TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

PULCHOWK CAMPUS

DEPARTMENT OF ARCHITECTURE AND URBAN PLANNING

MSC PROGRAM IN URBAN PLANNING

THESIS NO: 076/MSUrP/006

URBAN DEVELOPMENT IN RIVERSIDE CORRIDOR: A FLOOD HAZARD PERSPECTIVE

BY

MANISH KARMACHARYA

A THESIS REPORT

SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE AND URBAN PLANNING IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE IN MASTER OF SCIENCE IN URBAN PLANNING

SEPTEMBER, 2022

DECLARATION

I declare that this thesis has not been previously accepted in substance for any degree and is not being concurrently submitted in candidature for any degree. I state this dissertation is the result of my own independent work/ investigation, except where otherwise stated. I. hereby, give consent for my dissertation, if accepted, to be available for photocopying and understand that any reference to or quotation from my thesis will receive an acknowledgement.

_____

Manish Karmacharya

076msurp006.manish@pcampus.edu.np

Date: September, 2022

COPYRIGHT

……..

Head
Department of Architecture and Urban Planning
Pulchowk Campus, Institute of Engineering
Lalitpur, Nepal

ABSTRACTS

River corridors encompass an area around and adjacent to the present channel where fluvial erosion, channel evolution, and down-valley meander migration are most likely to occur. These areas used to have a great deal of damage occurring during flooding. These river corridors are always vulnerable to flooding during the monsoon and have a risk to the infrastructures near them. Thus, there is an ultimate need for river corridor management. This type of management merely depends upon the river geography, surficial geology, valley shape, and slope of the river flow. In addition, these river plains are always the target for various human encroachment. so these river corridors need to be properly maintained considering all the landscapes and infrastructures around them to minimize the risk and damage caused by the rivers.

This research is mainly carried out to demark the flooding plain across the riverside corridor of the Hanumante River and the possible development of the urban settlement across it. Urban development across riverside has been in haphazard development with the increase in the flooding status over the past few years. Hanumante riverside basin remains always the spotlight for the flooding situation and its major effects are on the residential zone across the riverside.

But for this research, only the stretch across the Radhe Radhe area to the Hanumante Bridge of Naya Thimi is selected with a total length of around 3km in length. This area includes the most flooded region of the Hanumante plains i.e Radhe Radhe area. This area encompasses the Bhaktapur, Madhyapur, and Suryabinayak Municipalities.

The research was conducted with the purpose to identify the current situation of the riverside corridor after the commissioning of the corridor projects to have the development of the nearby settlement with the possible reduction of the flooding hazards.

ACKNOWLEDGEMENT

This work of research has become possible only because of the help and cooperation of numerous people and institutions without whose support I couldn't complete my work in a meaningful way. Firstly, I would like to thank my thesis supervisor Prof. Dr. Sanjay Uprety for his guidance, encouragement, cooperation, productive comments, and beneficial suggestions throughout the work. His valuable time, suggestions, and feedback have been motivating factors for me. A special thanks and appreciation to all the jury members in the different presentations who guided me to accomplish this research. I would like to express my sincere gratitude and appreciation to the external examiners for their constructive comments, valuable articles, and encouragement as the jury members from the proposal presented to the final presentation of this thesis work.

The entire department of Architecture and Urban Planning, Pulchowk Campus, the coordinator of the department of Urban Planning Mr. Ajay Chandra Lal, and the head of the department of Architecture and Urban Planning Prof. Dr. Sudha Shrestha appreciated the valuable guidance throughout the research. I am thankful to Asso. Prof. Dr. Inu Pradhan-Salike for her valuable suggestions and guidance.

I would also like to thank Er. Sadichananda Pokhrel, Department of Urban Development and Building Construction (HPCIDBC) for providing necessary data and photographs, and Madhyapur Thimi Municipality for supporting me with necessary data during my thesis work. I would like to thank M.Sc. Urban Planning 2076 batch for their moral support, sincere cooperation, and generous assistance for this work. Finally, my love and thanks go to my family and supportive friends for providing a tremendous source of morale and strength to produce the best out of me.

Manish Karmacharya

076/MSUrP/006

ACRONYMS

A.D./(AD) Anno Domini

B.S./(BS) Bikram Sambat

BAP Bagmati Action Plan

CBS Central Bureau of Statistics

DUDBC Department of Urban Development and Building Construction

HPCIDBC High Powered Committee for Integrated Development of Bagmati Civilization

ICIMOD International Centre for Integrated Mountain Development

RCUP River Centric Urban Planing Guidelines

RRZs River Regulations Zones

NDCZ No development and Construction zone

DOTM Department of Transport Managemen

KVTDC Kathmandu Valley Town Development Committee

TDC Town Development Committee

LIST OF TABLE

LIST OF FIGURES

TABLE OF CONTENTS

1. CHAPTER I: INTRODUCTION

1.1. BACKGROUND

Every Human settlement and civilization emerges and develops near the origins of the riverside. Those riversides were suitable locations due to the easy availability of drinking water and irrigation purpose for agriculture. The most notable examples are the Ancient Egyptians, who were based on the Nile, the Mesopotamians in the Fertile Crescent on the Tigris/Euphrates Rivers, the Ancient Chinese on the Yellow River, and Ancient India on the Indus. These early civilizations began during the time of the Neolithic Revolution (12000 BCE)(Commission et al., 1998). These river civilizations play a significant role in the development of the human race.

River corridors encompass an area around and adjacent to the present channel where fluvial erosion, channel evolution, and down-valley meander migration are most likely to occur. These areas used to have a great deal of damage occurring during flooding. River Corridor as defined in Vermont statute "River Corridor" means the land area adjacent to a river that is required to accommodate the dimensions, slope, planform, and buffer of the naturally stable channel and that is necessary for the natural maintenance or natural restoration of a dynamic equilibrium condition(Government, 2016). These river corridors are always vulnerable to flooding during the monsoon and have a risk to the infrastructures near them. Thus, there is an ultimate need for river corridor management. This type of management merely depends upon the river geography, surficial geology, valley shape, and slope of the river flow. Also, these river plains are always the target for various human encroachment.so these river corridors needs to be properly maintained considering all the landscapes and infrastructures around them to minimize the risk and damage caused by the rivers.

Flood hazard areas are those areas of the floodplain that may be inundated by a range of flood frequencies up to and including the one percent annual chance of flood (i.e. base flood). Due to rapidly growing settlements and a growing number of infrastructures, the risk of urban flooding is high during the monsoon period. The flooding scenario is changing due to the urbanization trend and the growing number of settlements due to the increase in population in urban areas.

Urban flooding is also a major issue to be dealt with near the riverside corridor as most of the rainwater that doesn’t make its way to flow into the river through drainage channels gets accumulated and causes flooding scenarios. Urban flooding is a significant and evolving development concern. Urban regions are experiencing an increase in flood dangers, particularly for residents of developing country cities and towns that are expanding quickly. Urban flooding is a significant obstacle to growth and the quality of life for many people, especially those who live in fast-growing cities and towns in emerging nations(Subrina & Chowdhury, 2018).Urbanization, haphazard construction along flood plains and agricultural land fragmentation are three major human activities that have an impact on the hydrologic processes as well as the land use pattern. Increased flood flow results from this change in land usage. Without adequate spatial planning and strong rules governing land use, infrastructure and population become centralized in low-lying,

flood-prone areas that were formerly unoccupied or used as agricultural fields. This causes floods to occur, which have a severe impact on metropolitan areas. Aging drainage infrastructures, increased pavement, and other impermeable surfaces, and a lack of measures to reduce flood risk are all factors contributing to these impacts.

The urban fabric in the old Newari communities is a special combination all its own. The Kathmandu Valley's traditional settlements have not been affected by flooding since they were located on the high ground and low ground which are frequently floodplains and are ideally suited for agriculturally productive terraces and river plains(Sada, 2012). As a result, even during the monsoon rains, the human population was spared from the flooding and the agricultural fields received the water they needed to grow crops. Up to the time when planning was completed in the late 1990s, this conventional planning was maintained. However, the low-lying tala areas, which are also where residential areas are being developed, can be seen in the current setting. Recent decades have seen a change in the circumstances. With rising demand and population, the agricultural hinterland is becoming developed.

1.2. NEED AND IMPORTANCE OF THE RESEARCH

Various part of the Kathmandu valley is facing urbanization-related problems and mainly riverside areas are facing problems related to this unmanaged urbanization. These corridors are of vital importance for the preservation of biodiversity and to promote urban growth. As urban areas are formed through the different conversion of agricultural land to other landuse forms which should be carried out in well planned and well-managed manner. Further, the impact of urbanization brings the rivers pollutions and various land and settlement-related issues to the highlight.

The development of the river corridors can also bring many changes both positive and negative aspects. From the view from the surface, it merely brings many benefits to the surroundings like control of river flooding, easy connectivity of the roads to minimize traffic congestion, urban growth, etc. However, it has also some negative aspects too like haphazard development of the urban space and settlements, unmanaged sewerage and drainage mixed to the sources of the river if not managed accordingly, rapid change of the agricultural lands to the mixed residential and commercial usage, changes in the settlement pattern.

With the absence of control over the valley's urbanization growth pattern and land-use change, concerns linked to river corridor management are becoming increasingly prevalent. The Bagmati river corridor's land use is defined in the Kathmandu Valley's Building Bye-laws, although the reality is far from expected. On the banks of the river corridor, the development of apartment complexes and residential neighborhoods has transformed the former land use, which was typically utilized for agriculture. The eviction was proposed as part of a project by the High Powered Committee for Integrated Development of Bagmati Civilization(HPCIDBC) to lay sewer pipes along the Bagmati river corridor. River pollution is also a major issue in it.

This Riverside corridor of the Hanumante river has religious and cultural significance in society. authorities. These types of corridor projects need to focus on the proper reduction of flood hazards, proper disposal of solid waste management, proper sewerage lines, and various infrastructures. Also, the various impacts on land use and the land value nearby the river corridors are needed to be studied well.

1.3. SCOPE OF THE RESEARCH

The scope of the research is to study the development pattern along the riverside corridor mainly focusing on the making of the new development settlement pattern flood resilient. This research also covers the various flood hazard analysis, landuse pattern analyses, and various other issues related to the development of the corridor as well as the settlement nearby it.

1.4. PROBLEM STATEMENT

The river corridor concept considers the complete terrain corridor that the river passes through. Rapid urbanization has resulted from unregulated migration and rapid population increase, altering the landscape in the Kathmandu valley through settlement patterns and geographical distribution. The city's unplanned development has resulted in the disruption and degradation of the city's river corridors. The city's river corridors, which run through the core of the metropolis, are rapidly dwindling. The rivers of the Kathmandu valley have become a receptacle for both solid and liquid pollution, damaging the river ecosystem and harming the surrounding urban environment. The rivers' poor condition rendered them unusable for recreational, household, industrial, or agricultural reasons, and there are few socio-cultural activities visible.

The growth of towns on the flood plains of the River corridor has resulted in flooding of these places, which hurts the people who live there. The sand extraction from the river has increased the river's depth, lowering the groundwater level along the river corridor. The River corridor's incursion has changed the riverscape, leaving it devoid of natural character and with few or no aquatic life, flora, and animals. Urban flooding has always been a serious and growing challenge due to population growth, urbanization trends, and climate changes resulting in unprecedented floods and the subsequent shifting of RiverSource.

Urban flood risk has come to light as a result of recent flooding in cities. Rapid urbanization and shifting land-use patterns over the past few decades have led to a loss of floodplain storage and an increase in surface runoff. Urban pluvial flooding is caused by extreme rainfall events, which are anticipated to become more frequent and intense as a result of global warming. In addition, because of anticipated wetter and warmer winters with less snow and more rain, the risk of pluvial floods is set to rise even higher. This would certainly cause the risk of urban pluvial floods to rise dramatically along with urbanization and population growth. Due to a subpar water and sewerage management system with a subpar drainage and sewerage system that has neither been updated

nor is sufficient in the current situation, flooding has grown more common during periods of heavy rain. Urbanization and climate change have a significant impact on flooding and water quality. It is difficult to predict which will in the future pose the highest risk of urban pluvial flooding.

The minimum setback from the edge of the rivers was mandated by building bylaws, which contributed to the change in land use in the area. This river corridor's near-edge areas used to be agricultural areas but due to urban growth pressures the city was built on the river's flood plains. The river corridor has its issues due to shifting land-use patterns. The water flow has been restricted by the erection of stone walls along the river's banks. In most situations, the river corridor is constrained by the setback area, and the corridor is visibly diminishing.

The many plans and programs that have been implemented have failed to produce the anticipated results, resulting in a slew of issues and the degradation of the Bagmati river corridor's ecology. The challenge that will be investigated is the implementation and management of the Bagmati River corridor for reintegration into the urban environment. For the conservation and development of Kathmandu Valley's natural heritage, it is critical to address challenges as soon as possible. The research is focused to generate information about the planning practices that are being done on the Hanumante River corridor.

1.5. RESEARCH QUESTIONS

The research intends to get the answers to the following research questions.

- How do the flood and flood-related issues impact the daily lifestyle of the people nearby the riverside?
- What can be the flooding impact have in the next coming decades?
- What can be the new perspective for urban development nearby the riverside?
- How can nearby settlements be made flood resilient?

1.6. RESEARCH PURPOSE

Therefore this study focuses on the following objectives;

Main Objectives:

- To identify and map the flooding zone stretch(From Radhe Radhe to Naya Thimi section) along the Hanumante riverside corridor and its potential impact on the settlement near it.

Specific Objectives:

- To perform the hazard assessment of the flood-related issues in the urban settlement.

- To study urban development scope along the Riverside Corridor.
- To study the physical vulnerability of the settlement

1.7. LIMITATIONS OF THE RESEARCH

This study is limited to the hazard analysis of only the flood and flood-related issues alongside the river corridor. This study covers pocket settlement analysis of the flooding zone across the riverside corridor with only 3 pocket spaces in number. This study is also limited to the policy reviews related to the new development of the settlement according to the National building code, Municipal bylaws, and setbacks related to it.

1.8. VALIDITY OF THE RESEARCH

Although various studies have been carried out across the corridors of Bagmati and its tributaries with the mindset of attaining the desired output, there has been no research on the new urban development of the riverside corridor through the hazard analysis of the flooding. The mapping of the flooding zone is carried out as a whole to interpret the flooding status in coming decades but it doesn't bring a clear picture of the flooding in the specific section of the corridor as flooding impact varies across the riverside. So, this research will specifically study the major flooding zone across the riverside to get a specific flooding impact study. Various groups, government line agencies, and the local community can provide suggestions and validate the urban river corridor's current concerns. The Study could lead to a new understanding of the subject at hand.

1.9. CONCEPTUAL FRAMEWORK

Research Paradigm:

A paradigm is a distinct set of concepts or thought patterns, including theories, research methods, postulates, and standards for what constitutes legitimate contributions to a field(*Paradigm - Wikipedia*, n.d.). Each research has its own ontological, epistemology, and methodology. According to TerreBlanche and Durrheim (1999), a research paradigm is an all-encompassing system of interrelated practice and thinking that defines the nature of inquiry along these three dimensions (Research Methodology and Design). The paradigm is the initial step in the research process, and it has an impact on how knowledge is investigated and perceived.

The ontological position of the research is about the urban development through riverside corridor development lies in the interpretive paradigm. The understanding of knowledge can be attributed in part to being in the possession of people and at the same time a result of social interactions(Jonker & Pennink, 2010). The research will seek the various involved stakeholders that are needed to be considered in it. The qualitative research approach would be suitable for the research to gain an understanding of reasons, opinions, and motivations. This qualitative research

method involves the utilization of a diverse range of data in form of printed words, audio, images, etc from different media sources.

The interpretive approach will be adopted for the research of this nature of the problem to develop an understanding of the new development of the Hanumante corridor. The key to the synthesis of the information directing the research will be the analysis and interpretation of the viewpoints of numerous stakeholders, government agencies, and respondents. Various programs are being conducted within urban river corridors that are seen separately from the urban context, and as a result, these programs are failing to achieve the anticipated results. This is the research's main problem.

Epistemology can be described as the philosophy of knowledge, especially concerning its methods, validity, nature, sources, limits, and scope(Jonker & Pennink, 2010). The case study on-site, interactive engagement of stakeholders, focused group discussion with multiple stakeholders, on-site observation, and reference to secondary sources of data are the framework of the epistemology for the research, which is based on the interpretive paradigm. Various literature studies, policy documents and reports, the Kathmandu valley land use plan, and aerial pictures and maps of the research region serve as secondary data sources. The review of the policy documents and plans relating to the urban river corridor and water resource management will synthesize the understanding of the problem.

Deductive reasoning is a logical approach where you progress from general ideas to specific conclusions. It's often contrasted with inductive reasoning, where you start with specific observations and form general conclusions(Bhandari, 2022). To examine hypotheses and theories, the deduction method is utilized. Deductive reasoning is based on top-down logic, with a single result drawn at the end, whereas research based on the interpretive paradigm is unable to reach a single conclusion. The study is based on pattern observations, generalization, and inductive reasoning to deduce an explanation or theory about the issues of managing the urban river corridor.

Abductive reasoning is the logical process where one chooses a hypothesis that would best fit the given facts(Lee, n.d.). The abduction concept is used in this study with observation on the site and interpretation of the respondents' explanations to get a conclusion. Maps, images, site visits, and observations will be used to interpret the changes in land usage. The research's reliability and validity can be determined by related literature studies, site visits, documentation, and long-term observations.

As the research is based on the interpretive paradigm it cannot brings out a single conclusion. The research is based on the observations of the pattern, constructing the generalization, and inferring an explanation or theory based on Inductive thinking, relating to the challenges for the management of the urban river corridor**.**

1.10 RESEARCH METHODOLOGY

In this study, verbal and written descriptions of tangible things and observable behaviors are used to create a qualitative descriptive approach. This study uses naturalistic and observational research approaches to describe the pattern of development of riverbank communities. Phenomenology is utilized to disclose phenomena based on field observations and data. Phenomenology is an interpretive study of human experience, aimed at understanding and explaining human situations, events, and experiences "as things that arise and are present every day".(Eckartsberg, 1963)

In a qualitative research strategy, there is a holistic approach for a systematic, encompassing, integrated overview, the study is done through intense and prolonged fieldwork, knowledge gain is open-ended, narrative descriptions of analysis are given and data is collected involving people.. Likewise, various theoretical studies will also need to be followed. This is a descriptive study followed by a combined approach of ontological basis and epistemological basis. For the ontological part, site observation, perception generated, and interaction with the people would be a necessary parts.

The study's execution included several strategies and stages of the research process, including preparatory techniques, data gathering methods, methods for presenting and processing the data, techniques for editing and digitizing maps and objects, and procedures for data analysis.

The steps of this activity are designed to collect the necessary data, conduct the analysis, and ultimately produce the desired outputs in line with the goals of the research. Thus, the following activities will be involved in carrying out the research:

- **Literature Review**: It includes the study of the past thesis, research papers, and materials related to the topic to gain knowledge about it. It is an exploratory process that will provide background, theories, policy, main issues, and challenges, among other things. For the various technical issues regarding the flooding nearby, the riverside one needs to review the various reports and articles related to the subject like impact assessment, various arguments, and solutions to the problems regarding it. Also, flood management nearby the riverside using the geospatial technique is the major issue to be studied. The various guidelines related to disaster management and strategies by the national disaster risk reduction and management Authority related to it are needed to be reviewed and properly studied. A literature review will be conducted on case studies of various national and international cities to learn how these issues have been addressed in those cities. Only the most reliable literature will be reviewed.
- **Data Collection**: It includes the collection of the primary and secondary data
    - ✓ **Primary Data** includes field investigation, Visual survey, and observation for analyzing the existing situation of the area(Visual assessment), various interviews of key informants, officials, and general persons through questionnaire surveys

- ✓ `**Secondary Data** includes various aerial photographs from past to present, base maps, google images, reports, literature, and various past research works.

- **Data Analysis**: The collected data from different primary and secondary sources are processed and analyzed within the objective framework to get a logical conclusion. Programs like Excel, Autocad, and SPSS can be used.
- **Findings**: Analyzed data and results will be interpreted and generalized in various to address the research questions and the final output of the results are presented in graphs, maps, drawings, tables, etc. The data will be synthesized to give a conclusion as the main findings of the research.
- **Conclusions and Recommendation**: Interpreted conclusions are drawn based on calculated data and results and try to address all the research objectives. Recommendations for the problems will be made in the form of guidelines, policies, plans, and programs.
- **Further Research**: The other factors that this study doesn't cover and will need further research are recommended

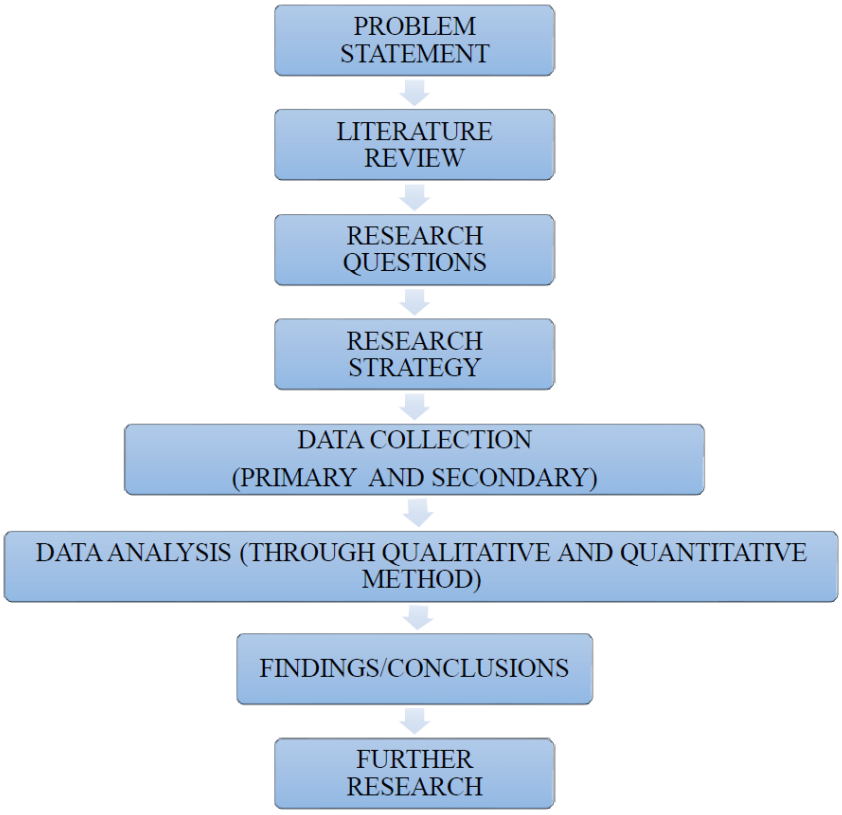


Figure 1 Research Methodology Chart

1.11 EXPECTED OUTCOMES

From this research, it is expected to point out the major reason for flooding in the riverside corridor, its possible impact on the new development of the settlement nearby it, and proper strategies & Impact assessments, and strategies for flood-resistant settlement development.

2. CHAPTER II: LITERATURE REVIEW

2.1 TREND OF URBANIZATION AND FLOODING SCENARIO

Urbanization is the process by which people migrate from rural to urban areas, promoting the expansion of cities and towns. It can also be described as the gradual rise in the population of towns and cities. It is heavily inspired by the idea that urban areas have outperformed rural ones in terms of economic, political, and social development. Since more and more individuals have a desire to move closer to towns and cities to obtain "privileged" social and economic services as well as benefits, urbanization is quite widespread in both developing and developed worlds.

Figure 3 Urban Flooding in City

Figure 2 Urban flooding in Kathmandu

Urbanization has emerged as a major global trend and a key phenomenon in all developing nations. Many factors contribute to the rapid population expansion in urban regions, but migration from rural areas and population growth are the main drivers.

In the case of Nepal, urbanization is a new thought. In Nepal, the number of urban centers expanded from 10 to 58 during the last five decades, from 1951 to 2001, while the urban population increased sixteen times as much. This rapid rate of urbanization has significantly altered the country's landscapes, creating significant land use changes in newly developing urban centers that hurt the environment and cause urban pluvial flooding.

Floods are natural disasters with the high-frequency occurrence and occur when an overflow of water submerges usually dry land (WHO, 2017). Flooding, a global phenomenon occurring most frequently among all-natural hazards causes major economic losses, devastation, and human life losses(Pandey & Dugar, 2019). Urban flooding is a significant and growing development concern, and people in quickly developing cities are particularly at risk. Expanding urban areas in developing nations. Rapid Urban development and urbanization have a higher likelihood of

flooding. The three elements Rapid population expansion, urbanization trends, and climate change are all contributing to an increase in the frequency and effects of floods.

The various causes of urban flooding are as follows;

- Meteorological Factors

    a. Unprecedented Rain

Due to an unprecedented amount of rainfall due to climatic conditions than a usual amount of rainfall flooding due to overflow in the drainage of the city. Due to clogged drainage, the rainwater causes flooding in the streets and the walkways.

    b. Influence of Microclimate

Microclimate plays a vital role in causing the changes in the rainfall pattern of the area. So due to the effects of this microclimate urban flooding occurs. Urban heat island effects are the major microclimatic effects causing the change in the climatic pattern to contribute eventually to urban flooding.

- Hydrological Factors

    a. Change in the River course

Due to the change in the river course due to the various geological and human-induced factors the river level might get discoursed and can induce urban flooding inside the settlements.

    b. Less Infiltration rate in the groundwater

The increase in the build-up space and the pavement areas with concrete, stone pavement, etc that prevents the infiltration of the water into the ground helps to flood the excess water from the rainfall and cause urban flooding.

- Human Induced

    a. Increase in the impermeable surfaces

Due to the increase in the build-up, the area in the settlements increases the impermeable surfaces which eventually restricts groundwater infiltration and results in urban flooding.

    b. Encroachment of floodplains and low-lying areas

Encroachment near the riverside plains by the squatter settlements makes the settlement vulnerable to flooding and those low-lying areas are always at risk of flooding scenarios.

c. Lack of Maintenance and Infrastructure and drainage channels

Lack of maintenance of the drainage in the settlement as well as public space brings the clogging of the excess rainfall and causes urban flooding.

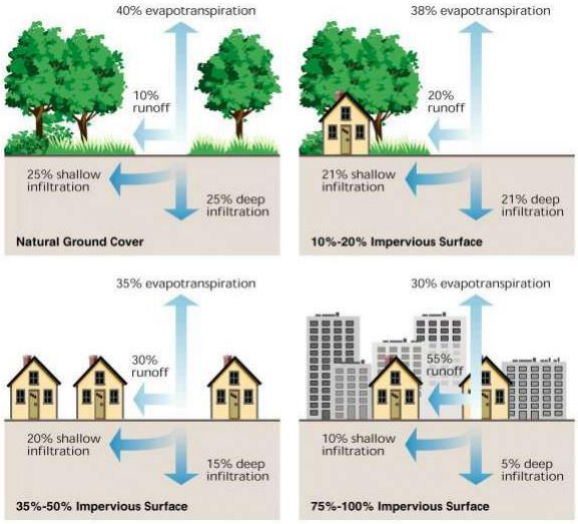


Figure 4 Effect of Impervious Surface on groundwater Infiltration

Urban flooding in the context of Nepal is a product of inadequate management of the urban drainage system and is strongly correlated with built-up areas and climate change. The major causes of the urban flooding in Kathmandu are as follows;

- Unprecedented Rainfall during Monsoon
- Encroachment of People towards River Corridor.
- Change in Land use Pattern.
- The insufficient size of the drainage
- Disturbing the natural pathway of the River.

The impact of flooding is from minor to severe levels depending upon the nature of the flood. The types of floods are as follows;

2.1.1. TYPES OF FLOOD

2.1.1.1. River or Fluvial Flood

When water levels exceed the tops of river banks, a flood occurs. Any river or stream channel could experience this flooding. Small streams and the biggest rivers in the world are included in this. Sudden river flooding events occur more often on smaller rivers, rivers with steep valleys, rivers that flow for much of their length over impermeable terrain, and normally dry channels(*What Is a Flood? | What Causes a Flood? | Flooding | Earth Networks*, n.d.). On the other hand, huge rivers with vast catchment areas are more likely to have low-rising river floods. A catchment area is any area of land where precipitation accumulates and drains off into a single outlet.

2.1.1.2. Pluvial or Surface Flood

Ponding is a form of flooding that can occur in largely level terrain. In most cases, rainwater that falls in a region is collected and stored underground, in canals or lakes, drained away, or pumped out. Flooding happens when there is more precipitation entering a water system than can be stored or removed from the system. In this instance, rain is what causes the flood; not water from a river, but water headed that way. Because of this, it is also known as a "pluvial flood."

2.1.1.3. Coastal Flood

A flood starts when waves move inland on an undefended coast or overtop or breach the coastal defense works like dunes and dikes(*Coastal Flooding*, 2008). The fact that the water level rises and falls in response to the tide is a key aspect of a coastal flood. The water could come in during high tide and go out again during low tide. Low tide is the best time to repair a breached sea defense.

2.1.1.4. Flash Flood

A flash flood occurs due to excessive rainfall and its runoff which causes a level up of a water surface. The rainwater that is collected on the slopes, flows downhill with gathering speed, and all the water accumulated in the river bed(*Flash Floods*, 2008). Due to this phenomenon water level rises at a fast pace and brings floods.

2.1.1.5. Urban Flooding

Urban flooding is distinct from other types of flooding because it results from poor drainage in urban areas. Nearly all of the precipitation must be transported to surface water or the sewage system because there is little open soil that may be used to store water. When the city's sewage system and drainage canals are unable to handle the amount of rain that is falling, high-intensity rainfall might result in floods. Water may even enter the sewage system in one location before being dumped on the streets of another city.

2.1.2 CAUSES OF THE FLOODING SCENARIO

There can be various causes of the flooding scenario mainly in the settlement areas due to urban flooding, riverside flooding, etc. Some of the major causes of it are as follows;

1. Topography (Slope & Elevations)

Flooding in low-lying places: In low-lying and flat terrains, pluvial floods rarely reach significant flood depths; instead, flood waters spread across wide areas, typically producing flood depths of tens of centimeters or less.

2. Unplanned Urbanization and Encroachment

The ever-increasing population has caused illicit landfilling and uncontrolled urban land development, which has caused the natural drainage pattern to vanish. It is a typical scene in the majority of the key city areas, which are spreading quickly and randomly. In metropolitan areas, encroachment along seasonal rivers and drains is widespread.

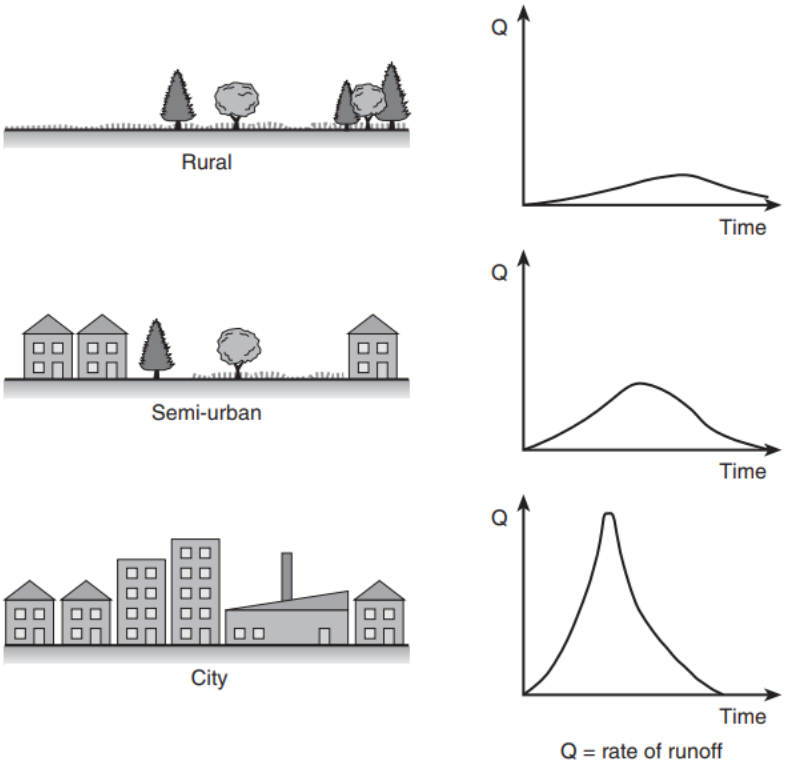


Figure 5 7Effects of urbanization on peak rate of runoff

Source: Urban Drainage book by David Butler and John W. Davis

3. The disappearance of the Natural Drainage system

Ponds, lakes, reservoirs, and canals make up the natural drainage system. The remaining canals and ponds rapidly get filled with foul-smelling water due to unplanned development and encroachment on natural water bodies (Sadia Subrina, 2018). In the natural world, when rainwater falls on a natural surface, part of the water evaporates or is transpired by plants, some seeps beneath

the surface and produces groundwater, and some runs off the surface as seen in Fig. 5. These processes are significantly impacted by the development of an urban area, which involves putting artificial surfaces on the ground. Artificial surfaces boost surface runoff in comparison to infiltration, increasing the overall volume of water reaching the river during or shortly after the storm. As a result, surface runoff moves more quickly on hard surfaces than on soft ones. This decreases infiltration, which in turn leads to a worse recharge of the groundwater and increases the risk of abrupt river flooding. In heavily populated places, surface runoff accounts for more than half of rainfall, and subsurface infiltration only accounts for a minor portion of the natural situation(Salike, 2017).

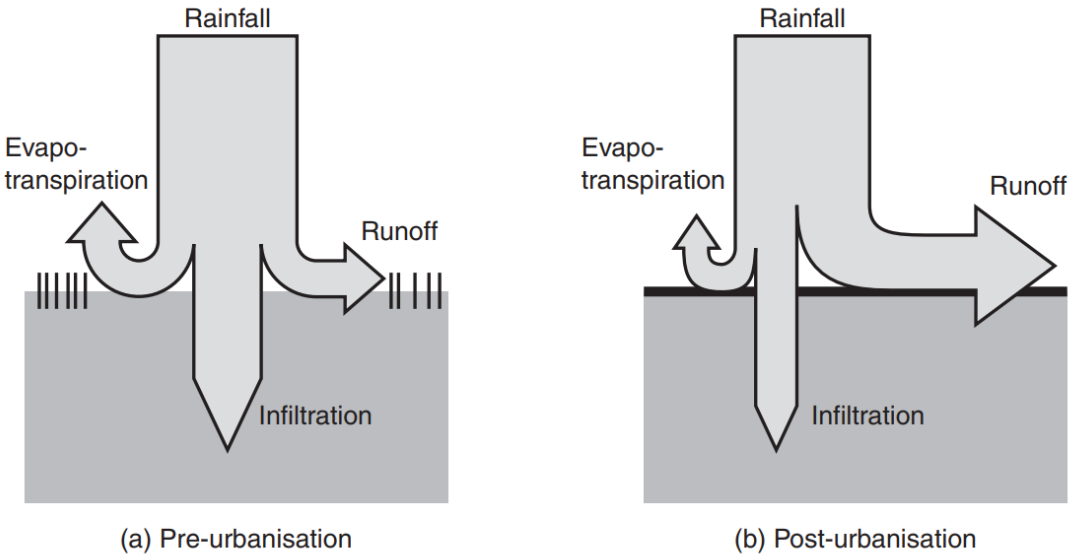


Figure 6 Effects of urbanization on the fate of rainfall

Source: Urban Drainage book by David Butler and John W. Davis

4. Loss of Drainage Capacity

The amount and rate of surface runoff have increased as a result of unplanned urbanization, significantly altering the drainage characteristics of natural catchments or drainage regions. Due to the careless dumping of solid wastes, drainage systems frequently have blockages and are unable to handle the increased amount of water.

5. Development below the flood plains: Construction in lowland areas and flood plains

The portion of a river's morphology known as the floodplain is particularly vulnerable to flooding in the event of an overbank spill caused by high-intensity surface runoff from rainstorms, collapsing reservoirs, or intentional discharge. The majority of early urbanism flourished along river valleys and floodplains.

Due to extensive socio-economic infrastructure development on these floodplains, floodplain encroachment has significantly raised the risk of flooding and the potential damage it can do, particularly in urban floods. In addition to other secondary effects like the depletion of water resources, cumulative impact on wetlands, and pollution of downstream surface waters, urban encroachment into floodplains alters the integration of surface runoff with the main channel, decreases the surface water holding capabilities, decreases the water quality (Burby et al., 2000). Due to a decrease in the floodplain's ability to attenuate floods, the practice of urban expansion on floodplains has also worsened the extension of internal flooding, making more regions of the urban built-up vulnerable to flooding(De Risi et al., 2020). Rising trends in urban floods are a result of the invasion of the floodplain. The issue is much more severe in emerging cities when there is weak institutional enforcement of floodplain rules and poor oversight of land use practices within floodplains.

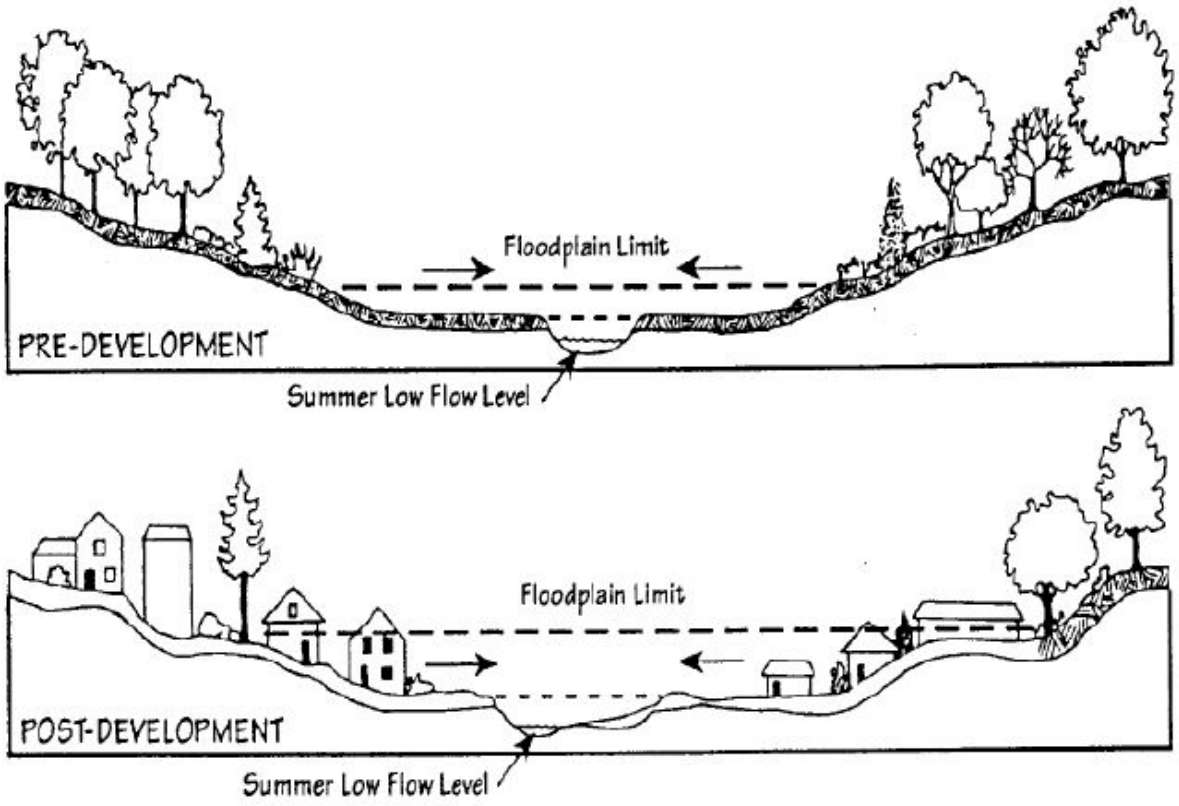


Figure 7 Change in Floodplain Elevations

Source: Urban Flood-Case Study of Bangalore, http://ces.iisc.ernet.in/energy

6. Impacts of climate change on Urban Floods

The phenomena of climate change are fueled by both natural and human activities. Climate change is the gradual alteration of the planet's or a region's typical weather patterns through time. Changes in temperature, precipitation, wind, storms, and other indicators are used to measure it. One of the biggest problems the world is currently facing is climate change. It refers to a shift in the global

atmosphere caused by human activity, either directly or indirectly, that is documented over comparable periods in addition to natural climate variability. Cities around the world are at risk from floods due to climate change, necessitating the development of effective, long-term protection measures. The impacts of climate change on several facets of human culture and the environment throughout the world are now quite obvious. Nepal has seen the effects of climate change in a variety of industries, including agriculture, forestry and biodiversity, water resources, and energy. Rapid rises in global surface temperatures and shifting precipitation patterns have had a direct impact on many industries and community livelihoods(CBS Nepal, 2022). When these rainstorms last longer, they flood streets, their floodplains, and rivers, frequently marooning the entire cityscape. The intensity of runoff is made worse by improper land-use planning in cities, which expands the amount of impermeable land. Urban flooding is also more likely due to inadequately planned stormwater drainage systems.

Nepal, which was placed 13th in the 2010 Global Climate Risk Index, is likewise extremely sensitive to the effects of climate change (Germanwatch 2010). The frequency, severity, spatial extent, length, and timing of extreme weather and climate events fluctuate due to a changing climate, and this can result in previously unheard-of extreme weather and climate events, according to the IPCC (2012, p. 5). Nepal is considered to be in an extremely vulnerable position to natural disasters due to its location in the Himalayas between China to the north and India to the south. Additional detrimental effects of climate change are likely to be seen by KV's climate-dependent disaster risk as well as general living circumstances. According to the regional climate model for the middle hills, rising temperatures and drier weather during non-monsoon seasons will make droughts and forest fires more likely, and agriculture would suffer significant difficulties.

The increase in rainfall intensity on small urban hydrology scales ranges from 10% to 60% from control periods in the recent past (usually 1961-1990) up to 2100, according to research on the global impacts of climate change on rainfall extremes and urban drainage. Rainfall of 20 mm to 50 mm per day exhibited an incremental tendency, while the intensity of extreme climate events in the study area showed an increasing trend. The study found that when the rainfall intensity of the baseline for 1968–2013 and time series RCP 4.5, 2040–2070 were compared, there would be an average rise of 12.73%, with a range of 15.58% to 9.89%(Bhatta & Pandey, 2020).

"Climate change and more severe weather are possible elements that could significantly hinder or impede sustainable urban growth in Nepal. Threats from climate change will most certainly make the numerous issues with urban development, such as the provision of suitable infrastructure and the provision of essential urban services, worse. Many different parts or resources make up the urban sector. These asset types include markets, public spaces, cultural heritage sites, informal settlements, urban drainage systems, urban roads, solid waste management facilities, and government buildings and housing. Threats from climate change such as extended periods of high temperatures, extreme rainfall events with high rainfall intensities, and high river flows with the possibility for flash flooding are the ones that have the most impact on urban assets(ICME International Centre Environmental Management with the DUDBC & MoSTE, 2014). It is important to assess pluvial flooding risk for future climate scenarios to increase cities' resilience to climate change(Salike, 2017).

Rainfall extremes are a further consequence of the changing climate's increased frequency and intensity of rainfall. The peak time will be further shortened by heavy rain over a brief period in an urbanized area with a high impermeability, overloading the drainage system and resulting in pluvial floods. The urban region will experience flooding in a variety of locations since more nodes will be affected by the increased flooding volume.

2.2.POPULATION GROWTH AND UNPLANNED DEVELOPMENT

Ever increasing population has led to unplanned urban land development and unauthorized landfilling that results in the disappearance of natural drainage patterns (Subrina & Chowdhury, 2018). According to national statistical authorities, the term "urban population" refers to those who live in urban regions. It is generated using urban ratios from the UN World Urbanization Prospects and population estimates from the World Bank. The number of people living in urban areas worldwide increased quickly from 751 million in 1950 to 4.2 billion in 2018(*World Population Prospects - Population Division - United Nations*, n.d.).

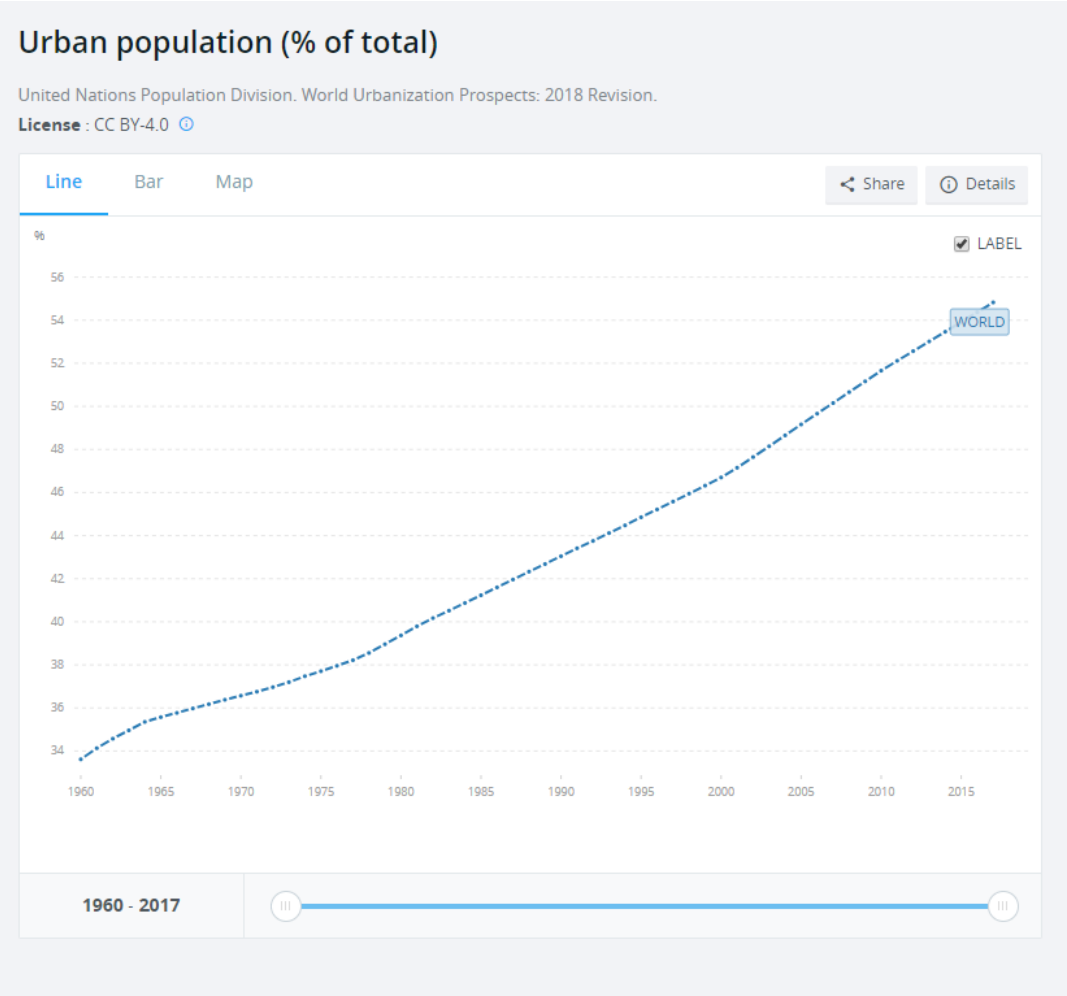


Figure 8 Urban Population(Source: The World Bank Data

But in the case of Nepal, the concept of urbanization is not relatively old. However, there has been a low level of urbanization at a high pace. In the country, only 3.7 % of the population lived in urban areas in 1961 A.D. and this has increased to 17.1% and 37% from 2011 to 2016 based on the census of 2011 A.D(Salike, 2017).

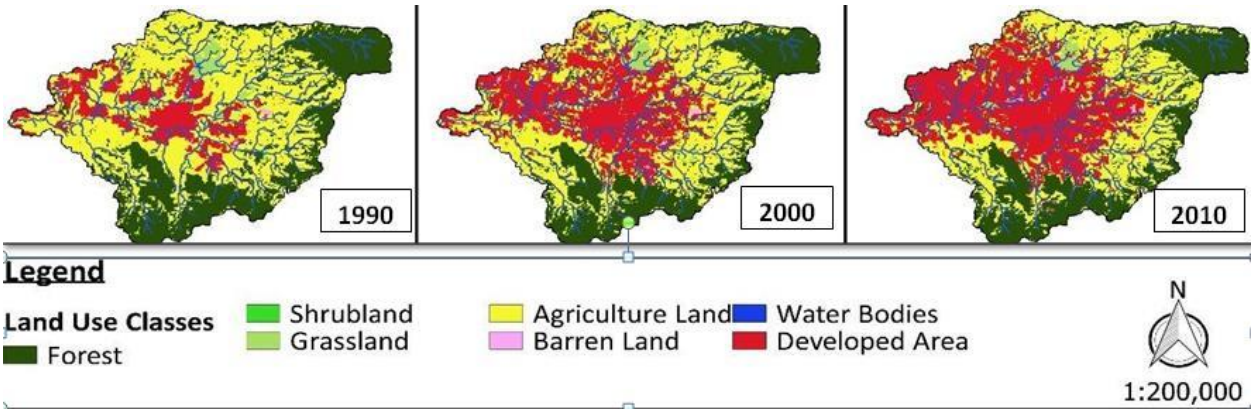


Figure 9 Changing of Land Use along the Hanumante River Basin

Source: *Bagmati River Basin Improvement Project Office, 2019*

Kathmandu valley is the most populated region and one of the fastest-growing urban agglomerations. Due to this the urban population of Kathmandu is increasing at a fast pace. As per the recent initial report of the census 2078 BS, the urban population of Kathmandu is at 66.08%. This increase in urbanization brings an increased number of the built-up area which increases the risk of flooding across Riverside.

The ever-increasing population has resulted in illicit landfilling and uncontrolled urban land development, which have caused the natural drainage pattern to disappear. It is a typical scene in the majority of the key city areas, which are spreading quickly and randomly. In metropolitan areas, encroachment along seasonal rivers and drains is widespread.

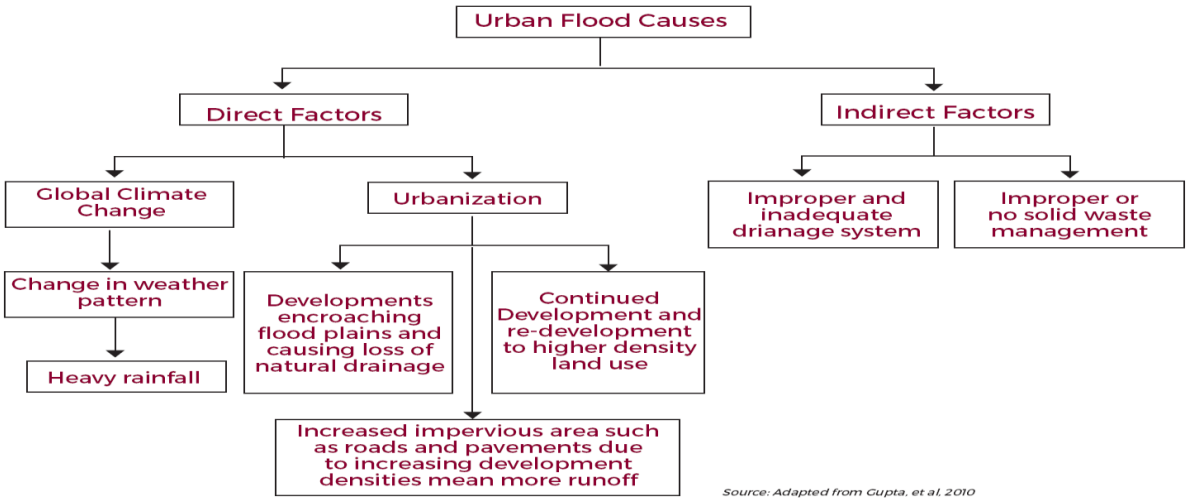


Figure 10 Causes of Urban Flooding in Urban Areas (Source: - Urban Flooding,2016,September)

2.3.PATTERNS OF SETTLEMENT NEAR RIVERBANKS

One of the crucial factors that should be taken into account while designing and building cities is the riverbank environment. The spatial organization, the network of connections between spatial components that are obvious and responsive to human needs, and cultural, historical, and regional environmental factors all influence the distribution of communities along riverbanks. Additionally, it is impacted by the topographic features of the surroundings and is connected to the arrangement of natural and man-made shapes in space. Settlements will grow in a manner that spreads or clusters based on the physical characteristics of the immediate surroundings. In brand-new communities without access, the pattern of spreading development takes shape. Road access serves as a cue for settlers to build communities, which leads to the clustered growth pattern. On river banks, highways, and beaches, linear patterns also developed as settlements grew. There are many patterns of settlement growth, including circular, rectangular, and grid patterns. The pattern of settlement development will influence the growth of building orientation and circulation patterns, and it will become a deciding factor for the creation of additional settlements(Rosyidah et al., 2022).

The Characteristic of Riverfront city spatial patterns is the appearance of an urban environment development pattern following the characteristics of the riverbank side which links the orientation

and various activities towards it and as a result of historical products of decision-making by many parties within a certain time and the development of the social life of the community(Rijal, 2018). The natural condition of the riverside affects the formation of the urban space nearby it. Those urban rivers play a vital ecological and social role in a wider urban system. In addition, the limited spaces for circulation bring distinct population activities to public spaces. This is following Doxiadis's theory that the form of settlement patterns is usually the result of various factors that shape it(Lussetyowai & Adiyanto, 2020).

Alongside the riverside, there is a layer of settlements, which are on the third layer known as stilt houses in proximity to the river while on the first layer houses are called landed houses as shown in the figure below.

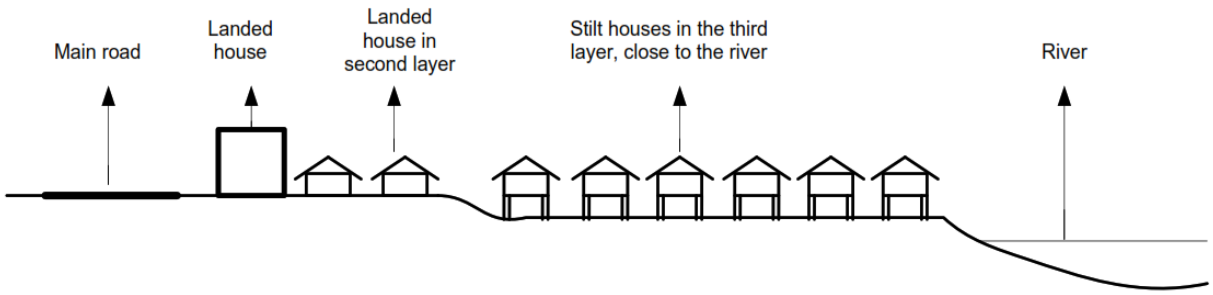


Figure 11 The physical conditions of riverside settlements

The elements of a characteristic of riverfront city spatial patterns are classified into two, namely, the physical elements of the city as the visually formed physical conditions and the non-physical elements as the unmeasured elements in which the city is a social order of society that influences the formation of urban spatial patterns(Rijal, 2018). The various elements of urban design elements which can be used as the basis for analysis of the study area are as follows:

2.3.1 ELEMENT OF URBAN SETTLEMENT PATTERN

- Land use

The arrangement of the land and river in space demonstrates that the transition zone between the two is also a zone where life between the two transitions, creating an aesthetically pleasing pattern where the transition zone, in this case, the riverbank region, becomes the center or nucleus of the space. From these spaces, the various layout of the settlement pattern near the riverfront can be of flowing types;

- Grouping Pattern

These types of the pattern are found in the transition area between the river and the water area in the form of market areas and settlements

- Spreading Pattern

These types of patterns are found in the land area in form of residential settlements.

- Mass and form of the buildings

The intensity of the building analysis, as well as the analysis of the building structure, analysis of building distance, and analysis of the building orientation pattern that is connected to the presence of highways and rivers, are the most crucial factors in the regulation of building mass. Building distance calculations take into account the separation between each building as well as the separation between each building and rivers, roads, pathways, and other structures.

- Circulation and parking

There are two primary means of transportation in communities besides rivers: roads and rivers. Usually, tiny roads or alleys connect these two circulation lines. There are typically boat docks and stairs leading down to the river at each intersection of the alley and the river. Locals still frequently use the river as a bathroom (bath, washroom, toilet) on the stairs. The riverwalk and the road are closely connected. River services as a circulation path are reduced when transportation modes switch from river to road. However, the river still serves as a different means of circulation in communities besides rivers.

- Open space

Settlements beside rivers have distinct types of open space than settlements on land. Movement corridors (roads, bushes, rivers) and areas between buildings are examples of open space. Public spaces like open spaces are typically found in areas that can be "trampled," thus there aren't many places for them.

- Pedestrian Path

The pedestrian path plays a significant role in transportation as well as the movement of people across the settlement near the riverside.

- Social Aspects

The various social aspects like people’s social values and norms play a significant role in the development of the settlement pattern across the riverside.

- Settlement Pattern

The pattern of the settlement nearby the settlement has oriented from the riverside road to the major road. The major road, a sizable river, and two smaller rivers that flow into a sizable river form the physical boundaries of each residential unit. There can be different forms of settlement nearby the riverside as shown in the figure below.

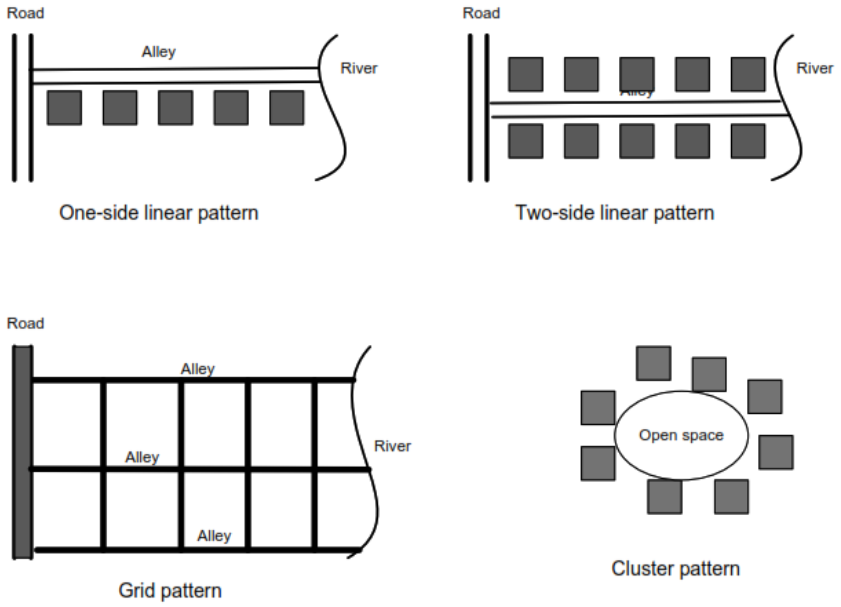


Figure 12 The spatial patterns of riverside settlements

- Settlement Orientation

The settlement orientation is mainly towards either the riverside or the major roadside outside the riverside. The settlement pattern uses a combination of the grid and linear patterns and there would be little dependence on the river, especially in terms of transportation.

2.4.FLOOD-RESILIENT URBAN SETTLEMENT

Floods become a threat to human life, development infrastructure, and economic activities, especially in complex, high-density, urban environments(*Water: Flood Resilience in Urban Areas*, 2005).Consider a four-phase strategy for Flood Resilience, starting with Prevention, Preparation, Response, and Recovery, as a simple way to make metropolitan areas resilient. The three steps in each phase are depicted in Flood Resilience Circle below.

Early warning systems use smart, interactive tools and analysis for the flood protection measures to protect assets and the prevention measures to early warn the people about the possible scenario of flooding to the people. From evaluation to the solution, we rely on a network of deep smarts who are experts in translating physics, the social environment, and the stakeholders involved into the real world with a focus on commercial and economic success.

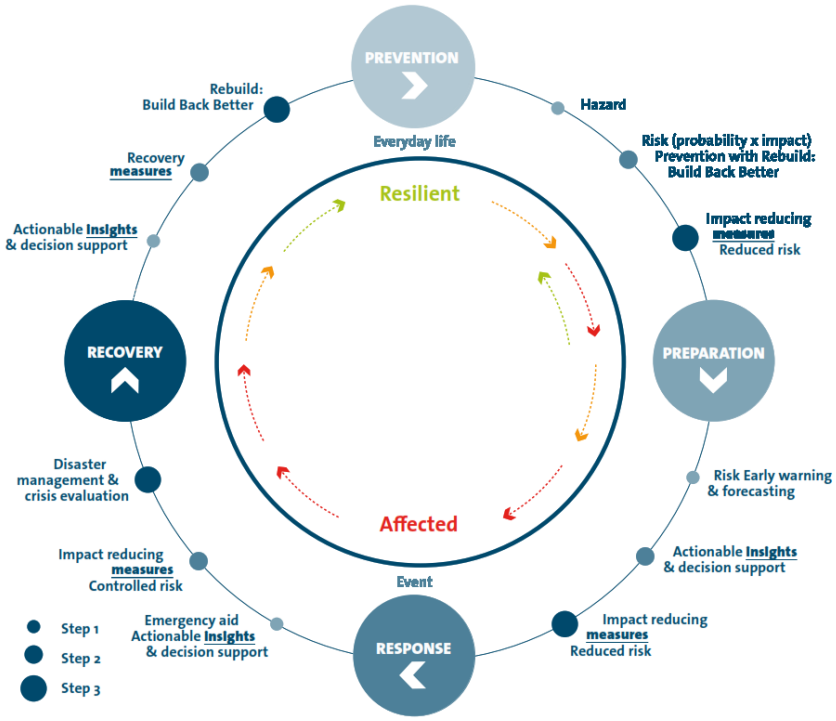


Figure 13 Resilience Cycle

Source: Disaster Management Cycle by Lisa Jane Wood

Traditionally, urban flooding is assumed to be an infrastructural problem and is thought to be solved with engineering solutions (Sahu et al., 2021). Traditional engineering, on the other hand, ignores the dynamic of land use change. A strong land use plan is needed for long-term sustainability, one that takes into account future disaster risks and balances current and future demands. Land use planning is a powerful tool in disaster risk reduction, thereby increasing the city's resilience(Burby et al., 2000).

The four steps for flood-resilient urban settlement are as follows;

- Prevention

For better prevention from any form of disaster, one needs to find out the nature of the hazard that can occur in the future. Also, the proper risk assessment (Probability x Impact) needs to be carried out with the prevention of Rebuilts: Build back better. Any form of preventive measures that can be followed to minimize the risks of the hazards needs to be analyzed and studied well.

- Preparation

For the preparation of any form of hazard, one needs to be prepared first. So, for better preparation of the risk early warning system and forecasting measures. Also, the impact-reducing measures to reduce the risk need to be better prepared. For actionable insights and decision supports the preparation strategies for any risks to be followed.

- Response

The very first step for the response is the Emergency aid actionable insights and decision support. Which have a significant role in making the response process to starts quicker. After that, the impact-reducing measures with the controlled risk measures are followed and the last steps need to be disaster management & crisis evaluation.

- Recovery

For the recovery phase, action insights & decision supports after the responses from any kind of disaster. Various recovery measures need to be followed to have the build back better concept.

2.5.WATER AND URBAN DEVELOPMENT

Water management in the urban and urban issues should be properly done to have the total water cycle, and various integration of the water factors in the early planning process which helps to encourage all levels of the government and industries and urban planning practices which helps to benefits the various community and settlements, their economy and environment.

Urban water refers to any water forms suitable or available within the urban environment and also includes sources from various natural forms like groundwater, surface water which can be used for potable use, sewage and other waste waters, stormwater, flood services, recycling of water (a third pipe, stormwater harvesting, sewer mining, managed aquifer recharge, etc.), techniques to enhance water use efficiency and reduce demands, water sensitive urban design techniques, living streams, environmental water and protection of natural wetlands, waterways and estuaries in urban landscapes.

The major aim of urban water management makes urban cities flood-resilient city to make productive and sustainable. They can interact with the hydrological cycle in ways like:

- Efficient use of the available water sources can provide water security too.
- Helps to conserve as well as protect the water sources and wetlands.
- Create various public as well as private spaces that can harvest, clean, and recycle the water resulting in the water resources along with the environmental, and social livability benefits.
- Helps to provide water for productive, sustainable, resilient, and liveable Communities.

Urban development which includes the development in the sectors like residential, rural-residential, commercial, and industrial, can have significant impacts on water and water resources. Additionally, water resources can have significant impacts on the situation, design, form, and performance of urban developments. Some urban developments are located in areas with shallow groundwater. the method and considerations for a shallow groundwater management system are detailed in Water resource considerations when controlling groundwater levels in urban development.

The various approaches that need to be considered by the local government regarding the water issues are as follows;

- As early as feasible throughout the project planning stages, address pertinent water resource management components, opportunities, and challenges (such as water service, stormwater/surface water and protection from flooding, groundwater, water quality, and protection of receiving waters).
- Adopt a water-sensitive urban design strategy.
- Design the urban form and infrastructure and use appropriate building techniques to avoid having unfavorable effects on water resources or unfavorable effects on the urban form and infrastructure caused by water resources.
- Acknowledge the requirement for site-specific solutions that comprise creative strategies and suitable non-structural and structural controls.

2.5.1 STORMWATER

Stormwater is a direct effect of the rainfall over the catchment areas and it flows over the land areas due to unprecedented flow off. Rainfall-runoff and any soluble or insoluble particles swept up in its flow make up stormwater.

In areas with a superficial aquifer, drainage canals may contain both groundwaters that have been purposefully blocked by drains and rainfall from surface runoff.

Systems for managing stormwater ought to be created so that:

- uphold public health and safety
- safeguard construction and infrastructure in the public and private sectors
- Waterways, estuaries, wetlands, and oceans should be preserved and their health restored.
- to make urban communities more livable.

In typical urban growth, impermeable surfaces like highways, parking lots, homes, and other structures replace the majority of the soil and vegetation. A local groundwater aquifer needs more water to be refilled, yet increased imperviousness reduces the amount of rainfall that can infiltrate into the soil. Additionally, it quickens and multiplies the amount of runoff that rainfall generates. Increased runoff leads to more pollutants being discharged into waterways, estuaries, wetlands, and oceans, as well as an increased danger of flooding for homes, roads, parks, and other areas downwind of the runoff.

2.5.2 WATER SENSITIVE APPROACH

To create water-sensitive cities and communities, urban drainage systems should, whenever possible, imitate the natural water cycle processes.

With this water-sensitive strategy, impervious surfaces are replaced with previous ones, overland flow paths are created, natural water bodies and drainage flow paths are preserved, and small rainfall events are managed as close to the runoff source as is practical. Additionally, vegetation is incorporated into the urban landscape and drainage management systems.

The foundation of integrated land and water planning is the complete water cycle management principle, which takes into account all elements of water, including drinking water, groundwater, stormwater runoff, wastewater, the health of waterways, and the reuse of water. As a result, water-sensitive urban design is produced and judgments about sustainable urban planning and development are made.

2.6.GREENWAYS

Greenways are linear open areas such as canals and picturesque roadways that run along riversides, hillsides, and valleys and have been converted to recreational usage along railways. Two words should be examined to make clear the definition. “Green” is defined as forests, riversides, and natural spaces like wildlife, and “way” as a route or an axis(Achparaki et al., 2012).

In the context of urban planning of the nineteenth century, the development process of greenways is classified into 3 categories. These are:

1. First Generation Greenways (the period between 1700 and 1960)

2. Second Generation Greenways (the period between 1960-1985)

3. Third Generation Greenways (the period after1985)

The functions and benefits of greenways are ;

- Environmental Benefits
- Educational Benefits
- Economic Benefits
- Aesthetics Benefits
- Recreational Benefits
- Social Benefits

Figure 14 Greenways near the riverside

2.7.RIVERBANKS AND FLOOD PLAINS AS OPEN SPACE

The riverbank region serves as both urban infrastructure and a gathering spot for people. Riverbank research is always a fascinating topic to investigate because it encompasses a wide range of physical and non-physical phenomena (related to social culture). Lots of people utilize the riverbank as a social space. Riverbank upkeep, flood prevention, and a disorganized transition space along the river are all issues that plague the suburbs.

These types of riverbanks and flood plains used as open spaces help to create public space and prevent flooding.

Figure 15 Riverbanks and Floodplains as open space

2.8 RIVERSIDE URBAN PLANNING GUIDELINES

2.8.1 RIVERCENTRIC URBAN PLANNING GUIDELINES, INDIA, 2021

The main objective for the preparation of RCUP guidelines are as follows;

1. It highlights the need of the river centric master planning and urban river management and provides guidelines to cities and towns
2. To provide a framework for river water conservation and development of the riverfront.
3. To devise various development regulations and zoning for riverfront development.
4. To recommend suitable planning strategies for river water management and riverfront development as a part of sustainable urban planning and development.

The major key points of the guidelines as river regulation guidelines are as follows;

- Proposal of the River regulation zones(RRZs) falling under the Environmental protection act, of 1986 to prevent encroachments along the rivers and floodplains.
- Proposal to declare river stretches and floodplain zones as River conservation zones and restricts the infrastructural development within them.
- National river conservation Authority under the Ministry of Environment, forest and climate change.
- The river regulation zones have been divided into three, depending upon the permission granted to carry out developmental activities;
    - Prohibited activities zones: up to 500 meters from the highest flood level in the past 50 years
    - Restricted activities zone: Outer limit of the prohibited zone to 1 kilometer.
    - Regulated activities zone: Outer limit of the restricted zone to 3 kilometers.

Urban River Zoning Regulations

Categorization of Urban River Stretches

Category I: Urbanized stretch shall include stretches of rivers (including their tributaries), with or without embankments, in designated urban areas where infrastructure facilities like roads, buildings (residential, commercial, recreational), temples, ghats, etc exist(D.S. Mishra and D. Thara, 2021).

Category II: Peri-urban stretch shall include stretches of rivers (including their tributaries) in suburban and rural areas with or without embankments, where infrastructure development if any is moderate and the land is primarily under natural vegetation, forestry, agriculture, and grazing(D.S. Mishra and D. Thara, 2021).

The other zones categorized under this category are;

1. No development and Construction zone (NDCZ)
2. High and Medium Impact zone
3. Eco-sensitive Zones
4. Recreational Zones(Active & Passive).

2.9 USAGE OF THE RIVERSIDE CORRIDOR

There can be various uses of the riverside corridor according to the usage pattern as follows;

1. Riverside walkways and Vehicular Transportation
2. Community connections, pedestrian and cycle linkages to cross river, and integration of riverside and new developments.
3. Open green parks and Recreational Activities
4. Religious and Cultural Significance
5. Flood Control.

2.10. URBAN BLUE CORRIDOR CONCEPT

This concept encompasses the development of the new and the old urban forms within the water courses in the setback form or the planned around with overland flow paths and ponding areas creating the network of the urban corridor.

‘Urban Blue Corridors’ is the collective name for several interconnecting features, which could include, but are not limited to, the following:

- Overland Flow Paths
- Rivers and Canals
- Flood Storage Areas

- Floodplains
- Ponding Areas
- Wetlands
- Historic River Channels
- Multiuse Parks

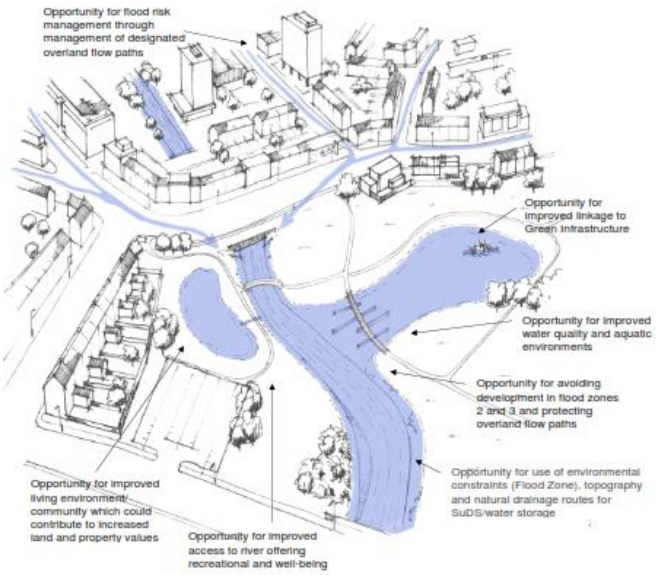


Figure 3: Multifunctional Use and Benefits of Urban Blue Corridors

Figure 17 Urban Blue Corridor

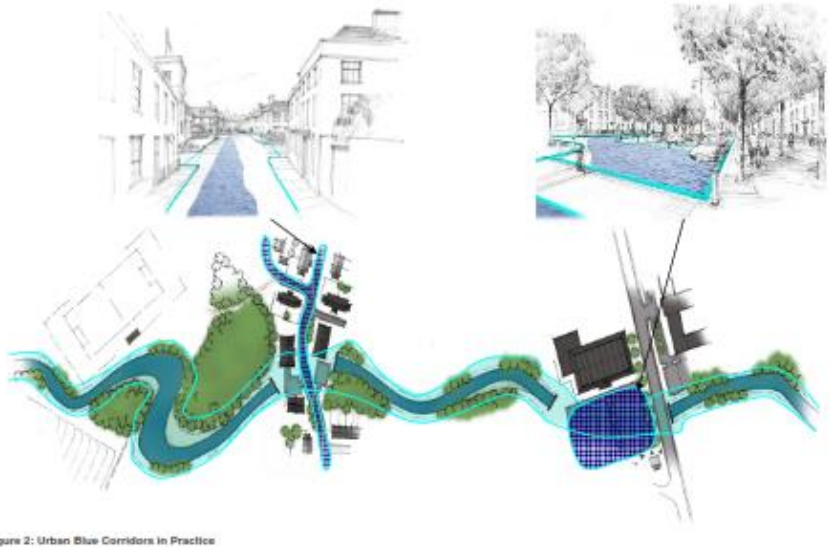


Figure 2: Urban Blue Corridors in Practice

Figure 16 Urban Blue corridor in Practice

2.11. RIVERSIDE CORRIDOR DEVELOPMENT IN KATHMANDU

In the context of the Kathmandu valley, various riverside corridors are constructed and many of them are still in the construction phase. Some of the corridor projects that are completed as well as in the running phase are as follows;

1. Bishnumati Riverside Corridor

Status: Ongoing
Planned Work:

- Landscaping and tree plantation/Bank protection
- Public toilet
- Sewerage and waste treatment
- Link Road

Purpose:

Flood control and traffic ease

Figure 18 Bishnumati Riverside Corridor

2. Dhobikhola Riverside Corridor

Status: Completed
Planned Work:

- Sewer line
- Footpath and Road Development

Purpose

Drainage and Ease of traffic

Figure 19 Dhobikhola Riverside Corridor

3. Manohara Riverside Corridor

Status: Ongoing
Planned Work:

- Ease of traffic congestion of jadibuti-Koteshwor

Purpose:

Ease traffic and flood control

Figure 20 Manohara Riverside Corridor

4. Bagmari Riverside Corridor

Status: Ongoing

Planned Work:

- Green open spaces
- Link Road
- Water quality improvement
- Sewarage treatment

Purpose

Revitalize and Improve water quality

Figure 21 Bagmati Riverside Corridor

5. Hanumante Riverside Corridor

Status: Ongoing

Planned Work:

- Green open spaces
- Link Road

Purpose

Flood control and Ease traffic

Figure 22 Hanumante Riverside Corridor

3. CHAPTER III: STUDY AREA

3.1.MADHYAPUR THIMI MUNICIPALITY

The selected study area lies in the Madhyapur Thimi Municipality of Bhaktapur District along the stretch of the Hanumante River of the Bagmati Province of Nepal. It lies between 27°40'0" and 27°42'0" North Latitude, and 81°22'30" and 85°25'0" East Longitude(Pujita Shrestha, 2019). It occupies a total area of 11.47 square kilometers.

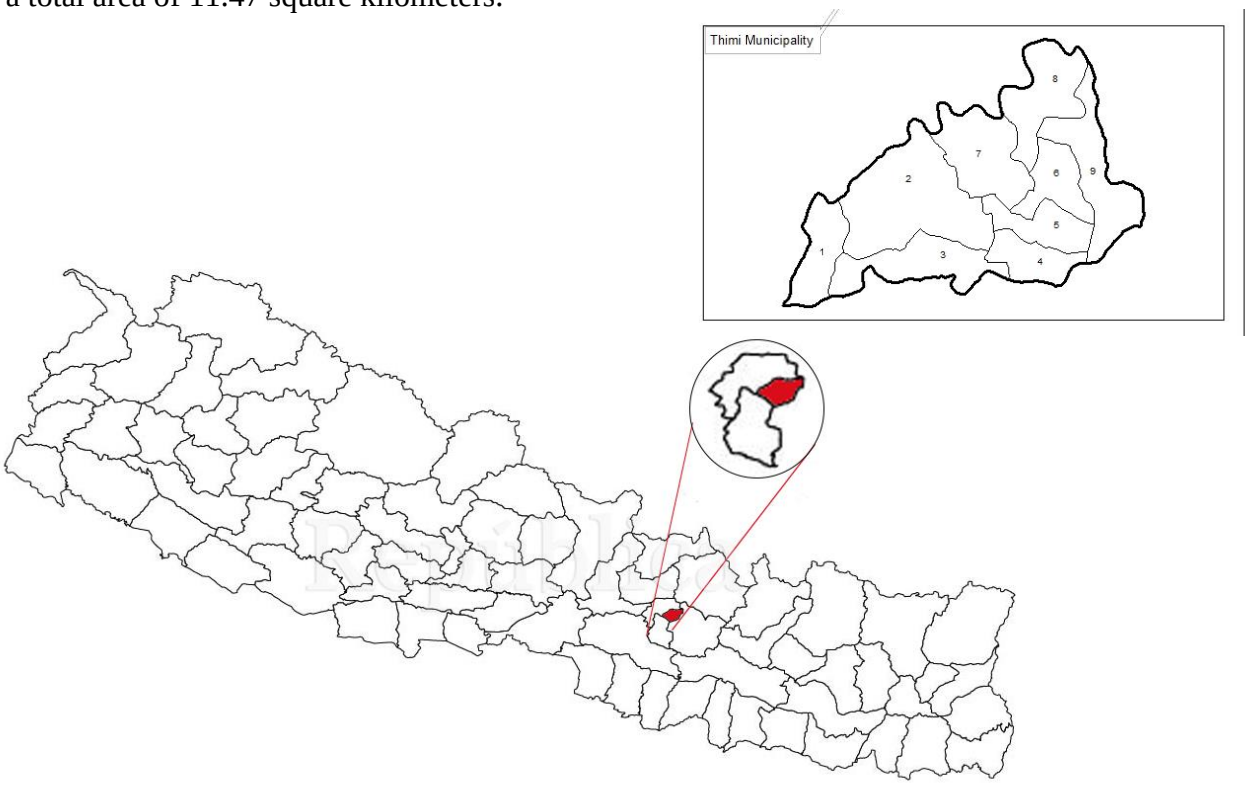


Figure 23 Map showing Madhyapur Thimi Municipality

Between Kathmandu, Lalitpur, and Bhaktapur is the town of Madhyapur Thimi. Hanumante River and Manohara River are both about the municipality on its east and south and west and north sides, respectively. The municipality is divided from Suryabinayak municipality, Lalitpur metropolitan city, and Bhaktapur municipality by the Hanumante River, which runs from east to west. The Manohara River divides the municipality from Kathmandu Metropolitan City into the north and northwest sides as it runs from northeast to southwest.

It is the fastly growing municipality in the Bhaktapur District. It is a historical town with an elevation of 1326 meters. Due to the good availability of the services like transportation, health, education, etc. pace of urbanization is taking up rapidly in recent years

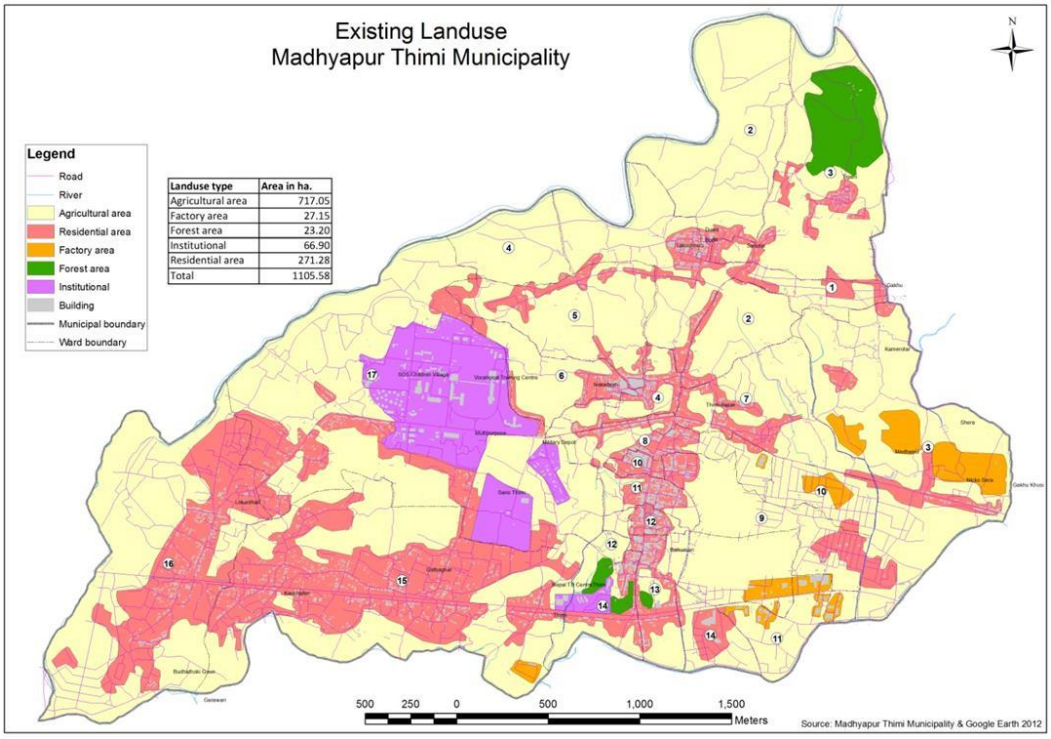


Figure 24 Existing Land use of Madhyapur Thimi Municipality

3.2.HANUMANTE RIVERSIDE CORRIDOR

The Hanumante is one of the important tributaries of the Bagmati River with a catchment area of around 143 km^2 and it originates from Mahadev Pokhari, Nagarkot(*Hanumante River - Wikipedia*, n.d.). This river course covers a total area of 3.92% of the total area of the Bhaktapur and Madhyapur Thimi Municipalities(Sada, 2012). The Hanumante river course passes through the major region of the Bhaktapur like Sallaghari, Suryabinayak, Jagati, and Madhyapur Thimi. Like other cities in the Valley, Bhaktapur faces rapid urbanization and annual population growth of 2.3 percent in recent years(Kindermann et al., 2020). Due to the rapid increase in urbanization around the river plains, there is an increase in flooding in the settlement in recent years. With this, land use patterns are changing rapidly. According to a study on land-use changes by the International Centre for Integrated Mountain Development (ICIMOD), the built area has increased by more than 250% over 20 years(Kindermann et al., 2020).

The Hanumante river plays a significant role for the people of Bhaktapur and its neighborhood for economic, cultural, and social reasons. Various religious sites are located around the banks of the Hanumante Rivers like Hanumanghat, Maheshworighat, Chupinghat, Mangal Tirtha, etc. Also, various temples and monuments are built across the riverside. Nearly 2 decades ago the water of the river was clean enough for the people to take baths, perform various rituals, and even drink them but after all those decades later various sources of drainage and sewage from the Municipalities of Bhaktapur and Madhyapur Thimi make the river water polluted and nonusageble for various purposes. During the Monsoon period, the river water is used for irrigation in the

agricultural land nearby the plains but during the dry season the river dries out almost half leaving just polluted water mixed with the sewerage and drainage mixed directly into the river.

The Urban river corridor is under the threat of various issues like pollution, encroachment, and various other urban problems like unplanned development through sprawl, growth of slums and squatters, improper road networks leading to traffic congestion and air pollution, etc. The rapid pace of urbanization in those areas leads to the transformation of the social, economic, and cultural fabric of the society. Also, the haphazard changes in the landuse pattern of the valley and the disposal of wastewater into the river have led the river to degrade which will ultimately affect the river ecosystem and nearby human settlement.

To tackle these problems related to the riverside corridors various plans and programs are launched through the High Powered Committee for Integrated Development of Bagmati Civilization. This committee has been working on the conservation of the Bagmati River and its tributaries.

Bhaktapur witnessed two major flood events; one on August 27, 2015, and the other on July 12, 2018(Pandey & Dugar, 2019). It is mainly due to the rise of unplanned urbanization and the rise in the urban population in Bhaktapur. In 2011, Bhaktapur had two municipalities (Bhaktapur and Madhyapur Thimi) with a population of 3,04,651 people, and 54.1 percent of the population living in urban areas(Government of Nepal; Central Bureau of Statistics, 2014)

Figure 25 Haumante Corridor

The trend of the Urban Population growth from the year 1955-2019 is shown in the figure below

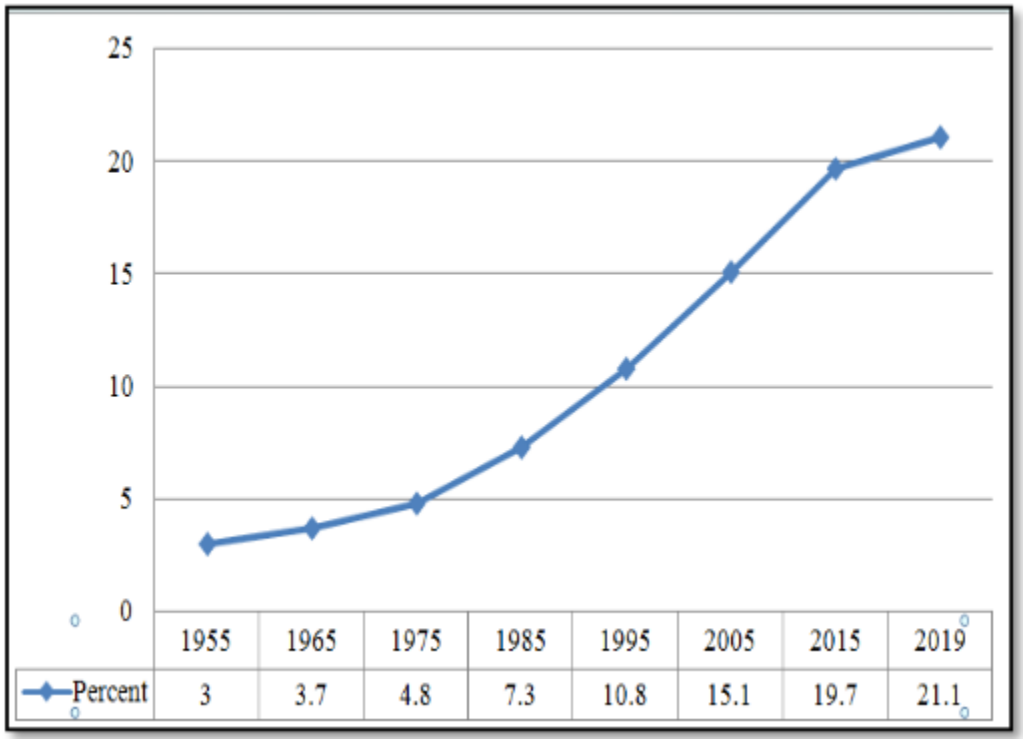


Figure 26 Urban Population Trend from 1955-2019

Source: www.worldometers.info/world-population/nepal-population

This trend of increasing urban population can be seen in the respective municipalities in these years too. This increasing population is seen in increasing concrete built-up structures and this rapid increase in built-up structures brings vulnerability nearby the riverside. As these unplanned settlements also lack open spaces too and lack proper drainage systems to tackle the overflow of the waters during the monsoon period. The projected population growth of these municipalities is shown in the figure below;

Year	Bhaktapur	Madhyapur Thimi Municipality	Suryabinayak
2011	83,658	84142	78490
2018	92465	125136	100280
2020	95148	140163	107551
2030	109775	247103	152623

Table 1Projected Population of Municipalities

Source: (Bhatta & Pandey, 2020)

Urbanization in Bhaktapur is happening at expense of cultivable lands which are gradually transformed into built-up areas which have increased from 1.8 percent to 24 percent from 1988 to 2015(Pandey & Dugar, 2019). In the past three decades due to haphazard settlement, more than 60

percent of agricultural land was converted to built-up area which is clearly illustrated in the land-use map as shown in Figure 10.

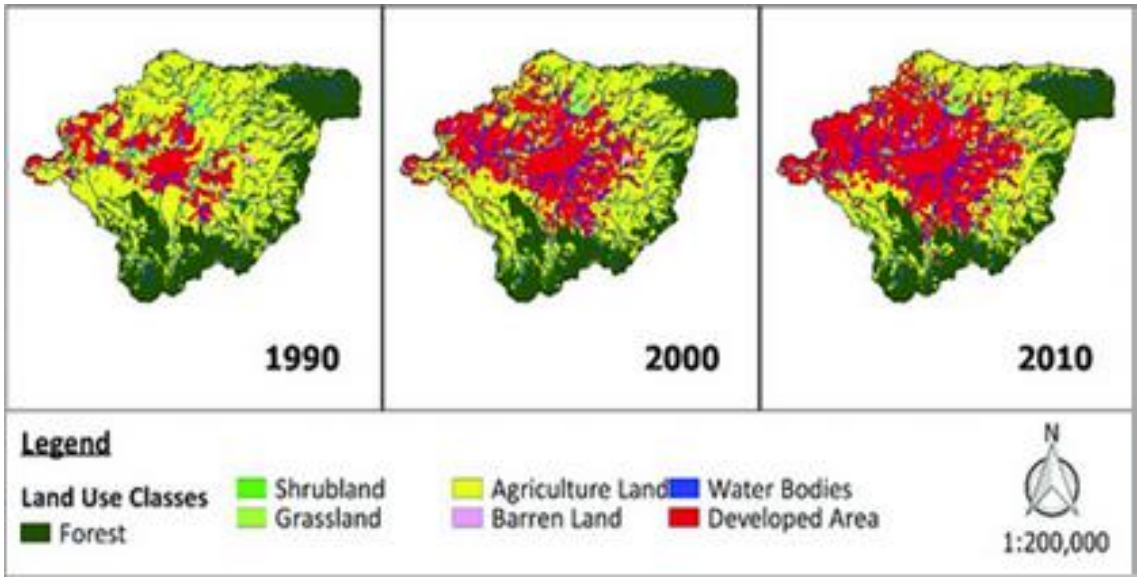


Figure 27 Land use Map from 1990 to 2010 (Source: Pandey and Dugar, 2019)

3.3.FLOOD-PRONE STRETCH AREA

The flood-prone area across the Hanumante river is mainly located in Bhaktapur, Suryabinayak, and Madhyapur Thimi municipalities as in figure 10 below.

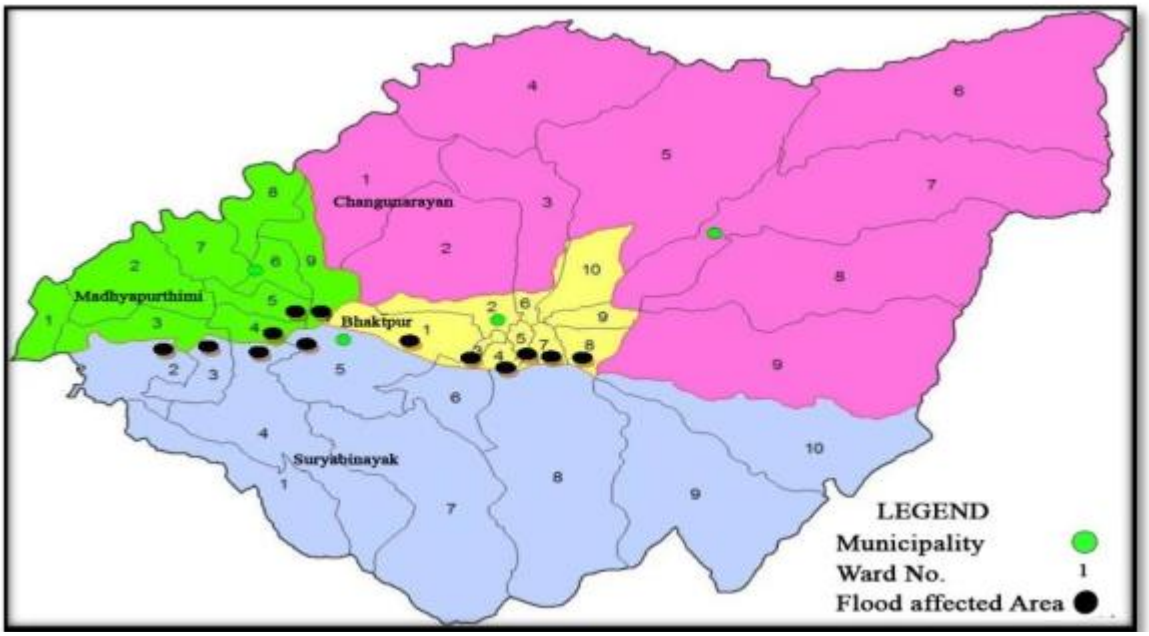


Figure 28 Topography Map of the Flooded region across Hanumante river

Source: Journal of APF Command and Staff College (2020)

Figure 29 settlements at Radhe Radhe and the Kamerotar land pooling project areas have become

Source: Setopati Online news

But for this research, only the stretch across the Radhe Radhe area to the Hanumante Bridge of Naya Thimi is selected with a total length of around 3km in length. This area includes the most flooded region of the Hanumante plains i.e Radhe Radhe area. This area encompasses the Bhaktapur, Madhyapur, and Suryabinayak Municipalities. The population of Bhaktapur, Madhyapurthimi, and Suryabinayak Municipalities are as follows: 83658, 83036, and 78490 people according to the Central Bureau of Statistics (CBS) 2011. The registration of houses in Bhaktapur Municipality (Bhaktapur Municipality, 2019), Madhyapurthimi Municipality (Madhyapurthimi Municipality, 2019), and Suryabinayak Municipality (Suryabinayak Municipality, 2019) in the last five years until Poush 2075 as per table 1 below(Bhatta & Pandey, 2020).

Municipality	2071/72	2072/73	2073/74	2074/75	2075/76*
Bhaktapur	440	467	966	994	322
Madhyapur Thimi	484	508	969	1035	373
Suryabinayak	467	824	688	565	1387

Table 2 Bhaktapur, Madhyapurthimi and Suryabinayak Municipality, 2075

The flood hazard mapping of the Radhe Radhe area in the various time frame are as follows;

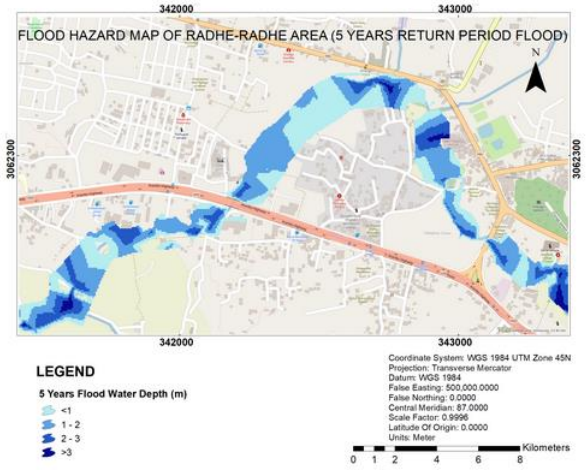


Figure 31 Flood hazard map of Radhe Radhe area in 5 years

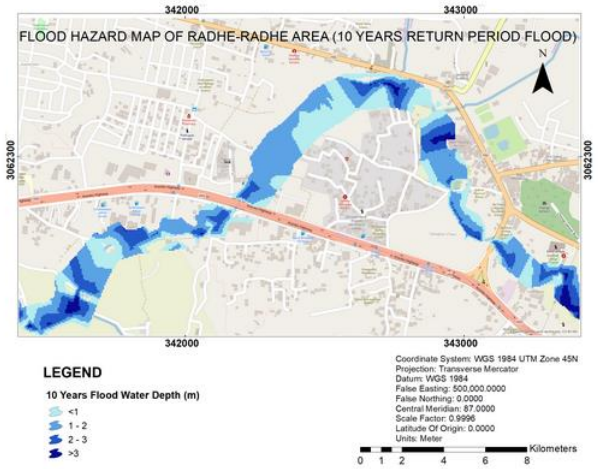


Figure 30 Flood Hazard Map of Radhe Radhe area in 10 years return period

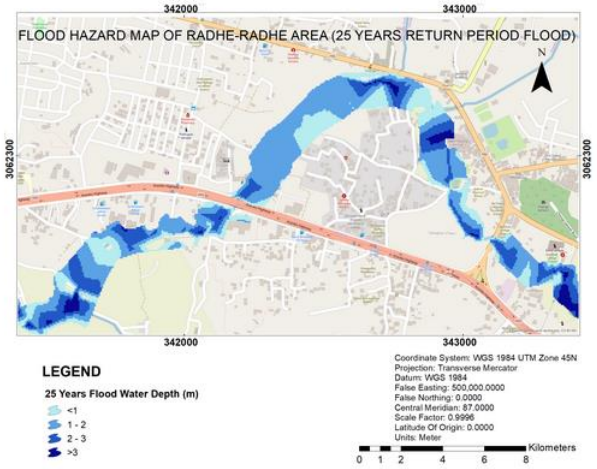


Figure 33 Flood Hazard Map of the Radhe Radhe area in the period

of 25 years

return period

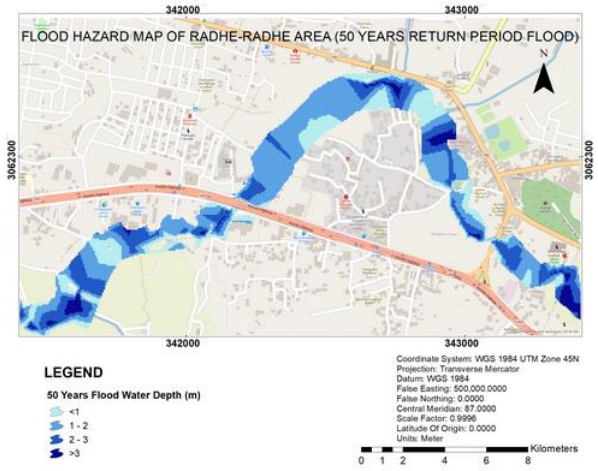


Figure 32 Flood hazard Map of the Radhe Radhe area in period of 50 years

Source: (Pandey & Dugar, 2019)

This area taken into consideration is the flood-prone zone stretched from the Hanumante bridge of the Naya Thimi, Bhaktapur to the Radhe Radhe area which would be around a stretch of the 3 km span. So the flood-prone mapping and the possible urban development scenarios would be studied along this span.

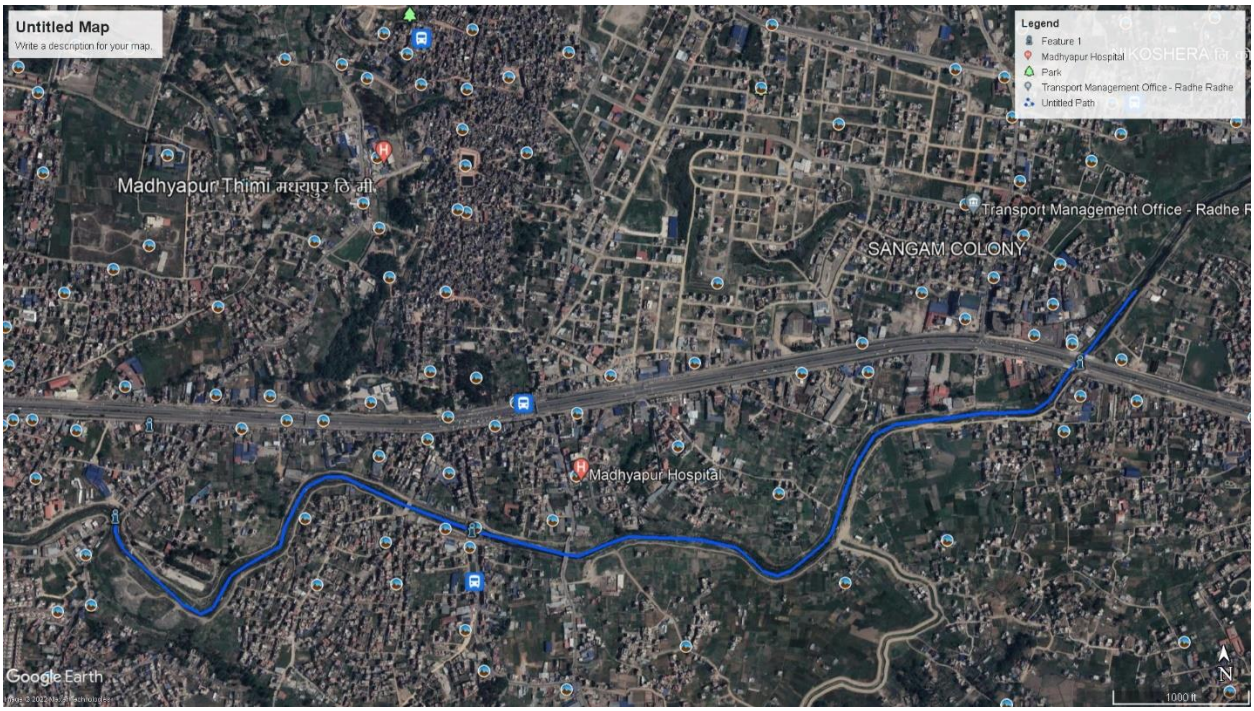


Figure 34 Site Area

4. CHAPTER IV: DATA ANALYSIS AND FINDINGS

4.1 FLOODING TREND

The flooding trend in the study starts way earlier in the 1980s to the latest in 2018. During the various field survey and KII from the different personnel and the various articles and documents from the online portals, the trend of flooding was analyzed. The exact numbers of casualty and damages to the house was difficult to calculate and some data since 2000 was recorded in the GON, Nepal Disaster Risk Reduction Portal. The trend of flooding scenarios is tabulated as follows;

Year	Rainfall Data(In MM)	Casualty	Means of Verification
1980			
1984			
1988			
1995	90		Report from Water Induced Disaster Prevention Technical Centre- February 1995
2000	61.2		News Article
2015	8.7	13	News Article
2016	69.2	72	News Article
2017	9.0	166	News Article
2018, July	129.6	17	News Article

2018, August	49.5	73	News Article

This flooding causes wholly to partial damage to the households, shops, and livestock nearby the flood plains. The water from the river passes into the floor of the house, into factories and various structures nearby damaging the outer walls, compound walls, and other public properties like roads, bridges, etc.

Figure 36 Flooding in Hanumante Bridge in Thimi

Figure 37 Flooding in the Araniko Highway

Source: https://steemit.com/nepal/@ultrapsycho/devastating-flood-in-bhaktapur-nepal

This part of the Hanumante region also receives a higher amount of rainfall throughout the monsoon period as shown in the figure below;

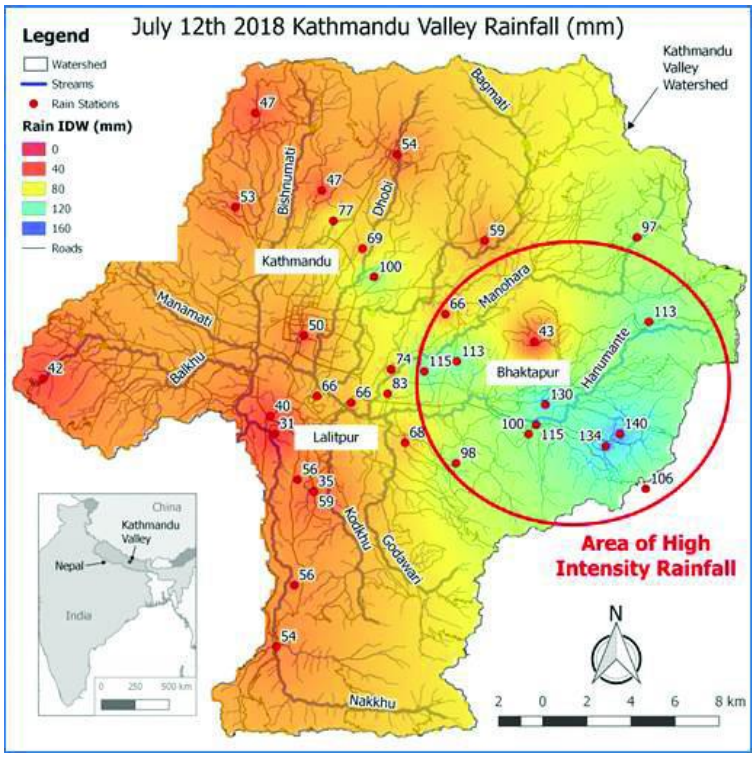


Figure 38 Rainfall (mm) of July 12th 2018 of Kathmandu Valley

Source: My Republica published on July 17th 2018

4.2 POPULATION DATA

	Population				Population Growth Rate		
Year	1991	2001	2011	2021	2001	2011	2011
Madhyapur Thimi Municipality	31970	47751	84142	119955(Initial)	4.11%	5.79%	-

Table 3 Population Data from census 1991,2001,2011 & 2022

Source: CBS Report 1991,2001,2011 & 2021

As per the latest preliminary data of the census 2021, the population increased by a tremendous 42.56% consisting of a male population of 60954 and a female population of 59001. As per the report, the Bhaktapur district in which Madhyapur Thimi Municipality lies has the highest population growth rate of 3.32%(CBS Nepal, 2022). So due to this Madyapur Thimi municipality have the highest rate of expanding urban areas adjacent to the Bhaktapur Municipality and other Municipality nearby.

The Madhyapur Thimi Municipality has a greater population growth rate than the national population growth rate and the population of Nepal's urban centers, according to Central Bureau of Statistics (CBS) data from 2001 to 2011. One of the nearby Kathmandu Metropolitan City's rapidly growing urban regions is Madhyapur Thimi. Due to the city's excellent development of

urban services such as road access, water supply, and health and educational infrastructures, the population has been rising quickly in recent years. Due to this expansion, there is a considerable demand for plots to provide room for the construction of new infrastructure and houses.

Migration to Urban Areas:

Both in-migration and natural population growth contributed to the population growth. The recent shift in the demographic makeup of city residents suggests that immigration is the primary driver of population increase in the municipality. To better understand migration flow to urban places, data on internal migration for 58 designated urban locations from the 2011 population census must be analyzed.

Zonesdistricts	Municipalities	Total population	Native born	%	Same district	%	Born in other districts						Born in foreign country	(%)
							Rural	%	Urban	%	Total (Number)	Total %		
Mountain districts	**Mountain towns**	**49,995**	**49,712**	**99.4**	**46,042**	**92.6**	**3,136**	**6.3**	**534**	**1.1**	**3,670**	**7.4**	**283**	**0.6**
	Col%	1.1	1.1		1.5		0.3		0.3				0.2	
Sankhuwasabha	Khandbari Municipality	26,658	26,494	99.4	23,979	90.5	2,236	8.4	279	1.1	2,515	9.5	164	0.6
Dolakha	Bhimeshwor Municipality	23,337	23,218	99.5	22,063	95.0	900	3.9	255	1.1	1,155	5.0	119	0.5
Hill districts	**Hill towns**	**1,003,126**	**985,714**	**98.3**	**788,975**	**79.3**	**175,939**	**17.8**	**27,800**	**2.8**	**203,739**	**20.7**	**17,412**	**1.7**
	Col %	22.2	22.6		25.4		16.3		13.8				10.7	
Ilam	Ilam Municipality	19,427	19,146	98.6	16,091	84.0	2,700	14.1	355	1.9	3,055	16.0	281	1.4
Dhankuta	Dhankuta Municipality	28,364	28,049	98.9	22,265	79.4	4,771	17.0	1,013	3.6	5,784	20.6	315	1.1
Udayapur	Triyuga Municipality	71,405	70,886	99.3	56,445	79.6	13,257	18.7	1,184	1.7	14,441	20.4	519	0.7
Sindhuli	Kamalamai Municipality	41,117	40,814	99.3	34,302	84.0	5,827	14.3	685	1.7	6,512	16.0	303	0.7
Kavrepalanchowk	Banepa Municipality	24,894	24,674	99.1	20,578	83.4	2,870	11.6	1,226	5.0	4,096	16.6	220	0.9
Kavrepalanchowk	Dhulikhel Municipality	16,283	16,183	99.5	13,990	86.4	1,599	9.9	594	3.7	2,193	13.6	80	0.5
Kavrepalanchowk	Panauti Municipality	28,312	28,215	99.7	25,947	92.0	1,648	5.8	620	2.2	2,268	8.0	97	0.3
Nuwakot	Bidur Municipality	27,953	27,699	99.1	25,803	93.2	1,462	5.3	434	1.6	1,896	6.8	254	0.9
Makawanpur	Hetauda Municipality	85,653	83,762	97.8	58,812	70.2	19,978	23.9	4,972	5.9	24,950	29.8	1,891	2.2
Gorkha	Gorkha Municipality	33,865	33,547	99.1	30,881	92.0	2,324	6.9	382	1.1	2,686	8.0	318	0.9
Tanahu	Byas Municipality	43,615	42,827	98.2	38,344	89.5	3,838	9.0	645	1.5	4,483	10.5	788	1.8
Syangja	Putalibazar Municipality	31,338	30,949	98.8	29,256	94.5	1,305	4.2	388	1.3	1,693	5.5	389	1.2
Syangja	Waling Municipality	24,199	23,951	99.0	22,659	94.6	1,120	4.7	172	0.7	1,292	5.4	248	1.0
Kaski	Lekhnath Municipality	59,498	58,742	98.7	47,892	81.5	9,774	16.6	1,076	1.8	10,850	18.5	756	1.3
Kaski	Pokhara Sub-Metropolitan City	264,991	256,153	96.7	167,040	65.2	78,841	30.8	10,272	4.0	89,113	34.8	8,838	3.3
Baglung	Baglung Municipality	30,763	30,388	98.7	26,306	86.6	3,284	10.8	778	2.6	4,062	13.4	395	1.3
Palpa	Tansen Municipality	31,161	30,616	98.3	25,648	83.8	4,116	13.4	852	2.8	4,968	16.2	545	1.7
Surkhet	Birendranagar Municipality	52,137	51,537	98.8	36,849	71.5	13,416	26.0	1,272	2.5	14,688	28.5	600	1.2
Dailekh	Narayan Municipality	21,995	21,964	99.9	21,414	97.5	416	1.9	134	0.6	550	2.5	31	0.1
Doti	DipayalSilgadhi Municipality	26,508	26,345	99.4	24,311	92.3	1,698	6.4	336	1.3	2,034	7.7	163	0.6
Dadeldhura	Amargadhi Municipality	22,241	22,167	99.7	20,754	93.6	1,129	5.1	284	1.3	1,413	6.4	74	0.3
Baitadi	Dasharathchanda Municipality	17,427	17,120	98.2	16,408	95.8	566	3.3	146	0.9	712	4.2	307	1.8
Kathmandu valley districts	**Kathmandu valley towns**	**1,464,984**	**1,418,572**	**96.8**	**820,042**	**56.4**	**500,765**	**35.3**	**117,765**	**8.3**	**618,530**	**43.6**	**46,412**	**3.2**
	Col %	**32.4**	**32.5**		**26.0**		**46.3**		**58.4**				**28.6**	
Lalitpur	Lalitpur Sub-metropolitan city	226,728	219,543	96.8	136,706	62.3	61,862	28.2	20,975	9.6	82,837	37.7	7,185	3.2
Bhaktapur	Bhaktapur Municipality	83,658	83,127	99.4	71,150	85.6	9,076	10.9	2,901	3.5	11,977	14.4	531	0.6
Bhaktapur	MadhyapurThimi Municipality	84,142	83,405	99.1	45,743	54.8	29,526	35.4	8,136	9.8	37,662	45.2	737	0.9
Kathmandu	Kathmandu Metropolitan City	1,003,285	965,875	96.3	504,769	52.3	379,680	39.3	81,426	8.4	461,106	47.7	37,410	3.7
Kathmandu	Kirtipur Municipality	67,171	66,022	99.2	41,674	62.8	20,621	31.0	4,327	6.5	24,948	37.4	549	0.8

Figure 39 In-Migration to urban areas (Source: Population Monograph of Nepal –Volume 1)

4.3 NUMBERS OF NEW BUILDINGS REGISTERED

No new registration of new houses			Change in no. of registration		Total Change
2001	2011	2018	2001-2011	2011-2018	2001-2018
131	4405	9668	4274	5263	9537

Table 4 Number of new registration for new houses from 2001 to 2018

Source: Data from the Municipality office.

4.4 LANDCOVER CHANGE AND URBAN EXPANSION ALONG THE SITE

The aerial google satellites images along the timelapse are as follows;

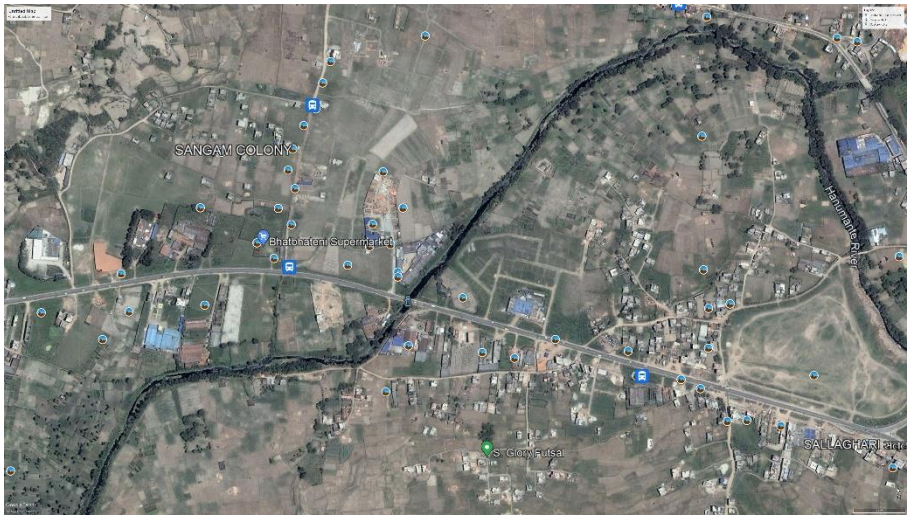


Figure 40 Aerial Map of 2005

z

Figure 41 Aerial Map of 2010

Figure 42 Aerial Map of 2015

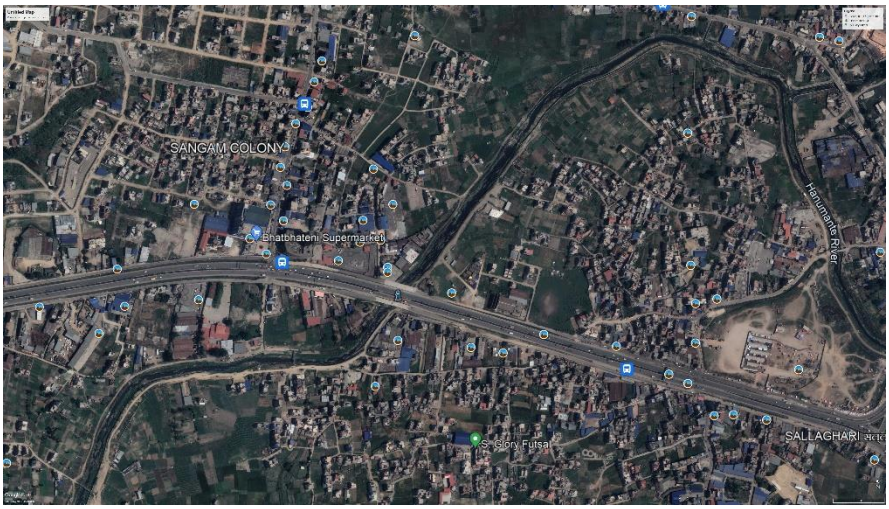


Figure 43 Aerial Map of 2022

This google satellite images show the tremendous increase in the buildup area due to the new construction of the houses nearby the Hanumante River. This section consists of residential buildings, institutional buildings, mixed-use buildings, temporary settlement buildings, and various shops. Therefore, this stretch is taken into consideration for the land use cover change as well as the flood hazard-prone mapping.

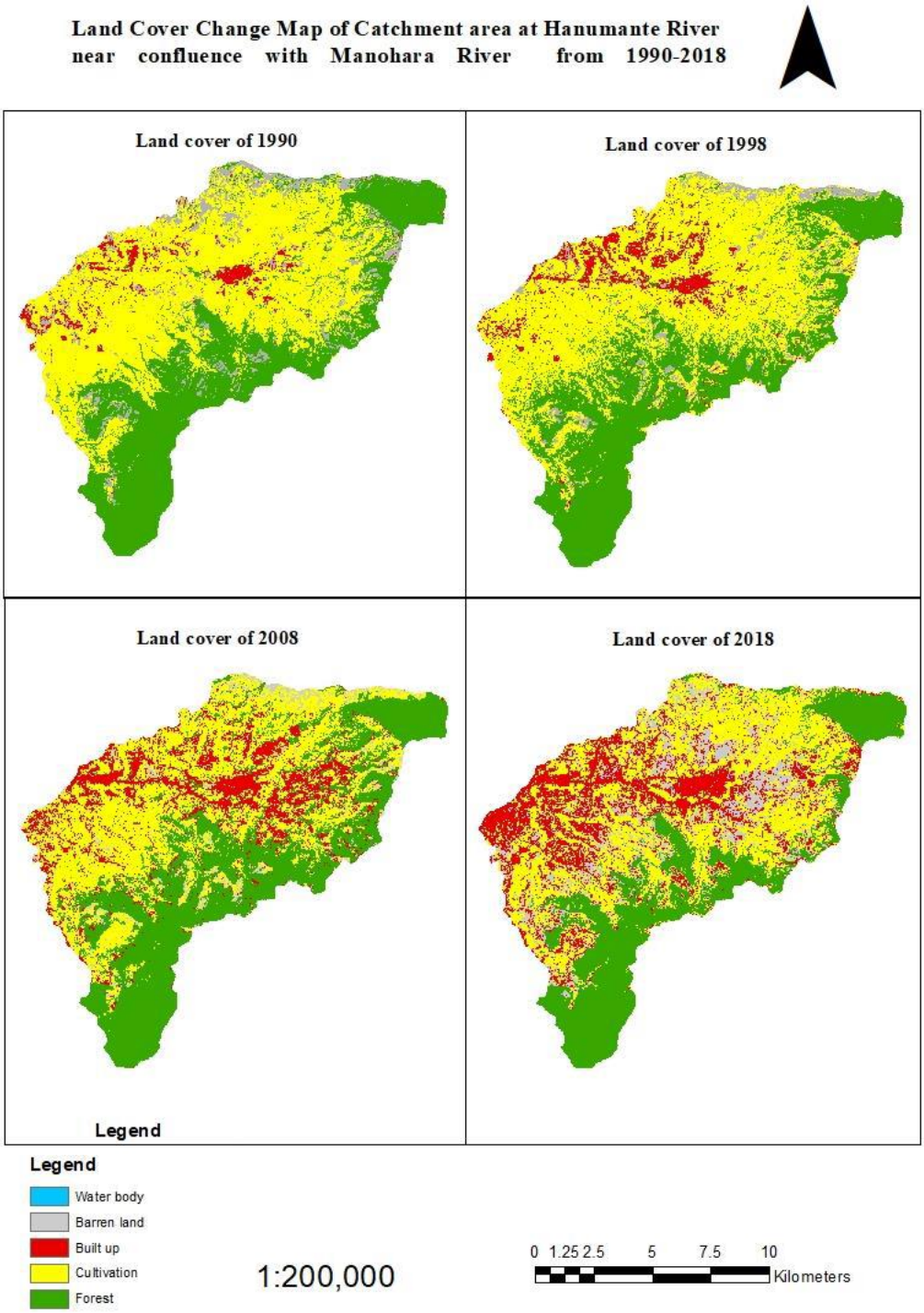


Figure 44 Land cover of 1990, 1998, 2008 & 2018 of catchment area of Hanumante River near the confluence with Manohara River

Source: Genesis of Urban Flooding:A Case Study of Madhyapur Thimi Municipality

4.5 IMPACTS OF THE HIGHWAY CONSTRUCTION

The connectivity and accessibility of the development are key components. The eight-lane Araniko Highway, which will serve as the valley's main thoroughfare, presents both challenges and opportunities. The construction of the highway prompted economic growth and contributed to the rapid urbanization of the highway side of the Madhyapur Thimi Municipality. The Thimi area's institutional zones' position and the valley's connections to the outside world are to blame for the rise in local migration. This led to population growth through in-migration, which in turn caused the size of built-up spaces to rapidly develop at the expense of the area of previous ground symbolized by cultivable land. Additionally, the natural drainage system in the area is impacted by road construction.

A catch drain structure upstream of the Araniko Highway was damaged during the recorded flood of August 6, 1994, which indicates that the system was insufficient to carry the flood discharge(Consultant, 1995).

4.6 RIVER ENCROACHMENT

Flooding results from the natural water flow path of a river being encroached upon by land. Hanumante stream's width was once between six and ten meters in 1964, but it is currently only two meters wide (Prajapati.R, 2018). Additionally, the Hanumante River needs 50 meters of width to pass flood, according to the Department of Water-Induced Disaster Management.

Figure 45 depicts the Hanumante River's flow course and width in the years 2005, 2010, 2015, and 2022 near Radhe Radhe. The river's breadth in the chosen segment was 12.53 meters in 2005, 7.67 meters in 2010, 5.31 meters in 2015, and 2.33 meters in 2022. Thus, the measurement's outcome in Google Earth likewise demonstrates the river's encroachment. As a result, the river's run-off area also decreases, which contributes to floods during rainy seasons.

Google Image of 2005

Google Image of 2010

Google Image of 2015

Google Image of 2022

Figure 45 Change in width and flow path of Hanumante River, near Radhe Radhe from 2005 to 2022

4.7 CHANGE OF THE OCCUPATIONAL SHIFT

Wheat, rice, and vegetables were among the agricultural products famously produced in the Madhyapur Thimi Municipality, and these products were the main source of income for the people who lived there. Due to the altered way of life, people are pursuing new careers that offer greater financial rewards than agriculture, and the amount of agricultural land owned by farmers is declining. As a result, rice farming reduces as well, which is the finest water management during the monsoon because the cultivation field would catch the rainwater. Terrace irrigation is frequently available where agriculture depends on rainfall.

Pre-monsoon management of water bodies was previously offered. At the end of May or the beginning of June, the farmers of the Newar community celebrate Sithinakha in the Kathmandu Valley. This day is used to clean and repair homes and their surroundings, particularly wells. During that time, which is the dry season, water from the wells is removed for cleaning purposes and to manage water in the agricultural field to grow the seeds for rice. To replenish the aquifers during the monsoon season, the well will be dry. The source might be used and the groundwater could be replenished if the monsoon balances the recharge, which is helpful to hold the water during the monsoon season.

4.8 BUILDING REGULATIONS ACROSS FLOOD PLAINS

According to the New Building Byelaws 2077 by Madhyapur Thimi Municipality, New regulations prevents new kind of new development within the flood plains and preserved zone. The purpose of the zoning was to prevent the loss of prime farmland to unplanned urban sprawl and to support ongoing farming methods for environmental reasons. At the riverbanks and in the forest, green zones have been established. It is forbidden to develop anything within 20 meters of a river bank, and that area has been set aside as a green belt.

Municipality	Landuse Zone	Area
Madhyapur Thimi Municipality	Traditional Residential Zone	Old traditional settlement
	Institutional Zone	Public Institutions
	Developing zone	New Residential, commercial, and industrial and Special Planning Zone
	Preserved Zone	Designated agriculture area
	Green Zone	River banks and forests

Table 5 Different Landuse Zoning by Municipality

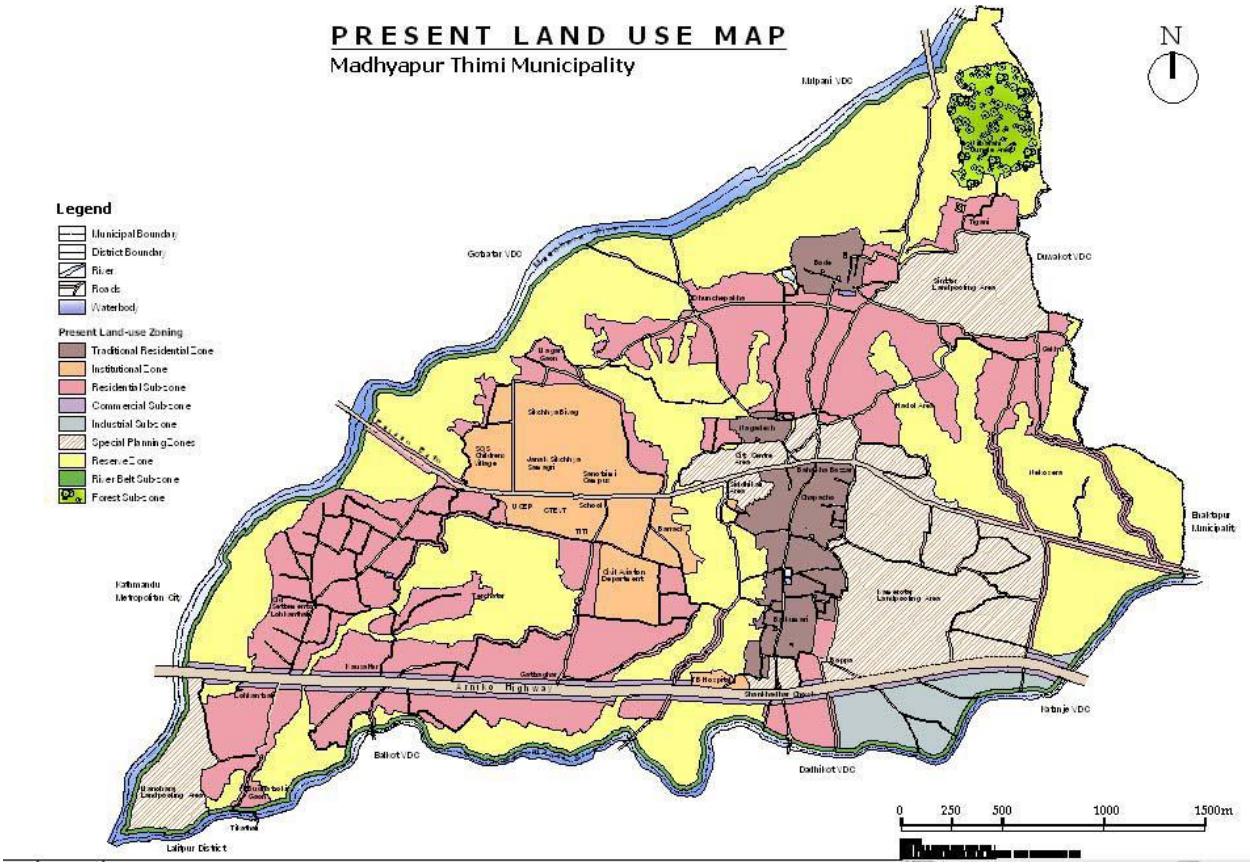


Figure 46 Land Use Map of Madhyapur Thimi Municipality (Source: Madhyapur Thimi Municipality)

The construction of residential buildings and the plotting of land for housing, however, is observed to be uncontrolled, unplanned, and haphazard in the area at the Hanumante river belt, Gatthaghar, Lokanthali, and Kaushaltar because the implementation of the land use regulation is not seen to be effective. Urban areas are being created on agricultural land to accommodate rapid population development.

On low-lying places near the banks of rivers and across the fields through which drains and sewers should be installed, human settlement is expanding quite quickly. Due to its proximity to the Araniko Highway and the relative affordability of the land, the Hanumante River floodplain is being increasingly encroached upon for residential purposes. People from different regions of the country or migrants from former communities live in those lowlands.

4.9 QUESTIONAIRE SURVEY

For the proper documentation of the flood-prone areas a questionnaire survey using the KOBO Toolbox is performed near the settlement areas near the Hanumante River is performed. The main objective of this questionnaire survey is about the flooding situation faced by the people and the measures they have taken for preventing and taking during flooding scenarios.

This questionnaire survey was done on the center point places in flood stetched area with the 200 m radius. The main content of this questionnaire survey is to find out the number of households being lied on the flood plains, their impacts from past flood experiences, their flood structural damages in the buildings, impacts on their daily lifestyle, and possible rescue and evacuation plan in the case of the flooding scenarios. This questionnaire survey was carried out in a random sampling way in the settlement lying in the various belts of the flood plains according to their flood vulnerability status. This helps to identify the perception of the people towards the flood and the flooding issues that they have to face regularly. Also, the required infrastructure in the riverside corridor can be identified through this questionnaire survey.

5. CHAPTER V: RESULTS AND DISCUSSION

5.1 FLOOD HAZARD ANALYSIS

This analysis is done based on the settlement marking that lies within the flooding risk zone identified by the municipality as well as the literature review. According to the recent municipal byelaws of the Madhyapur Thimi Municipality the 20-meter distance from the riverbed with 2-meter additional setback is defined(Municipality, 2020). So, For flood hazard analysis houses lies within the 20-meter defined zone and additional 50 meters and 70-meter buffered zone are created and marked within the satellite images from 2010, 2015, and 2022 year as shown in the figure below;

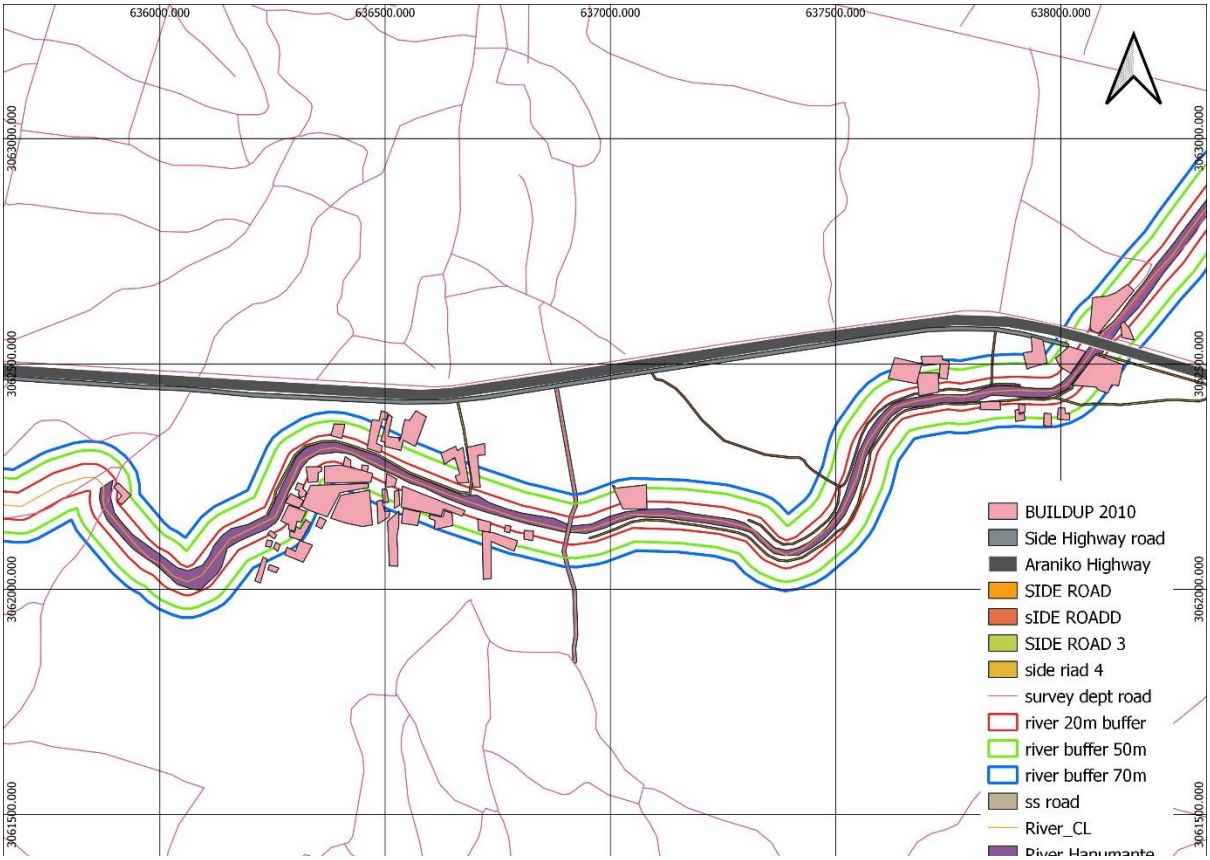


Figure 47 Hazard Mapping of the Year 2010

Year	Houses Number		
	Buffer 20 Metre	Buffer 50 Metre	Buffer 70 Metre
2010	25	88	104

Table 6 Houses number of 2010

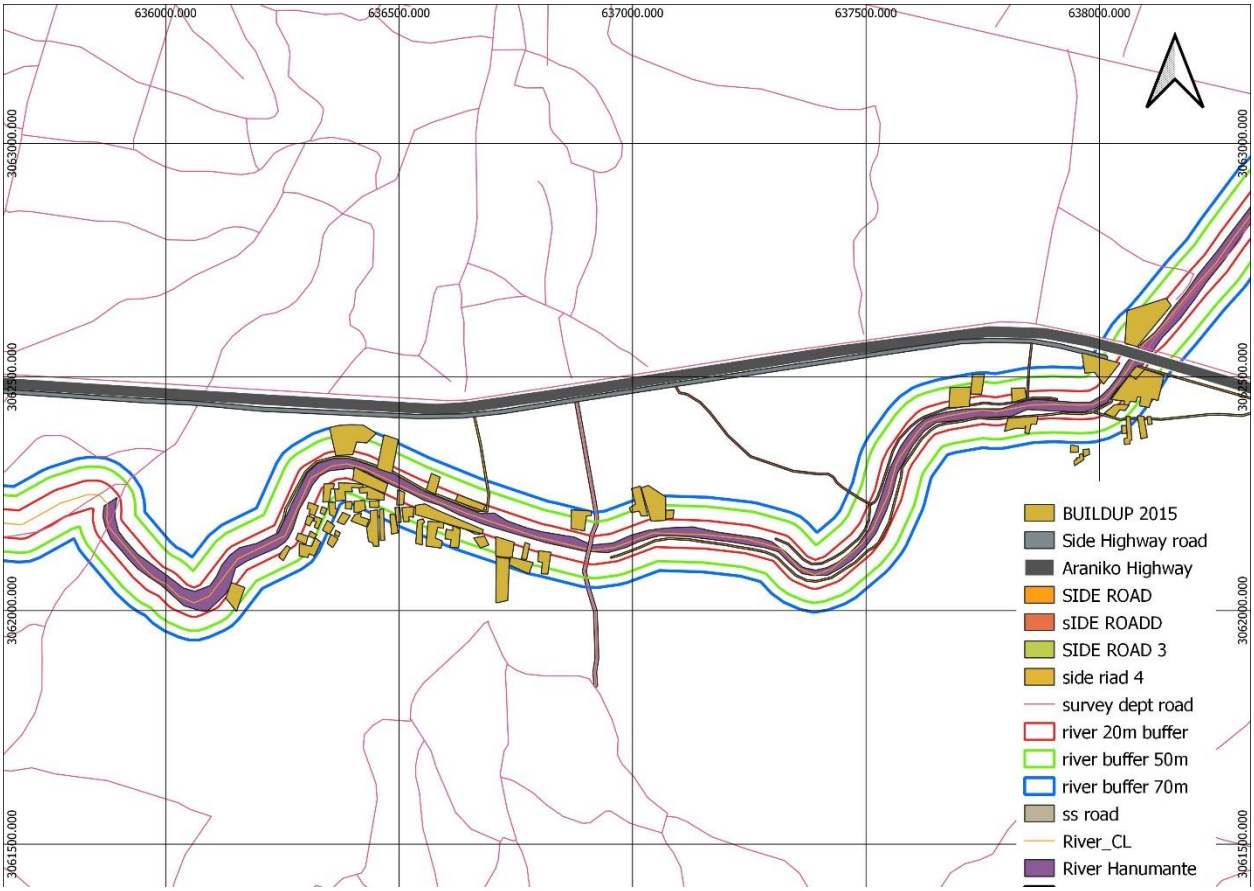


Figure 48 Hazard Mapping of the year 2015

Year	Houses Number					
	Buffer 20 Metre	% Change from 2010	Buffer 50 Metre	% Change from 2010	Buffer 70 Metre	% Change from 2010
2015	14	-44%	105	+19.31%	149	+43.26%

Table 7 Houses Number of 2015

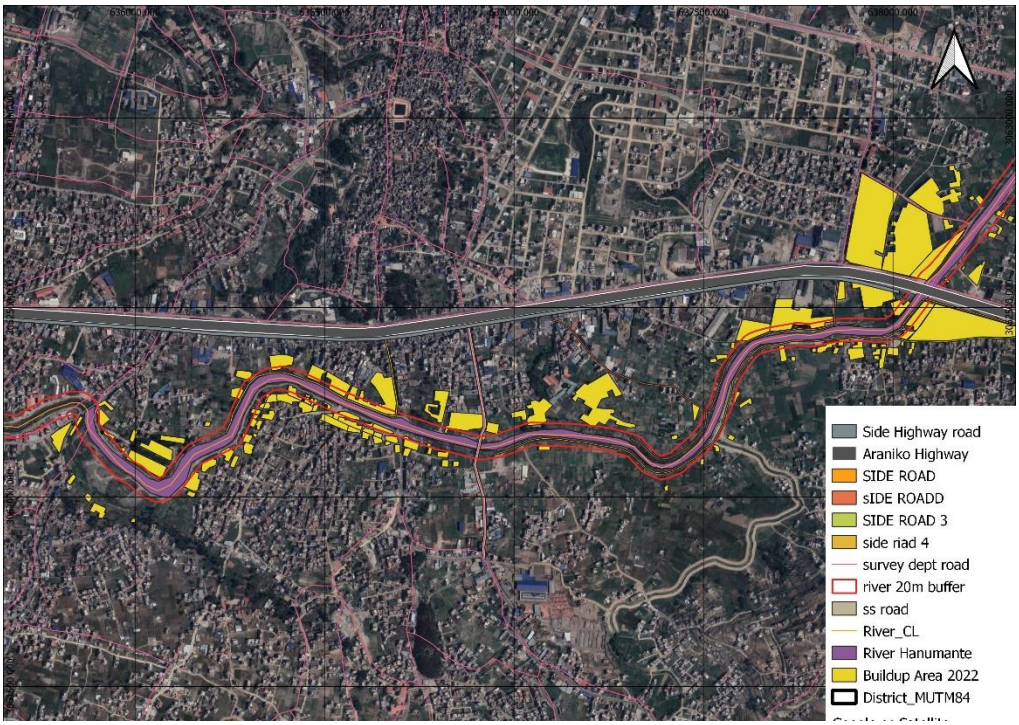


Figure 50 Hazard Mapping of year 2022 in 20M

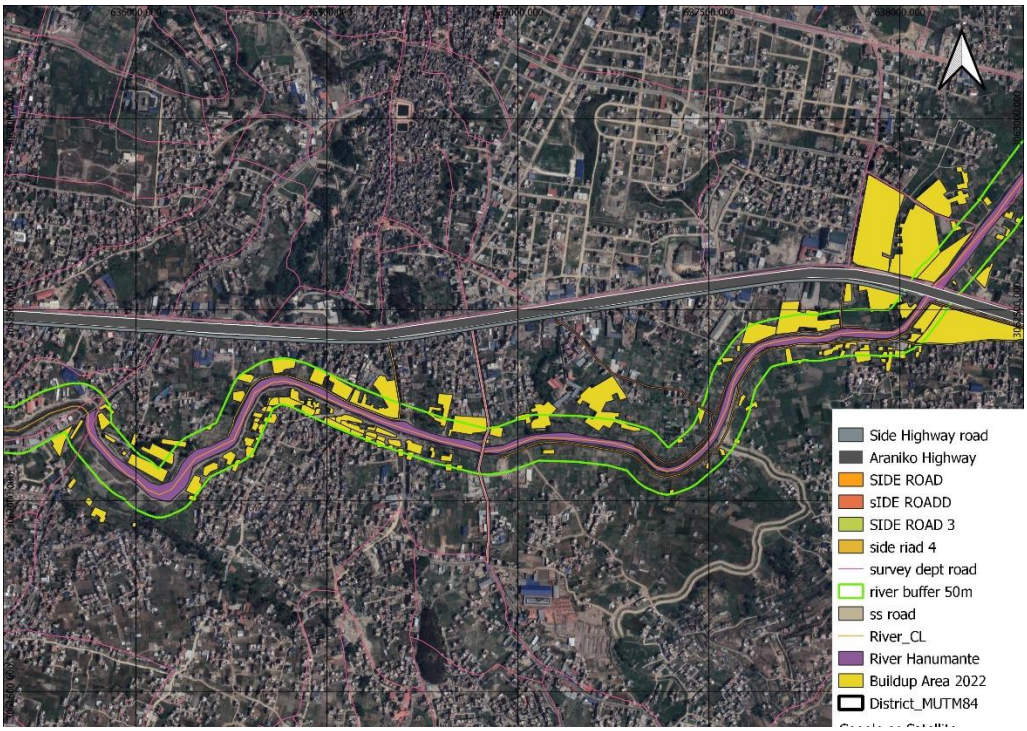


Figure 49 Hazard Mapping of Year 2022 in 50M

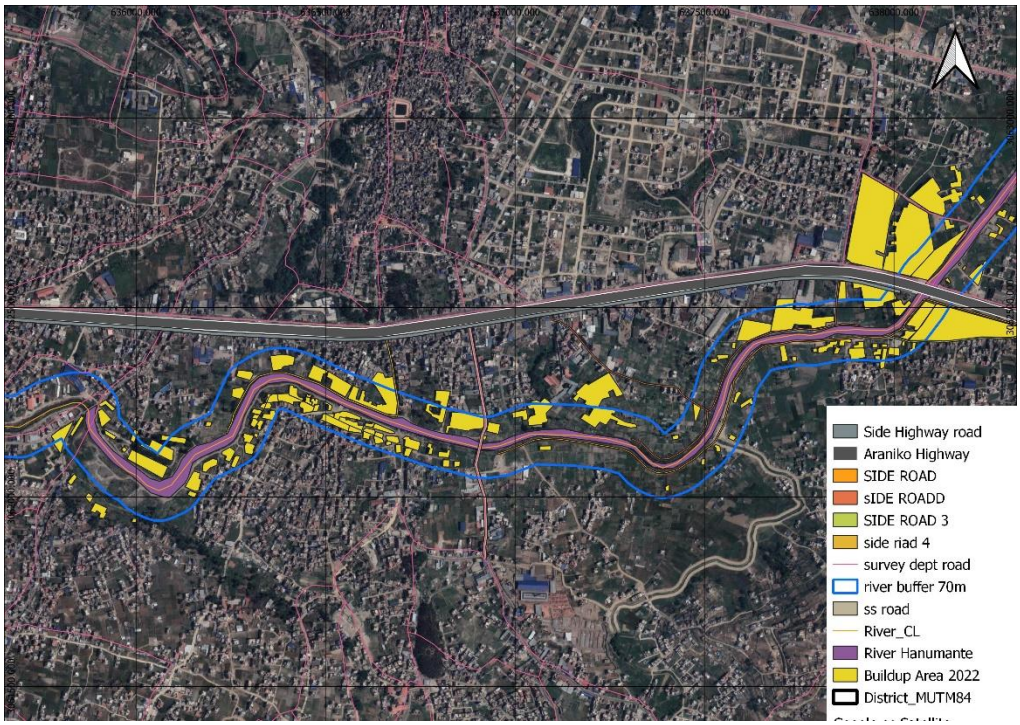


Figure 51 Hazard Mapping of year 2022 in 70M

Year	Houses Number					
	Buffer 20M	% change from 2015	Buffer 50M	% change from 2015	Buffer 70M	% change from 2015
2022	49	+71.42%	194	84.1%	315	52.69%

Table 8 Houses Number of year 2022

5.2 FINDINGS FROM QUESTIONAIRE SURVEY

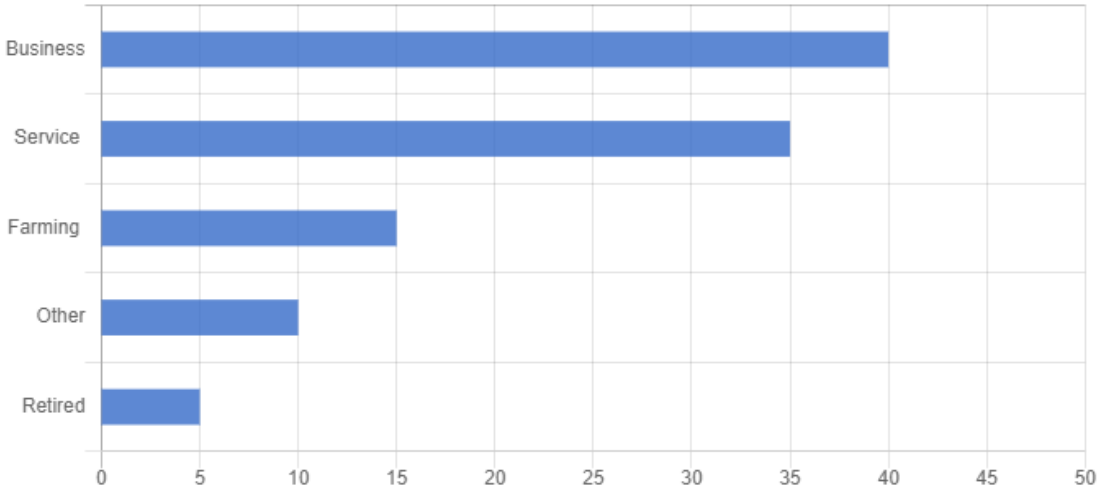


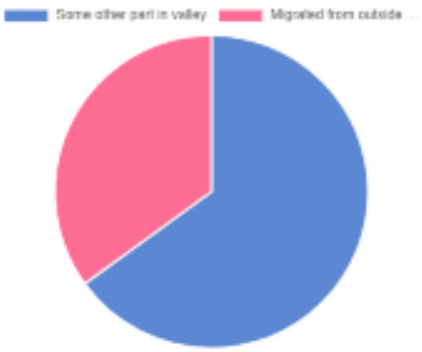
Figure 52 Occupation of respondends

Value	Frequency	Percentage
Ownership	15	75
Rental	5	25

Figure 53 Ownership status

Where are you originally?

TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)



Value	Frequency	Percentage
Some other part in valley	13	65
Migrated from outside valley	7	35

Figure 54 Location status

Land Owned

TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)

Value	Frequency	Percentage
3-6 aana	13	65
Below 3 aana	7	35

Figure 55 Land Owned

House setback

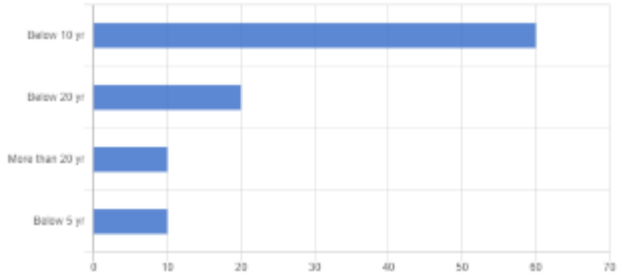
TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)

Value	Frequency	Percentage
Below 20M	11	55
More Than 20M	9	45

Figure 56 House setback

Age of the Building

TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)

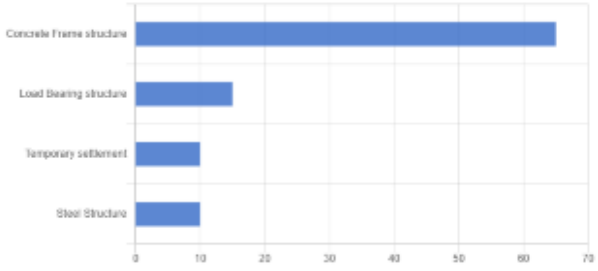


Value	Frequency	Percentage
Below 10 yr	12	60
Below 20 yr	4	20
More than 20 yr	2	10
Below 5 yr	2	10

Figure 57 Age of Building

Building Type

TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)

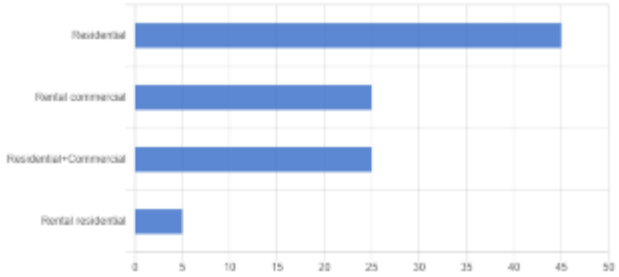


Value	Frequency	Percentage
Concrete Frame structure	13	65
Load Bearing structure	3	15
Temporary settlement	2	10
Steel Structure	2	10

Figure 58 Building Type

Building usage by owner

TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)



Value	Frequency	Percentage
Residential	9	45
Rental commercial	5	25
Residential+Commercial	5	25
Rental residential	1	5

Figure 59 Building Usage

No of storey

TYPE: "TEXT". 20 out of 20 respondents answered this question. (0 were without data.)

Value	Frequency	Percentage
3	7	35
1	6	30
4	4	20
2	2	10
4.5	1	5

Figure 60 House storey

Are you aware of the risk of flood?

TYPE: *SELECT_MULTIPLE*. 20 out of 20 respondents answered this question. (0 were without data.)

Value	Frequency	Percentage
Yes	20	100

Figure 62 Flood awareness

Are you aware about the setback of 20M from the riverside for new construction?

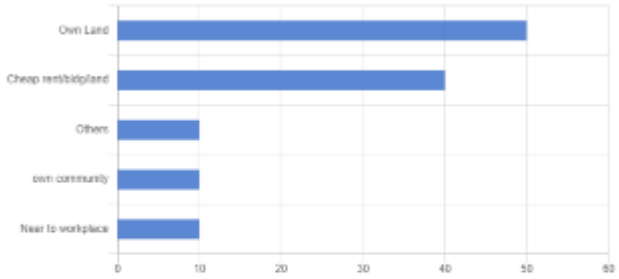
TYPE: *SELECT_MULTIPLE*. 20 out of 20 respondents answered this question. (0 were without data.)

Value	Frequency	Percentage
Yes	16	80
No	4	20

Figure 61 New construction

Why did you come to stay?

TYPE: *SELECT_MULTIPLE*. 20 out of 20 respondents answered this question. (0 were without data.)

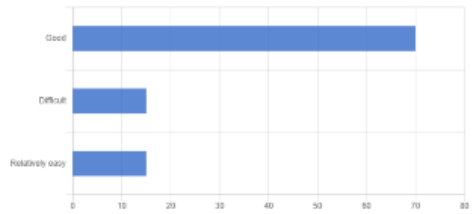


Value	Frequency	Percentage
Own Land	10	50
Cheap rent/bldg/land	8	40
Others	2	10
own community	2	10
Near to workplace	2	10

Figure 63 Reason for Migrate

How do you find daily travel to and fro from the area?

TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)

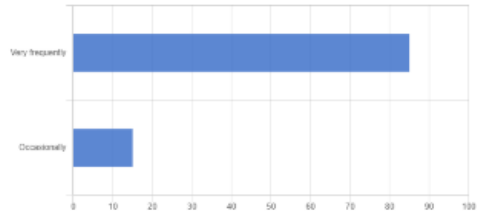


Value	Frequency	Percentage
Good	14	70
Difficult	3	15
Relatively easy	3	15

Figure 65 Travelling easeness

How frequently do you use the hanumante river corridor for travel?

TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)

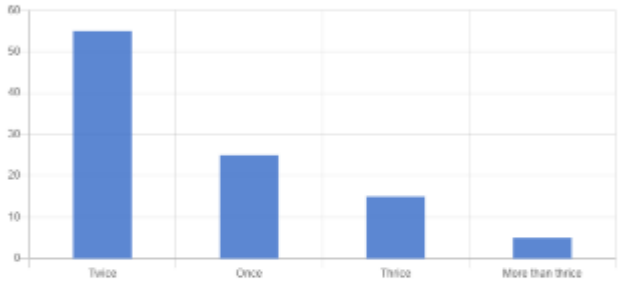


Value	Frequency	Percentage
Very frequently	17	85
Occasionally	3	15

Figure 64 Frequency of travel

If Yes, How many times did you face flood while living in this address?

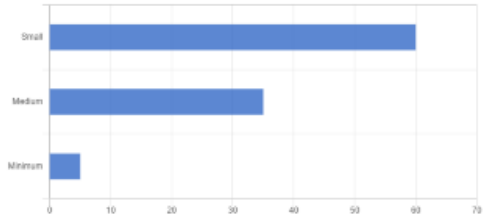
TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)



Value	Frequency	Percentage
Twice	11	55
Once	5	25
Thrice	3	15
More than thrice	1	5

Figure 66 Flood Experience

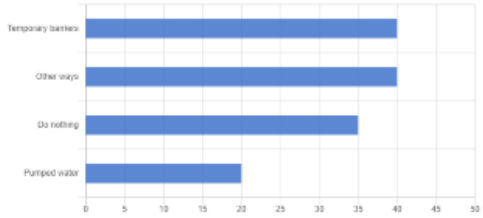
. What was the amount of structural damage to your building?
(
TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)



Value	Frequency	Percentage
Small	12	60
Medium	7	35
Minimum	1	5

Figure 67 Flood control measures

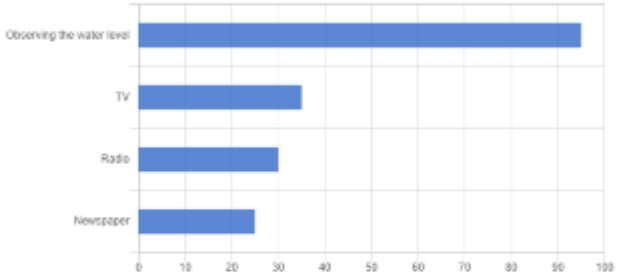
Any measure taken for flood damage control?
TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)



Value	Frequency	Percentage
Temporary barriers	8	40
Other ways	8	40
Do nothing	7	35
Pumped water	4	20

Figure 68 Structural Damage

. Just before the flood, how did you first become aware that flood waters might reach your home?
TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)

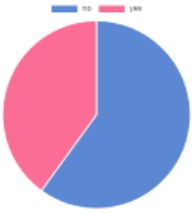


Value	Frequency	Percentage
Observing the water level	19	95
TV	7	35
Radio	6	30
Newspaper	5	25

Figure 69 Information measures

Are you and your family able to evacuate, in case of a flood?

TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)



Value	Frequency	Percentage
no	12	60
yes	8	40

Figure 71 Flood evacuation

Is there any shelter to stay during the flood evacuation?

TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)

Value	Frequency	Percentage
No	15	75
Yes	5	25

Figure 70 Flood shelter

Are you satisfied with the prevention measures and evacuation by government and other organization?

TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)

Value	Frequency	Percentage
Satisfied	13	65
Not much satisfied	7	35

Figure 73 Government Satisfaction

How much are you satisfied with current situation of the riverside?

TYPE: "SELECT_MULTIPLE". 20 out of 20 respondents answered this question. (0 were without data.)

Value	Frequency	Percentage
Less satisfied	10	50
Satisfied	10	50

Figure 72 Satisfaction

What do you feel is lacking in the area(problems) and what can be done for further development?

TYPE: "TEXT". 20 out of 20 respondents answered this question. (0 were without data.)

Value	Frequency	Percentage
Road, drinking water, municipal drainage	1	5
Side road and green park	1	5
No monetary value of land and bldg,road,drinking water	1	5
No such problems	1	5
Front road,no municipal drinking water,sewarage,drainage	1	5
Proper solid waste disposal, cleanliness, drainage	1	5
Proper road infrastructure, drainage, solid waste	1	5
Road infrastructure,drainage,solid waste,river cleanliness	1	5
Good accessibility,river cleanliness,drainage,walkways	1	5
Drainage,drinking water,cleanliness	1	5
Road transportation, river cleanliness	1	5
River Cleanliness,solid waste, good road	1	5
Clean road and river, Green trees	1	5
Safer road, No solid waste, No smell	1	5
Improve road condition, solid waste,	1	5
Proper drainage, Road, sanitation, greenery	1	5
Solid waste,River flow	1	5
River consistant flow	1	5
Easy rent affortability	1	5
Easy accessibility, green parks	1	5

Figure 74 People's recommendation

Most of the respondents from the questionnaire survey are aware of the flooding scenario and its consequences as they have experienced the recent big flood of 2018. They were in constant fear during the flooding as no proper evacuation procedure and plans were better prepared before. But after the proper commission of the stone walls to constrict the water flow moving across the flood plains has decreased the risk of flooding in recent years. But the issues of urban flooding still exist due to poor drainage systems to drain out the excess rainwater from the settlement. The booming urban settlement near the riverside increases the built-up space and reduces ground infiltration. Also, the other problem issued by the respondent is about the future of the project commissioned for the proper transportation across the riverside corridor as political issues and various institutional hindrances resulted in the termination of the Hanumante riverside corridor and the planning across the flood plains. In the current days, the road condition and environment across this riverside corridor got more worsen and various other issues like solid waste, illegal construction, and grass densification are arising.

5.3 BYELAWS FOR THE RIVERSIDE CORRIDOR

For the current byelaws of the Hanumante riverside by the Madhyapur Municipality is only the setbacks from the Riverbanks. No any further byelaws are made for the urban development and the building construction specific for those buildings who are going to be affected directly and indirectly due to Riverside. Also in the Model byelaws for the Building construction the setbacks of 30M is only specified for the buiding near the riverside. This provision is clearly not enough to incorporate the needs of the certain building to be safe from the risks of the flooding. Building byelaws near the riverside corridor should encorporate the other possible byelaws like Specific FAR, Storey Height, Plinth Height, Building structure etc to the byelaws for riverside corridor. Also, the setback distance from the riverbanks for the new construction of the building as per the model byelaws for the building construction needs to be site specific and the condition, type of the river to properly incorporate the model building byelaws.

6. CONCLUSION AND RECOMMENDATIONS

The place is prone to flooding scenario from the past times to the till now due to changes in the urbanization pattern, river course, climatic factors, encroachment, and Human-induced causes which increases the risk to lives and property. In recent years flooding scenario in flooding is mainly been caused by the clogged drainage system near the riverside corridor resulting the urban flooding in the settlement. Also, the topography of the site is located on the lowland valley type so the water is accumulated on the ground rather than flowing towards the riverside. Mostly the flow of the Hanumante River is constrained by the high stone walls but the full commissioning of the project couldn't be carried out as the land acquisition for the green belts and the road expansion could be carried out due to the political and landowners. This results in the incomplete commission of the Riverside corridor project and degrades the current situation.

Thus it is summarized that there is a direct correlation between the flooding situation and the increase of urban settlement across the riverside corridor. Due to a lack of political consensus to hear out the problems arising due to the riverside corridor project the stretch across the corridor is worsening condition. The fertile agricultural land is rapidly decreasing across the corridor resulting in haphazard land planning and increasing the built-up area to change the landuse from the past. The land lies in the risk zone i.e 20M is useless for both built-up spaces as well as the fertile agricultural land to be used. The structures lying within this flooding zone are always at risk of flooding. So proper plans and policies should be made to prevent the construction of these structures in the flooding zone.

The possible way forward after this study can be as follows;

1. Possible Intervention of that Builtup area under the Possible risk of the flooding zone.

The built-up areas or the structures lying in the flooding zone needs to be resettled to prevent the life and property of the people living there and to ease out the commission of the riverside corridor project to the full pace.

2. Possible Identification of the evacuation routes during the flooding situation

There is a lack of identification of the evacuation routes for the people residing near the riverside corridor during the flooding situation and people are forced to stay within their houses during the disaster. Although people with a multiple-story house can reside on the upper floors the house with one story or less would need the proper evacuation. So to have risk minimization, a proper evacuation route needs to be identified and designed.

3. Possible intervention in the building by-laws to incorporate the flooding risk as most of the building lacks the Plinth level, High floor stories, No structural Barriers, etc.

The current building bylaws only restrict the new building of the structure within the high-risk zone as well as the Corridor project setbacks of 20M. But there is a need for a change in the building bye-laws to tackle the building the flooding situations like demarking plinth level, FAR, Building story, and various other safety provision measures to be followed by the house owners and designers during the construction of the building near the riverside corridor.

4. Possible structural safety of the river floodplains.

Also, the proper structural infrastructure like barrier walls, breast walls, etc or any other safety structure should be provided to prevent the settlement during flooding situations.

5. Possible zoning of the Riverside according to the language

The proper zoning of the riverside areas according to their usage pattern needs to be designed to have proper planning and land mitigation measures for the Flood hazards as well.

6. Possible Early warning system and Framework for disaster response and recovery

Also, there is a need for an early warning system during the disaster time and a rigid institutional framework by the local government or municipality with coordination with the national disaster reduction strategy to minimize the damages during the floods.

7. Possible river regulation and guidelines for the new development of the Houses nearby Riverside and the flooding plains.

There is a need for river-centric urban planning guidelines to have the urban planning norms and regulations to be followed to prevent haphazard urbanization across the riverside which eventually brings a lot of challenges in future growth and development.

7. REFERENCES

Achparaki, M., Thessalonikeos, E., Tsoukali, H., Mastrogianni, O., Zaggelidou, E., Chatzinikolaou, F., Vasilliades, N., Raikos, N., Isabirye, M., Raju, D. V. ., Kitutu, M., Yemeline, V., Deckers, J., & J. Poesen Additional. (2012). We are IntechOpen , the world ' s leading publisher of Open Access books Built by scientists , for scientists TOP 1 %. *Intech*, 13. http://dx.doi.org/10.1039/C7RA00172J%0Ahttps://www.intechopen.com/books/advanced-biometric-technologies/liveness-detection-in-biometrics%0Ahttp://dx.doi.org/10.1016/j.colsurfa.2011.12.014

Bhandari, P. (2022). *What Is Deductive Reasoning? | Explanation & Examples*. https://www.scribbr.com/methodology/deductive-reasoning/

Bhatta, B. P., & Pandey, R. K. (2020). Bhaktapur Urban Flood related Disaster Risk and Strategy after 2018. *Journal of APF Command and Staff College*, *3*(1), 72–89. https://doi.org/10.3126/japfcsc.v3i1.27530

Burby, R. J., Deyle, R. E., Godschalk, D. R., & Olshansky, R. B. (2000). Creating Hazard Resilient Communities through Land-Use Planning. *Natural Hazards Review*, *1*(2), 99–106. https://doi.org/10.1061/(asce)1527-6988(2000)1:2(99)

CBS Nepal. (2022). *Nepal Census 2021* (pp. 1–96). https://censusnepal.cbs.gov.np/Home/Details?tpid=5&dcid=3479c092-7749-4ba6-9369-45486cd67f30&tfsid=17

Coastal flooding. (2008). https://www.floodsite.net/juniorfloodsite/html/en/student/thingstoknow/hydrology/coastalfloods.html

Commission, W., River, B., & River, B. (1998). *River valley civilizations*. https://courses.lumenlearning.com/suny-hccc-worldcivilization/chapter/river-valley-civilizations/

D.S. Mishra and D. Thara. (2021). *River Planning Guidelines*.

De Risi, R., Jalayer, F., De Paola, F., Carozza, S., Yonas, N., Giugni, M., & Gasparini, P. (2020). From flood risk mapping toward reducing vulnerability: the case of Addis Ababa. *Natural Hazards*, *100*(1), 387–415. https://doi.org/10.1007/s11069-019-03817-8

Eckartsberg, R. Von. (1963). *Existential-Phenomenological*. *1962*, 3–4.

Flash floods. (2008). https://www.floodsite.net/juniorfloodsite/html/en/student/thingstoknow/hydrology/flashfloods.html

Government of Nepal; Central Bureau of Statistics. (2014). *Population Monograph of Nepal*. https://doi.org/10.1111/j.1469-8749.1961.tb10378.x

Government, V. (2016). *River Corridors | Flood Ready*. State of Vermont. https://floodready.vermont.gov/flood_protection/river_corridors_floodplains/river_corridors

Burby, R. J., Deyle, R. E., Godschalk, D. R., & Olshansky, R. B. (2000). Creating Hazard Resilient Communities through Land-Use Planning. *Natural Hazards Review*, *1*(2), 99–106. https://doi.org/10.1061/(asce)1527-6988(2000)1:2(99)

CBS Nepal. (2022). *Nepal Census 2021* (pp. 1–96). https://censusnepal.cbs.gov.np/Home/Details?tpid=5&dcid=3479c092-7749-4ba6-9369-45486cd67f30&tfsid=17

Coastal flooding. (2008). https://www.floodsite.net/juniorfloodsite/html/en/student/thingstoknow/hydrology/coastalfloods.html

Commission, W., River, B., & River, B. (1998). *River valley civilizations*. https://courses.lumenlearning.com/suny-hccc-worldcivilization/chapter/river-valley-civilizations/

D.S. Mishra and D. Thara. (2021). *River Planning Guidelines*.

De Risi, R., Jalayer, F., De Paola, F., Carozza, S., Yonas, N., Giugni, M., & Gasparini, P. (2020). From flood risk mapping toward reducing vulnerability: the case of Addis Ababa. *Natural Hazards*, *100*(1), 387–415. https://doi.org/10.1007/s11069-019-03817-8

Eckartsberg, R. Von. (1963). *Existential-Phenomenological*. *1962*, 3–4.

Flash floods. (2008). https://www.floodsite.net/juniorfloodsite/html/en/student/thingstoknow/hydrology/flashfloods.html

Government of Nepal; Central Bureau of Statistics. (2014). *Population Monograph of Nepal*. https://doi.org/10.1111/j.1469-8749.1961.tb10378.x

Government, V. (2016). *River Corridors | Flood Ready*. State of Vermont. https://floodready.vermont.gov/flood_protection/river_corridors_floodplains/river_corridors

Hanumante River - Wikipedia. (n.d.). Retrieved May 16, 2022, from https://en.wikipedia.org/wiki/Hanumante_River

Jonker, J., & Pennink, B. W. (2010). The Essence of Research Methodology - Complete Book. In *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:No+Title#0

Kindermann, P. E., Brouwer, W. S., van Hamel, A., van Haren, M., Verboeket, R. P., Nane, G. F., Lakhe, H., Prajapati, R., & Davids, J. C. (2020). Return level analysis of the hanumante river using structured expert judgment: A reconstruction of historical water levels. *Water (Switzerland)*, *12*(11), 1–29. https://doi.org/10.3390/w12113229

Lee, S. (n.d.). *Abductive Reasoning*. Retrieved May 25, 2022, from https://www.brown.edu/Departments/Joukowsky_Institute/courses/greekpast/4886.html

Lussetyowai, T., & Adiyanto, J. (2020). A study on urban spatial patterns of riverside settlement: A case study of Musi Riverside, Palembang. *IOP Conference Series: Earth and Environmental Science*, *402*(1). https://doi.org/10.1088/1755-1315/402/1/012010

Municipality, M. T. (2020). मध्यपुर तितम नगरपातलका भवन तनमाण मापदण्ड सङ्ग्रह. *The Musical Times*. https://doi.org/10.2307/952648

Pandey, P., & Dugar, S. (2019). Flood Hazard Mapping in an Urban Context : A Case Study of Hanumante Stream , Bhaktapur (Nepal). *Proceedings of IOE Graduate Conference*, *6*, 435–444.

Paradigm - Wikipedia. (n.d.). Retrieved May 24, 2022, from https://en.wikipedia.org/wiki/Paradigm

Pujita Shrestha. (2019). No Titीले. *Genesis of Urban Flooding: A Case Study of Madhyapur Thimi Municipality*, 1–9. https://doi.org/.1037//0033-2909.I26.1.78

Rijal, M. (2018). The configuration of residential area in urban structure of the palace in Siak Sri Indrapura - Riau. *IOP Conference Series: Materials Science and Engineering*, *352*(1). https://doi.org/10.1088/1757-899X/352/1/012060

Rosyidah, S., Iswandi, M., Kadir, I., & Simatupang, M. (2022). The Development Pattern of the Lasolo Riverbank Settlement in Kendari, Southeast Sulawesi-Indonesia. *Future Cities and Environment*, *8*(1), 1–11. https://doi.org/10.5334/fce.147

Sada, R. (2012). Hanumante River: emerging uses, competition and implications. *Journal of Science and Engineering*, *1*, 17–24. https://doi.org/10.3126/jsce.v1i0.22489

Sahu, A., Bose, T., & Samal, D. R. (2021). Urban Flood Risk Assessment and Development of Urban Flood Resilient Spatial Plan for Bhubaneswar. *Environment and Urbanization ASIA*, *12*(2), 269–291. https://doi.org/10.1177/09754253211042489

Salike, I. pradhan & J. R. P. (2017). *Impact of Urbanization and Climate Change on Urban Flooding_ A case of the Kathmandu Valley.pdf*.

Subrina, S., & Chowdhury, F. K. (2018). Urban Dynamics: An undervalued issue for water logging disaster risk management in case of Dhaka city, Bangladesh. *Procedia Engineering*, *212*, 801–808. https://doi.org/10.1016/j.proeng.2018.01.103

Water: Flood Resilience in urban areas. (2005). https://www.royalhaskoningdhv.com/en/markets/flood-resilience-in-urban-areas/5733

What is a Flood? | What Causes a Flood? | Flooding | Earth Networks. (n.d.). Retrieved July 25, 2022, from https://www.earthnetworks.com/flooding/

WHO. (2017). *Floods*. https://www.who.int/health-topics/floods#tab=tab_1

World Population Prospects - Population Division - United Nations. (n.d.). Retrieved July 26, 2022, from https://population.un.org/wpp/

ANNEXES

Annex 1: SITE PHOTOGRAPHS

Figure 76 Raised Plinth

Figure 75 Newly built residence

Figure 78 Muddy side road and temporary buildings

Figure 77 Raised water level

Figure 80 Temporary structures near riverside

Figure 79 Barren space nearby riverside

Annex 2: QUESTIONAIRE

Thesis "Urban development near riverside corridor: A flood hazard perspective"

Enter a date

yyyy-mm-dd

House and Household Information

House S.N

Household Name

Age

- [ ] 15-30
- [ ] 31-45
- [ ] 46-60
- [ ] above 60

Education

- [ ] Below SEE/SLC
- [ ] +2
- [ ] Bachelor
- [ ] Masters and Above

Occupation

- [ ] Service
- [ ] Business
- [ ] Farming
- [ ] Retired
- [ ] Other

Household Number

Location

latitude (x.y °)

longitude (x.y °)

altitude (m)

accuracy (m)

Ward No.

Resident Type

- [ ] Ownership
- [ ] Rental

Where are you originally?

- [ ] Migrated from outside valley
- [ ] Some other part in valley

Land Owned

- [ ] Below 3 aana
- [ ] 3-6 aana
- [ ] Above 6 aana

House setback

- [ ] Below 20M
- [ ] More Than 20M

Age of the Building

- [ ] Recently Built
- [ ] Below 5 yr
- [ ] Below 10 yr
- [ ] Below 20 yr
- [ ] More than 20 yr

Building Type

- [ ] Concrete Frame structure
- [ ] Load Bearing structure
- [ ] Temporary settlement
- [ ] Timber structure
- [ ] Steel Structure

Building usage by owner

- [ ] Residential
- [ ] Residential+Commercial
- [ ] Rental residential
- [ ] Rental commercial
- [ ] Rental institutional

No of storey

_____

Plinth Level

_____

Exposure

Vehicle ownership

- [ ] 2 wheeler
- [ ] 4 wheeler
- [ ] Cycle
- [ ] None

Are you aware of the risk of flood?

- [ ] Yes
- [ ] No

Are you aware about the setback of 20M from the riverside for new construction?

- [ ] Yes
- [ ] No

Why did you come to stay?

- [ ] Own Land
- [ ] Near to workplace
- [ ] Cheap rent/bldg/land
- [ ] own community
- [ ] Others

How do you find daily travel to and fro from the area?

- [ ] Relatively easy
- [ ] Good
- [ ] Difficult
- [ ] Very Difficult

How frequently do you use the hanumante river corridor for travel?

- [ ] Very frequently
- [ ] Occasionally
- [ ] Vey little

Did you face flood related issues near your house?

- [ ] Yes
- [ ] No

If Yes, How many times did you face flood while living in this address?

- [ ] Once
- [ ] Twice
- [ ] Thrice
- [ ] More than thrice
- [ ] Many times

. What was the amount of structural damage to your building? (

- [ ] Minimum
- [ ] Small
- [ ] Medium
- [ ] High
- [ ] Very High

Susceptibility

Any measure taken for flood damage control?

- [ ] Pumped water
- [ ] Temporary barriers
- [ ] Other ways
- [ ] Do nothing
- [ ] Option 5

. Just before the flood, how did you first become aware that flood waters might reach your home?

- [ ] TV
- [ ] Radio
- [ ] Newspaper
- [ ] Siren
- [ ] Observing the water level

Are you and your family able to evacuate, in case of a flood?

- [ ] yes
- [ ] no

Is there any shelter to stay during the flood evacuation?

- [ ] Yes
- [ ] No

Lack of Resilience

Are you satisfied with the prevention measures and evacuation by government and other organization?

- [ ] Much satisfied
- [ ] Satisfied
- [ ] Not much satisfied
- [ ] Unstatisfied

Do you get financial flood support?

- [ ] Yes
- [ ] No

How much are you satisfied with current situation of the riverside?

- [ ] Very satisfied
- [ ] Satisfied
- [ ] Less satisfied
- [ ] Unsatisfied

What do you feel is lacking in the area(problems) and what can be done for further development?

_____

Photos

Click here to upload file. (< 5MB)

076MSUrp006-THESIS REPORT.pdf

ORIGINALITY REPORT

15%
SIMILARITY INDEX

PRIMARY SOURCES

1	conference.ioe.edu.np Internet	257 words — 2%
2	www.water.wa.gov.au Internet	184 words — 1%
3	journals.ub.uni-koeln.de Internet	168 words — 1%
4	nepjol.info Internet	167 words — 1%
5	mohua.gov.in Internet	151 words — 1%
6	Muhammad Rijal. "The configuration of residential area in urban structure of the palace in Siak Sri Indrapura - Riau", IOP Conference Series: Materials Science and Engineering, 2018 Crossref	115 words — 1%
7	mafiadoc.com Internet	115 words — 1%
8	dec.vermont.gov Internet	110 words — 1%
9	www.futurecitiesandenvironment.com Internet	

त्रिभुवन विश्वविद्यालय
Tribhuvan University
इन्जिनियरिङ अध्ययन संस्थान
Institute of Engineering
डीनको कार्यालय
OFFICE OF THE DEAN

GPO box- 1915, Pulchowk, Lalitpur
Tel: 977-5-521531, Fax: 977-5-525830
dean@ioe.edu.np, www.ioe.edu.np
गोश्वारा पो ब. न- १९१५, पुल्चोक, ललितपुर
फोन- ५५२१५३१, फ्याक्स- ५५२५८३०

Date: September 19, 2022

To Whom It May Concern

This is to confirm that the paper titled "*Flood Hazard Mapping and Vulnerability Analysis of Hanumante Riverside Corridor Section*" submitted by **Manish Karmacharya** with Conference ID **12135** has been accepted for presentation at the 12th IOE Graduate Conference being held in October 19 – 22, 2022 at Thapathali Campus, Kathmandu.

Khem Gyanwali, PhD
Convener,
12th IOE Graduate Conference

Annex 3: Comments of the Final Presentation

S.N	Comments	Response to Comments in P.G No.
1	Grammatical correction in the paragraphs	PG. 1, 2 & 5
2	Correction of the citation in the paragraphs	PG 1 & 2
3	Schedule Correction	Table of schedule removed
4	Need to add more discussion part of model byelaws of 2072 in results and discussion sections	PG 66
5	Cross checking of the fulfillment of the objectives in the conclusion and Recommendation section	Checked pg4 and pg 67
6	Needs to add more details in prescribed Format	Added pg I and II
7	Mentioning of the 200m radius in questionnaire survey	PG 52
8	Place photo separately	Pg 36