your area? Did you consider on EIA?
- Have you found any link between infrastructure development and disaster?
- If yes, please provide example.
- In your view point how should the local government respond?
- Optional: Do you find any relation of irrigation and its drainage system on flood and inundation?
-

**Appendix 'C'**

(Refer to Page No.15)

**INTERVIEW QUESTIONS TO CDO OFFICER**

Tenure :

Current Address:

Previous Address:

- Do you have any experience of flooding and inundation in Rautahat during your job tenure?
- What was the disaster management strategy adopted?
- How was the disaster management /response handled?
- What was the role of national/provincial government during the disaster management?
- What are the challenges you have faced to manage the inundation?
- What are the strategy adopted by your office for the river management in your area?
- Has there been any research regarding the yearly inundation in your area?
- If yes, what has been the cause of such inundation? / In your view, what was the cause of such inundation?
- What are the mitigating measures adopted by your office?
- What should be done to mitigate the threat of inundation in the future?
- Have you found any link between infrastructure development and disaster?
- If yes, please provide example.
- In your view point how should the government respond?
- There are some major development works, i.e. Railway, Highway, Irrigation, Dam (in India Border), has there been any link to the inundation? If yes, what should have been done differently.
- Optional: Do you find any relation of irrigation and its drainage system on flood and inundation?

**Appendix 'D'**

(Refer to Page No.15)

**INTERVIEW QUESTIONS TO ENVIRONMENTALIST**

Position Held:

Office:

Contact No:

Current Address:

Previous Address:

- What has been your major point and issue that you have found regarding the inundation in the area?
- Can you provide an example by linking your view point with the inundation?
- What has been the role of government and different stakeholder with regard to your view point?
- What should have been done differently?
- What are the activities that you have conducted so far?
- Has there been change due to such activities? if yes, elaborate
- What has been the status of infrastructure development in your area?
- Have you found any link between infrastructure development and disaster?
- If yes, please provide example.
- Among the various development projects, which has been a main reason for the inundation? In your view.
- Do you find any challenges that you have identified but government has not been able to see?
- Optional: Do you find any relation of irrigation and its drainage system on flood and inundation?

**Appendix 'E'**

(Refer to Page No.15)

**INTERVIEW QUESTIONS TO DEVELOPMENT PARTNERS**

Contact Number:

Office:

Position:

Current Address:

- What is your involvement in the development works?
- Can you elaborate the development planning and how it is implemented? Both local and national?
- In what kind of project EIA is need or does not need?
- Did you conduct EIA? And has your development projects in compliance with EIA?
- If no, what are the challenges that you have faced in implementing the EIA?
- While developing a plan, does the threat of disaster in future is taken as a consideration?
- Have you found any link between infrastructure development and disaster?
- If yes, please provide example.
- In your view, has there been any development projects that has been the major reason for the inundation and flooding at Rautahat?
- How could be it better managed?
  - Railway
  - Irrigation
  - Dam
  - Road

**Appendix 'F'**

(Refer to Page No.15)

**INTERVIEW QUESTIONS TO SECURITY FORCES**

Rank:

Position:

Organization:

Current Address:

Previous Address:

- In your tenure have you found any cases of inundation? If yes please elaborate
- Have you been briefed about the previous inundation and disaster management plan for your AOR? If yes, please elaborate
- What are the causes of inundation in your AOR?
- Have you ever been participated in flood management? Any other experience (district)
- In your view point, what are the difference between previous experience and the experience at Rautahat?
- Is there any limitations to the current disaster management plan and preparedness? (Co-ordination/resource (human and economic, technical), participation)
- Did you conduct any preparedness plan along with the community participation recently? if yes, provide example of some
- Has there been any challenges during the disaster management and preparedness? Only to commander who have seen inundation.

**Appendix 'G'**

(Refer to Page No.15)

**PHOTOGRAPHS DURING FIELD SURVEY**

Researcher with the KII (Ward Chairperson of Ishanath Municipality Ward No. 1)

**Appendix 'H'**

(Refer to Page No.20 )

**IMPACT OF BAGMATI RIVER FLOODING IN 1993**

District loss	Affected		Death	Houses damaged		Land loss (Area)	Livestock loss	Infrastructures					Food grain loss	Total Worth (NRs)
	HH	Pn		C	P			R	B	D	Bu	Pu		
Bhaktapur Kathmandu	10	58*	2	8	0	3	159	0	0	0	0	0	0	867,274,750
Lalitpur	0	0	6	57	51	135	0	0	1	0	1	0	0	**
<b>Makwanpur</b>	14,748	101,482	242	1,732	1,879	4,656	665	7.92	16	1	251	118		119,864,381
Kavre	2,958	10,642	20	914	92	1,030	159	0	0	0	0	0	0	86,274,750
Sindhuli	11,051	59,142	52	1,206	1,314	4,061	1,930	26	41	5	6	24	1,186	86,349,764
<b>Rautahat</b>	14,644	89,146	111	2,003	4,541	1,366	3,211	40	13	0	1	37	31,673	899,680,261
Sarlahi	15,560	83,265	687	7,066	8,494	25,966	17,736	266	81	4	117	184	0	1,118,918,500

Source: (Shrestha A. , 2008)

\*HH= Household, Pn= Population; C=Completely, P=Partially, R= Raod, B=Bridge, D=Dam, Bu=Building; Pu= Public

## Appendix 'I'

(Refer to Page No.27)

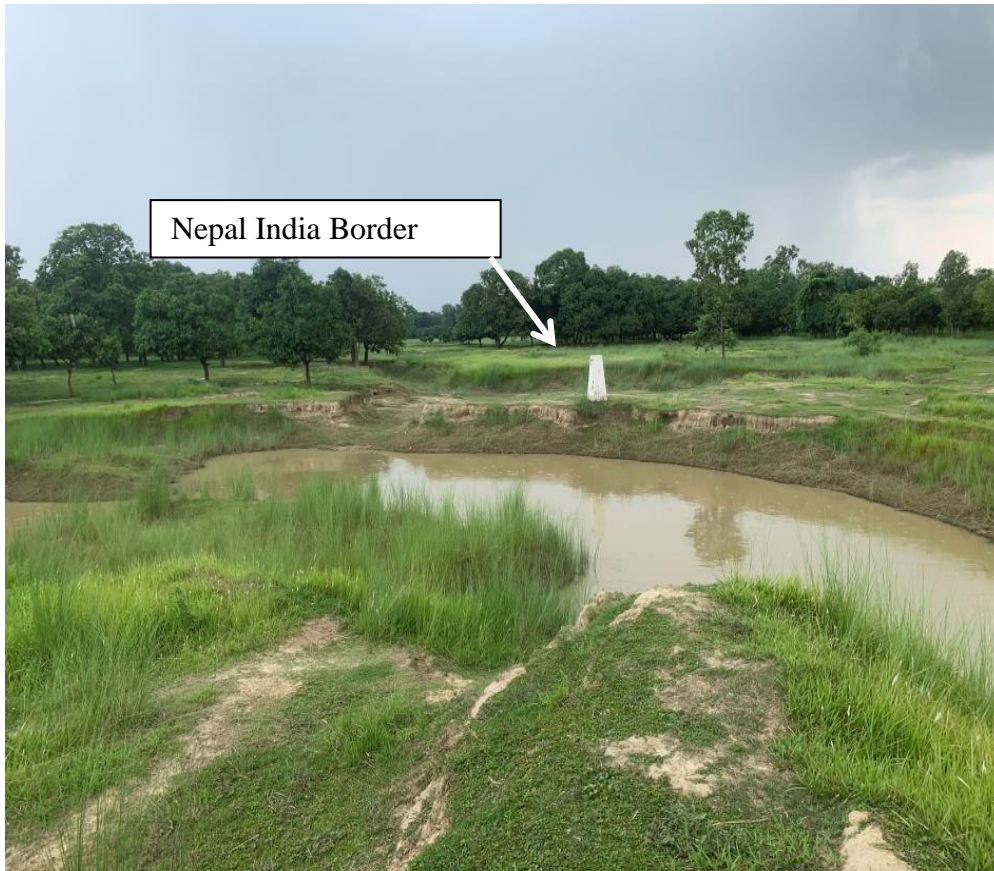
## POPULATION IN FLOODING AFFECTED AREA

Municipality and Ward No.			Population	
	Household	Total	Male	Female
<b>Chandrapur Municipality</b>				
8	1,622	8,566	4,294	4,272
<b>Dewahi Gonahi Municipality</b>				
1	547	3,713	1,852	1,861
2	523	3,834	1,940	1,894
3	566	3,869	1,983	1,886
4	432	3,057	1,568	1,489
5	481	3,230	1,687	1,543
6	640	4,333	2,254	2,079
<b>Total</b>	<b>3189</b>	<b>22,036</b>	<b>11,284</b>	<b>10,752</b>
<b>Ishanath Municipality</b>				
1	410	2998	1550	1448
2	871	5696	2991	2705
3	777	5136	2639	2497
9	658	4340	2149	2191
<b>Total</b>	<b>2716</b>	<b>18170</b>	<b>9329</b>	<b>8841</b>
<b>Gaur Municipality</b>				
1	594	3,950	2,013	1,937
2	554	3,552	1,914	1,638
3	619	4,056	2,116	1,940
4	708	5,028	2,693	2,335
5	871	5,165	2,653	2,512
6	703	4,854	2,540	2,314
7	346	2,572	1,340	1,232
8	374	2,346	1,242	1,104
9	866	3,414	1,779	1,635

<b>Total</b>		<b>5635</b>	<b>34,937</b>	<b>18,290</b>	<b>16,647</b>
<b>Paroha Municipality</b>					
	2	508	3,253	1,609	1,644
	3	870	5,586	2,878	2,708
	4	630	4,837	2,487	2,350
	5	513	3,705	1,892	1,813
	6	583	4,028	2,135	1,893
<b>Total</b>			<b>21,409</b>	<b>11,001</b>	<b>10,408</b>
<b>Phatuwa Bijayapur Municipality</b>					
	1	573	3,742	1,950	1,792
	2	493	3,659	1,875	1,784
	7	317	2,026	1,003	1,023
	8	547	3,244	1,651	1,593
	9	441	2,684	1,343	1,341
<b>Total</b>		<b>2371</b>	<b>15,355</b>	<b>7,822</b>	<b>7,533</b>
<b>Rajpur Municipality</b>					
	1	880	6,300	3,291	3,009
	2	746	4,605	2,063	2,542
	3	747	5,407	2,707	2,700
	7	483	3,684	1,848	1,836
	8	446	3,502	1,742	1,760
	9	624	5,098	2,560	2,538
<b>Total</b>		<b>3926</b>	<b>28,596</b>	<b>14,211</b>	<b>14,385</b>
<b>Yamunamai Gaunpalika</b>					
	1	664	4,225	2,146	2,079
	2	466	3,436	1,768	1,668
	3	877	5,803	2,901	2,902
	4	1,287	7,450	3,878	3,572
	5	482	2,970	1,518	1,452
<b>Total</b>		<b>3776</b>	<b>23,884</b>	<b>12,211</b>	<b>11,673</b>
<b>Grand Total</b>		<b>20519</b>	<b>154783</b>	<b>79113</b>	<b>75670</b>

**Appendix 'J'**

(Refer to Page No.34)



Source: Field visit, 2022

**Appendix 'K'**

(Refer to Page No.35)

*Culverts of Railway track*

**Source:** Field visit, 2022

**Appendix 'L'**

(Refer to Page No.36 and 43)

*Security personnel monitoring the area where the spar was damaged and repaired on July 02, 2021*



Source: Jha, 2021

*Houses of Rautahat District during the inundation*



Source: Jha, 2021

**Appendix 'M'**

(Refer to Page No.46)

**PHOTOGRAPHS OF SANDBAGS**



Indian side Preparation



Nepalese side Preparation

**Appendix 'N'**

(Refer to Page No.47)

*APF Bn Inundation during 2017*

Source: The Himalayan Times, 2017