Socio-economic and environmental impacts of changing land use pattern of Rangamati District

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CERTIFICATE OF APPROVAL

This is to certify that the dissertation titled **" Socio-economic and environmental impacts of changing land use pattern of Rangamati District "** submitted by Md. Maksudur Rahman to fulfill the requirement of a Ph.D. degree at the Institute of Disaster Management and Vulnerability Studies of the University of Dhaka, Bangladesh, has been carried out under our supervision. It is also confirmed that the work provided here is eligible for submission for the Ph.D. degree and the candidate swears that this dissertation, or any portion of it, has never been submitted anywhere for any other degree previously. We are forwarding the dissertation for necessary action.

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Abstract

Land is an important resource for the environment, civilization, and every community. Almost all human activity on land is powered by agriculture, housing, and a variety of natural resources. It should be managed appropriately to ensure that this finite resource is put to the best use for the advantage of the most considerable amount of people. Day by day, human involvement and natural phenomena generate changes in land usage. Land use change, in turn, can impact the social and environmental conditions of any area. Many applications require precise land use information, such as natural resource management, planning, and monitoring programs. Land cover change is becoming a critical component of modern natural resource management and environmental change monitoring systems. There has been a rise in research on land use change due to the rapid investment and development of land use mapping. This study aimed to analyze Land Use Land Cover (LULC) changes in the Rangamati district of Bangladesh between 1977 and 2019, the consequences of land use change in socio-economical and environmental situations, and investigate the significant driving forces of land use in the study region. The 'Normalized Different Vegetation Index' (NDVI) is a dimensionless index with values between -1 and 1. Higher NDVI values indicate healthy vegetation, whereas lower (0) NDVI values indicate unhealthy vegetation. Values near zero but not negative suggest a settlement, bare land, rock, and sand beach, respectively, while negative values indicate the absence of green vegetation. Landsat Satellite image from five different years (1977, 1989, 2000, 2011, and 2019) was used to calculate the NDVI value for January. To produce a land use land cover map and identify changes, the NDVI values are reclassified using a "Defined Interval" algorithm. The highest NDVI value was discovered in 1977 (0.88), indicating the presence of healthy vegetation at the time.

After 1977, it was found that the NDVI value was dropping (0.79 in 1989, 0.74 in 2000, 0.71 in 2011, and 0.53 in 2019), indicating a quickly degrading shift in the plant cover in the studied region. Population growth, migration from plain land, rapid urbanization, the Kaptai Dam, the government's migration policy, high land prices, unplanned development, tourism industry development, firewood collection, and poverty were identified as the significant drivers of LULC changes in the study area. Additionally, analysis of NDVI results confirmed that forest or dense vegetation area is decreasing while settlement area and sparse vegetation area are gradually increasing, which may be a significant threat to ecosystem function and climate change. The accuracy of the NDVI-based classified

images is evaluated by computing the overall classification accuracy and the Kappa coefficient using a confusion matrix. Overall classification accuracy ranged from 84 to 90%, with Kappa statistics ranging from 80 to 88% for TM and OLI TIRS images.

The study attempts to reconstruct history to comprehend the dynamics of LULC changes for environmental degradation. Land surface temperature (LST) is one of the most important variables of environmental changes. The environmental changes in the Sadar Upazilla of Rangamati were observed using the extracted LST of satellite imagery of January for three different years: 2000, 2011, and 2019 in this study. This was compared to data from the Bangladesh Meteorological Department (BMD) and Google. The retrieved data from satellite imagery is supported by the BMD and Google Data. The NDVI value is significantly associated with the LST taken from the satellite image. As the NDVI value rises, the temperature falls, and as the NDVI value falls, the temperature rises. It revealed that the temperature was low when the vegetation was high and progressively increased when the vegetation was low. The increasing trend of LST in Rangamati is indicative of the district's overall environmental situation. The government and development agencies should view these findings as a critical issue in Bangladesh's southeastern region. The field survey in the Rangamati district gave a clear picture of the socio-economic and environmental change in the locality identifying overpopulation as the significant driving force responsible for land use change.

CHAPTER SIX

CHAPTER SEVEN

CHAPTER EIGHT

List of Figures

List of Tables

List of Abbreviations

BBS	Bangladesh Bureau of Statistics
BMD	Bangladesh Meteriological Department
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
ha	Hectare (1 ha = 2.47 acre)
Kg	Kilogram
KII	Key Informants Interview
LGED	Local Government and Engineering Department
LST	Land Surface Temperature
Mm	Millimeter
NGO	Non-Government Organization
OLI & TIRS	Operational Land Imager & Thermal Infrared Sensor
Sq. Km.	Square Kilometer
UNDP	United Nations Development Programme
GIS	geographic information system
TM	Thematic Mapper
SRS	Satellite Remote Sensing
USGS Glovis	United States Geological Survey Global Visualization Viewer

CHAPTER ONE

INTRODUCTION

1.1 Introduction

The land is an important resource for the environment, civilization, and every community. Almost all human activity on land is powered by agriculture, housing, and a variety of natural resources. Land use change detection can help identify people's socioeconomic and environmental situations and maintain the coastal region's biological balance. Remote sensing and GIS techniques are valuable tools for assessing current resources and the area's social, economic, and environmental conditions (Musa, 2008). The present field observations and the satellite image analysis found that the forest area of the Rangamati district is decreasing year by year. The hills were cut for agricultural purposes. The land surface temperature of Rangamati Sadar also increases, indicating the Rangamati district's overall scenario. Urbanization is also a major driving force for Rangamati accelerating land use and land cover changes. One of the purposes of this study was to analyze changes in Land Use Land Cover (LULC) in the Rangamati district of Bangladesh between 1977 and 2019, using reclassified NDVI values from satellite images. Landsat Satellite image from five different years (1977, 1989, 2000, 2011, and 2019) was used to calculate the NDVI value for January. To produce a land use land cover map and identify changes, the NDVI values are reclassified using a "Defined Interval" algorithm. The land use land cover map will indicate important information about land use changes' overall socio-economic and environmental impact.

1.2 Background of the Study

Rangamati is a district rich in natural wonders and cultural legacy. It is bordered on the north by Tripura, on the south by Bandarban, on the east by Mizoram, and on the west by Khagrachari and Chittagong. It's part of the Chittagong Division. Rangamati is Bangladesh's biggest district by area. The Chittagong Hill Tracts include it. This district has ten Upazilas, two Pourashavas, fifty Unions, 1349 villages, and 159 mouza. In 1891, it was designated as a subdivision, and in 1983, it was elevated to a district. Rangamati is supposed to have derived its name from the land's Radish Soil, which denotes Rangamati in Bengali. Rangamati district covers a total size of 6116.13 square

kilometers. Rangamati District has a vast history and legacy of tribal and Bengali people with a vibrant culture.

Apart from Bengalis, tribal people include the Chakma, Murong, Pankho, Marma, Chak, Tripura, Lucai, Kheang, Tanchanga, Khumi, and Boam. This district has a population of 6,20,214 (BBS, 2011).

Rangamati is also known for its cashew nuts, watermelon, Bangla bananas, and fresh fish from Kaptai Lake. A hydroelectric power plant in Kaptai and a Terrestrial Earth Satellite data receiving facility at Betbunia, Kawkhali are notable features of the region. Near town, there is a hilltop point called Furman Peak, from which one can see the entire town. Tourism, hydroelectric power, agriculture, fisheries, and forest & forest resources are the primary economic activities in the studied region. The lake is a biologically diverse basin with a wide variety of fish, fauna, aquatic animals, and many local bird species and a stopover point for many migrating birds. So, the Rangamati is different from any other plain district of Bangladesh of its diversified landform, population, cultural, environmental, and socio-economic activities.

1.3 Statement of the Problem

Our primary food production facility is land, a scarce and potentially fruitful natural resource. Changes in the land use pattern of Rangamati lead to transformations in the hydrological, biological, geomorphologic, anthropogenic, socioeconomic, and environmental systems. This would greatly influence the surrounding ecosystem: risks of losing agricultural land, destruction of forest resources, water depletion and deprivation, and the benefits generated from the land. The rapid population expansion in the Rangamati district's urban-rural edge area makes it increasingly vulnerable to disasters like landslides, flash floods, etc. Most planners and policymakers lack reliable, timely, and cost-effective urban land use planning and appropriate data to make judgments about land resource management at the juncture of fast growth on the urban-rural fringe. Quantifying relevant data in the context of changing land use planning and land cover is thus critical for effective monitoring and resolution of negative repercussions and impacts on the surrounding ecosystem, biodiversity, and community people's livelihood. For monitoring and resolving the dire consequences, quantifying changes in land use and land cover in the future is crucial. This might benefit the research area's land use management and environmental development.

1.4 Rationales of the Study

Land use and land cover change are very complicated and swift processes (Thakkar et al. 2014). It includes the earth's natural and physical cover and the many ways humans use land, such as settlements, agricultural areas, reservoirs, and transportation networks, as well as the many ways humans use land. LULC change detection is an essential tool (Sahebjalal and Dashtekian 2013). Changes in land use pattern is a major pressure on the limited land resources that are driven by different biophysical, environmental, and anthropogenic factors, particularly population growth and migration. The findings of this study would provide actual quantitative data and information about the changing pattern of land use plans as this study has applied GIS and the Remote Sensing approach for understanding the ground realities. The evidence of the factor responsible for altering land use was documented in the Research Base. It would also allow for a better understanding of the change trends in various sectors due to driving variables. By following GIS mapping this study has measured the sequential changes in land-use patterns of the Rangamati district. The Research base documented evidence of the factor responsible for changing land use. The findings also provide the opportunity to understand the trends of changes in different areas as a result of analyzing many driving variables. The study found very diversified land surface, agricultural practices, socio-economic and demographic traits, distinct cultural heritage, different livelihood strategies, and socio-economic activities of the Rangamati, are so much different from any other plain district of Bangladesh. The study also indicates that by assessing the past four decades' nature of diffusion, changes, and concentration of land use patterns, we would be able to address the havoc of various natural and man-made disasters to a greater extent. Moreover, the findings of this study would be an initial input for future policy implications and research direction for concerned planners, professionals, and researchers.

1.5 Research Questions

The research questions of the present research have been set as follows:

- What Kind of changes has been occurring in land use pattern in the Rangamati district between 1977 and 2019?
- What are the major driving forces of changes in land-use patterns in the study area?

- How the socioeconomic status and environmental setting have been impacted due to changing land-use patterns in the study area?

1.6 Objectives of the study

This research looks at the pattern of land-use changes and their socioeconomic and environmental effects on the studied population's livelihood. The broad and specific objectives of the study are given below:

The broad objective:

The broad objective of this study is to explore the pattern of land use changes and their socio-economic and environmental impacts on the livelihood of the study population.

The specific objectives of the study are:

- To assess the temporal dynamics of changing land-use patterns in the study area between 1977 and 2019.
- To explore the major driving forces of land use changes in the study area, and
- To identify the effects of land use changes on socio-economic and environmental conditions of the research population.

1.7 Basic Methodology of this Research

Two essential and relevant data which have been used in this research are the survey of the Rangamati District of Chittagong hill tracks for a socio-economic and environmental survey of the study area and the Landsat time series of LULC data sets from the imagery of MSS, TM, and OLI_TIRS, which were acquired from January 1977, 1989, 2000, 2011 and 2019. The dry season was selected because less cloud cover affects the Landsat images(Tovar 2011). All images were captured in level 1T and geometrically adjusted (L1T). Furthermore, due to cloudiness or noise-free sceneries, the time interval between all satellite photographs was more than 16 days. According to (Sun et al. 2009), two criteria were used to choose satellite photos for this study: (1) the satellite images must have less than 10% cloud coverage (if feasible, cloud-free); and (2) the satellite images must be accessible for an extended period.

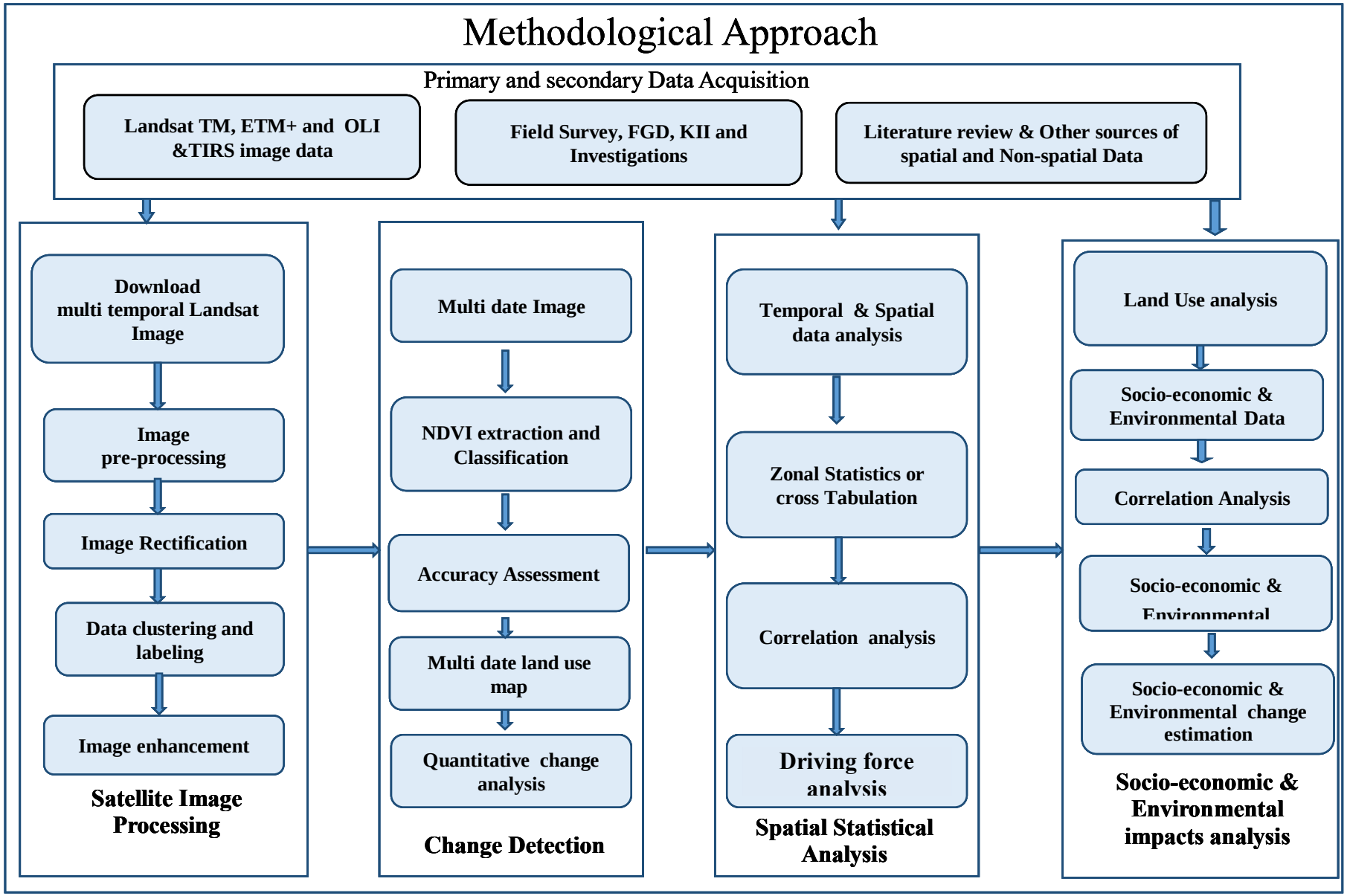


Figure 1. 1 Methodological approach (Modified approach of Mesev-2007)

1.8 Limitations of the Study

The present study has been conducted with some shorts of limitations. As a developing country, Bangladesh lacks a well-organized database for all sectors on both national and regional levels. Some government and non-government departments will start digital database systems, but they are still far away from their destination due to a lack of coordination among different organizations. In some cases, unwanted intervention from government policymakers has been done to show more progress than is happening at the regional or local level. Here are outlined limitations of the present study as follows:

- The current provision of image spatial resolution is very much poor and the same date of different years' cloud-free quality image is not available and, needs to be accommodated.
- The latest impact factor research journal and relevant literature and text must be available in our country, especially in different research and local government institutions.
- Most of the departments & offices are in the process of digitalization but some data banks are part of an analog system. This challenging condition needs to be overcome by making provision of accessibility so that temporal secondary data can easily be retrieved.
- Access to the study area is quite challenging due to its hilly topography and diversified languages. Therefore, conducting this type of research is quite challenging, and needs to be overcome.

  Inadequate funds for undertaking research. Field surveys in distant mountainous areas and the analysis of improved resolution satellite images for various periods are both required for more accurate land use analysis.

1.9 Thesis Structure and overview of the chapters

This study or dissertation consists of ten chapters that are organized and summarized in the following ways:-

Chapter-1: This chapter contains a brief description of the background study of the Rangamati district. It also includes the research aims, objectives, and research structure. It also includes the research methodology in detail with kind attention.

Chapter-2: The existing literature review on land-use changes and the impacts. Summary of various research studies related to land use and its effects are described here.

Chapter-3: The chapter describes the general facts and figures of the Rangamati district, the study area. It includes information about the district's geography, history, and institutional authority.

Chapter-4: Here discussed the overall research approach used in this study.

Chapter-5: The results of satellite image analysis to detect land-use pattern changes were presented in this chapter.

Chapter-6: The socioeconomic profile of the Rangamati district is discussed in this chapter, which is based on a questionnaire field survey.

Chapter-7: The environmental profile of the study area is discussed in this chapter, which is based on a questionnaire field survey.

Chapter-8: This chapter discusses the outcomes of the field survey questionnaire, the FGD, and the KII.

Chapter-9: The overall analysis has been discussed in this chapter.

Chapter-10: Finally, the last chapter includes the summary, the findings, conclusions, and recommendations of this study.

Chapter Two

Literature review

2.1 Introduction

This chapter is about the literature review of land use and its socio-economic and environmental impacts. To understand a study, a literature review is a must. The more precise the literature review is, the more our study will be enriched with knowledge.

2.2 Terminologies & Basic concept

The land on Earth comprises everything that occurs above and below this surface, including the near-surface climate, soil and terrain forms, surface environmental science (such as shallow lakes, riverbeds, and swamps), and near-surface sedimentary levels and their associated groundwater reserve. Additional sections on plant and animal populations, human settlement patterns, and the physical repercussions of historical and contemporary anthropogenic activities. (FAO 1995). Land used to be a physical object defined by where it was and how it looked. This is usually linked to an economic value, usually expressed in the price per hectare when someone bought or sold the land.

Use the term "land" to describe many different types of natural resources in a profile that goes from the air above ground to a few meters below it. Natural resources need to have a good climate, landform, soil, vegetation, wildlife, water, and so on (Wolman 1987). The land's geography, structure, agriculture, and minerals are all examples of land qualities. The temperature, the availability of clean air and water, and factors like quiet, seclusion, and aesthetic appearance are also examples of land qualities (Hoover and Giarratani2020).

"Land cover is the biophysical state of the earth's surface and the area near it" (Turner et al. 1994). If there are plants on the surface, how much water is available, or what kind of soil is in the ground, it's called "surface cover" (Meyer and Turner 1994). When the term was first used, it only meant the type of vegetation that covered the land surface. It has since been expanded to include human structures like buildings and pavement and other parts of the physical environment, like soils and biodiversity (Moser 1996). FAO says that land use refers to how land is used by the people there. It

can also be called human activities that are directly connected to the land, use land's resources, or affect them. A wide range of natural resource features can be found in a profile from the atmosphere above the surface to a few meters below the surface. The term "land" is used to describe this profile. Natural resources need to have a good climate, landform, soil, vegetation, wildlife, water, and so on (Wolman 1987). The land's geography, structure, agriculture, and minerals are all examples of land qualities. The temperature, the availability of clean air and water, and factors like quiet, seclusion, and aesthetic appearance are also examples of land qualities (Hoover and Giarratani2020).

Analyses of the environmental effects of land cover changes show how essential it is to separate land use and land cover types. As Meyer (1994) says, it is crucial to keep the definition of grassland based on its ecological characteristics (vegetation structure and composition) rather than its primary use as a feeding ground for livestock. It is impossible to directly link land use to the main physical processes that change the world's environment. Land use can't be directly linked to different types of global change because it is a qualitative term. Land use categories are types of things that aren't real and can't be used in process models that try to predict how the world will change over time and space. It's land cover, not land use, that has the most mechanical impact on the world's environment, not land use (Meyer 1994)

GIS:

"A geographic information system is an all-in-one piece of software designed to work with geographic data. It does a wide range of data-handling tasks. These tasks include data input, storage, retrieval, and output and a wide range of descriptive and analytical tasks." (Calkins and Tomlinson- 1977).

TM:

Thematic Mapper (TM) images consist of seven spectral bands with a spatial resolution of 30 meters for Bands 1 to 5 and 7. Spatial resolution for Band 6 (thermal infrared) is 120 meters but is resampled to 30-meter pixels. The approximate scene size is 170 km north-south by 183 km east-west.

Landsat 7 ETM+:

Landsat 7 Enhanced Thematic Mapper Plus (ETM+) images consist of eight spectral bands with a spatial resolution of 30 meters for Bands 1 to 7. The resolution for Band 8 (panchromatic) is 15 meters.

OLI & TIRS:

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9. New band 1 (ultra-blue) is helpful for coastal and aerosol studies.

WRS Path & WRS Row:

The Worldwide Reference System. The Worldwide Reference System (WRS) is a standard nomenclature for Landsat data worldwide. It enables users to request satellite pictures for any region by supplying a nominal scene center identified by Path and Row numbers. (https://landsat.gsfc.nasa.gov/the-worldwide-reference-system/).

2.3 History of Land use

When people live on the earth, they have a very close connection. The land has always been the source of man's food, clothes, etc. There are many different ways people have used land over time, and these changes are based on where the land is and how people live. I think people should know about land resources and land use to meet their own needs. Different people have tried to figure out what land use means from various perspectives. A society's cultural background, skills, and physical needs all play a role in how land is used. On the other hand, the land itself has a lot to offer (Ram and Kolarkar 1993).

Humankind is intrinsically related to the land. The land has historically provided man with food, shelter, and clothes. As a result, humans have utilized land in various ways, depending on their location and period, as well as their social and economic demands. As a result, I feel that man's understanding of land resources and land usage is necessary to satisfy his demands. Numerous academics have sought to define "land use" in several ways. Historically, land use has been considered the outcome of interactions between a society's cultural legacy, capabilities, and physical necessities on the one hand and the realistic possibilities of land on the other (Ram and Kolarkar 1993). Landuse is another name for human actions on land that are inextricably linked to the land (Clawson and Stewart 1965).

In that sense, we can say it is one of the main conditions to visualize the development planning of any developed nation. As a nation, we are in the developing group. The barriers to the development are our population and a limited land resource. In this present world, it is obvious to prepare and correct data to fulfill the present needs and

the future generation's betterment. Throughout its long history, it has been found that scientists are trying to control land use and preserve its quality through their research. At different times, different geographers have worked for Nature in a type of land use. Although, the land survey system had been much improved in the ancient Egyptian Nile civilization.

2.3.1 Land Use Conflicts

In most developing nations, land use conflict is a regular occurrence. The need to generate more food and fuelwood and fodder and lumber for home and industrial usage is causing conflict. As a result of deforestation, forest areas in this region continue to diminish. Strong political will and dedication constantly strengthen land-use policies, resource conservation, and sustainability, and their implementation in the field.

2.4 Importance of land use change study

Land use analysis is critical for both the land parcel's user and comprehending the surrounding environment. A specific area's land-use pattern varies throughout time in response to changing demands. The changes are due to changes in the overall functional demand and the physical environment. It is challenging to design a future development strategy for an area or region without first comprehending the pattern of land-use change (Khorram et at. 1991). It is vital to understand the potential of a land resource and the changing land-use trends in a particular location to maximize the land's utilization. On a more mundane level, everyday activity affects future land use patterns: The relationship between land use and land cover change is crucial, according to Briassoulis (2000), since land cover changes primarily mediate the environmental effects of land use its contribution to global change. As a result, their research looks at the interaction between land use and land cover change at different geographical and temporal scales. In terms of the latter, the assumption is that changes in local land use will not always result in significant changes in local land cover. They may aggregate spatially and temporally at a more significant level (e.g., regional or national), resulting in significant land cover changes. For instance, agricultural land is converted to urban uses due to individual landowners' decisions to repurpose their farms. Similarly, land-use changes may look qualitative at lower geographical and temporal resolutions, but they become quantitative at higher resolutions and with time.

2.5 Satellite Image Landuse Mapping

2.5.1 Change detection

The two primary picture categorization approaches are unsupervised (calculated by the software) and supervised (human-guided). The user may specify which algorithm to use and how many output classes they want; however, this does not include aid categorization.

2.5.2 Supervised Change Detection

Supervised classification is the most often utilized approach for quantitative remote sensing image data analysis. The idea behind it is to partition the spectral domain into sections that may be connected with different ground cover classes depending on the application. In reality, these zones may only intersect on rare occasions. The work may be accomplished in various methods, and this chapter will discuss the most frequent ones. The various methodologies vary essentially in their approach to identifying and characterizing spectral space areas.

2.5.3 Unsupervised Change Detection

Unsupervised categorization provides outputs (groupings of pixels with associated features) based on software analysis of an image without the user providing example classes. The computer uses algorithms to determine which pixels are related and categorize them properly. While the user may choose the algorithm to use and the number of output classes they want, this does not help categorize the data. The user must be acquainted with the categorization area when matching the computer's groupings of pixels with similar properties to fundamental ground features.

2.5.4 Normalized Difference Vegetation Index (NDVI)

Remote sensing data is often utilized to monitor large-scale changes in vegetation cover (Nath and Acharjee 2013). Because the NDVI is a dimensionless index, its values range from -1 to 1. (Munthali et al., 2019). Higher NDVI values indicate healthy vegetation, whereas lower (0) NDVI values indicate unhealthy vegetation. Values near zero but not negative suggest a settlement, bare land, rock, and sand beach, respectively, while negative values indicate the absence of green vegetation (Tovar 2011). Three Landsat time-series imagery of Level 1 MSS, TM, and OLI_TIRS were acquired and used to evaluate LULC changes reclassifying NDVI values for this study.

2.5.5 Land use Mapping

Although satellite data for determining Landuse features has been recognized since the early 1970s, substantial studies were only discovered in the 1980s. The advent of better-resolution satellite carried scanners, notably spot and Landsat TM, has increased the number of outstanding works (Khan, 1998). The sensors' feature detecting capabilities, such as resolution and bandspread, have been extensively researched and often 33-hanged and effectively boosted. Since the introduction of Landsat-1 (ERTS) in 1972, numerous studies have been conducted in geographical, hydrological, geological, and agricultural remote sensing, as well as land-use detection and analysis. These studies may be found in the Remote Sensing Manual, volumes I through XI (1975, 1985). The guides covered a variety of theoretical and practical elements of remote sensing applications.

Here, a review of some critical works done in Bangladesh and the world in the context of the present study are presented, The application of remote sensing technology in Bangladesh began in 1948 with the availability of aerial photographs taken for cartographic Mapping, forest inventory, and water resource studies in 1978 Bangladesh Landsat program (BLP), now known as SPARRSO, they introduced satellite remote sensing technique first time in Bangladesh which is BLP successfully prepared for the Landuse map of St. Martins Island in Bangladesh by using Landsat MSS data and documented as BLP REPORT (1978). The study was, to some extent, a detailed work where the agricultural lands, villages, barren lands, and roads were shown. In the same year, BLP conducted another Landuse classification study collaborating with the Geography Department of Dhaka University on Nachole Thana of Rajshahi districts, Bangladesh. This was using aerial photographs and Landsat MSS images. In a noticeable work, Sharma (2003) identified the Landuse changes and growth of Delhi Metropolitan Area, India, between 1972 and 1977. Landsat MSS data for September 1972, November, and May 1977 were used in the study. The researcher mainly intended to find out how Landsat MSS data could be used for urban Landuse detection and analysis and whether multi-temporal data could be used to identify urban growth. Some research work of different authors is discussed below.

Pramanik, M. A. H. & Jabbar, M.A. (1990) the applications of satellite data in the Bangladesh coastal zone to identify geomorphologic changes and the determination of estuarine water circulation. Data from Landsat 4 of 1984 and Metsat (NOAA AVHRR)

of 1986/87 were used. For geomorphologic changes, the period under study was between 1960 and 1984. For estuarine water circulation, Metsat data of 1986/87 were used. Both erosion and accretion are prominent in the study area. North/south water movements can be noticed in the estuarine water circulation. Most erosion on the bayfront is probably the result of tide and wave action.

Chowdhury, A.M. et al. (1990) studied the temporal rate of deforestation of Chakoria, Sundarban in South-Eastern Bangladesh along the Coast using remote sensing techniques. The study was made using a series of aerial photographs and Landsat imagery supplemented by several ground-truth verifications examination of black and white aerial photographs taken in 1981 shows that destructive deforestation had started. In contrast, the study of 1975 aerial photographs did not show this feature. Year-wise deterioration of forest cover combined with the expansion of shrimp farms was shown in graphical form. Gradually shrimp farms were established by replacing mangrove vegetation.

Lam-dao (2011), in his study, changes in land cover in Ca Mau Peninsular (the southern section of the Mekong delta) and erosion of the Mekong River's banks were identified using remote sensing technologies. The principal method used in this work is change detection utilizing time series optical and radar satellite pictures (Landsat, SPOT, and Radarsat). According to the findings, more than half of the mangrove area had been transformed into shrimp farms. As a result, forest cover had drastically decreased. The Mekong River's riverbank had also been shown to be eroded and accreted in a complex pattern. Hot spots were characterized as areas along the left and right banks of the Tien and Hau rivers that had been severely eroded. Topographic maps from 1966 to 1968 were used as a baseline, while satellite pictures from 1989 through 2009 were studied alongside them.

Majumdar et al. (1991) used visible infrared (IR) and thermal infrared (IR) data to investigate the landuse categorization of a portion of the Kamiichi region in Japan. Five separate land use classes were effectively identified, including vegetation paddy fields, woodland, grass, lawn, urban area, and bare soil. Furthermore, each class of interest's visual, IR, and thermal IR data might be used to establish higher-level categorization.

Pariyar and Singh (1995) established a system for identifying land use/land cover changes using remote sensing methods and GIS. The Chitwan district of Nepal was chosen as the case subject for this study. The study used Landsat TM digital photos

from 1990 and aerial shots from 1992 to determine a land-use change in the study region. ERDAS version 8.0 raster-based GIS and image processing software for image pre-processing, image enhancement, image analysis, and categorization of digital pictures, and ARC/INFO version 6.1 for digitizing, labeling, and edge matching if various maps and land use map generation were utilized. A land-use classification scheme was successfully identified with five land-use classes: vegetation, cultivated land, forest land, urban land, and the river bed. The researchers recommended using remote sensing data for updating the land use database and land use planning purposes. Wanpiyarat et al. (1995) employed visually interpreted Landsat TM FCCs, to detect the land-use change in a 340 km coastline region in Thailand. The authors wanted to track land cover and land use changes, particularly about mangrove forest and paddy conversion to shrimp farms, and estimate shrimp farming areas. The technique involved a study of temporal Landsat TM pictures, field verification, polygon overlay, and land-use change monitoring. The authors evaluated the hard copy photographs individually, and field verification was done to improve the accuracy of the interpretation. On the FCCs, land use classifications are defined by variances in color and texture. The authors claim that identifying the kind of fruit tree using Landsat TM photos is ineffective without field verification. However, the study effectively detected coastline displacement and land-use change/transformations.

Land feature identification and change detection are essential to preparing development planning for land resources management and any other regional planning. So, it is essential to find a time to add a cost-effective technique for land use detection. The remote sensing technique has proven its effort in this purpose. All the previous Landuse studies in Bangladesh were conducted using low-resolution satellite data except Khan (1998). Several studies were done with Landsat MSS data, and the spatial extent of these studies was smaller. Some of the studies identified Landuse features as a by-product of other works. Land use of the wider region such as district label or larger region was not mapped to existing knowledge of the researcher using remotely sensed data in Bangladesh, especially the high-resolution satellite data. So the present study is aimed to prepare a Landuse map of a rapidly changing area of the country, the western Chittagong region using satellite data Landsat ETM+ and TM. So this study it is aimed to assess the applicability of multi-date data of Landsat satellite platforms having an individual spatial resolution to detect the Landuse pattern and land resource assessment.

Anjhum et al. (2021), in their research study, analyzed the land-use change in a hilly district in the Chittagong division, which is called Rangamati, Bandarban, and khagrachari. They used remote sensing techniques to analyze the land-use change because of the tourism of that place. The remote sensing (RS) and Google Earth Engine were beneficial for studying changes in land use and cover. They used multi-temporal satellite images to see the temporal change of the buildup areas. As in this study, Anjhum also used the confusion matrix to determine the accuracy of land cover change and the classification's efficiency.

2.6 Changes in Land Use and Landcover

Changes in land cover, usage, and management have happened in most of the world's regions throughout history as people's civilizations grew and collapsed (Dale et al., 2000). A change in the area covered by specific land use or cover class over time is often described as a change in the area covered by that land use or cover class (Farrow and Winograd, 2001).

Any change in land use might transfer to a new purpose or an expansion of an existing one. According to Turner and Meyer (1994), land-use change is likely to cause land cover change; nevertheless, land cover can change without influencing current land use. When a regular timber harvesting or shifting cultivation rate is surpassed, a well-managed forest gradually deteriorates. Land-use change is the most visible indication of human interaction with the biosphere, and it is an ongoing, continuous process. Due to rapid population growth and technological improvement, the breadth and pace of change in land use are greater now than in history. Actions are directly involved in land-use change, which substantially impacts the atmosphere and the entire biosphere. Conversion of land for agriculture, infrastructure, urbanization, industry, and unsustainable forestry highlights the bulk of the struggle for space between people and other species (Adger and Brown, 1994). Changes in land use and cover are identified using GIS and satellite data. " A geographic information system (GIS) is a software program that enables the processing of various data types and is specially designed for use with geographic data. "These duties include data input, storage, retrieval, and output and a broad variety of descriptive and analytical procedures" (Calkins and Tomlinson-1977). The science of remote sensing is the collection of data about the earth's surface without physically touching it.

Remote sensing and geographic information system (GIS) technologies give information about the nature, extent, and rate of LULC changes in the landscape, but they do not explain why they occur (Wondie et al., 2011). Between 1977 and 2019, the NDVI index was used to track changes in the Rangamati District's land use and cover. This study will be able to track the evolution of land use and land cover across time in this manner. Additionally, the study explores what local inhabitants consider the critical reasons for the study's changes in LULC.

2.6.1 Land Use Changes research study

There is a correlation between land-use change and the level of human disturbance in earthquake-stricken areas, changes in the landscape pattern index, and the intensity of human disturbance. There is a tendency toward "encircling" or "distributing" good landscapes. Bo Peng and Yongsheng Fu conducted this study (2019).

Chowdhury (2020), the Landsat 2 MSS data, Landsat 5 TM data, and Landsat 8 OLI/TIRS data were used to look at land use, and land cover changes in the Halda Watershed over the last 40 years. It shows a significant shift away from vegetation (35.1%) and water (85.47%) and toward Agriculture, Bare Soil, and settlements in the LULC and overlay maps that come out of the process. This study makes it easier for people who work with land use and development to choose the best option for the Halda Watershed.

Rasul (2004) addressed that shifting cultivation is essential for growing food in Bangladesh's Chittagong Hill Tracts (CHT). People who depend on the environment could lose their jobs if there are environmental problems. Because there isn't enough information about how land use systems have changed over time and the forces driving them, policies and initiatives to support new land use systems haven't worked. Cluster analysis was used in this study to find three types of land in Bandarban, which is a typical CHT hill area. Each type of land had a different intensity of use, level of diversification, and commercialization. Factor and regression analyses were used to look into the factors that affect the evolution of land use systems, like how they change over time. The most critical factors that led to three different land use system types were their fundamental aspects, their productive resource base, and their distance from a market and service center.

Islam (2021), in this study of Bangladesh's southeastern area, assessed land use land cover changes that directly and indirectly influence climate change (CC). Satellite images from 2001, 2006, 2011, and 2016 were utilized to examine changes in land usage and land-covered areas over five years. It also looked at land surface temperature change using the MODIS LST 8-day differences 1 km resolution and meteorological station dataset from 2001 to 2016. According to the findings, a considerable decline in farmed cropland throughout the research region resulted in a big rise in salt and shrimp cultivation. People were threatened by agricultural production and food security because it is a heavily inhabited region and one of the country's ago-based regions. They were destroying vast amounts of forest and vegetation to acquire cultivable land. Rapid urban growth had many environmental problems, including habitat quality, by infilling low-lying regions and destroying vegetation. Climate change's visible effects, such as rising temperatures and a variable rate of precipitation rise, we're also harming agricultural and cultivated land across the research locations. Because reliable and current data for Bangladesh's southeastern area is scarce, the land use and land cover maps developed in this study will aid in making long-term land-use choices and anticipating future growth patterns.

Hasan (2020), in the study, came up with two land cover change scenarios for the years from 2010 to 2040 business as a usual and environmental conservation priority. They also predicted the future land cover in the research area. They used the Dynamics of Land System (DLS) model to determine how the land would be used based on driving processes. The data showed that from 2010 to 2040, there would be a lot more built-up land and less agricultural land, forestry land, and farmland. Environmental protection is the most important thing to do. Forests, grasslands, and built areas would grow, while cultivated land and water areas would shrink under this scenario. Politicians who want to protect the environment and grow the economy in a more environmentally friendly way can use the study's findings to help them do this. Shrestha (2017), in their study, offered a thorough examination of current land change, both in terms of national scope and the utilization of extensive geographic data on land change, socioeconomic aspects, and case study synthesis. Eight forms of land cover were identified by their research, including 70% farmland, 10% wetlands (such as rivers and shrimp ponds), and 8% woodland. Agricultural, forest, and mangrove regions exhibited a decreasing trend, whereas bare soil, brush, water bodies, and residential areas showed an increasing trend.

Gao (2015) discovered that in 2003, 2007, and 2012, remote sensing (RS) images and geographic information system (GIS) technologies were utilized to examine land use changes in China's Yimeng Mountain ecological restoration zone. The findings indicated that: Cultivated land was used the most during the previous decade, followed by forest and grassland; both cultivated and unused land decreased by 28.43 percent and 44.32 percent, respectively. The only thing that increased was forestland. Forest land changed the greatest between 2003 and 2007, followed by unoccupied land and grassland. Between 2008 and 2012, the most significant changes were in the water area and land for water facilities, followed by grassland and unoccupied land. The amount of land utilized was more significant than average throughout the developing and degenerating periods of 2003–2007 and 2008–2012. Changes in the microtopography, plant cover, and land use distribution generated by ecological restoration programs contributed significantly to the region's land-use change.

Bin (2006), in his article, an analysis of land use changes over 13 years in China's Xiamen Special Economic Zone was done to improve understanding and find out what caused land use to change so that land use could be used more sustainably. There was a significant change in how much land was used for crops because many people moved to cities.

Parveen's (2002) article looked at the effects of the Kaptai Dam on the Rangamati. Around 100000 people were displaced when the dam was erected in 1962, and just a minority received proper compensation. The initial displacement issue was also explored in light of the region's geopolitical history.

2.6.2 Driving force feature of the land use change

Land-use change directly results from human influences on the natural environment, whose evolution is influenced by both natural and human forces. Biological variables such as height, landform, slope, downhill direction, soil, vegetation, and others, and human factors such as population, economy, system policy, and technological measures, are all important in the land use distribution of the ecological environment.

People have utilized and maintained land in various ways throughout history, and this has emerged as a critical source of land cover across the world. As a result, land use and management are becoming increasingly important in the global ecosystem (Dale et al., 2000). Land-use change is influenced by a mix of socioeconomic, political, and

biophysical factors, referred to as land use drivers (Veldkamp and Fresco1997). Physical, climatic, and demographic variables, poverty levels, and the economic and institutional framework of resource usage are all critical determinants of land use and land-use change, according to Kates and Haarmann (1992). Usher (1992) also mentioned how human economic and social situations influence land-use patterns and how technical innovation affects land management. All of these are evolving aspects of human societies, such as how land is utilized for the advantage of individual owners or the benefit of society members. The interplay of the biophysical and human dimensions in place and time drives land cover alteration and conversion (Turner et al., 1995). Social and economic factors frequently influence land use. Rather than natural change, human usage is the central element in land cover alteration and conversion (Veldkamp and Fresco, 1996). Population change is frequently studied as one of the leading causes of worldwide land use changes (Heilig, 1994). Many lands use changes, and their underlying causes are closely linked to population expansion (Dale et al., 2000). Other causes driving global land use change, such as technology innovation, lifestyle changes, or political decisions, can exacerbate or dampen demographic consequences (Dale et al., 2000; Heilig, 1994). Forests and other agricultural areas, which compete for land, are frequently connected to population expansion (Viitanen, 1996). One reason for this disparity in attention is that the latter is more subtle, long-term, and sensitive to the effect of many more complicated, less evident, and provable elements than the former. However, it's worth noting that environmental and socioeconomic consequences are inextricably linked, with the former affecting the latter, which in turn causes the former to cause the latter, potentially resulting in several cycles of land use change. Land use change begins with forest clearing, followed by agriculture, intensive grazing, and finally, land abandonment and relocation to a new place, where the sequence is repeated (Blaikie and Brookfield 1987).

2.6.3 Socio-economic impact

One of the three main parts of production in classical economics is; land, labor, and capital. It's used to make both housing and food. As a result, land use is essential and agricultural economies, and it has a lot of economic and social benefits. Changes in how land is used are needed for economic and social progress. Other than that, it's not free to change your behavior or how you use your phone or tablet. When farming and forests are turned into cities, the amount of land used to grow food and wood decreases.

Soil erosion, salinization, desertification, and other soil problems caused by intensive farming and deforestation are hurting land quality and lowering the amount of food that can be grown there in the future (Lubowski et al. 2006).

Farmers on the outskirts of cities face many problems because of the growth of cities. Non-farm neighbors and vandalism, such as crop destruction and damage to farm equipment, keep farmers on the outskirts of town from living their best lives. Equipment sharing, land rental, custom work, and improving irrigation systems are examples of farmers working together in the field. People who live near farms will lose these benefits if the farms are turned into homes or businesses. Some farmers may no longer be able to get help from each other by sharing information and setting up official and informal business partnerships with other farms. This could lead to more local rules that require farmers to pay for some of the adverse effects of farming. To make more money, farmers might have to pay more or wait longer for equipment repairs because there isn't a lot of demand for farm supplies. Farmers may have to pay more for labor because there is a lot of competition for workers from other industries. If the amount of farmland in the area falls below a certain amount, the local agricultural economy may fall apart. Many times, urbanization has affected rural areas. Many people have moved to cities, which has made some rural areas uninhabitable for people to live. In some places, a lack of jobs has led to the demise of once-thriving villages. Income segregation and economic differences between people living in cities and those living in the suburbs worsen when cities grow. Land-use change has significant socioeconomic consequences that raise severe issues at all geographical scales. Food security, water shortages, population relocation, and, more broadly, human security and susceptibility to natural and technological risks are all examples of global socio-economic repercussions.

2.6.4 Environmental Impacts

Changes in land use cause environmental deterioration and change. Deforestation, urbanization, farming, and other human activities have impacted the Earth's surface. Changing land in this way can impact critical ecological processes and services for a long time. Many types of animals need to have open space and a place to live on farmland. People who do a lot of farming could damage the environment. The government's policy on using the land for farming, for example, affects water contamination. A lot of water pollution comes from runoff from agricultural fields. This

is true in both inland and coastal areas. Many animal species have died out because wetland areas have been turned into farmland, and irrigation water has been moved. Many environmental problems, such as air pollution, water pollution, and the loss of wildlife habitat, have been linked to the growth of cities. It is common for runoff from cities to be filled with nutrients, silt, and harmful chemicals. These things can cause water pollution and changes in streamflow and temperature. Humans have been blamed for the destruction, fragmentation, and change in the habitats of animals. This has led to a loss of biodiversity. It was written in 2000 by Czech, Krausman, and Devers.

There is, however, more significant concern about the long-term viability of development at all geographic scales when it comes to land-use changes. Land use and change are significant to think of sustainability as a balance between social, economic, and environmental goals. The environment and the local economy are hurt by changes in land use, making it more challenging to meet the needs of local people, both short-term and long-term. In this case, careful thought must be given to how land is used and managed. Making the most of what's available on the land while not causing any damage to the environment and keeping up with societal changes are the resources of land use and climate change management (FAO 1995). Forests have a lot of good things for the environment. They help protect biodiversity by providing important habitats for wildlife, capturing carbon dioxide from the air, stopping rain, reducing surface runoff, and preventing soil erosion and floods. When forests are used for farming or to expand cities, critical ecological functions are lost or removed. For example, deforestation and urban growth, farming, and other human activities have changed and broken up the Earth's vegetative cover in a big way. Disturbances can change how energy flows on the planet's surface, changing the global concentration of carbon dioxide, a critical heat-trapping gas, and the climate in different parts of the world (Marland et al. 2003).

2.7 Theoretical Approaches and Conceptual Framework

The theoretical and conceptual framework clarifies a study's route and anchors it in theoretical notions. The two frameworks' overarching goal is to make research findings more meaningful, acceptable to research field theoretical notions, and generalizable (Adom, Hussain & Joe, 2018).

2.7.1 Theoretical Approaches of LULC

Theoretical Framework is the research's 'blueprint' or guidance (Grant & Osanloo, 2014). It's a framework for research that's based on an existing theory on the topic (Adom, Hussain & Joe, 2018). The term "theory" is derived from the Greek word "theories," which translates as "observing something." As a result, the term "knowledge" refers to the outcome of the observation. The term "theory" refers to "a collection of related concepts employed in the explanation process" (Johnston et al. 1994). According to Chapin and Kaiser (1995), a theory is "a way of thinking that use logical formulations to explain a process, action, or other phenomenon occurring in reality" (Chapin and Kaiser 1995). Briassoulis (2000) summarized existing theories of land-use change in his research study, classifying them into three broad groups based on theorization tradition: urban and regional economics, sociological (and political economy), and nature-society (or human-nature) theorization traditions. More specific criteria can be used to further classify theories within each of these three primary categories, as addressed in the following.

Table 2. 1 Categories of Theorization

Category of theorization	Approaches
The urban and regional economics	2 Microeconomic approaches 3 Macro-economic approach 4 Other theoretical approaches in regional science
The sociological	• Functional behaviorist approach • Institutionalist structuralist theoretical approach • Core periphery theory
The nature-society	• Humanities based theories • Natural science-based • Social science-based

2.7.1.1 Microeconomic approaches:

J. F. von Thunen's agricultural land rent theory, W. Alonso's urban land market theory, and agent-based urban and regional spatial organization theories are just a few examples. The notion of the "price for the use of a piece of land" or, more accurately, "the price of the services given by land over a particular period" underpins Alonso's (1964) urban land market theory. Alonso's (1964) theory seeks to characterize and explain both individual family residential placement behavior and the following spatial organization of an urban region. The emphasis is on residential locations; this theory shows business activity more superficially and broadly. The bid-rent function of any family or business is the most important thing to understand. The "bid rent" that can be "paid for a unit of land (e.g., per acre) located some distance from the city center" is the "maximum rental that can be paid." (Hoover and Giarratani 2020). Alonso's idea has been widely employed in studies of urban spatial organization and effect evaluations of urban projects. Several limiting assumptions limit its ability to approximate observed land use patterns and investigate land-use change. However, unlike Alonso's theory (i.e., how much space an agent uses), "agent-based" theories do not frequently directly address land use, instead of focusing on the characteristics of agents and the processes by which and under what circumstances they interact in space.

To put it another way, for the time being, these are only hypotheses about why land use has changed. Unlike urban land rent theory, which takes a microeconomic approach, agent-based theoretical techniques focus on the individual qualities of these actors and how they are connected to and interact with one another in space. The primary claim made by agent-based theories is that earlier locational decisions affect agents' decisions and actions and influence future location decisions. Because of this, new patterns in space begin to emerge.

2.7.1.2 Macro-Economic Theoretical Approaches:

This method is based on "spatial economic equilibrium theory" ideas. In contrast, the second method is based on many theories that wouldn't have to do with where individuals reside. In welfare economics, utility maximization theory applies to a disaggregated economy. Spatial equilibrium theory is the application of this theory to a disaggregated economy. The goal of the theory is to figure out the prices and wage levels of goods and services and the flow of goods and resources (labor and capital) between the places where they are sold and bought. There are a lot of factors that go

into making this distribution happen. People who live on the points (i.e., in the demand areas) or business owners who run businesses on the supply points work hard to make the most money possible. Consumer well-being can be measured in several ways, including how much money they make, how many products they use, etc. Mathematical equations that show how to maximize the welfare of a group of people are made. Then, the conditions under which this equilibrium is reached in the spatial system are found. The distribution of people, resources, accessibility, and preferences are all common assumptions used when using spatial equilibrium theory. These aren't all the same, but that's what people think.

Furthermore, there should be a market economy with perfect competitiveness, full technical knowledge, and no barriers to market access. Assumptions are also made about how areas are linked together and how much raw material they have. Myrdal's "cumulative causation hypothesis" and Perroux's "growth pole theory" are two other well-known ideas (Perroux 1955, Boudeville 1966). The "cumulative causation hypothesis" considers regional resources in terms of human, natural, and skill endowments and says that development starts in places with more of them. It happens because one region is becoming more industrialized, which causes a shift in the amount of money people have between different parts of the country. When Perroux first came up with the "growth pole hypothesis" in 2955, he thought growth would start in a place with a strong industry and then spread to other places. This is how the "growth pole hypothesis" works.

2.7.1.3 Other theoretical approaches in Regional Science:
Even though economics-based theories are the most common, the field of Municipal Science has a wide range of other theories that attempt to explain the framework and transformation of geographic systems and, as a result, help with the assessment of land-use change.

2.7.1.4 Functionalist-Behaviorist Theories:

People who study land use change from a functionalist or behaviorist point of view use human ecology theories to do this. Human ecology saw the process of urban development as a way to build and maintain an equilibrium system and help the city system return to a stable state after a disruption. The concentric ring, the radial sector, and the many nuclei patterns are all land-use patterns made by this process. Burgess (1925) came up with the idea of a concentric zone hypothesis to help explain how city

layouts change as a result of the biological processes above. Commercial, administrative, financial, and recreational facilities are found in the center of a monocentric city, which comprises five rings that each serve a specific purpose in the city. "Zone of transition": It's surrounded by run-down neighborhoods and old homes that businesses and light manufacturing have taken over as the CBD grows. This interpretation of urban land use structure and development is very similar to those made by von Thunen and Alonso on different (but related) grounds, so it is clear that this interpretation is very similar. Hoyt (1939) came up with the radial sector hypothesis, which said that similar residential land use types are clustered in wedge-shaped sectors that spread out from the city center along transportation corridors. Harris and Ullman (1945) came up with the many nuclei theory of urban land use structure to get around some of the limitations of the previous two theories (especially the monocentric city assumption). They came up with a plan for the city based on the fact that urban land uses are usually spread out around specific "nuclei" (pre-existing agglomerations or new centers of activity) rather than a single "core."

2.7.1.5 Structuralist-Institutionalist Theory:

The way people think about space, how people interact in space, where and how conflict happens, and how the system of power works and changes space is different between structuralist and institutionalist views. In 1977, Castells came up with the idea of urban social movements. Scott came up with the idea of the urban land nexus theory in 1980, and Harvey came up with a crisis theory of late capitalism in 1973.

2.7.1.6 Core-Periphery Theories:

Core-periphery theories are a component of core-periphery theories that look at things that aren't in an urban area (up to the global). They want to figure out and explain how human activities are spread out worldwide based on how much power each person has in social, economic, and political matters. In this way, they can be thought of as providing general-level theorization schemas about land use and changes caused by the development of dependencies between the core (a developed, but not necessarily physical, area) and the periphery (underdeveloped regions). It is very different from other theories, like dependence theory and unequal exchange theory, in that it emphasizes the stability of places and ignores the regional disparities of labor in capitalist economies (Johnston et al. 1994)

2.7.1.7 Humanities-Based Theories:

Humanities-based theories reveal a varied spectrum of theoretical methods and viewpoints on the nature-society relationship at various spatial dimensions, from global to highly local and personal. The methods used to uncover the patterns and processes of understanding the relationship under investigation include ethnographic analysis and other similar qualitative techniques. Most of these studies focus on land-use change's social and human aspects, but the connection between land use and change is rarely established. Because of this, they don't use a standard and rigid model of man that can be used in all places and times. Instead, they generally use non-positivist epistemological positions and emphasize the culture-specific and variable nature of the nature-society relationship (Briassoulis 2000).

2.7.1.8 Natural Sciences-Based Theories:

There are a lot of theories about why people do what they do, but "environmental determinism" is the most well-known one (Johnston et al. 1994). Environmental determinism talks about cultural change and, indirectly, environmental change by looking at how a place or region looks (Turner 1994).

2.7.1.9 Social Sciences-based theories:

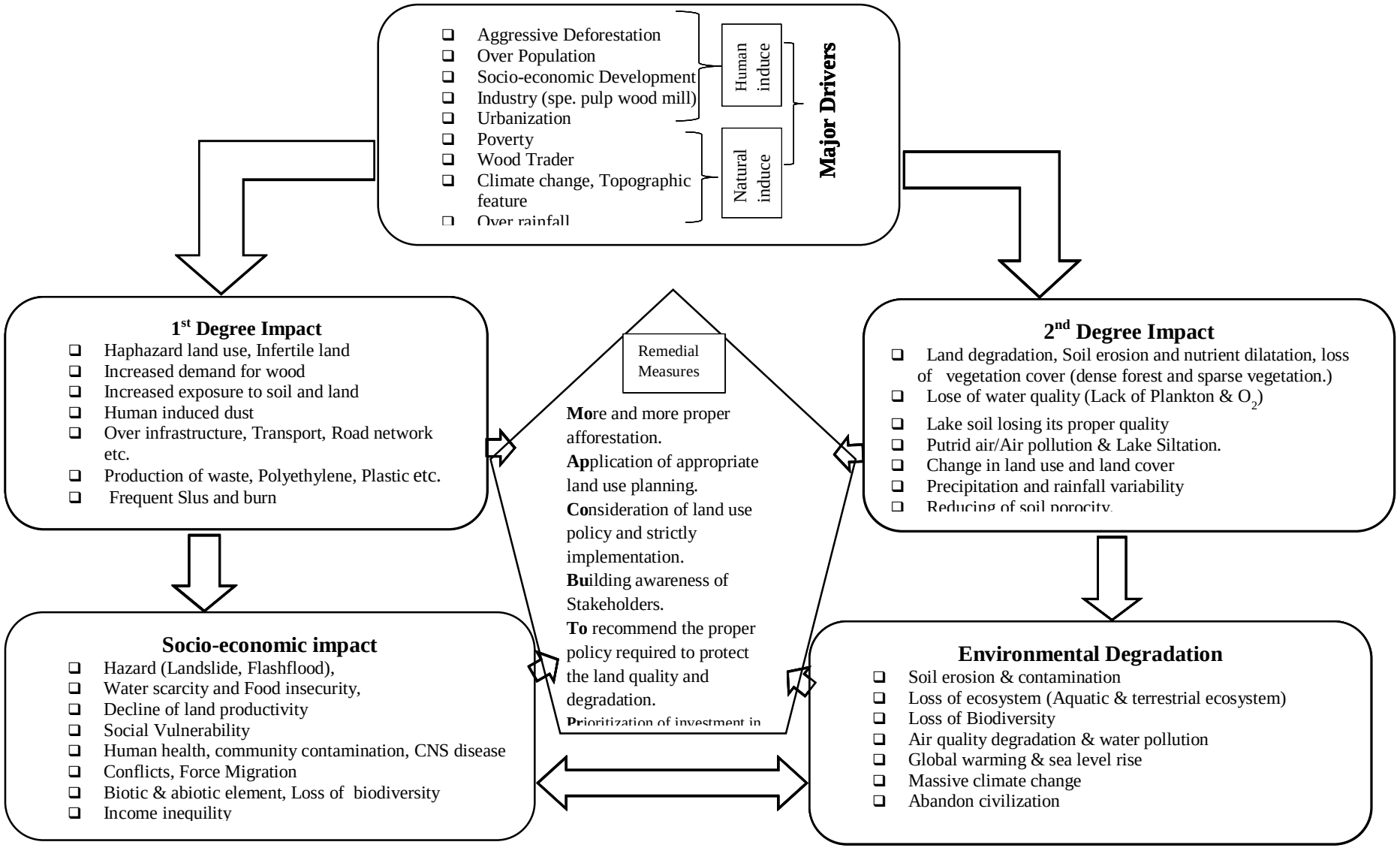
The Social Sciences can be described in both a narrow and broad sense, and some of the theories above, especially those that came from the Humanities, can also be called Social Sciences. These theories are all based on theories from the Social Sciences that deal with nature and society in general, like theories from the fields of Environmental Economics and Environmental Politics, which deal with the relationship between nature and society in general (Briassoulis 2000).

2.7.2 Conceptual Framework of LULC

Conceptual frameworks, according to Luse, Mennecke, and Townsend (2012) allow the researcher to more simply clarify and define concepts within the study's problem. It describes the relationship between a study's primary concepts from a statistical standpoint. It is organized in a logical order to aid in the creation of a picture or visual representation of how the ideas in a study relate to one another (Grant & Osanloo, 2014). Researchers feel that a conceptual framework can best describe the natural growth of the phenomenon under investigation (Camp, 2001). It is the researcher's description of how the research question will be investigated. It depicts an integrated

approach to an issue under investigation (Liehr & Smith, 1999). It is connected to the researcher's notions, actual study, and key theories for promoting and systemizing other information (Peshkin, 1993). Conceptual Frameworks, according to Miles and Huberman (1994) might be "graphical or narrative in nature, displaying the important variables or constructs to be explored and their hypothesized relationships." It also demonstrates the sequence of steps the researcher wants to take in a research project (Dixon, Gulliver & Gibbon, 2001). According to Akintoye (2015), researchers typically employ a conceptual framework when current theories aren't suitable or sufficient for constructing a solid study structure. Any research can benefit from a conceptual framework in a number of ways. For example, it can help the researcher recognize and create his or her perspective on the phenomena under investigation (Grant & Osanloo, 2014). The conceptual framework is the most basic manner for a researcher to give his or her proposed solutions to the problem they've identified (Liehr & Smith, 1999; Akintoye, 2015). As a result, the research's conceptual framework of LULC in the Rangamati is outlined below.

Figure 2. 1 Conceptual framework on the socio-economic & environmental impacts of changing land use pattern in the Rangamati district.



2.8 Summary of Literature Review

- A review of the available literature reveals that there is not any comprehensive analysis regarding the temporal dynamics of land use and its driving forces and socio-economic and environmental impacts.
- Reviewing the literature shows that the land-use change affects its surrounding elements.
- There is no specific study on Rangamati that can be beneficial for identifying the land use change.
- There is less study on socio-economic and environmental changes due to land use land cover change.
- The past attempts were made to identify some driving forces and consequences of land use changes.
- However, the assessment of the temporal dynamics of land use changes and the socio-economic and environmental impacts of such changes is still lacking.
- Hence this study attempts to bridge the gap in finding socio-economic and environmental impacts of changing land-use patterns in the study area.

2.9 Conclusion:

Literature review on land use land cover change has been addressed. This literature review focus on the change and the socio-economic and environmental impact rather than the spatial models or descriptions. Some driving forces and consequences of land use and land cover change have been mentioned. In Rangamati, there are fewer studies about the land surface temperature and land use change and its impacts. So the literature can be helpful for further research.

Chapter Three

Study Area at a glance: Rangamati District

3.1 Introduction

This chapter deals with the area where this research was conducted. The description includes the geographical location and environmental features of the study area. The district of Rangamati has been used as a research area for land use change using satellite imagery. All other work, including Questionnaire Surveys, Focus Group Discussions, and KII, has been completed on Rangamati town and its adjacent Union of Sapchhari. Furthermore, because the Rangamati district was initially divided into three satellite imaging blocks, it was impossible to collect satellite images for all three blocks at the same time and date. As a result, only Sadar Upazila of Rangamati district was employed in the analysis of surface temperature, which encompasses just one block, in order to assess the environmental impact of land use change. Rangamati district as a whole has been described as a description of the research area below.

3.2 Geographical area and location

Rangamati is Bangladesh's largest district in terms of land area. It is a district of natural splendor and cultural significance. It is located in 22º 00' 27" & 23º 00' 44" north latitude and 91º 00' 56" & 92º 00' 33" east latitude. It is bounded on the north by Tripura, on the south by Bandarban, on the east by Mizoram, and on the west by Khagrachari and Chittagong (Fig-3.1). It is under Chittagong Division. It is included within the Chittagong Hill Tracts. It is divided into ten Upazilas, two Pourashavas, fifty unions, thirteen hundred and forty-nine villages, and 159 mouza. It was incorporated as a subdivision in 1891 and elevated to a district in 1983. Nothing is known regarding the district's etymology. The name Rangamati is supposed to have derived from the land's Radish Soil, which in Bengali translates as Rangamati. Rangamati district covers an area of 6116.13 square kilometers (Rangamati 2019). This district has a population of 6,20,214 residents (BBS, 2011). Rangamati District has a vast history and heritage of tribal and Bengali people with a vibrant culture. Apart from Bengali, tribal people include the Chakma, Murong, Pankho, Marma, Chak, Tripura, Lucai, Kheang, Tanchanga, Khumi, and Boam. Rangamati is also well-known for its cashew nuts,

watermelon, Bangla bananas, and fresh fish from the Kaptai lake. Additionally, the area is well-known for housing a hydropower plant in Kaptai and a Terrestrial Earth Satellite in Betbunia, Kawkhli. Additionally, there is a hilltop point near Furman Peak from where one can view the entire town (LGED 2014). The study area's primary economic activities are ecotourism, hydroelectric power, agriculture, fishery, and forest & forest resource management. The lake is a biologically diverse basin, home to various fish, biota, aquatic mammals, and numerous species of local birds. It serves as a stopover for a large number of migratory birds. (United Nations Development Programme, 2013)

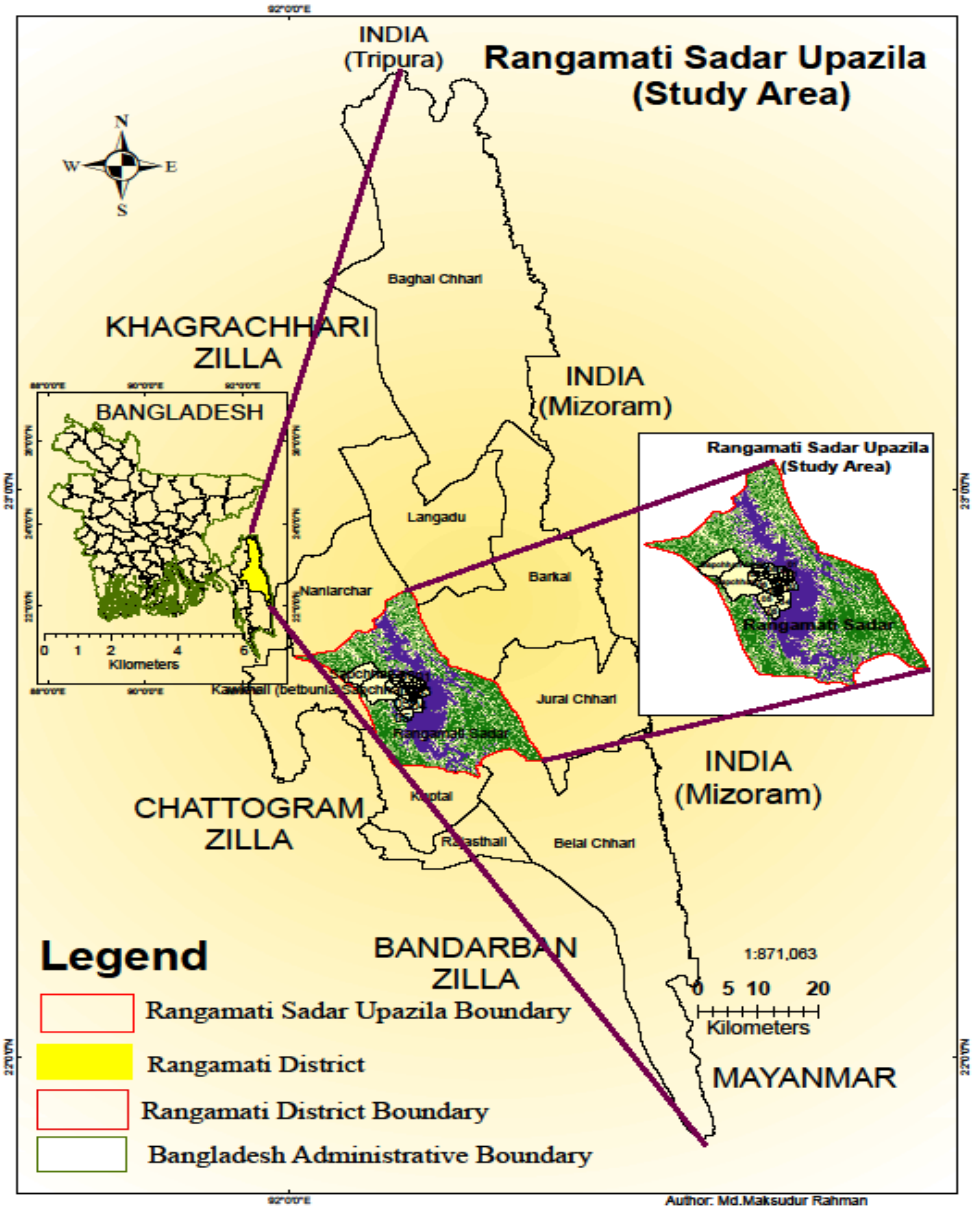


Figure 3. 1 Rangamati District Map as Study Area (source: Author)

3.2.1 Climate

Monsoons have a significant impact on the weather in this area. They make it rain a lot. At this time of the year, it rains a lot. This time of year is known as winter because it lasts from November to February, and it is the driest and coldest of the year. When the pre-monsoon (or hot) season comes around, it lasts from March to May. This season has the hottest temperature and rate of evaporation of the three. Some places are at threat of landslides or flash floods in this area, which can happen very quickly.

3.2.2 Temperature and Rainfall

During the year, the average temperature in this district ranges from 36.5°C to 12.5°C, and the average amount of rain that falls each year is 2673 mm.

3.3 Demographic condition

It is crucial to think about demographics regarding land-use changes. The number of people living in the Rangamati District has risen dramatically. It grew 7.11% each year from 1974 to 1981, 3.1% from 1981 to 1991, and 4.1% from 1991 to 2001 in the Rangamati District, shown in Fig3.2. Between 1974 and 2011, the general population of the country grew by 96 percent, while the population of the CHT grew by 227 percent (FAO, 2013). Pressure on the population and changes in the land area have a lot to do with each other. With more people, it is seen that forest areas are getting smaller. Settlements are being built on top of the vegetation.

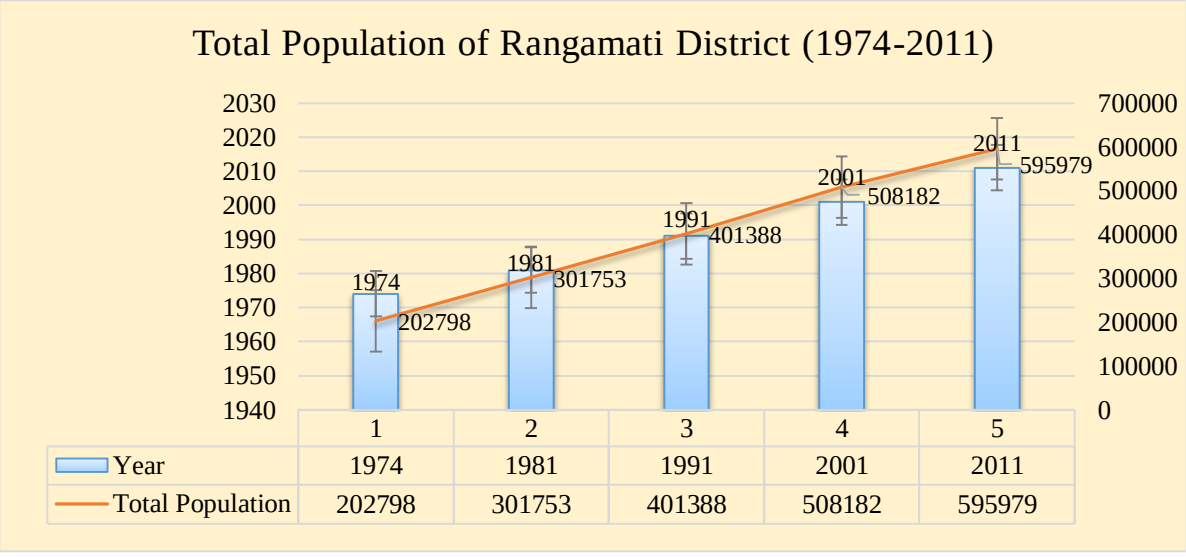


Figure 3. 2 Population trend of Rangamati District (1974-2011), Source: Population Census of various census years of BBS (Bangladesh Bureau of Statistics).

3.4 Economic condition

Economic Situation: Rangamati's economy is primarily agricultural. Farms that produce a variety of crops, such as local and HYV rice, wheat, vegetable, cash crops, and others, account for 74.10 percent of the district's total 108,263 holdings. The area of Rangamati is known for its enormous production of jackfruit and pineapples. Banana, guava, olive, papaya, and other fruits are vital. In this area, rare types of fish such as Ruhi, katal, and chital thrive. All of these fish species were taken in the lake. Aside from agriculture, the primary family income sources include cattle, forestry, and fishing. Forest resources abound throughout the district. Non-farming activities have a low profile in the district. (BBS 2011)

3.5 Conclusions

Rangamati is a prospective tourism destination. With the future tourism demand, this neighborhood is at the forefront of the industry. However, future management plans would be considerably more challenging to govern without policymakers' comprehensive strategy and analysis. This chapter's primary focus was Rangamati's entire profile.

Chapter Four

Research Methodology

4.1 Introduction

This chapter deals with the research methodology of the area where this research was conducted. The methodology includes selecting the study area, data collection, process and implementation.

4.2 Research Methodology

4.2.1 Selection of Study Area

Rangamati is a tourist area. It is known as the Lake City since it is situated on the shores of the picturesque Kaptai Lake. Rangamati, Bangladesh's biggest district, is nestled among the verdant hills, lakes, and rivers of the Chittagong Hill Tracts. It has beautiful terrain, picturesque splendor of nature, a blue aquatic lake, and colorful indigenous tribes' lifestyles. But almost every year, Rangamati faces landslides, flash floods, and many more. From the literature review, it was clear that the forest cover of Rangamati is decreasing. So, this study's primary objective is to identify the land use land cover change over the past years and the socio-economic and environmental impacts of the change. The respondents indicated some major driving forces for land use change in this survey.

4.2.2 Data Collection, Data source, and Data Analysis method

To serve the purpose of the three main objectives of this research, satellite data and qualitative and quantitative data were collected from and by questionnaire survey. The data, data sources, and the methods which were used to find out the objectives of this study are given below:

Table 4. 1 Data, Data Source, and Method of the study

Objectives	Data	Source of Data	Method
1. Identification of temporal	Land cover satellite data for a different year, that	Historical remote sensing data (Landsat	Satellite image processing and interpretation,

dynamics of land use	is quantitative data	MSS/TM/ETM image).	Mapping land covers of different years.
2. Explore the driving forces of such changes	Physical dimension (Land, water, vegetation) & Human dimension data	Primary and Secondary sources (Published and Unpublished literature)	Field survey, Questionnaire survey, Interview and All kinds of Literature Review
3. The effect of land use changes on socioeconomic and environmental conditions	Physical dimension data & Human dimension data or qualitative and quantitative data, temperature data.	Economic, Social, Industrial, Cultural, Environmental and Land use policy, Satellite image, and BMD.	Field survey, Questionnaire survey, KII, Interview, Published and unpublished document. Satellite image extraction temperature data compared with BMD temperature data of Rangamati Sadar Upazila.

4.3 Data and method

4.3.1 Data acquisition and preparation

Landsat is a satellite series that has been delivering data since the 1970s as part of the Earth Observatory System (EOS) (Almazroui et al., 2017). Because of the medium spatial resolution and the availability of long-term data, Landsat satellites are regarded as a vital source of observation and monitoring of global changes (Masek et al., 2008; Wulder et al., 2008). Users can get most Landsat satellite data for free over the internet. The USGS's FTP (File Transfer Protocol) system or the GLOVIS (USGS Global Visualization Viewer) can be used to obtain Landsat satellite data. The Landsat sequence of LULC data sets was created using imagery from MSS, TM, and OLI TIRS obtained in January 1977, 1989, 2000, 2011, and 2019.

The selected five years and the matching months and days have been chosen to obtain the most precise temporal changes. The images from the same month and day that have identical clouds and are noise-free are the most beneficial and logical for comprehending the greatest alterations. The majority of these traits are covered in the

study's chosen images. The dry season was chosen because the Landsat images are less affected by cloud cover (Tovar 2011).

All images were acquired in level 1T and geometrically adjusted (L1T). Furthermore, the time interval between all satellite images was more than 16 days due to cloudiness or noise-free sceneries. According to (Sun et al. 2009), two criteria were used to choose satellite photos for this study: (1) The satellite images should have a cloud coverage of less than 10% (if possible, cloud-free); (2) the satellite images should be available for a long time series. The comprehensive details of the remote sensing data are shown in Table 4.2.

Table 4. 2 Detailed information on Landsat Images used in this study

Year	Date of acquisition	WRS Path	WRS Row	Cloud Cover	Image Quality	Sensor Id	Spatial Resolution
1977	02/01/1977	146	44	0	5	MSS	60
	02/01/1977	146	45	0	5	MSS	60
	01/01/1977	145	45	2	7	MSS	60
1989	13/01/1989	136	44	0	9	TM	30
	13/01/1989	136	45	0	9	TM	30
	10/02/1990	135	45	0	7	TM	30
2000	28/01/2000	136	44	0	9	TM	30
	12/01/2000	136	45	0	7	TM	30
	23/01/2001	135	45	0	9	TM	30
2011	26/01/2011	136	44	0	7	TM	30
	26/01/2011	136	45	0	7	TM	30
	04/02/2011	135	45	0	7	TM	30
2019	16/01/2019	136	44	3.18	9	OLI_TIRS	30
	01/02/2019	136	45	.03	9	OLI_TIRS	30
	09/01/2019	135	45	1.27	9	OLI_TIRS	30

Source: Based on the acquisition of Satellite image configuration collected by the author (1977-2019)

4.3.2 Data pre-processing

This research extensively used GIS and remote sensing tools (Bello et al., 2018). Pre-processing techniques for satellite images often include radiometric and geometric adjustments since they are needed before the major data analysis and information extraction. Radiometric corrections include transforming the data to appropriately represent the reflected or emitted radiation detected by the sensor, correcting the data for sensor abnormalities and undesirable atmospheric noise, and so on. Geometric corrections involve converting the data to actual world coordinates on the earth's surface and compensating for geometric distortions resulting from sensor-earth geometry discrepancies. It's crucial to keep in mind that this process's ultimate purpose is to extract data from an image that isn't easily available in its raw form (Bhatta, 2008)

4.3.3 Satellite Image Classification

Forest resource management makes extensive use of remote sensing. NDVI is particularly important in the work related to forest area, rate of increase and decrease of afforestation, the growth rate of vegetation, and classification of the forest. Therefore, this index has been used in this study to classify the satellite images considering the vegetation cover of Rangamati.

4.4 Questionnaire Surveying Method

4.4.1 Justification of sample size selection

The growing demand for research has necessitated the development of a quick technique for calculating the sample size required to be representative of a particular population. The National Education Association's research section provides a method for estimating sample size in the article "Small Sample Techniques." Regrettably, there hasn't been a table available for quick and straightforward reference that might have been created using the method below.(Krejcie, R. V., & Morgan, D. W., 1970)

$$S = X^2 NP(1 – P) \div \{d^2(N -1) + X^2 P (1- P)\}$$

Here,

S = required sample to be calculated

X^2= the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841)

N = the population size (which is 28000)

P = the population proportion, (which is .75)

d = the degree of accuracy expressed as a proportion (.05)

To obtain the required sample size enter at N = 28000. The sample size representative of the respondents in this example is 285.151

For the convenience of this study total of 300 sample sizes have been taken to account.

4.4.2 FGD and KII

As with focus groups, key informant interviews are conducted to acquire information on a particular issue. Future actions are influenced by the knowledge gained. There are pros and downsides to every approach to appraisal.

A focus group is a conversation led by a qualified facilitator in a small group. Discussing complicated issues in-depth is what it's used for. Focus groups provide several advantages: The group structure encourages discussion, fresh ideas, and exploration of the unknown. Principal drawbacks: Hiring and scheduling suitable members might be challenging when using a focus group that requires an experienced facilitator.

These in-depth interviews with specialists are known as key informant interviews. Key informant interviews have some advantages: Meetings between staff and community leaders can be held in person or over the phone, and they help to create trust between the two groups. As a result, it involves a careful selection of subjects to get feedback from the most knowledgeable individuals; it also demands meeting a large number of people so the findings may be generalized. Summary Table 4.4. provides information on the questionnaire surveys of the respondent distribution.

4.4.3 Distribution of Respondents

Table 4. 3 The questionnaire surveys of the respondent distribution.

The table below shows the distribution of responders at a glance.

Activity	Selection	Coverage	Focus of Activity
Household Questionnaire Survey	Respondents from households have been selected based on poverty, and educational background	300 Households were drawn as samples from Pourashava and its adjacent union of Sapchhari based on age and education	Changing land use patterns and demographic profile, livelihood choices, agricultural production, and their impact on socio-economic and environmental conditions were identified in a holistic and comprehensive way
Focus Group Discussion	FGDs were conducted with selected local ethnic and Bangalee community people	Four (04) Group Discussions were made (one in an Urban area, 2 in a rural area, and one in a tourist spot (Pada Ting Ting) area	Major Areas concerned: Relationship between land use change and socio-economic and environmental condition, impact on socio-economic and environmental status, agriculture and livelihoods, existing vulnerability and interventions, possible solutions
Key Informant Interview	Responsible local officials, community leaders, Forest officers, Land officers, agriculture officials, and NGO representatives	Interview (Pourashava and Rural (Shapchhari Union) & Semi-urban area)	Major challenges concerned: Major driving forces of inappropriate and destructive land use practice and its impact on the socio-economic and environmental conditions, agricultural production and livelihood options and their possible solutions

Table: 4.3 Distribution of respondents at a glance.

4.5 Conclusions

The methodology and processes followed by the researcher to complete the entire thesis research work. Some of the processes needed surveying and field visits. Data collection is one of the significant changes in any research work. So a proper methodology can simplify any research for better accuracy of the work.

Chapter Five

Application of Satellite Remote Sensing to detect the changes in Land Use Land Cover

5.1 Introduction

In Rangamati, the three primary land uses are forest, waterbody, and human settlement. Rapid population growth has always pushed human settlement to marginal and hazard-prone areas. The demand for land for non-agricultural purposes and urban use has increased sharply due to the rapid growth of urbanization and industrialization in a few decades (Chowdhury, 1990). However, to cope with the population pressure and steady progress, Rangamati has been facing charges in its land use, although very slow toward economic development. This chapter summarizes land use changes over time to help inform decisions related to land use to cope with the overall rising problems for Rangamati.

5.2 Satellite Image

Landsat Satellite images of five different years were downloaded. Three adjacent Landsat images (Path & Row,146 & 44, 146 & 45 and 145 & 45 for Landsat MSS, Path & Row, 136 & 44, 136 & 45 and 135 & 45 for TM & OLI_ TIRS) are needed to cover the Rangamati District (Figure 5.1). To layer stalk downloaded images (TIFF file), ERDAS IMAGINE 2014 was used, followed by a radiometric correction, mosaicking (Figure 5.1), and subset (Teillet et al., 2001). Consider the example the figures 5.2 & 5.3.

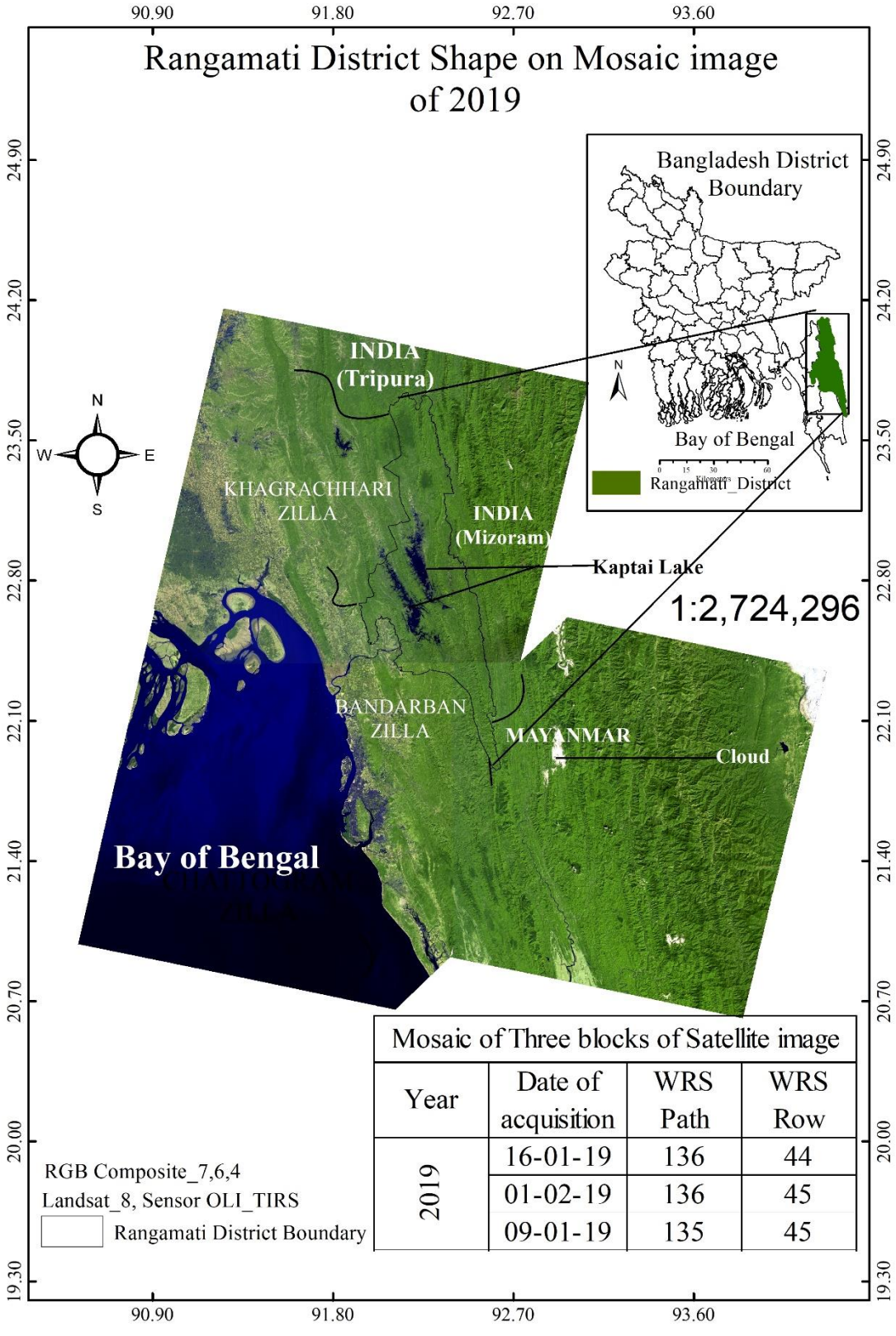


Figure 5. 1 Mosaic Image (as a sample) of the Study Area (Before Subset)

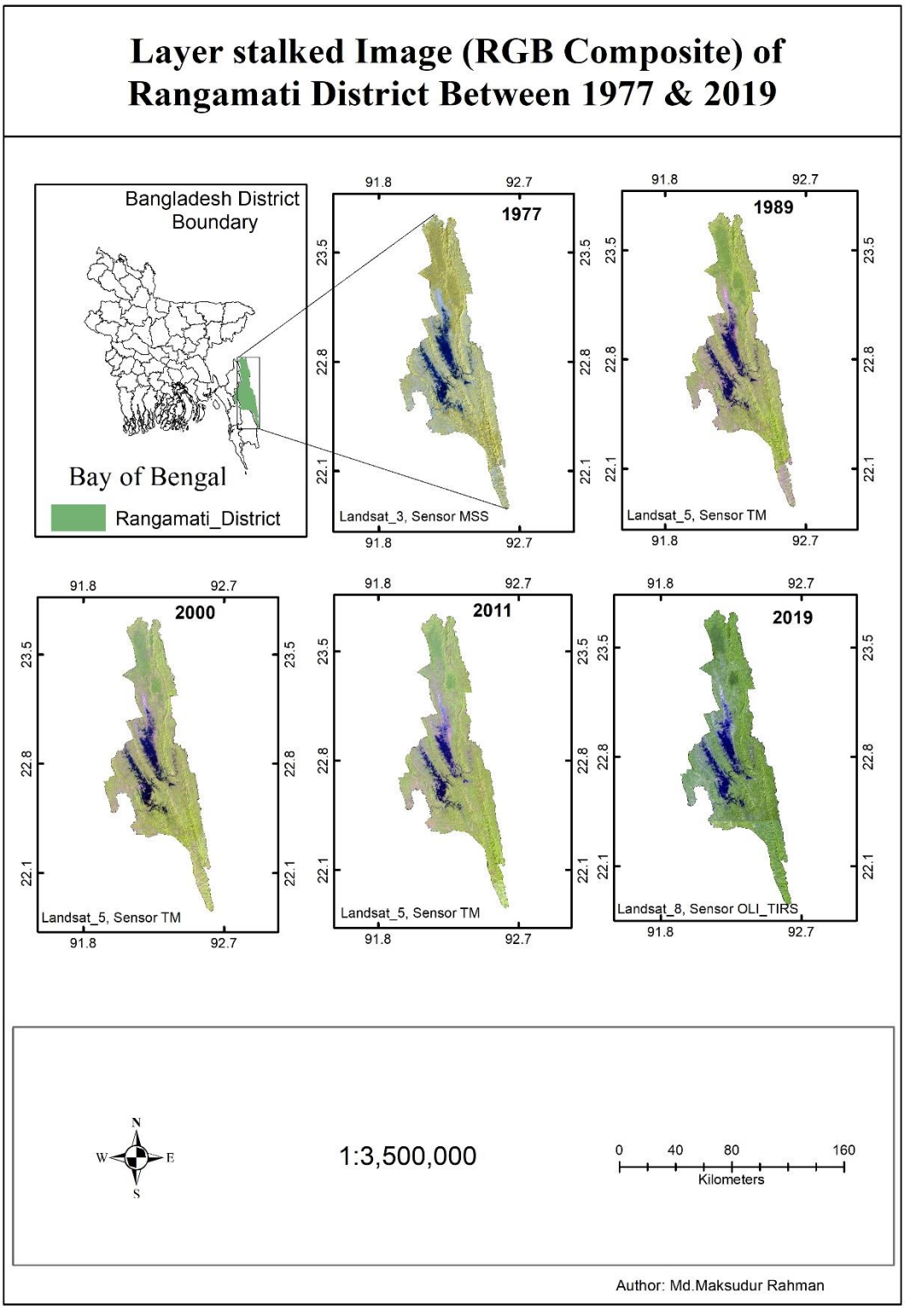


Figure 5. 2 Layer Stalked & Subset image of Rangamati District 1977 & 2019 at a glance

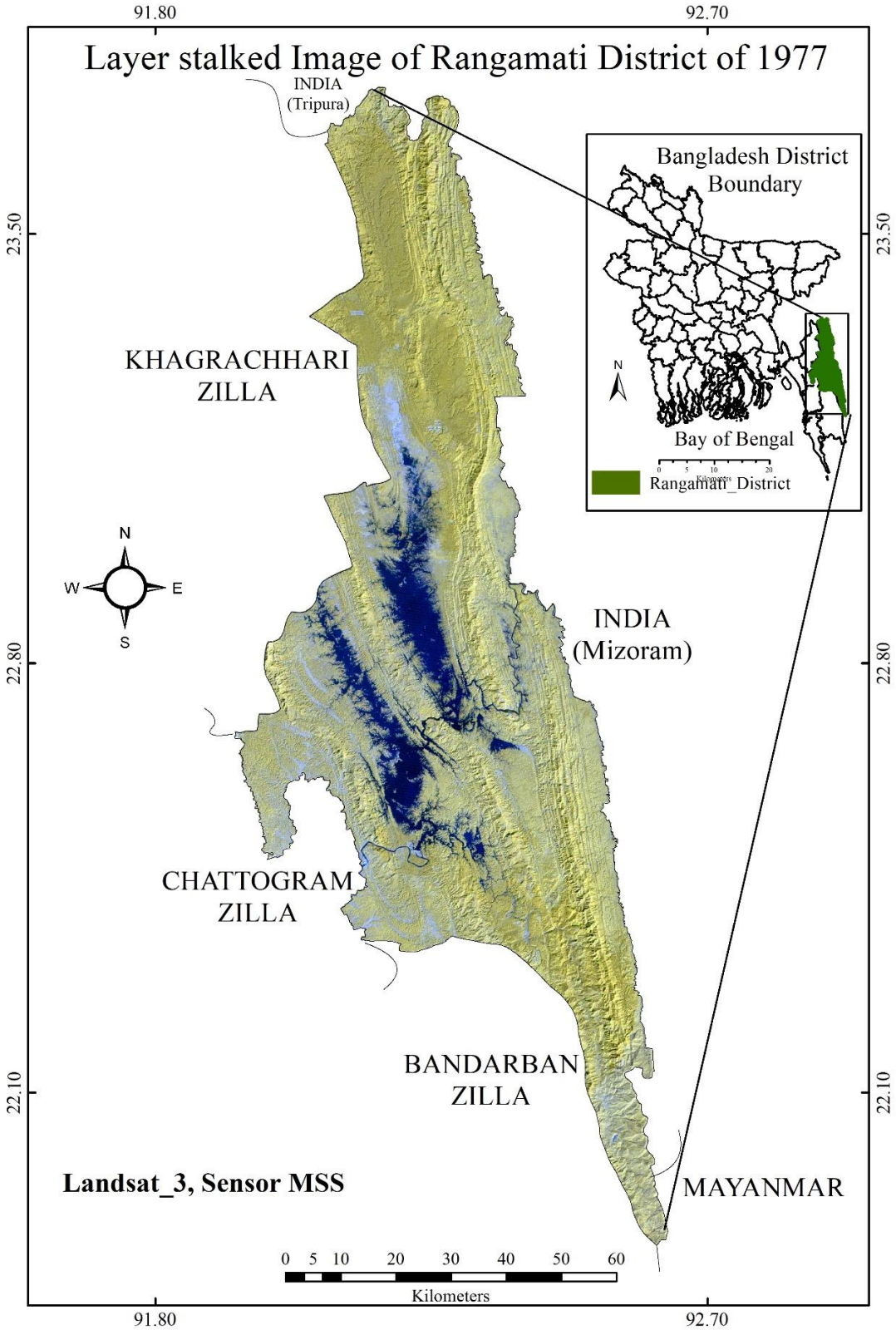


Figure 5. 3 Layer Stalked & Subset image of Rangamati District of 1977

5.3 Satellite Image Processing

Satellite image processing is a group of techniques for the manipulation of satellite images by computer. It varies based on the kind of image format, the initial state of the image, the information of interest, and the scene arrangement (Bhatta, 2008). After pre-processing rest of the techniques of image processing are image enhancement, image transformation, and image classification. The extraction process of NDVI is given below for image classification.

5.4 NDVI extraction

NDVI values were calculated using ArcGIS 10.4.1 for each image (from 1977 to 2019), linking the NIR and red band of Landsat MSS, TM, and OLI TIR images (Teillet et al. 2001). Landsat(1-3) MSS (Multispectral Scanner) with 80 m spatial resolution used visible Red band 5 and visible Near Infrared band 6; Landsat TM sensor with 30 m spatial resolution used visible Red band 3 and visible Near Infrared band 4, and Landsat OLI TIRS sensor with 30 m spatial resolution used visible Red band 4 and visible Near Infrared band 5 (Akter and Ahmed 2017).

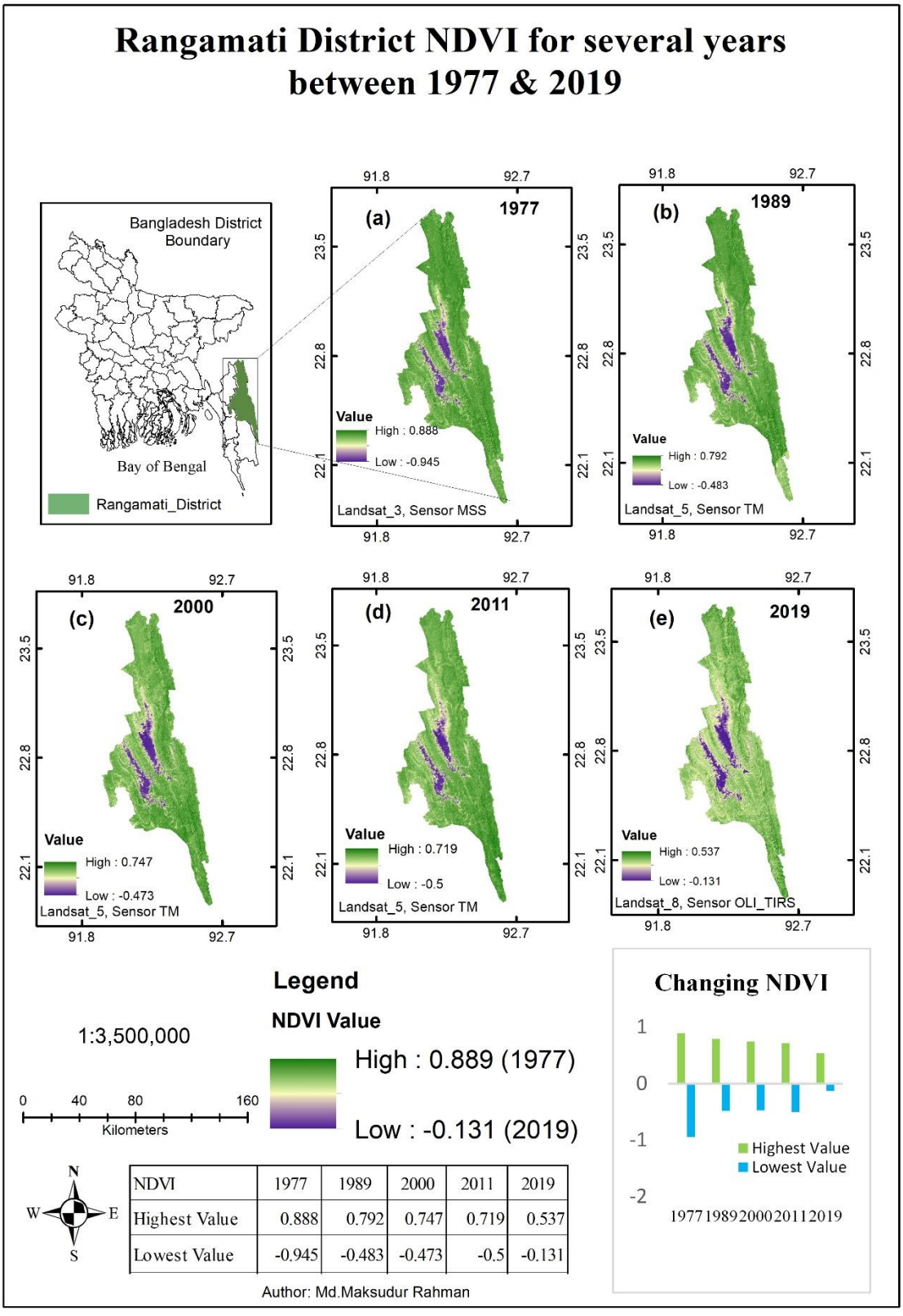
The Landsat (1-3) MSS spectral bands 5 and 6 have wavelengths of 0.6 to 0.7 m and 0.7 to 0.8 m, respectively. Spectral data from Landsat TM Band 3's wavelength range from 0.63 to 0.69 m, while Band 4's range from 0.76 to 0.90 m. OLI TIRS Landat spectral Band 4 has a wavelength from 0.636 to 0.683 μm, and Band 5 has a wavelength from 0.851 to 0.879 μm.

The NDVI spectral index equation (Rouse et al.1973) is given below –

NDVI = (Near Inferred Band − Red Band) / (Near Inferred Band + Red Band)

The NDVI is determined by the difference between the NIR and red bands in the observing vegetation; it should be higher with higher chlorophyll density. It normalizes the (NIR-Red) difference to compensate for the effects of illumination variations, such as shadows cast by hills, trees, or clouds (Gandhi et al., 2015). After extracting the NDVI values, then the fixing process of the threshold values are given below.

Figure 5.4 depicts the NDVI of different year at a glance and figure 5.5 to 5.9 depicts the NDVI of individual year.



NDVI	1977	1989	2000	2011	2019
Highest Value	0.888	0.792	0.747	0.719	0.537
Lowest Value	-0.945	-0.483	-0.473	-0.5	-0.131

Figure 5. 4 NDVI map of Rangamati district for five different years (1977-2019) at a glance, Source: Based on Satellite image processing done by the author (1977-2019).

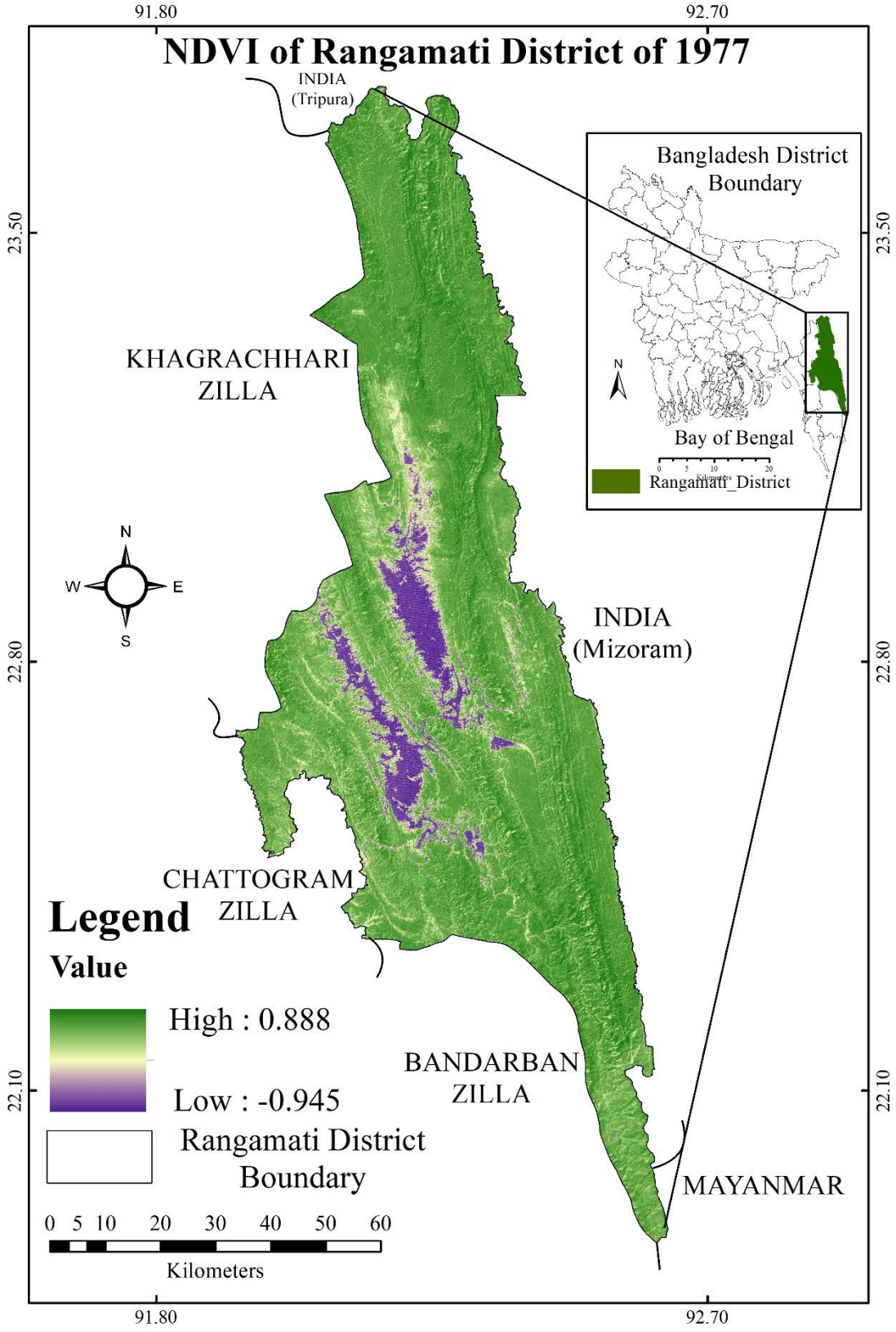


Figure 5. 5 NDVI map of Rangamati district of 1977, Source: Based on Satellite image processing done by the author.

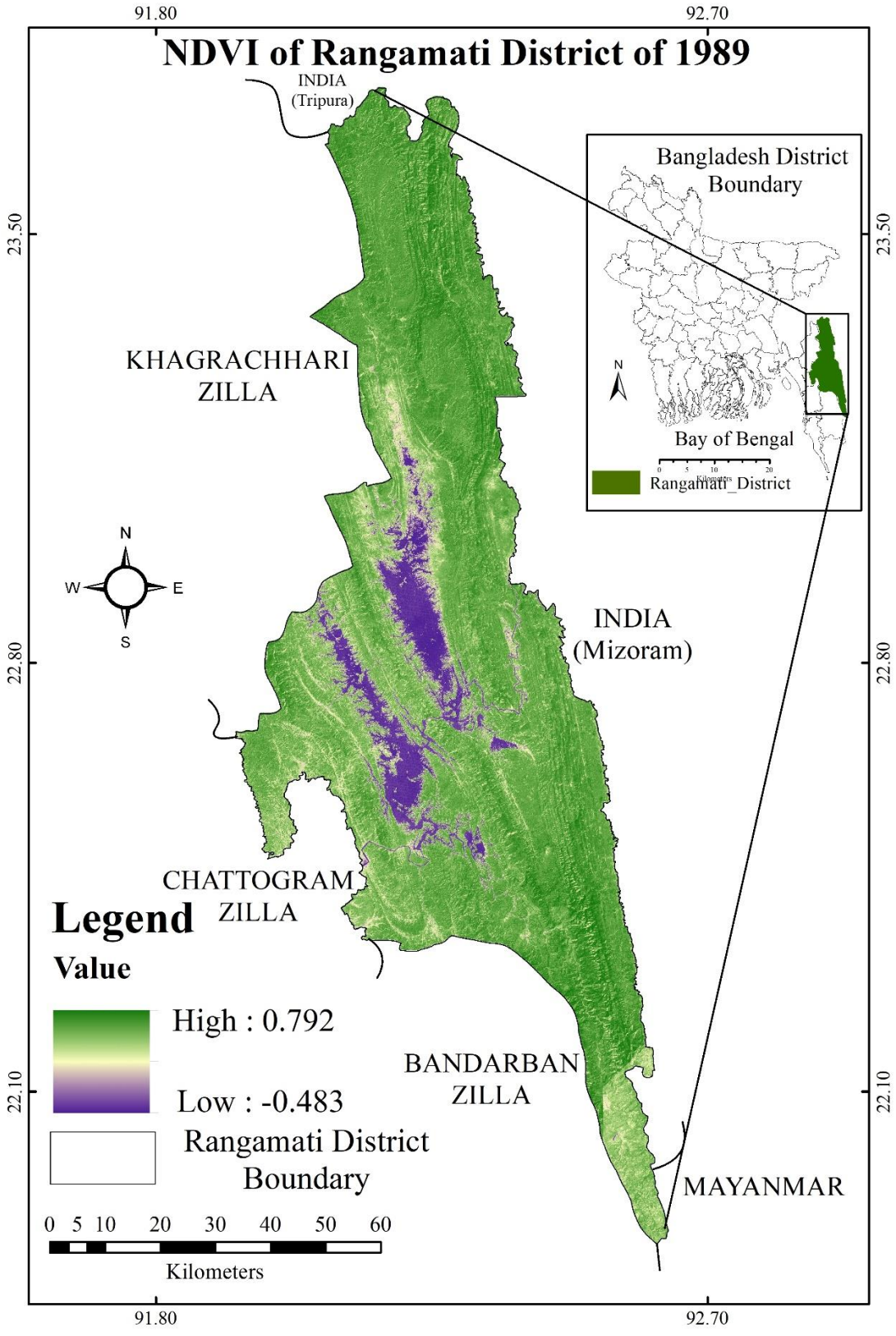


Figure 5. 6 NDVI map of Rangamati district of 1989, Source: Based on Satellite image processing done by the author

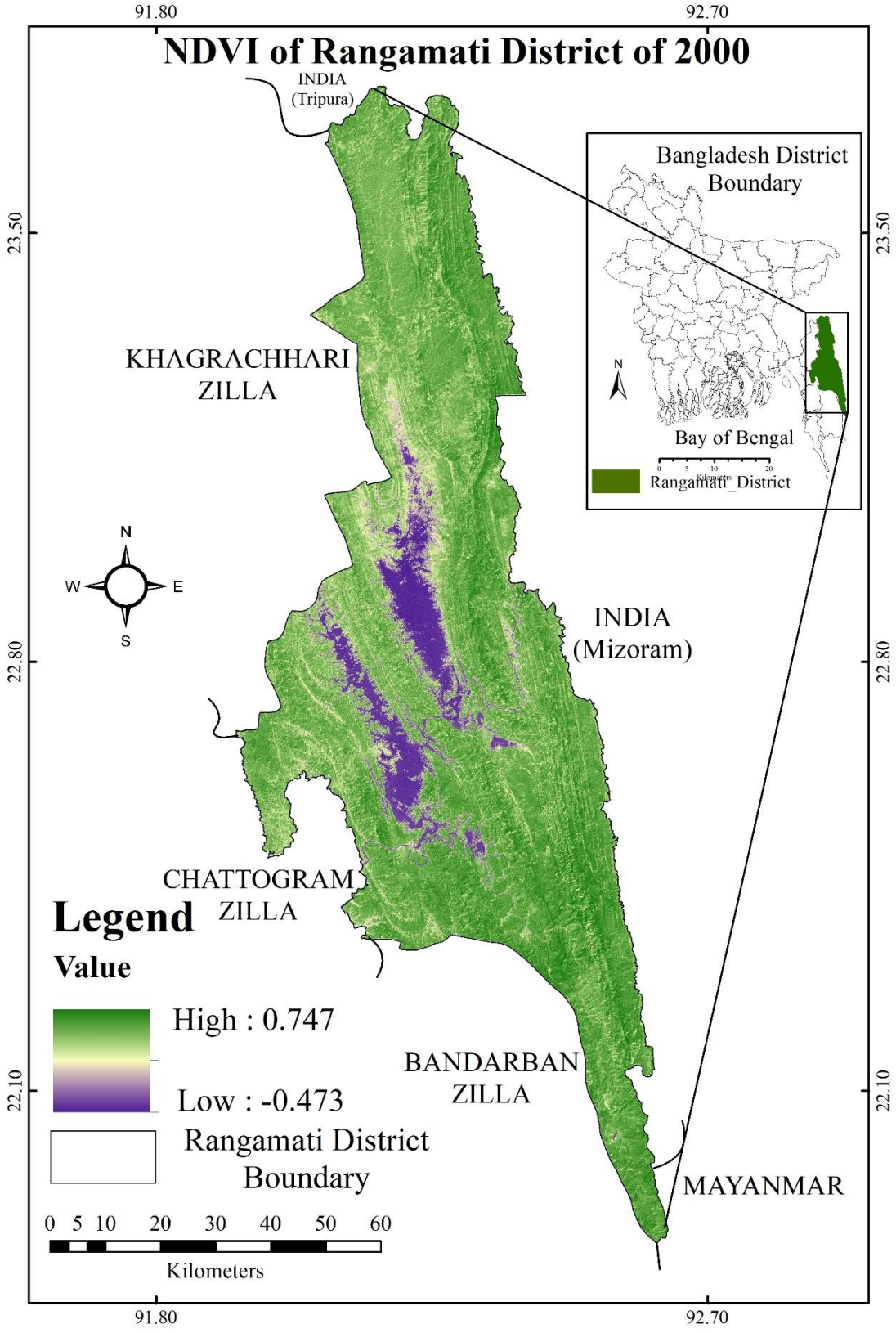


Figure 5. 7 NDVI map of Rangamati district of 2000, Source: Based on Satellite image processing done by the author

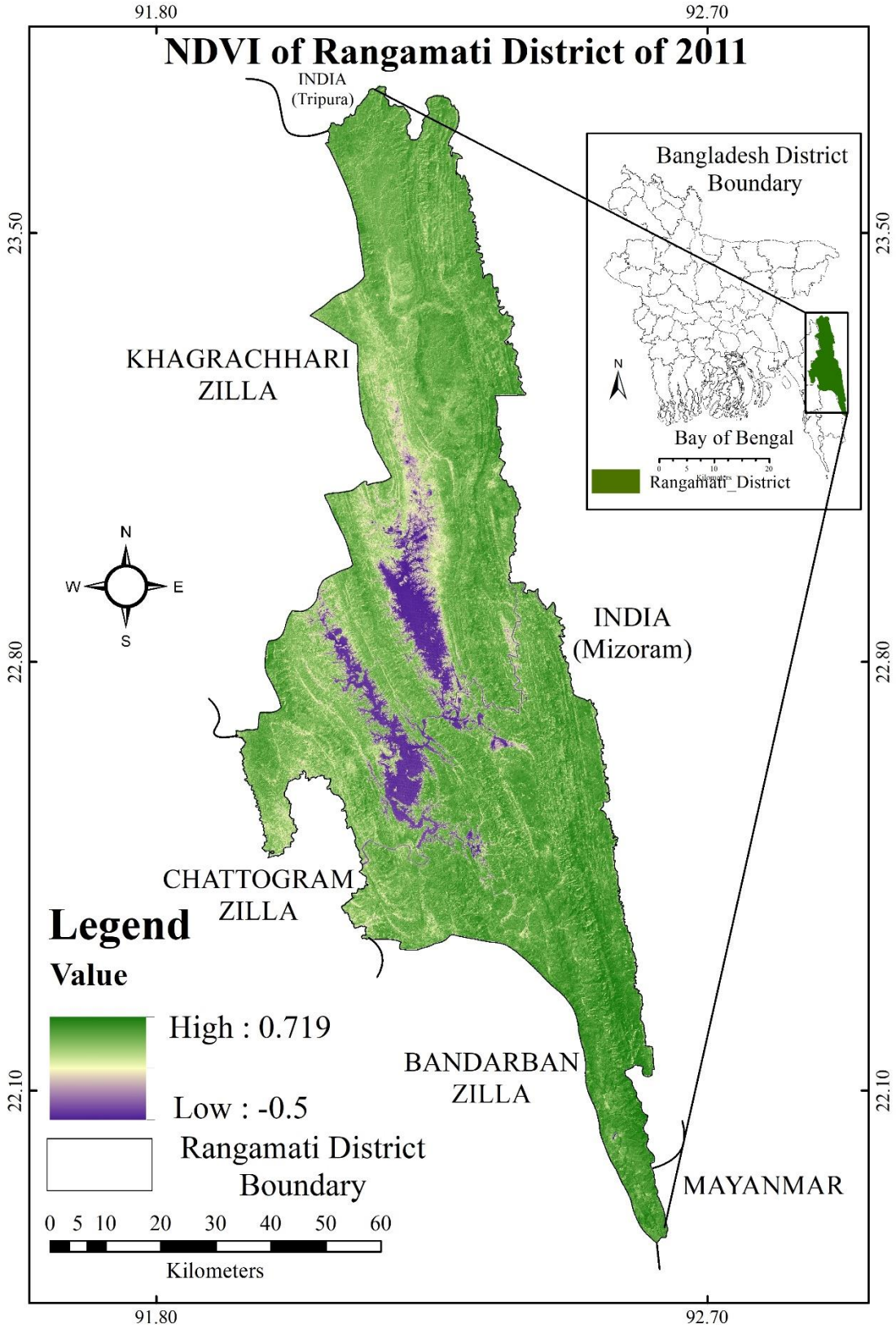


Figure 5. 8 Figure 5. 8 NDVI map of Rangamati district of 2011, Source: Based on Satellite image processing done by the author.

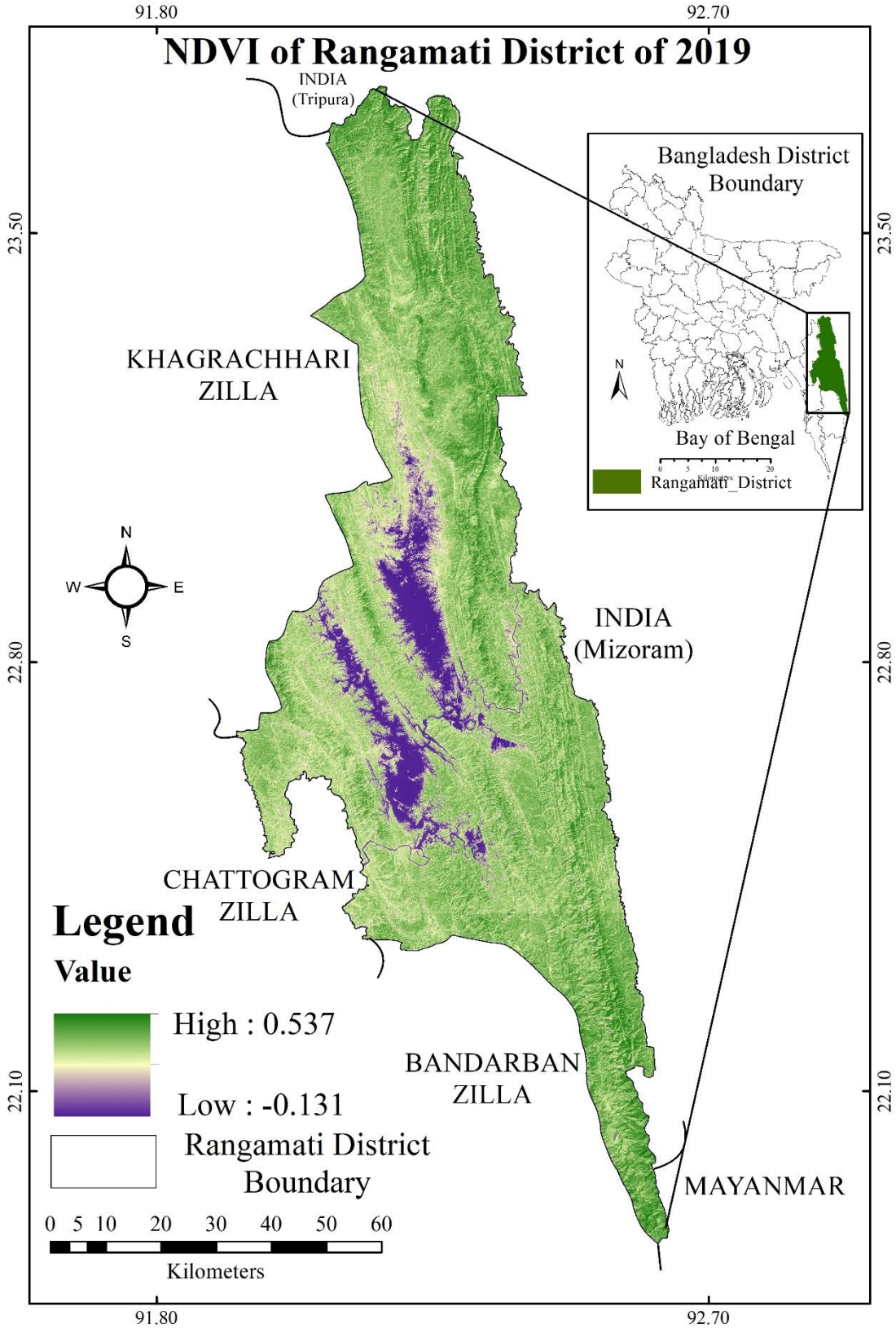


Figure 5. 9 NDVI map of Rangamati district of 2019, Source: Based on Satellite image processing done by the author.

5.4.1 Threshold Value Fixing for Classification

The range of threshold value or greenness value is divided into discrete classes by partitioning the range of NDVI values into five ranges by fixing the thresholds for NDVI classification (Table 5.1). Threshold values partioning & fixing by the accuracy assessment and previous literature.

Table 5. 1 Threshold Value used in NDVI Classification

LULC type	Threshold Value				
	1977	1989	2000	2011	2019
Water Body	-0.9 -0	-0.45-0	-0.45-0	-0.5-0	-0.09-0
Bare Land	0-0.1	0-0.1	0-0.1	0-0.1	0-0.1
Settlement	0.1-0.15	0.1-0.15	0.1-0.15	0.1-0.15	0.1-0.15
Sparse Vegetation	0.15-0.25	0.15-0.45	0.15-0.45	0.15-0.45	0.15-0.45
Forest/Dense Vegetation	0.25-0.9	0.45-0.8	0.45-0.75	0.45-0.75	0.45-0.55

The study investigated and identified strategies for assessing land cover changes using the spectral index NDVI and categorization using NDVI. (Akter and Ahmed, 2017). Several data sets (Table 1) were developed using ERDAS IMAGINE 2014 and ArcGIS 3.4.1 software, while field survey data was created using SPSS 20 statistical software and a spreadsheet. Landsat time-series images analyzed LULC changes for this study.

5.4.2 NDVI Classification

There are several approaches for detecting seasonal changes in vegetation using satellite photos, one of which is to use vegetation indices that assess greenness (Chuvieco 1998). The NDVI is one of the most often used indices in vegetation remote sensing (Wheeler and Dietze 2019). It's also employed in phenological change, land cover categorization (Loveland et al. 2000), land use/cover change (Lunetta et al. 2006), different vegetation deterioration (Pettorelli et al. 2005), ecological change (Jacquin et al. 2010), and fire damage(Fernandez et al. 1997).

The spectral index NDVI and categorization using NDVI were used to investigate and identify ways of estimating land cover changes (Akter and Ahmed, 2017). ERDAS IMAGINE 2014 and ArcGIS 3.4.1 software created several data sets, while field survey data was created using SPSS 20 statistical software and a spreadsheet. For this investigation, three Landsat time-series imagery of Level 1 MSS, TM, and OLI TIRS

were acquired and used to assess LULC changes using "Defined Interval" reclassifying NDVI values. The reclassification results in the NDVI value, is falling year by year.

5.5 Change Detection

The NDVI value-based statistics are categorized into the following classes, i.e., waterbody, Bare land/ char land, Settlement area, Sparse Vegetation, and Forest or Dense Vegetation. The description of these classes is given in table 5.2

Table 5. 2 Land use land cover classes were used in this study.

Class Name	Descriptions of Classes
Water Body	All water sources (like rivers, streams, lakes, ponds, and creeks) can be detected by Remote Sensing in the study area.
Bare Land/Char land	Areas with no vegetation cover, include exposed soils, char land, fallow land, and landfill sites.
Settlement Area	Residential, commercial and services, Industrial, Transportation, Roads, Mixed urban and all buildup area like Stadium, shop, office, school, college, Factory, etc.
Sparse Vegetation	All cultivated lands area, permanent and seasonal grasslands along lake, river, stream, marshy land, and swamps. Which vegetation surrounding the buildup areas is included in this class. Crop fields, agricultural land, fallow land, and vegetable land are also included.
Forest/Dense Vegetation.	Reserve forest, plantations, deciduous forest, mixed forest, palms, conifer, and scrubs

From 1977 to 2019, Table 5.2 depicts the spatial representation of LULC types. Table 5.3 describes the proportionate coverage area of each of the five classes extracted in Rangamati from 1977 to 2019 of LULC changing patterns (Munthali et al. 2019). In 1977, forest-covered 86.87 percent of the land area (Figure 5.11); in 2019, it covers 0.72 percent (Figure 5.15). According to satellite image processing results, forests constituted the most prominent area in 1977. Between 1977 and 2019, waterbodies decreased from 7.32 to 6.91, while bare land and settlement areas expanded from 1.14 to 4.67 percent and 1.01 to 18.06 (Gao et al. 2015) (figure 5.10). Sparse vegetation has increased by 3.66 to 69.64 percent (Figure 5.10).

Table 5. 3 Decadal land use land cover area (%) of Rangamati district during 1977-2019

	Area (%)				
LULC type	1977	1989	2000	2011	2019
Water Body	7.32	7.51	7.5	6.36	6.91
Bare Land/Char land	1.14	1.72	2.02	2.71	4.67
Settlement Area	1.01	2.43	2.93	3.82	18.06
Sparse Vegetation	3.66	17.18	28.65	41.96	69.64
Forest/Dense Vegetation	86.87	71.16	58.9	45.15	0.72
Total %	100	100	100	100	100

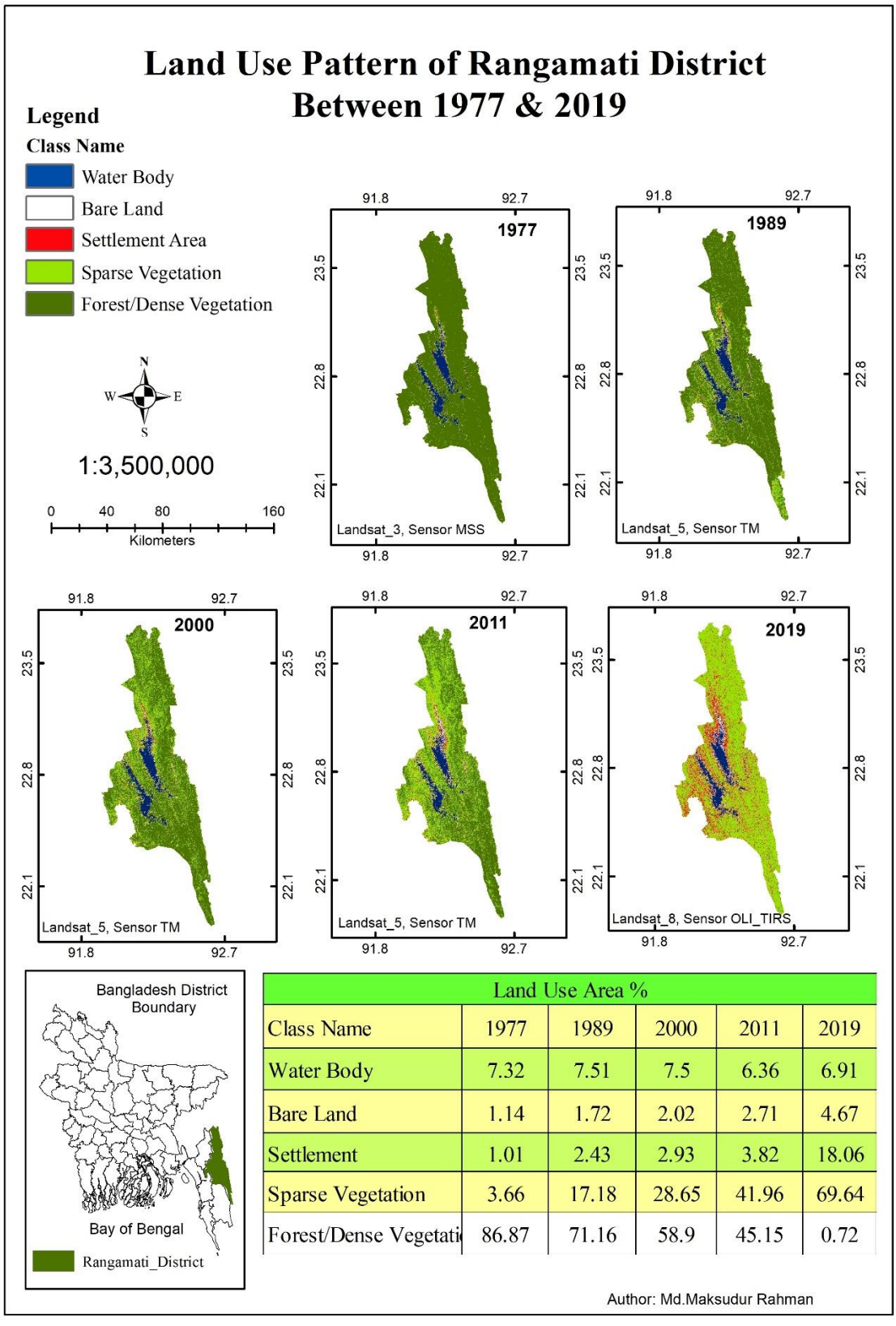
Source: Authors' calculation based on Satellite image processing, (1977-2019)

Table5.4 depicts the rate of land-use change, where -44.43 percent of the total land-use change from 2011 to 2019 is represented by dense forest and 27.64 percent by sparse vegetation. While the amplitude of change in the dense forest was the largest, the third, and fourth stage of total land-use change was a settlement, bare land 14.24 and 1.96 percent respectively and little irregular change was observed in surface water bodies, which accounts for a total land-use change of 0.55 percent between 2011 and 2019. Even reserve woods in CHT were progressively dwindling as a result of illicit logging and the growth of agricultural fields. The forest acreage of the Kassalong reserve decreased down from 150000 hectares in 1963 to 89000 ha in 1991. Similar trends were seen in the Rankhiang reserve forest, where between 1963 and 1991, the forest's acreage decreased from 382,000 hectares to 251,000 ha (BFRI, 2000). According to a soil and land use survey done in 1966, 73% of the land in CHT is only suited for forestry, 15% is good for horticulture, and just 3% is suitable for intensive terraced agriculture (Forerstal, 1966).

Table 5. 4 Land use Change Area %

LULC type	Change Area (%)			
	1977-1989	1989-2000	2000-2011	2011-2019
Water Body	0.19	-0.01	-1.14	0.55
Bare Land/Char land	0.58	0.3	0.69	1.96
Settlement Area	1.42	0.5	0.89	14.24
Sparse Vegetation	13.52	11.47	13.31	27.64
Forest/Dense Vegetation	-15.71	-12.26	-13.75	-44.43

Source: Authors' calculation based on Satellite image processing, (1977-2019)



Land Use Area %					
Class Name	1977	1989	2000	2011	2019
Water Body	7.32	7.51	7.5	6.36	6.91
Bare Land	1.14	1.72	2.02	2.71	4.67
Settlement	1.01	2.43	2.93	3.82	18.06
Sparse Vegetation	3.66	17.18	28.65	41.96	69.64
Forest/Dense Vegetati	86.87	71.16	58.9	45.15	0.72

Figure 5. 10 The land use pattern of Rangamati district for five different years (1977-2019) at a glance, Source: Based on Satellite image processing done by the author.

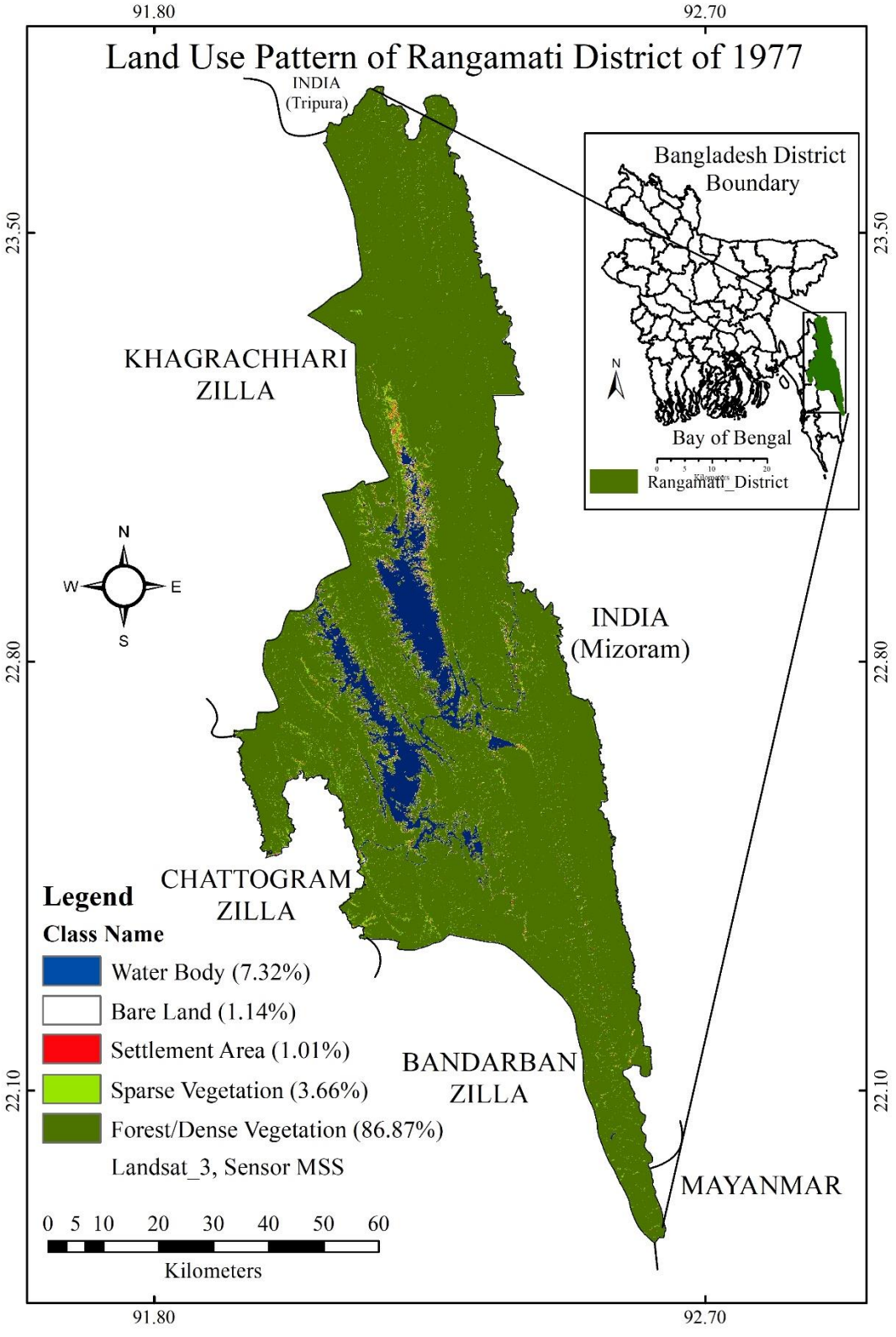


Figure 5. 11 The land use Pattern of Rangamati district of 1977, Source: Based on Satellite image processing done by the author

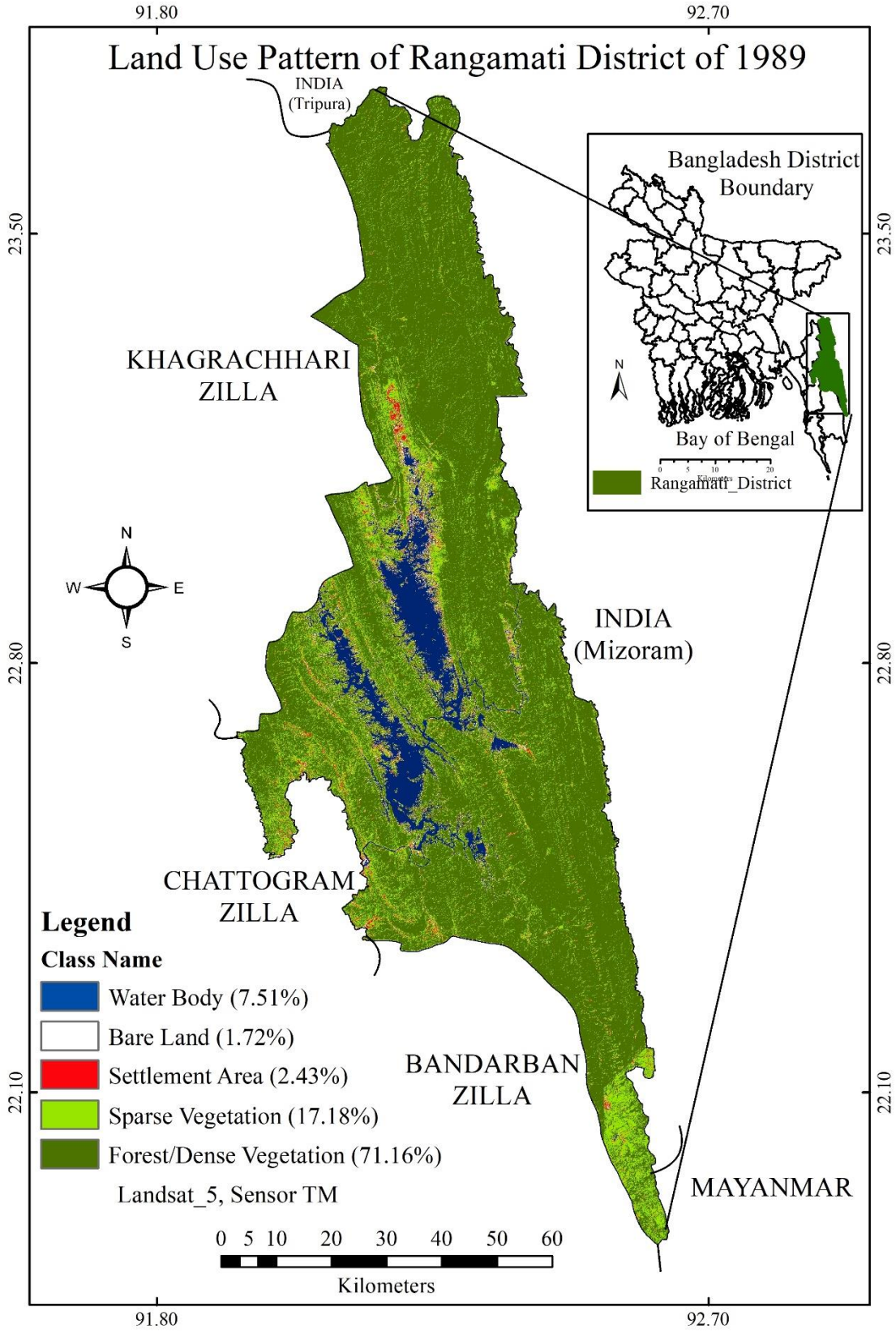


Figure 5. 12 The land use pattern of Rangamati district of 1989, Source: Based on Satellite image processing done by the author.

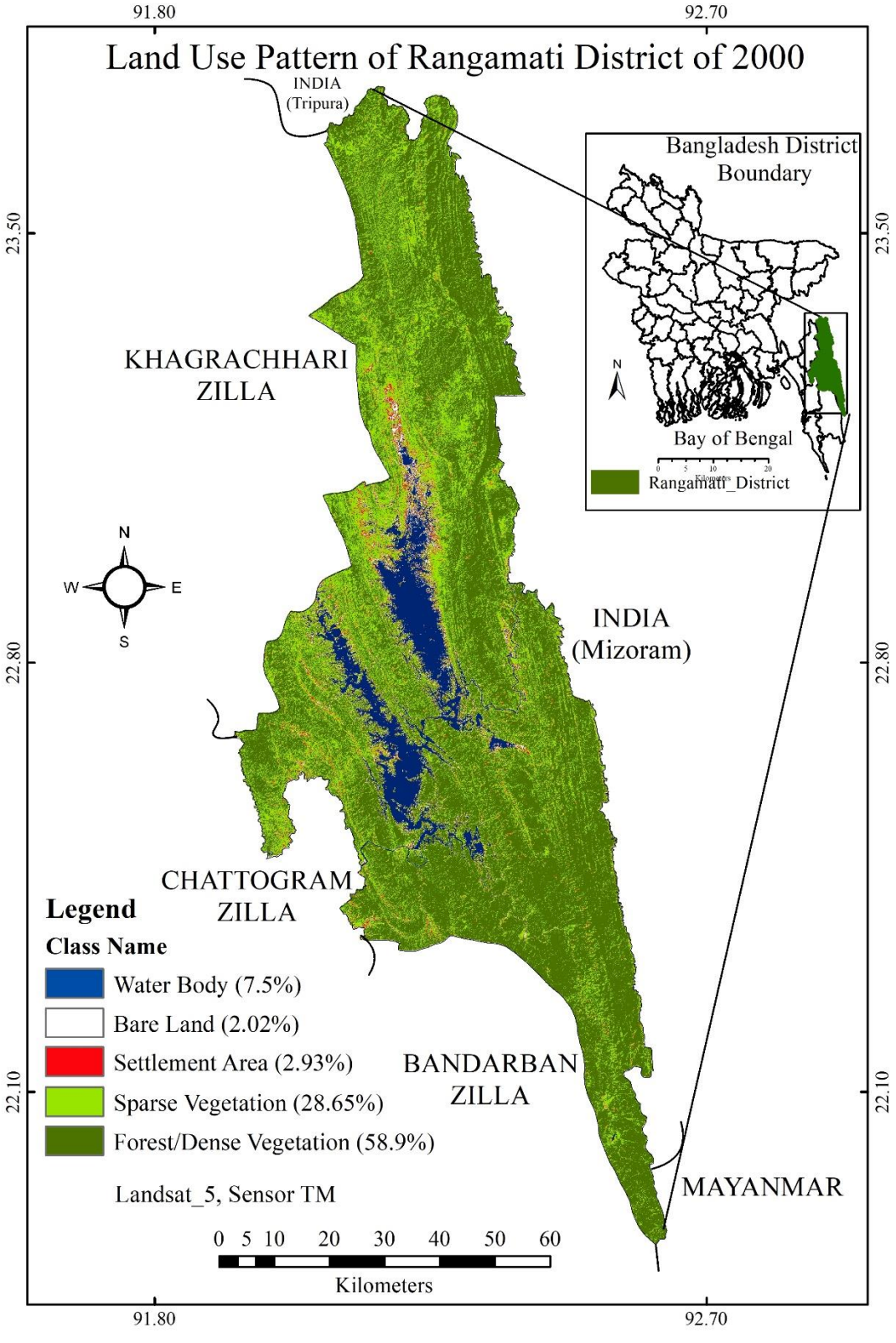


Figure 5. 13 The land use pattern of Rangamati district of 2000, Source: Based on Satellite image processing done by the author.

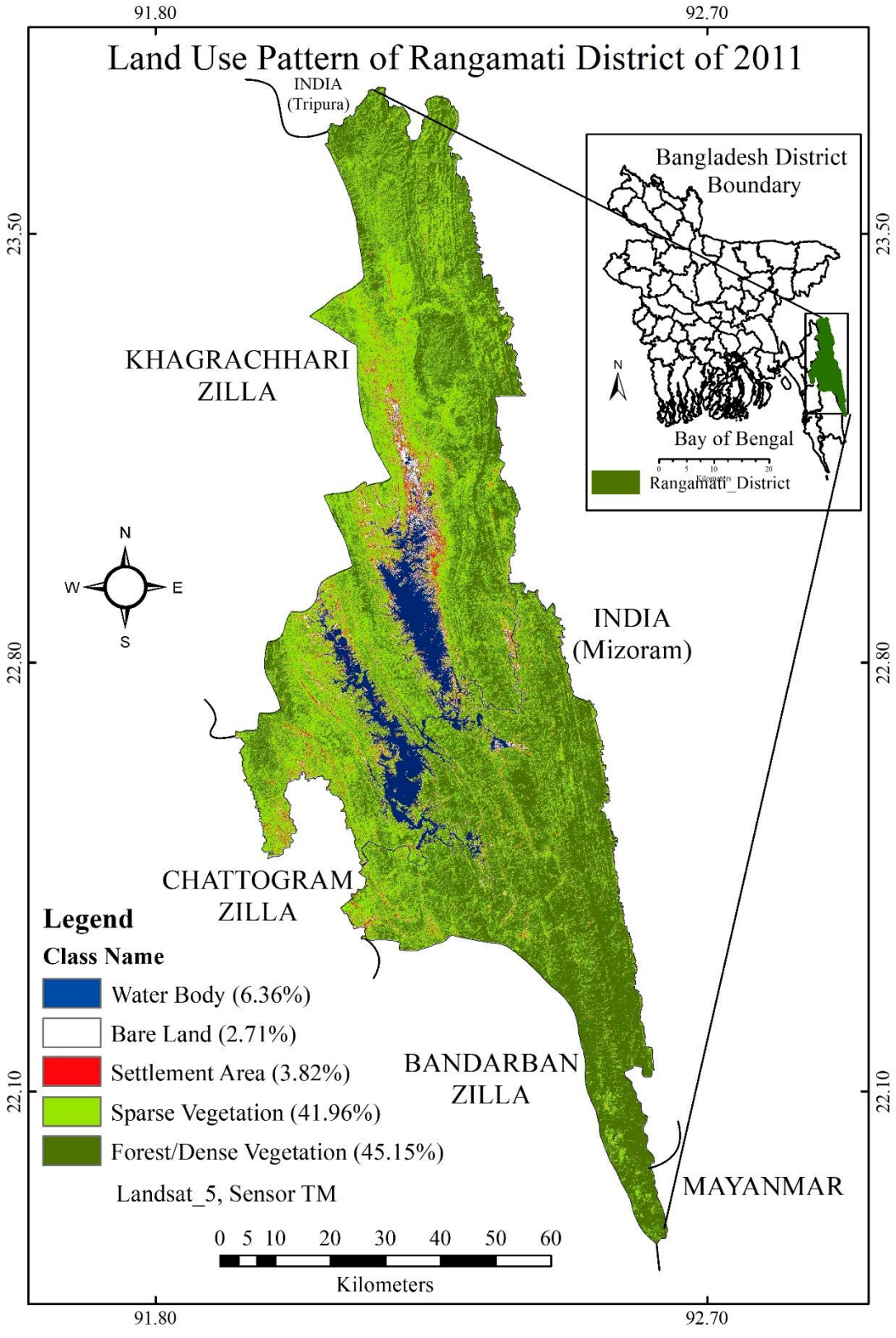


Figure 5. 14 The land use pattern of Rangamati district of 2011, Source: Based on Satellite image processing done by the author.

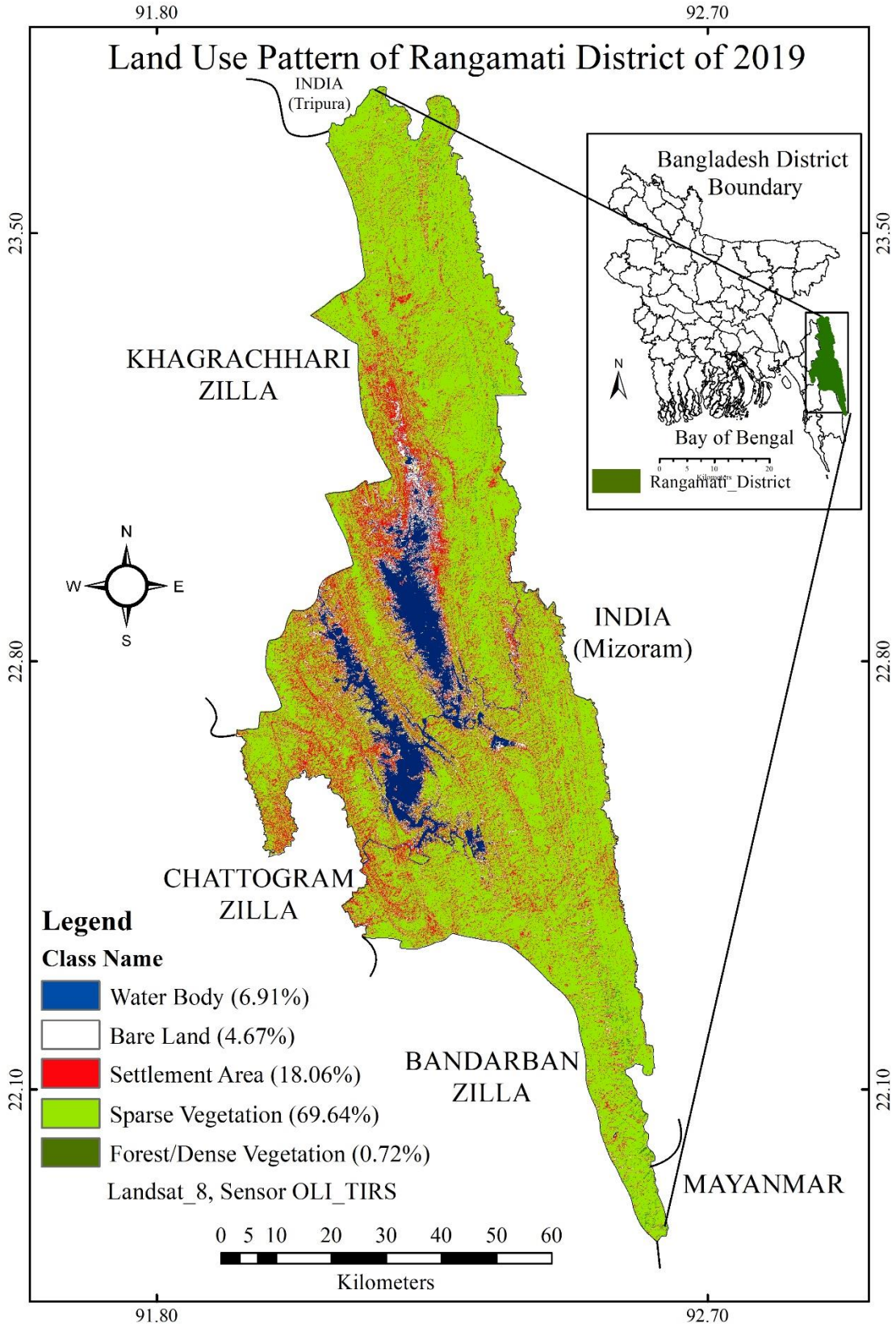


Figure 5. 15 The land use pattern of Rangamati District of 2019, Source: Based on Satellite image processing done by the author.

5.6 Accuracy Assessment

The accuracy of satellite imagery-based classification is affected by various factors such as weather, cloud cover, leaf structure, chlorophyll concentration, moisture content, and sample selection processes (Foody 2008; Gaur and Chouhan 2017). The correctness of the ground truth data was checked by comparing it to the categorized image. The classification accuracy was measured using the accuracy of the user and producer (Singh 2012; Taufik et al. 2017). The degree of correspondence between satellite and reference data is called classification accuracy (Congalton 1991). It is incomplete unless an accuracy assessment is performed on the categorization process (Lillesand 2004). For this, 50 stratified random samples of testing pixels were selected from each (2000, 2011, and 2019) classified image. Their classes were compared with the land use land cover field reference and Google map (Thakkar et al. 2014). Still, accurate assessment of other (1989 and 1977) previous images was impossible due to vague Google maps or noisy Google images (Thakkar et al. 2014). A confusion matrix was created to keep track of the outcomes. The classification accuracy was also measured using a non-parametric Kappa test, which accounts for all items in the confusion matrix rather than the diagonal elements (Rosenfield and Fitzpatirck-Lins 1986). The overall accuracy of NDVI generated, and usage classifications were 84 to 90 percent, with Kappa statistics of 80, 88, and 87.5 percent, respectively (table 5.5), verifying the suggested accuracy of 85-90 percent for LULC mapping investigations (Anderson et al. 1976)

Table 5. 5 Results of accuracy assessment of land use/cover map produced from Landsat TM and OLI_TIRS data

LULC Classes	2000		2011		2019	
	Producer's accuracy (%)	User's accuracy (%)	Producer's accuracy (%)	User's accuracy (%)	Producer's accuracy (%)	User's accuracy (%)
Water Body	90.91	100	90.91	100	83.33	100
Bare land	88.89	80	100	90	80	80
Settlement	77.78	70	88.89	80	90	90
Sparse Vegetation	66.67	80	75	90	100	90
Forest	100	90	100	90	100	90
Overall Accuracy	84%		90%		90%	
Kappa Coefficient (T) 80%	80%		88%		87.50%	

Source: Based on Satellite image classification calculated by author, (2000, 2011 & 2019)

5.7 Conclusions

This chapter was about the Application of Satellite Remote Sensing to detect the changes in Land Use and Land Cover in the area where this research was conducted. The Application of Satellite Remote Sensing to detect the changes in Land Use Land Cover includes the Change detection and accuracy assessment of the study area.

Chapter Six

Socio-economic Status of Rangamati

6.1 Introduction

The socio-economic condition of an area or region can be understood from its demographic characteristics, resource base, and various economic and social indicators. The socio-economic condition is also influenced by the physical and social infrastructure available in and around the area. The Socioeconomic condition of the study area is described under the following categories.

- Demographic characteristics
- Land Tenure and Ownership
- Housing Characteristics
- Agricultural practice
- Economic characteristics
- Characteristics of Livelihood and Social facilities
- Land use change in Rangamati

Table 6. 1 Sampled household characteristics in the studied landscape (sample size = 300)

Household Attribute	**Value**
Educational level (highest % in class one to five, household head)	29
Mean Age of household head	48.3
Gender (female, %)	3.3
Ethnic group of the Head (Bangalee, %)	50
Marital status (married, %)	98.3
Education (literate, %)	28
Occupation (Farmer, %)	26.3
Disaster and hazard type (landslides %)	26
The main problem of Locality	16.80
Household Head Occupation (Agriculture %)	30.3
Monthly Income (Range 10,000- 15,000, %)	28.3
Sources of income (agriculture, rank)	1
Household Structure (Kutcha %)	45.3

6.2 Demographic characteristics

6.2.1 Demographic composition

6.2.1.1 Household members:

According to BBS 2011, the nationwide household size is 4.8 on average. Among the 300 respondents, most of the households in the study area have 3-6 members. 37% of households have 4 members, 24.3% of households have 5 members, 14.7% of households have 6 members, and 13.3 % of households have 3 members. The average household size of CHT is 5.2 according to the socio-economic baseline survey CHT 2009 (Abul Barkat et al. 2009).

6.2.1.2 Gender:

The study area is in the Rangamati Sadar Upazila, where among the 300 respondents, 50% people are Bangalee and this is why the head of the household is male in 96.7% of households.

6.2.1.3 Age:

In a total of 300 respondents, The age of the household head mostly ranges between 35-55 years (67.11%).

6.2.1.4 Marital status:

Almost all the 300 respondents some people married is 98.3% and 1.7% are widows/widowers.

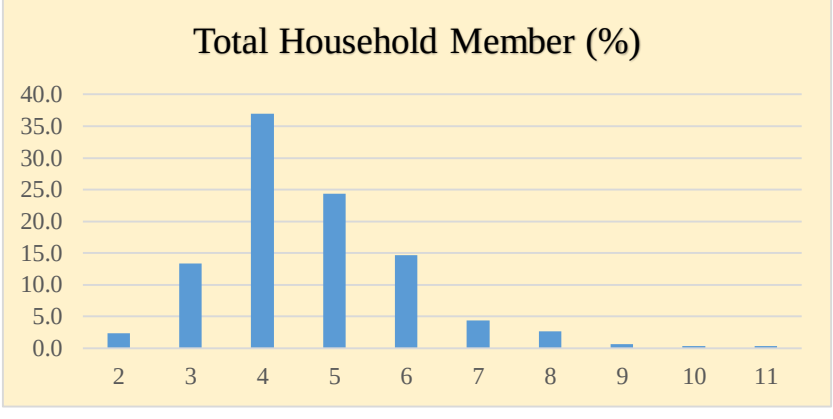


Figure 6. 1 Household Member (Source: Author, data: Field survey 2019)

Table 6. 2 Gender of the head of household

Gender of the Head of Household	Percent
Male	96.7
Female	3.3

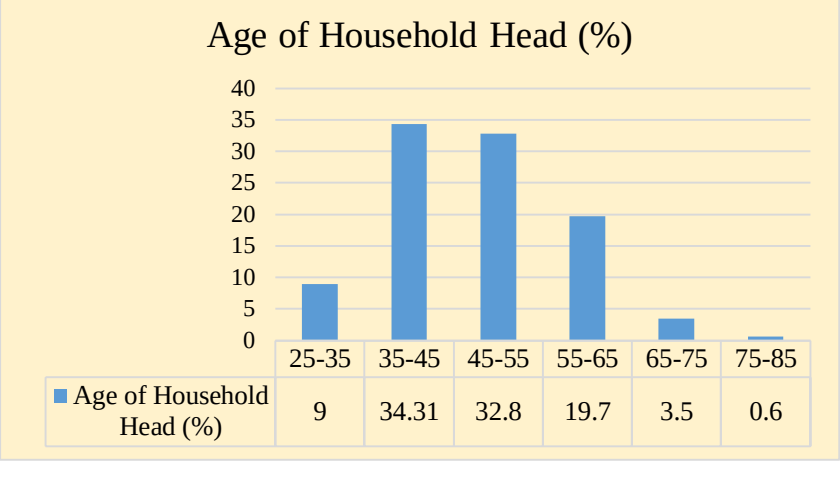


Figure 6. 2 Age of household head (source: Author, data: Field survey 2019)

Table 6. 3 Marital status

	Marital status (%)
Married	98.3
Widow/widower	1.7

6.2.1.5 Ethnicity:

Rangamati's population is made up of both Bangalee and non-Bangalee Pahari. There are two types of Bangalees: settlers and permanent inhabitants. Each Phahari has its own dialect, social structure, and culture. The Settlers are destitute Bengali-speaking Muslims who have lost their land. They were relocated from the plains, mainly in the districts of Chattagram, Noakhali, Comilla, and Sylhet. They are given food rations, khas land, money, and housing by the government. As early as the seventeenth century, settlers began to migrate in small groups to the Hill Tracts.

The figure below shows that among the 300 respondents, 50% people in the study area are Bengalis, and the other half is comprised of different ethnic groups 43% Chakma, 6% Marma, and 1% Tangchangya. Migration from plain land, rapid urbanization, the

migration policy of the government, high land prices, and the development of the tourism industry are the reasons behind this statistic.

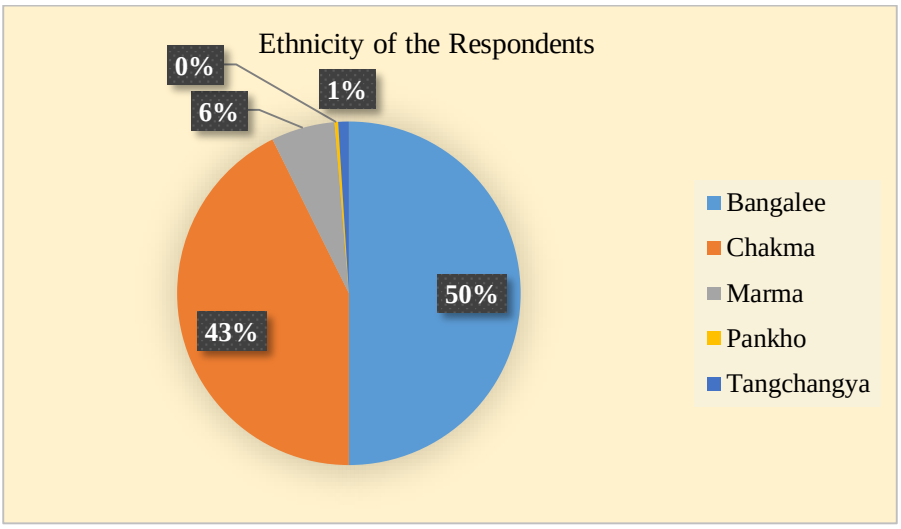


Figure 6. 3 Ethnic Group Percentage of the respondents (Source: Field survey 2019)

6.2.1.6 Religion:

The people in the study area are mostly Bengali and Chakma. The religion of the Chakmas is Buddhism. So the main religions among the 300 respondents in the study area are Buddhism (52%) and Islam (46%). There are also 1% Hindu and 1% Christian people.

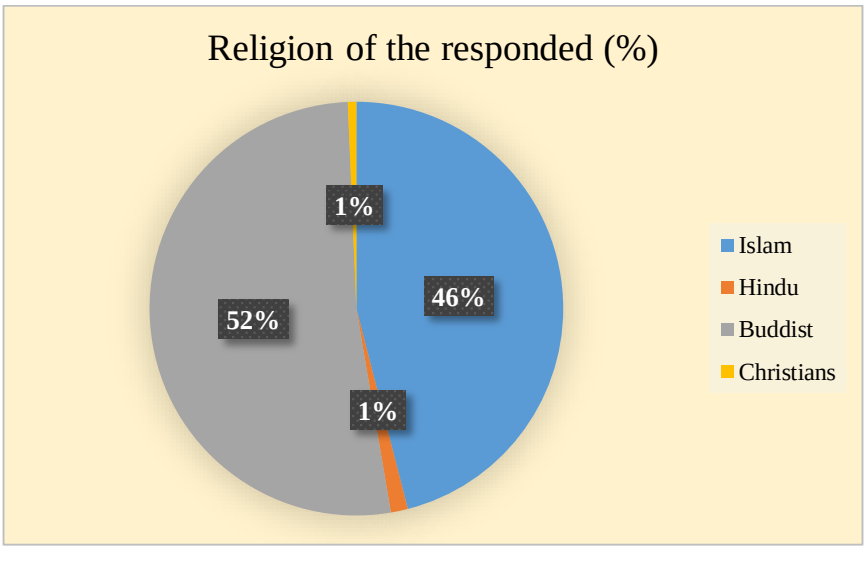


Figure 6. 4 Religion of household head of the respondents (Source: Field survey 2019)

6.2.1.7 Education level:

One of the most critical aspects of human capital is educational attainment. It is an essential variable of socio-economic and environmental impact assessment. Now Rangamati's situation is excellent regarding literacy and years spent in school. However, the Socio-economic Baseline survey of CHT (2009) reveals that the situation is awful in terms of literacy in CHT. This study used six different factors to classify the household head's educational attainment. The factors are illiterate or no education, class one to five, class six to nine, SSC or equivalent, HSC or equivalent, and higher education (Honors or Masters). This calculation is based on the average percentage of urban, rural, and semi-urban areas comprising indigenous and Bangalee people. Among 300 respondents, the literacy rate of the people of the household head of the study area is 72%, while the national literacy rate is 72.8%, and the global average is 86.3%. 29% of people received only primary education. Only 9% of people received secondary education, 8.3% received higher secondary education, and 5.3% received higher education.

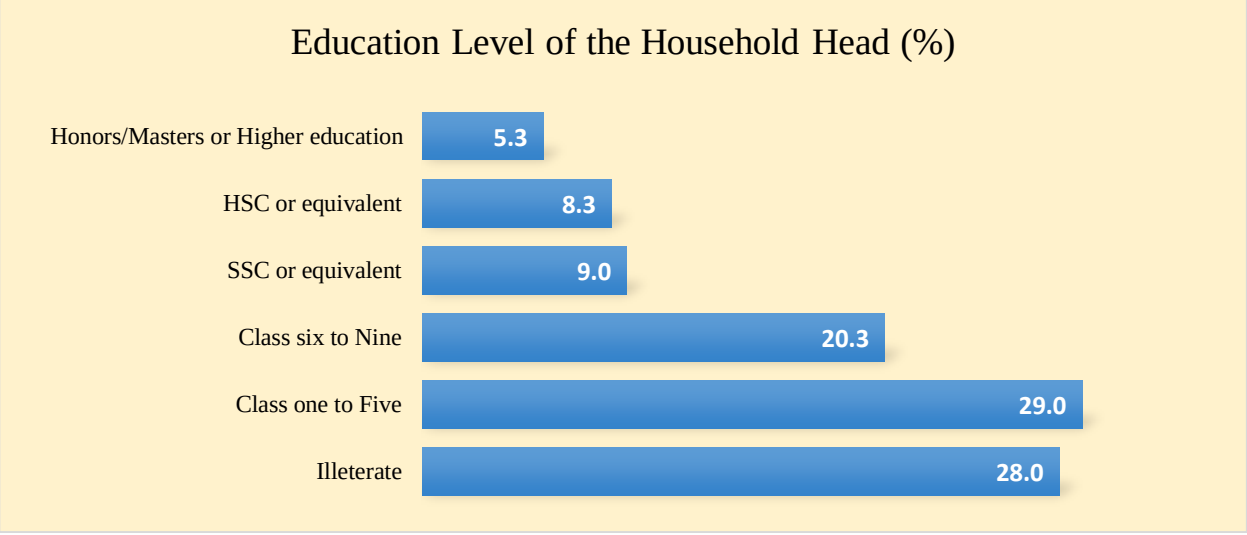


Figure 6. 5 Education Level of the Household Head (Source: Field survey 2019)

6.2.2 Migration status

After the liberation war in 1971, migration took place in a different part of Bangladesh. Among the 300 respondents, Rangamati is the birthplace of 75% of household heads, and 25% of household heads are immigrants in Rangamati from other places.

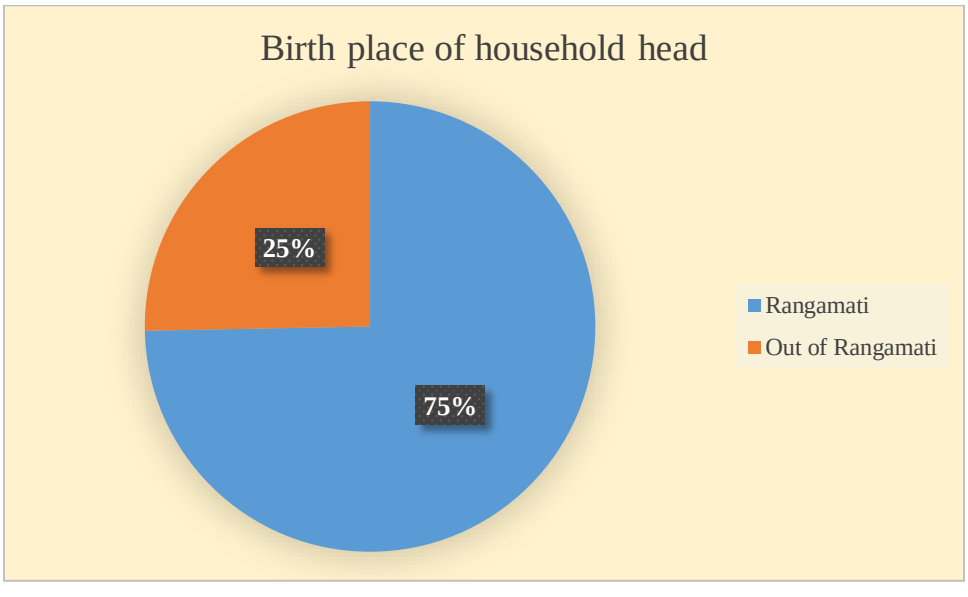


Figure 6.6 Birthplace of household head (Source: Field survey 2019)

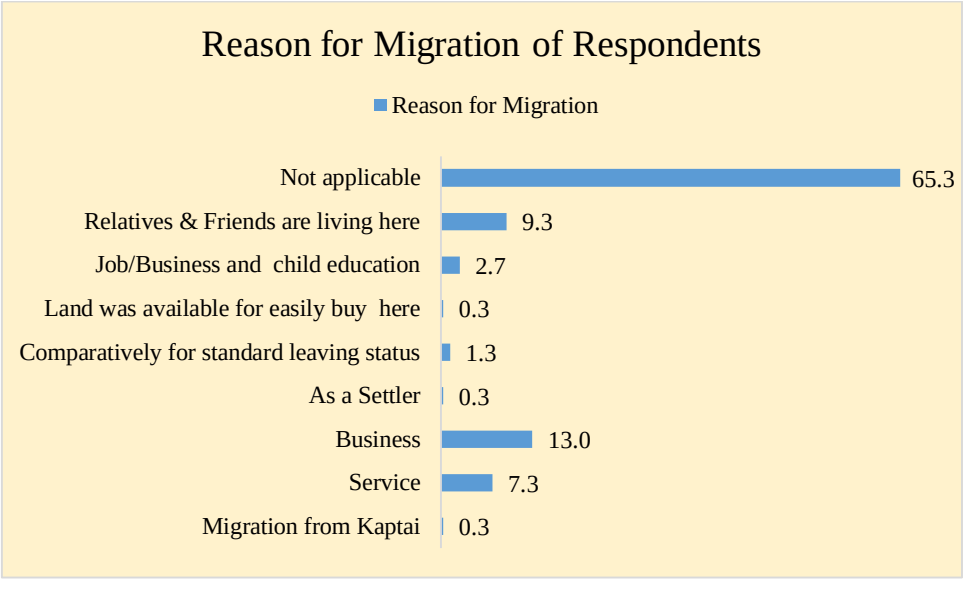


Figure 6. 7 Reason for Migration (Source: Field survey 2019)

Figure 6.7 shows the reasons for people immigrating to Rangamati from other places. Most of the people among the 300 respondents have immigrated here because of the development of the tourism industry, and they can do business there. 13% of people have this reason. 9.3% of people have migrated because they have relatives and friends living here, 7.3% migrated for service, 2.7% migrated for child education, 1.3% for a comparatively better standard of living, 0.3% migrated from Kaptai, 0.3% bought readily available land and 0.3% as a settler. According to the socio-economic baseline

survey 2009, Before the CHT Accord was signed in 1997, at least one household member in 13% of CHT rural households had to leave their para. After signing the CHT Accord, out-migrated members of around 10% of CHT households returned. A tenth of those relocated has done so because of security concerns or communal or political strife.

6.3 Land Tenure and Ownership

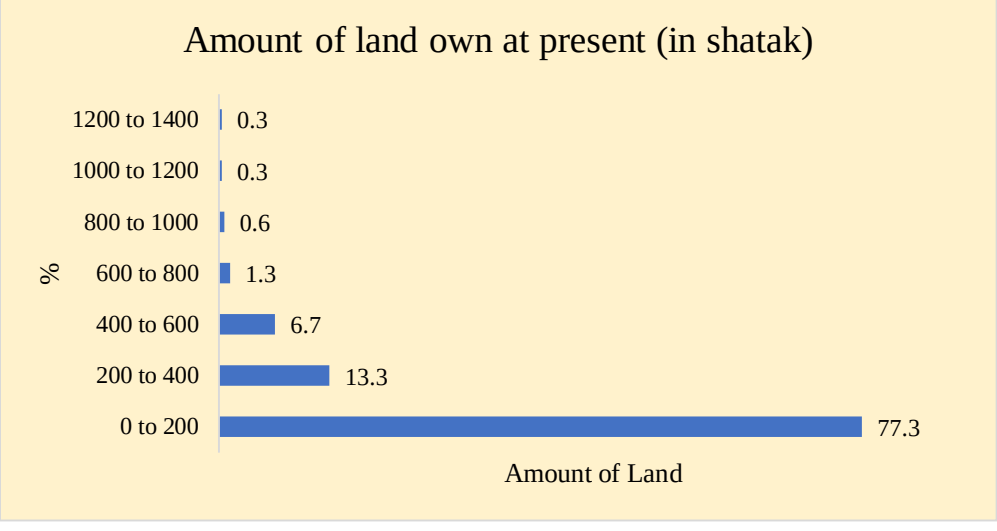


Figure 6. 8 Amount of land owned at present (in shatak) (Source: Field survey 2019)

Figure 6.8 shows the amount of land owned by the household of a total respondent of 300. Among the 300 respondents, 77.3% of households own 0-200 percent land, 13.3% own 200-400 percent land, 6.7% own 400-600 percent land, and 2.3% of households own more than 600 percent land.

Figure 6.9 shows the ownership percentage of agricultural land. Where among the 300 respondents, 44% of households have agricultural land, 16% of households had agricultural land before but not now, and 21% never had any agricultural land.

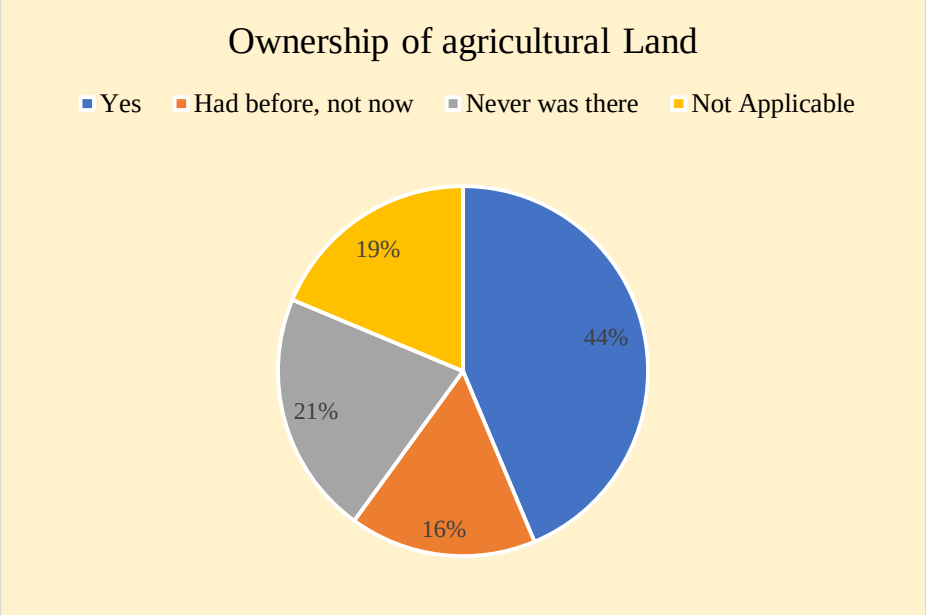


Figure 6. 9 Ownership of agricultural Land (Source: Field survey 2019)

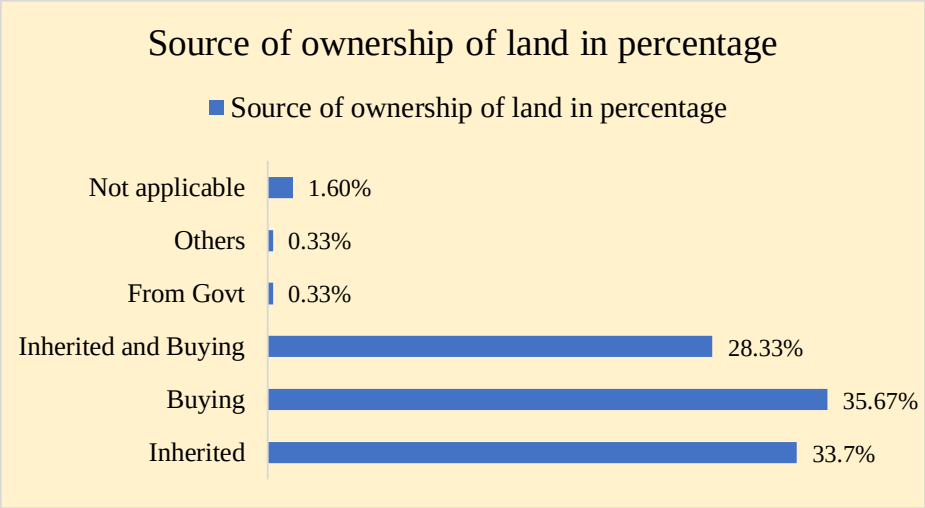


Figure 6. 10 Source of ownership of land in percentage (Source: Field survey 2019)

Figure 6.10 shows the source of ownership of land. Among the 300 respondents, 35.67% of households have bought the land, 33.7% of households have inherited land, 28.33% have inherited and bought land, and 0.33% have land from the government.

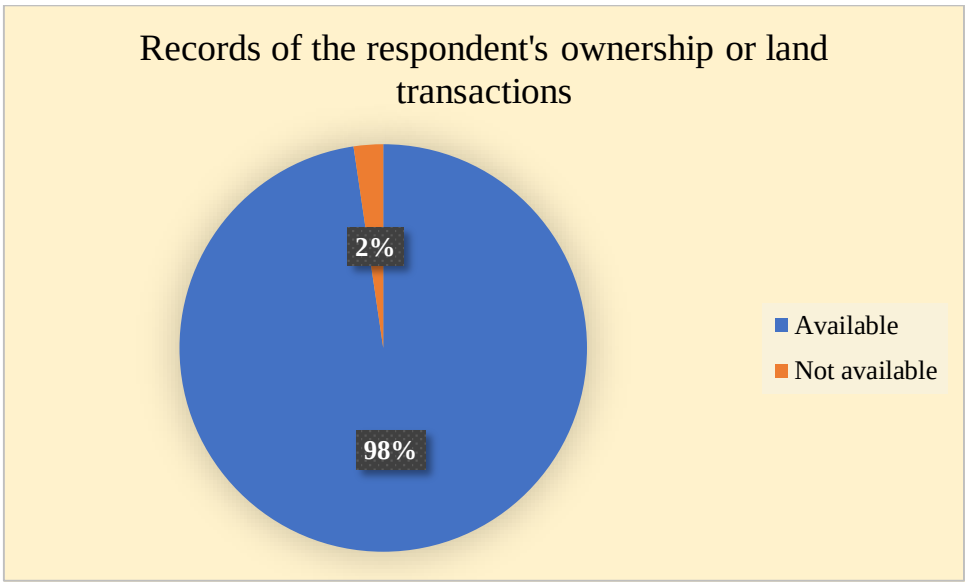


Figure 6. 11 The legal record of the respondent's ownership or dealing land (Source: Field survey 2019)

Figure 6.11 shows the percentage of households among the 300 respondents who have a legal record of land. 98% of households have their land, and all have a legal record of dealing with land.

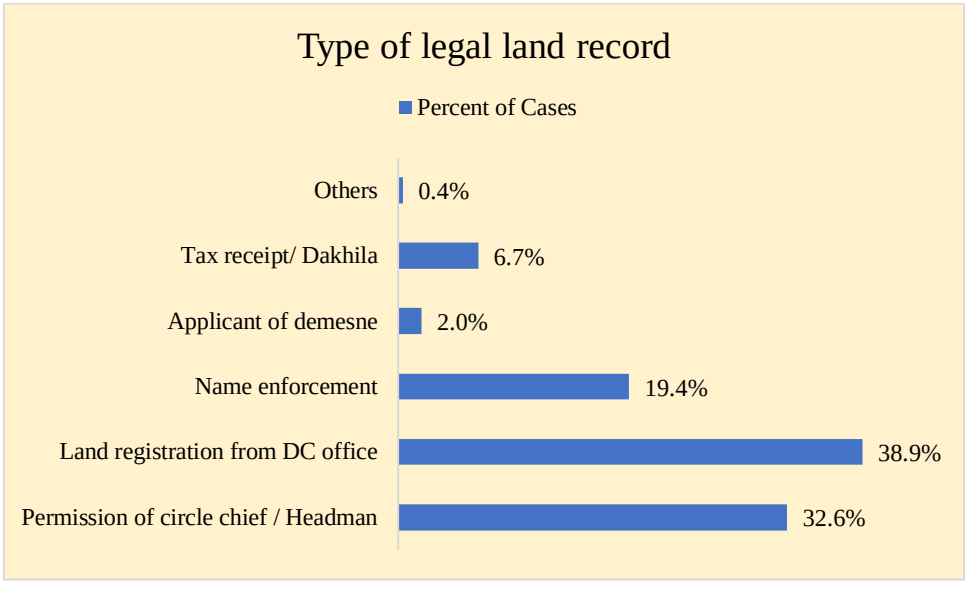


Figure 6. 12 Type of legal land record (Source: Field survey 2019)

Figure 6.12 shows the type of legal land records collected from a total of 300 respondents in Rangamati. 38.9% of lands have land registration from the DC office, 32.6% have the permission of circle chief/ headman, 19.4% have name enforcement, 2% are the applicant of the demesne, 6.7% have tax receipt/Dakhla, and 0.4% others.

Table 6. 4 Handover or selling rights of land

	Handover or selling rights (own or dealing land)
Yes	98.3%
No	1.7%

Table 6. 5 Occupancy rights on own or dealing land

	Occupancy rights on own or dealing land
Yes	98.3%
No	1.7%

Table 6. 6 Ownership rights of women member

	Responded (%)
Yes	2%
No	98%

Table 6. 7 Ownership of house and the monthly house rent

	Percent
Tenant	2.0
Own house	98.0

In Taka	**If the tenant then monthly house rent of responded (%)**
0	98.0
2000	1.0
2500	0.3
3500	0.3
5000	0.3

Table 6.7 shows the house owners of the total respondent and the monthly house rent. 98% of households among the 300 respondents have their own house and 2% are tenants. The monthly rent is 2000 taka in 1% of households and more than 2000 taka in 0.9% of households.

Table 6. 8 Represents the former landform type in the area around the home and before the house was built. (Field survey 2019)

Type of land	Responded (%)
Forest	71.7
Agricultural land / Jumming land	11.0
Pastureland	16.3
Fruits Garden	0.3
Others	0.7

Table 6.8 Shows the previous landform type surrounding the home and before the house was built. 71.7% of among the 300 respondents are forest land, 16.3% pasture land, 11% agricultural/jum land, 0.3% fruits garden, and 0.7% others. This information reveals the land-use change in the study area because of rapid urbanization, population growth, and migration from the mainland.

6.4 Housing Characteristics

6.4.1 Structure of household

The structure of a household depends on the topography, climate, development status, economic condition, and tradition. Rangamati is a hilly region. 4 types of households are found in the study area. Figure 6.13 shows the type of household among the 300 respondents in the study area, both in the present and past. In the past, the houses were primarily jhupri (27.3%) and kutcha (63%). There were only 0.3 % pucca and 9.3 % semi-pucca houses. Most houses are kutcha (45.3%) and Semi-pucca (42%), following 12.5% pucca and 0.2% jhupri houses. Due to rapid urbanization and migration from the plain land, the structure of the houses in the study area is changing gradually from jhupri & kutcha to pucca.

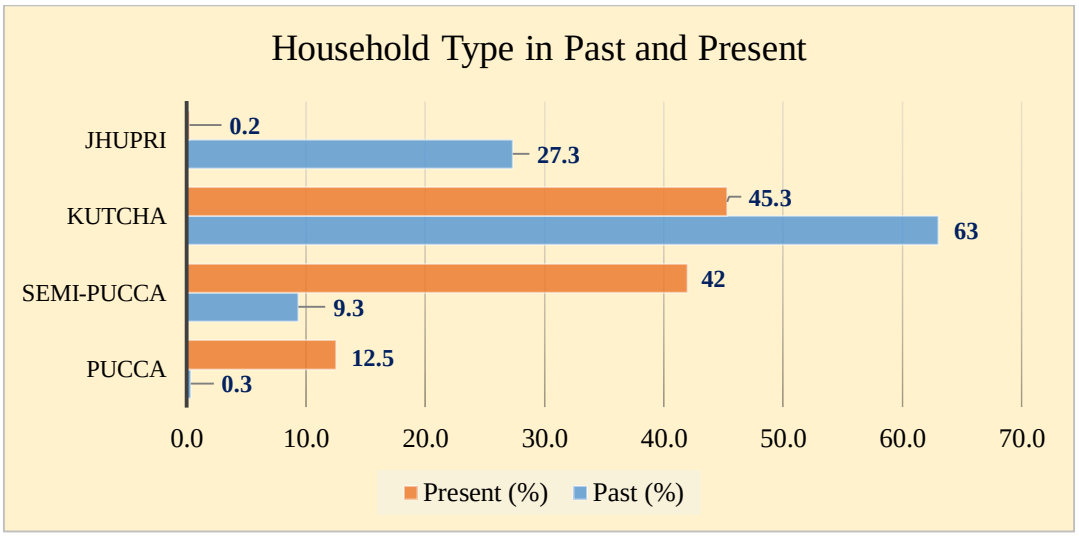


Figure 6. 13 Household Type in Past and Present (Source: Field survey 2019)

6.4.2 Kitchen location

The graph below shows the location of the kitchen in the present and past times, where among the 300 respondents, very few (0.6%) households have a separate kitchen. In the past, 52.7% of households had a separate room for the kitchen, and 46.7% of households had the kitchen in the same room of the house. At present, some houses have the same room in the house kitchen (82.7%) among the 300 respondents, and 16.7% of households have a separate room in a house kitchen. The reasons for this change are shortage of land, population growth, migration from plain land, rapid urbanization, Kaptai Dam, the migration policy of the government, high land price, unplanned development, development of the tourism industry, and poverty.

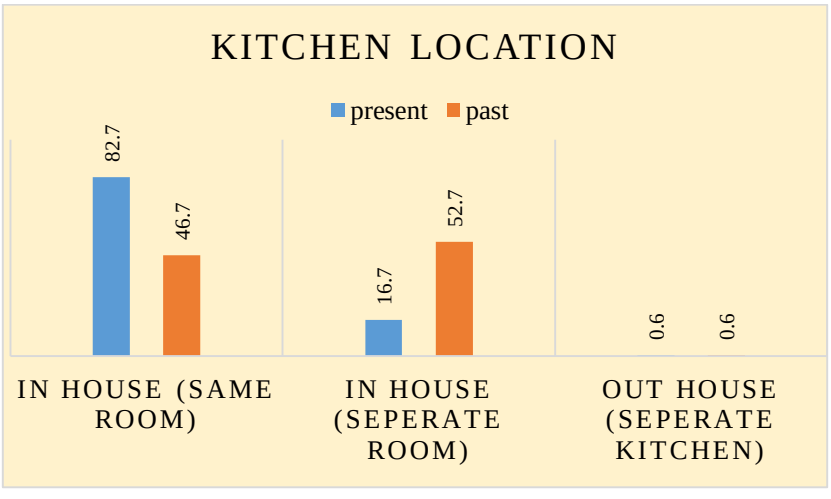


Figure 6. 14 Kitchen location (Source: Field survey 2019)

6.4.3 Toilet condition:

In the past, 86.30% of households had a kutcha toilet among the 300 respondents, 8.70% used the open place as a toilet, 3.30% had a pit latrine, and only 1.70% had sanitary toilet facilities. With rapid urbanization and gradual development, the quality of life of the people in the study area has improved. The structure of the houses is changing from kutcha to pucca. 95% of households have sanitary toilet facilities now. Only 3.30% of households have a kutcha toilet, and 1.70% have a pit latrine.

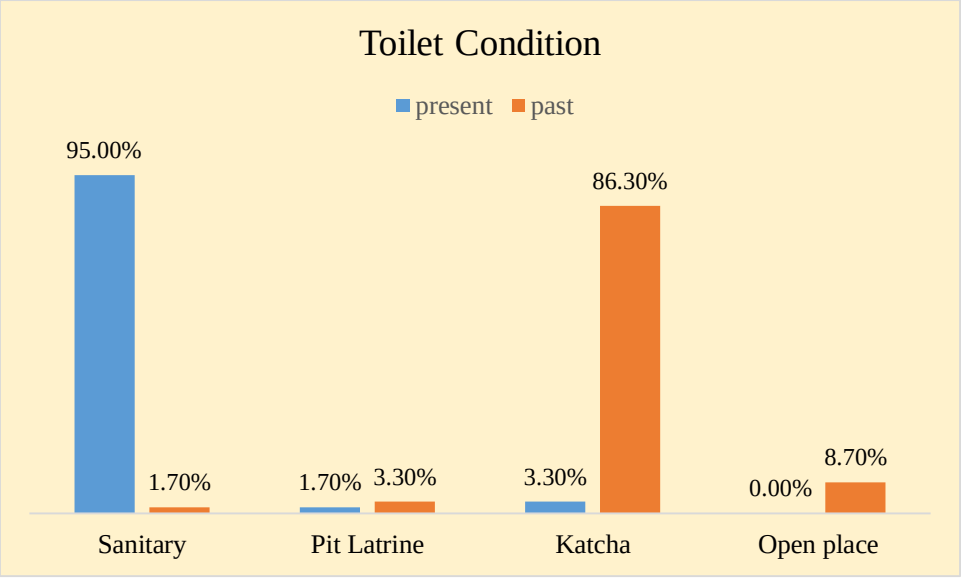


Figure 6. 15 Toilet Condition (Source: Field survey 2019)

6.5 Agricultural practice

The possibility of soil erosion must be considered while managing cover. It reflects the overall impact of vegetation, soil cover, soil biomass, and soil disturbance activities on erosion. The proportion of cultivated land in a geographic area reflects the stress that human activity has placed on the environment. Natural vegetation like wood or grass shields the soil from the effects of rain and runoff, lowering the danger of erosion. Seasonal agriculture causes more soil disturbance than perennial cultivation. Seasonal farming increases erosion risk more than permanent cropping due to canopy, ground cover, and soil surface disturbance (Hossain, 2005). Therefore, unrestrained land cover degradation, unscientific usage, and farming promote land use change.

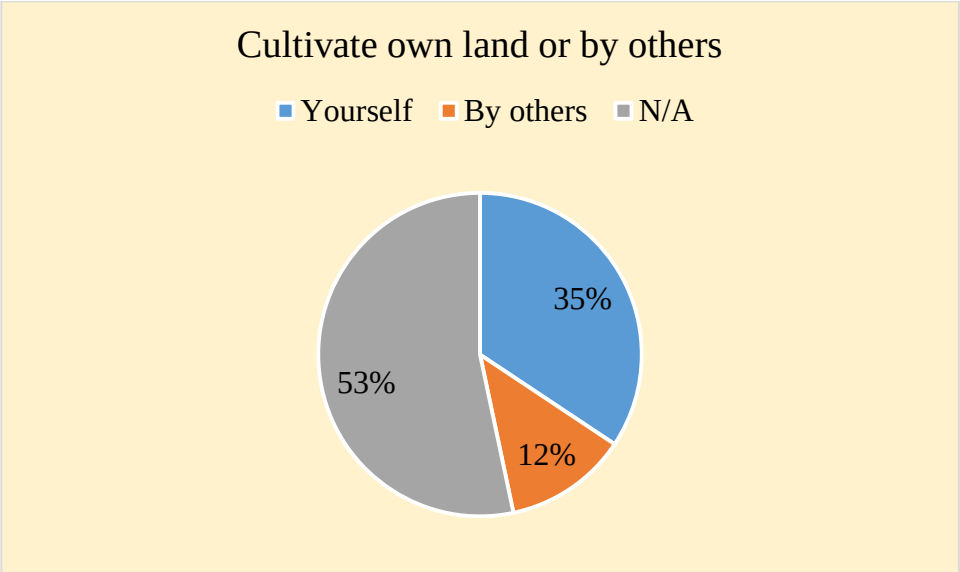


Figure 6. 16 Cultivate own land or by others (Source: Field survey 2019)

Figure 6.16 shows that among the 300 respondents, 47% have their agricultural land. Among them, 35% cultivate their land, and 12% cultivate their land with others and 53% respondent have not any cultivable land.

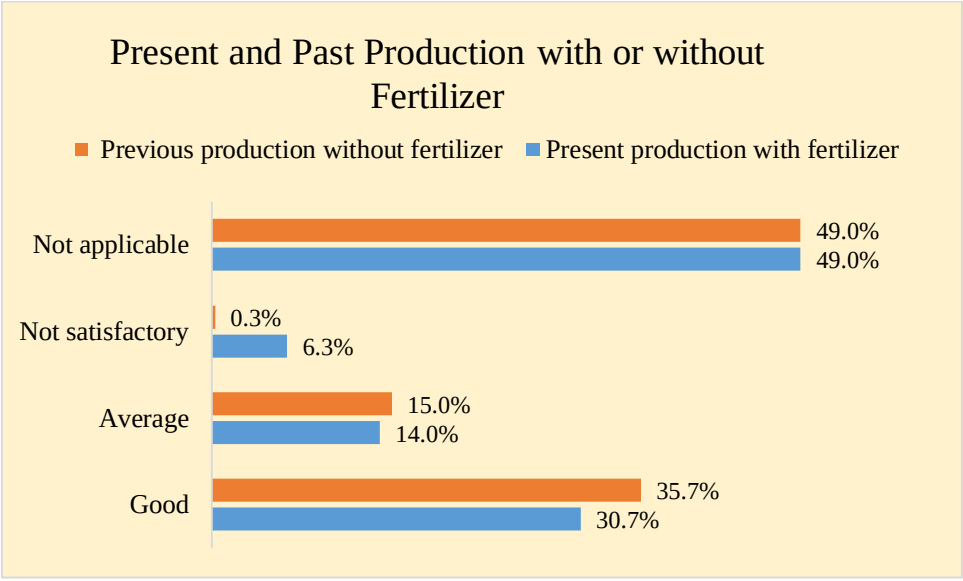


Figure 6. 17 Present and Past Production with or without Fertilizer (Source: Field survey 2019)

Figure 6.17 compares current and past production with and without fertilizer. It can be seen that the production was better without the fertilizer in the past than the production in the present with fertilizer.

6.5.1 Jhum status:

Jhum (Jhoom) refers to the ancient agricultural method used in Rangamati for decades. It is also called slash and burn or shifting farming. It is prevalent in the hilly area. If the fallow interval after the farming phase is long enough to restore soil fertility, then this agriculture technique is environmentally benign. The fallow time has recently been cut down to five years, which has led to soil deterioration, particularly soil erosion and nutrient depletion of land (Hossain, 2005). And such continuous erosion changes land use and creates permanent hazards. So, it is the important variable of land use land cover changes of the hilly area. The cultivation tools used in CHT for crop culture are plow and jhum, depending on the suitability of the soil, according to the socio-economic baseline survey 2009. Farming households made up about two-thirds of rural households. One-third of households (34 percent) conducted only field cropping, one-fifth (19 percent) did only jhum cropping, and a minor percentage (9 percent) did both field and jhum agricultural. The present and past jhum status and fallow periods are given in tables 6.9 & 6.10.

Table 6. 9 Jhum status in percent

	Responded (%)
Yes	3.0
Not	17.3
Had before but not now	29.0
Not applicable	50.7

Table 6. 10 Jhum fallow period in present and past

Jum fallow period present (Year)	0	1	2	3	4
Case response (%)	42.7	2.3	17.0	37.7	0.3

Jum fallow period past (Year)	0	4	5	6	7	8	9	10	11	12	15
Case response (%)	42.7	0.7	7.3	6.3	12.3	13.3	1.0	11.3	0.7	3.7	0.7

6.5.2 Irrigation

Irrigation is the process of giving water to crops. Irrigation is the technique of providing plants with regulated amounts of water at regular intervals. In arid places and during seasons of below-average rainfall, irrigation aids in the growth of crops, the maintenance of landscapes, and the revegetation of damaged soils. Irrigation may also be used to deliver nutrients to the crops. (Ali 1995).

Figure 6.18 shows the percentage of the necessity of irrigation in the agricultural land among the 300 respondents.54% of respondents favor irrigating the land, and 3% of the respondents commented on the issue of not irrigating the land.

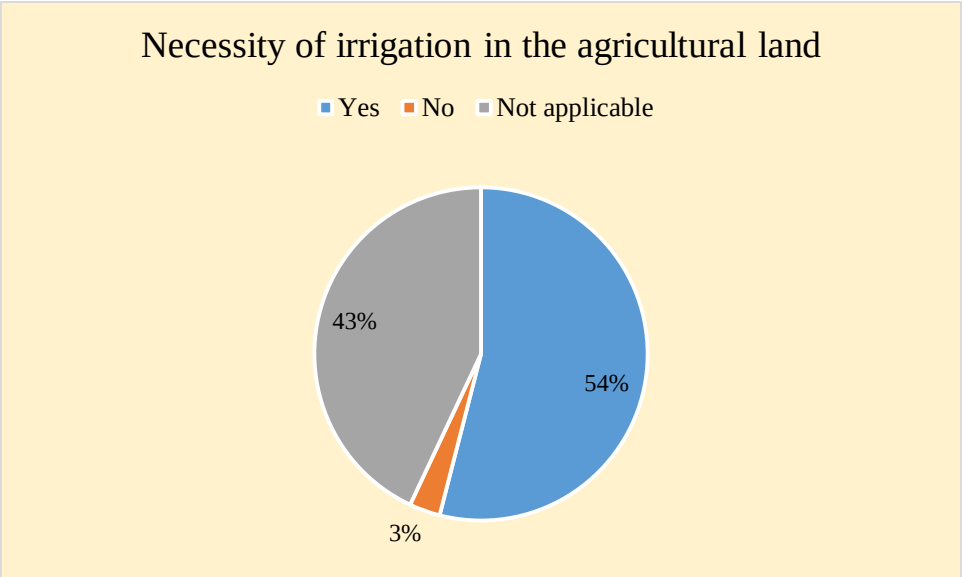


Figure 6. 18 Necessity of irrigation in the agricultural land (Source: Field survey 2019)

6.5.3 Cattle status

Cattle are by far the most significant livestock since they supply milk, meat, and skin in addition to the non-human farm energy needed for plows, crushers, and transportation (Marma et al., 2019). There are around 23.9 million cattle in Bangladesh, and native zebu cattle make up 90% of that number (Selim, 2017).

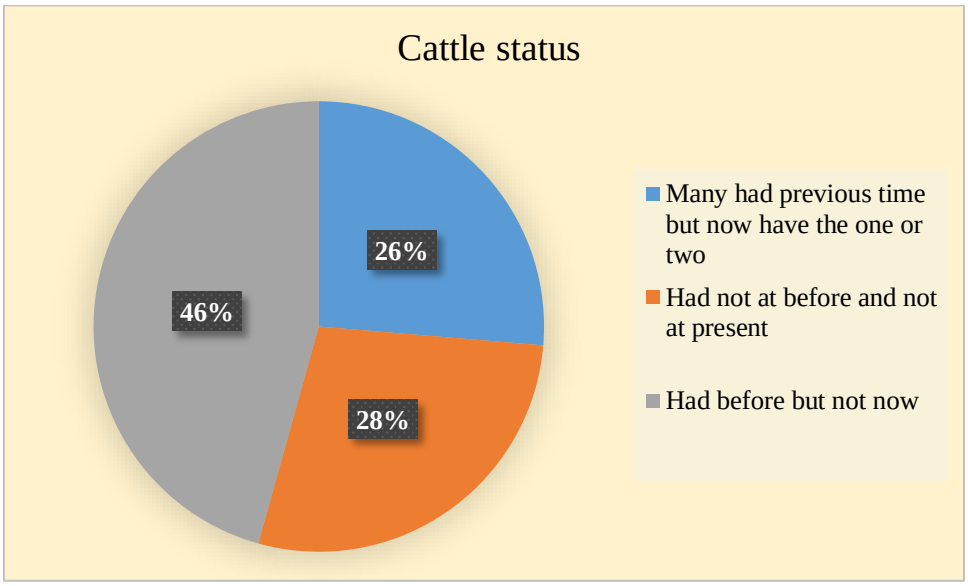


Figure 6. 19 Cattle status (Source: Field survey 2019)

Figure 6.19 demonstrates that 28% of the 300 respondents in the research region had never had cattle, 46% had livestock previously but no longer do, and 26% had many cattle previously but now only have one or two.

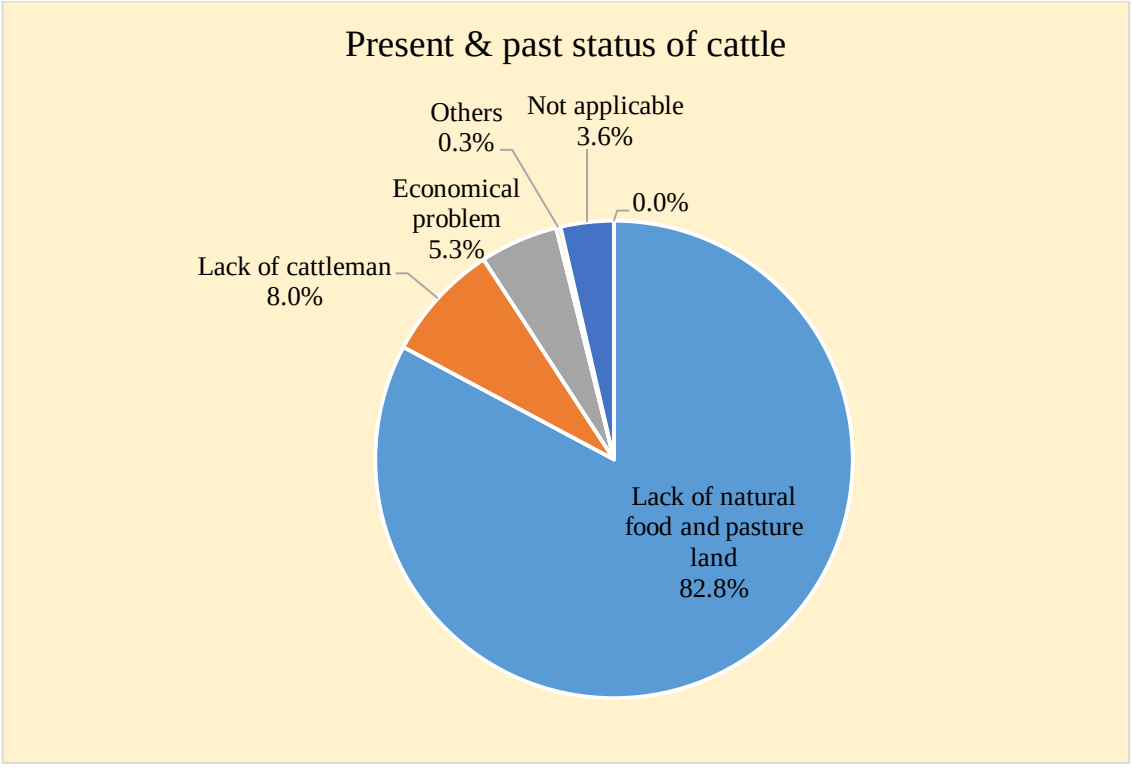


Figure 6. 20 Present & past status of cattle (Source: Field survey 2019)

The reasons for not keeping cattle are now shown in Figure 6.20. Out of 300 respondents, 82.8 % blamed a lack of natural food and pastures for the fall in cattle,

while 8% blamed a lack of competent staff for animal husbandry and 5.3 percent blamed poverty.

6.6 Economic condition

6.6.1 Occupation

Most of the heads of households among the 300 respondents in the study area are involved in agriculture (30.3%) and business (29.7%). Bangladesh is an agricultural country 50% of its population is involved in agriculture, and 70% population is dependent on agriculture for livelihood. The study area is not an exception. The development of the tourism industry in Rangamati is why its population chooses business as a profession. 12% of the head of household among the 300 respondents have a government job, 13% have a private job, 7.3% work in day labor, and 3.3% are pensioners. According to a baseline survey in 2009 of socio-economic conditions in CHT, Jum cultivation was the occupation of 14% indigenous population. About 3% and 3.5% population respectively were involved in business and salaried jobs. More than 9% of the population were day laborers (farm/non-farm) (Abul Barkat et al. 2009)

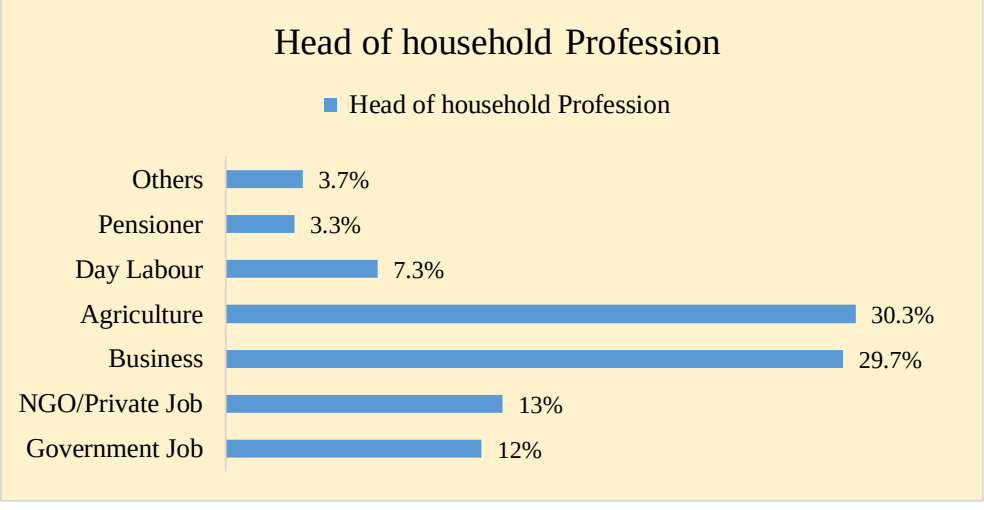
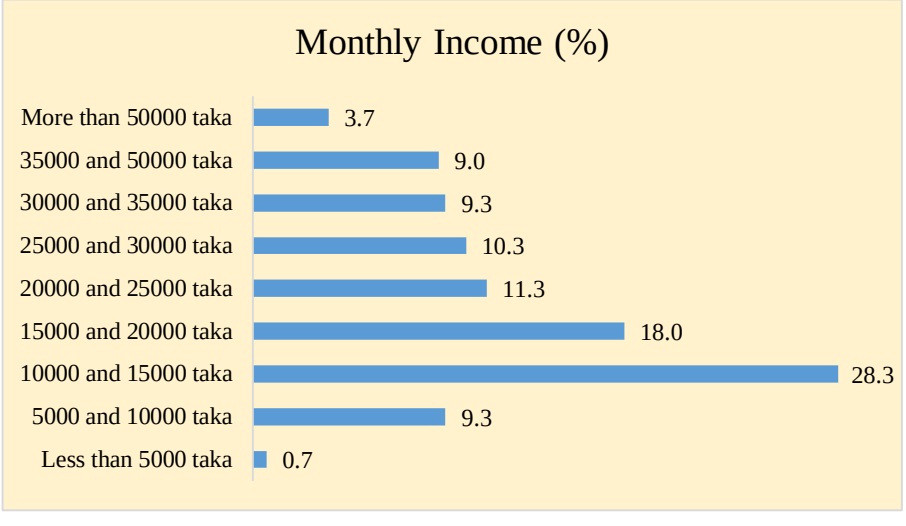


Figure 6. 21 The profession of household head (Source: Field survey 2019)

6.6.2 Income

Figure 6.22 shows the monthly income of the households among the 300 respondents. Most of the heads of households among the 300 respondents are involved in agriculture and business. 9.3% of households have a monthly income of 5000-10000 taka, 28.3% have 10000-15000 taka, and 18% have 15000-20000 taka. The monthly income crosses 20000

takas in 39.9% of households, 50000 takas in 3.7% of households, and less than 5000 takas in 0.7% of households.



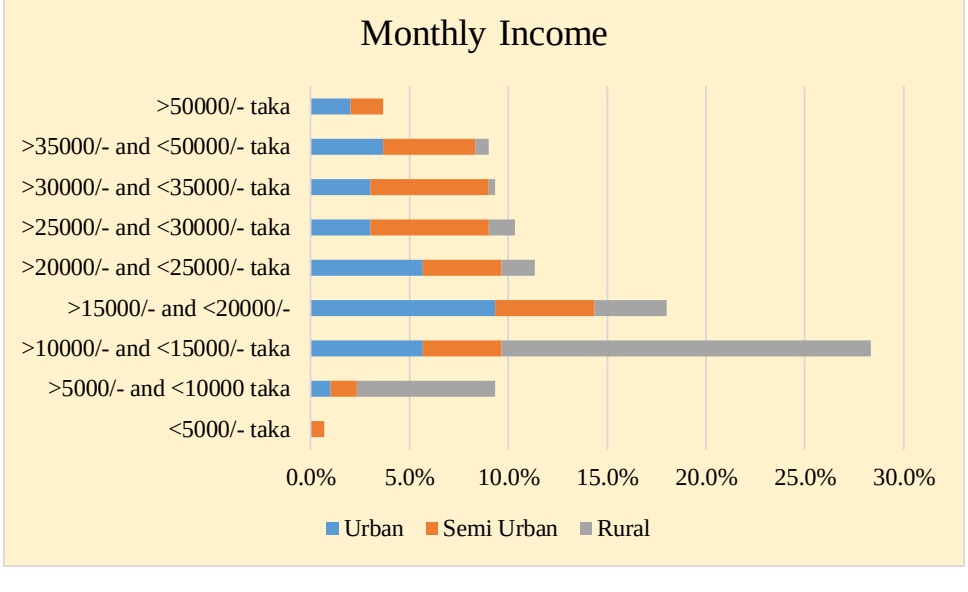
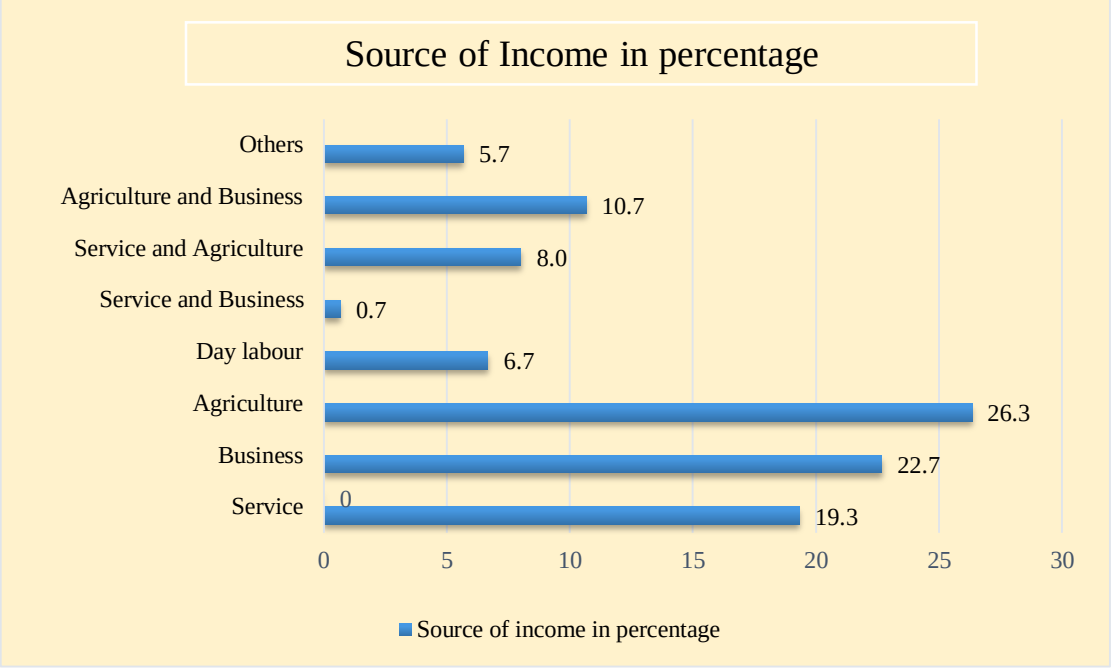


Figure 6. 22 Monthly Income (%) (Source: Field survey 2019)



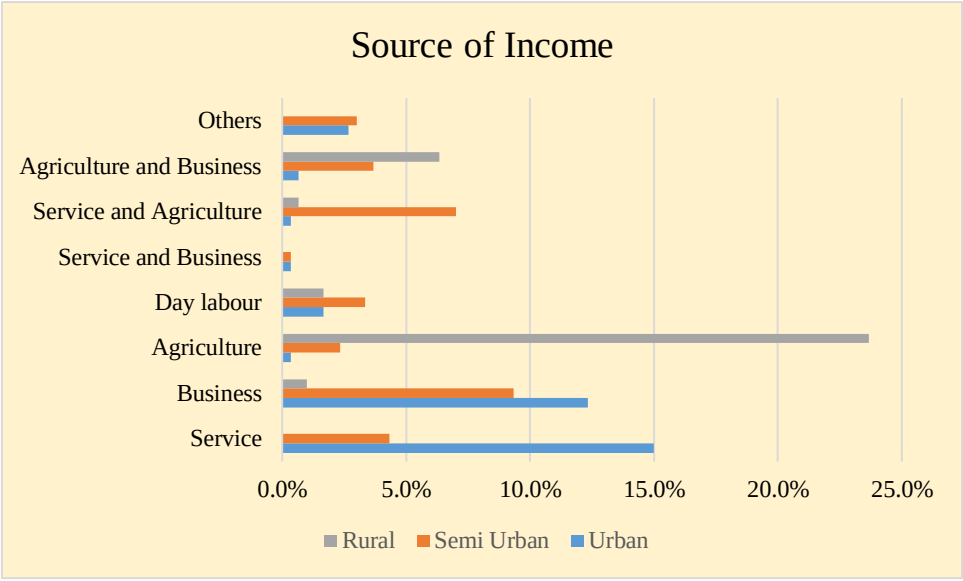


Figure 6. 23 Source of Income in percentage (Source: Field survey 2019)

The main occupations of the head of households among the 300 respondents are agriculture and business. The sources of income of the households among the 300 respondents are agriculture (26.3%), business (22.7%), service (19.3%), agriculture and business (10.7%), service and agriculture (8%), day labor (6.7%), service and business (0.7%) and others (5.7%).

Agriculture makes up the majority of the district's sources of income, accounting for 59.08% of total income, followed by non-agricultural laborers at 6.06%, industry at 0.46%, commerce at 10.70%, transport and communication at 1.06%, services at 13.48%,

construction at 0.83%, religious service at 0.19%, rent and remittance at 0.73%, and others at 7.41% (Source: Bangalpedia).

6.6.3 Expenditure

Figure 6.24 shows the monthly expenditure of the households among the 300 respondents in the study area. In 21.7% of households, monthly expenditure ranges between 5000-10000 taka, 21.3% of households have a monthly expenditure of 10000-15000 taka, and 19.7% of households have a monthly expenditure of 15000-20000 taka. Monthly expenditure crosses 20000 takas in 33.9% of households, more than 50000 takas in 2% of households, and less than 5000 takas in 1.3% of households.

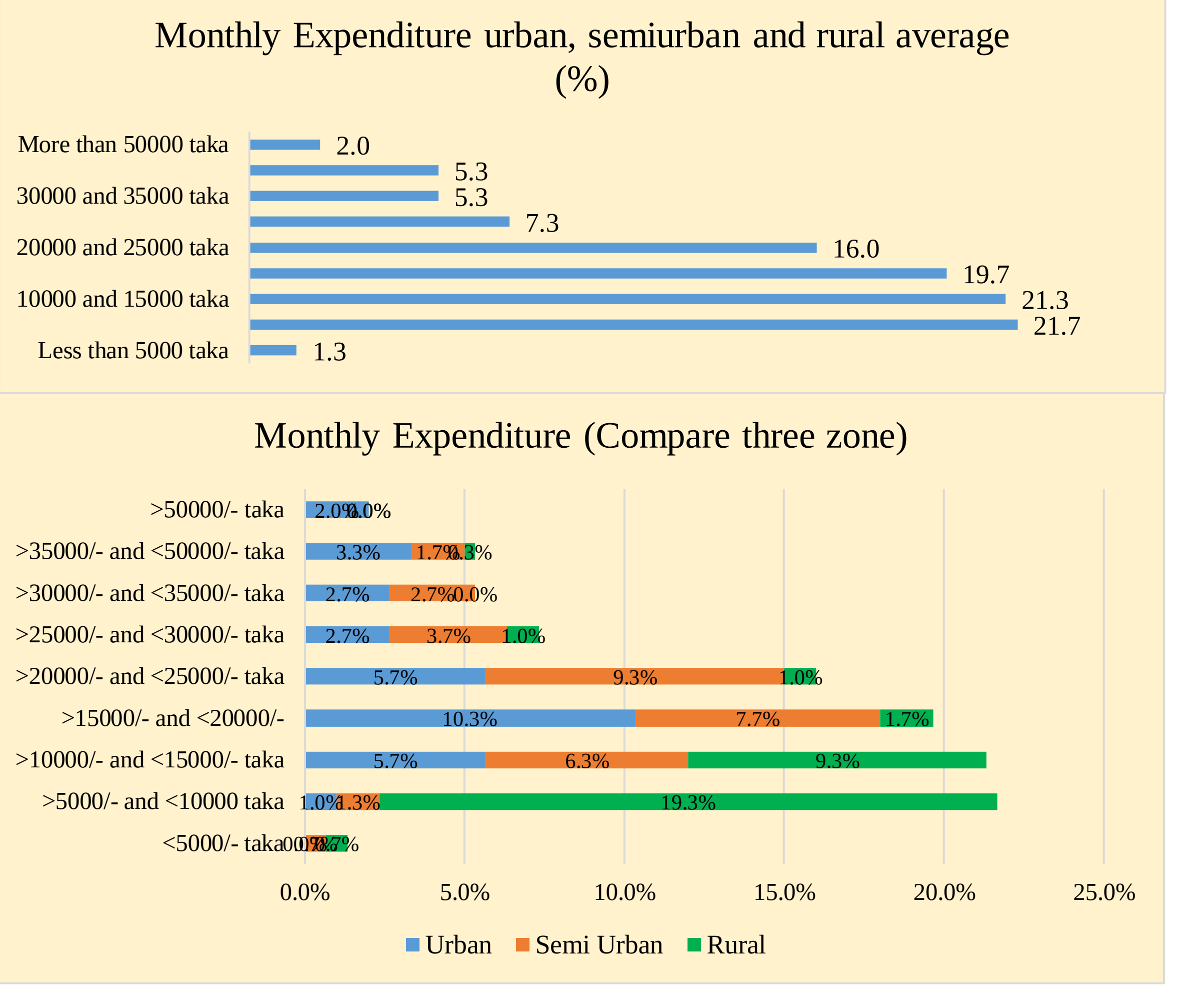


Figure 6. 24 Monthly Expenditure (%) (Source: Field survey 2019)

6.6.4 Savings

Table 6. 11 Household savings of responded (%).

Response	Monthly savings responded (%)
Yes	51.0
No	49.0

(Source: Field survey 2019)

Table 6.11 shows that 51% of households do not have monthly savings, and 49% of households have savings.

Table 6. 12 Amount of savings (Source: Field survey 2019)

Descriptive Statistics	Minimum	Maximum	Mean
Amount of savings	0	20000	2103.83

6.7 Characteristics of Livelihood and Social facilities

6.7.1 Fuel used in household

In the past, the 300 respondents mostly used wood and bamboo as fuel (96.70%). Only 0.3% of people used LP gas, and 3% used cow dung/Straw/Leaf. At present, 50.80% of people use LP gas as fuel, 48.30% use wood and bamboo, and only 1% use electricity as fuel.

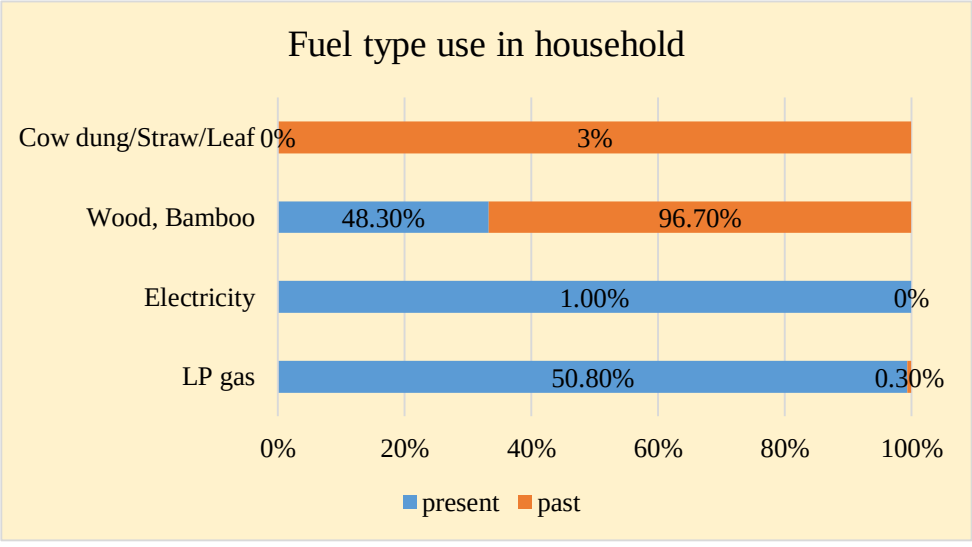


Figure 6. 25 Fuel used in the household (Source: Field survey 2019)

6.7.2 Source of light

Among the 300 respondents, there was no electricity in the study area. 99% of people used kerosene lamps. Due to rapid urbanization and development, 98.7% of households in the study area now have modern amenities like electricity. The monthly average electric bill of 82.7% of households ranges from 301-1000 taka. The bill crosses 1000 taka in 8.3% of households and remains below 300 takas in 8%.

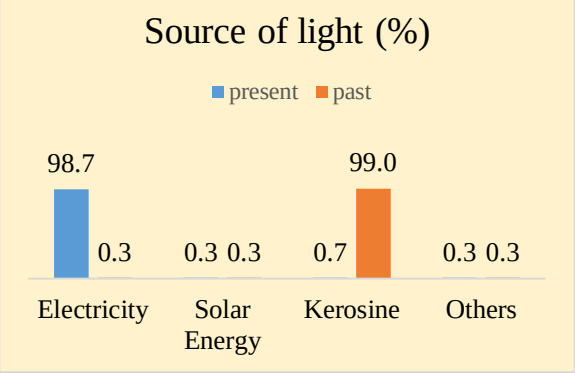


Figure 6. 26 Source of light
(Source: Field survey 2019)

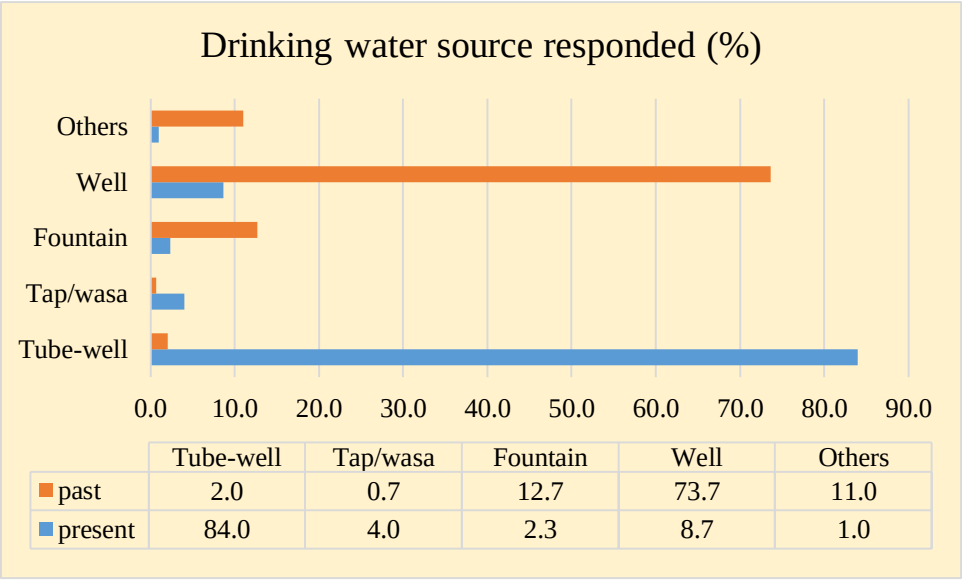
Table 6. 13 Monthly average electric bill

(Source: Field survey 2019)

Monthly average electric bill	Percent
150-300	8.0
301-500	42.0
501-1000	40.7
>1000	8.3
N/A	1.0

6.7.3 Drinking water source

In the past, according to the socio-economic baseline survey 2009, In CHT, the primary source of drinking and cooking water was unsafe. Arsenic pollution did not test in the majority of tube-wells. People must travel large distances and spend a significant amount of time obtaining drinking water. Seasonal differences in distance and travel time exist (dry and wet). According to the socio-economic survey conducted for this research study, 300 respondents used water collected from the well (73.7%) for drinking purposes. 12.7% of people used fountain water, only 0.7% people used tap water, and 2% of people used tube-well water. Now, 84% of people use tube-well water, 8.7% use water from the well, 4% use tap water, and 2.3% use fountain water for drinking purposes.



	Tube-well	Tap/wasa	Fountain	Well	Others
past	2.0	0.7	12.7	73.7	11.0
present	84.0	4.0	2.3	8.7	1.0

Figure 6. 27 Drinking water source (Source: Field survey 2019)

6.7.4 Transport system

The transport system of the study area has developed a lot in the last 25 years. In the past, among the 300 respondents, 80% of people used to walk, and 19% used the bus to go to one place from another. Rapid urbanization, improvement of economic conditions, and development of the tourism industry have accelerated the development of the transport sector of the study area significantly. At present, 87% of people use CNG, 9% use the self-motor cycle, and 4% use a private motor car.

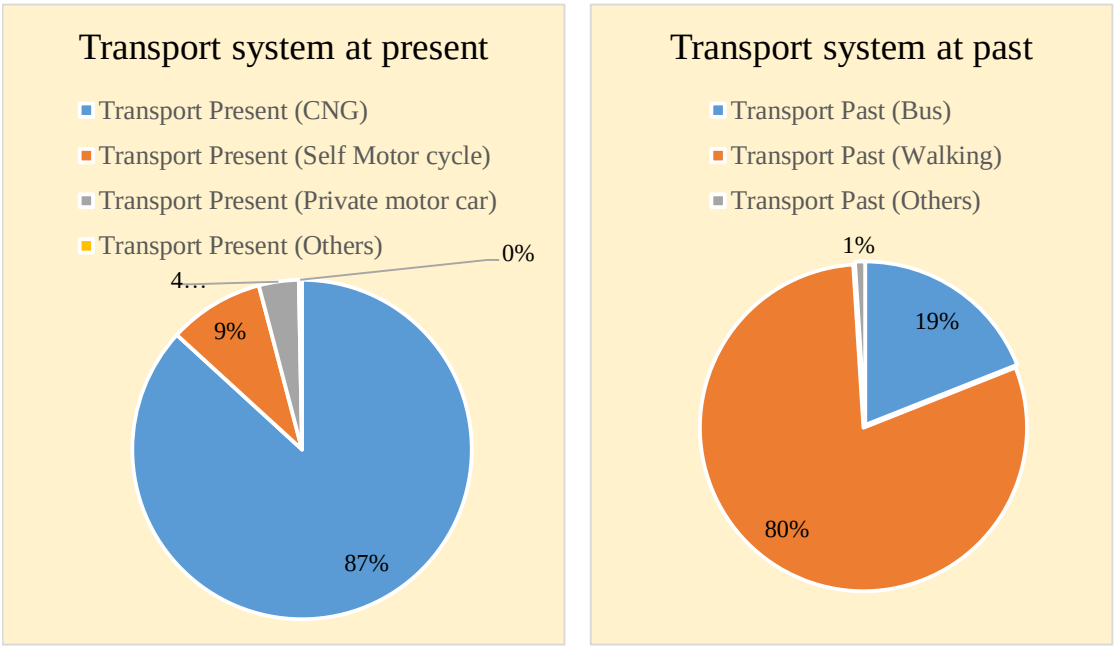


Figure 6. 28 Transport system in the present and past (Source: Field survey 2019)

6.7.5 Drainage system

Figure 6.29 demonstrates that 97 % of those polled believe there is no sewage or drainage system in place, and that whatever is in place ends up in the Kaptai lake.

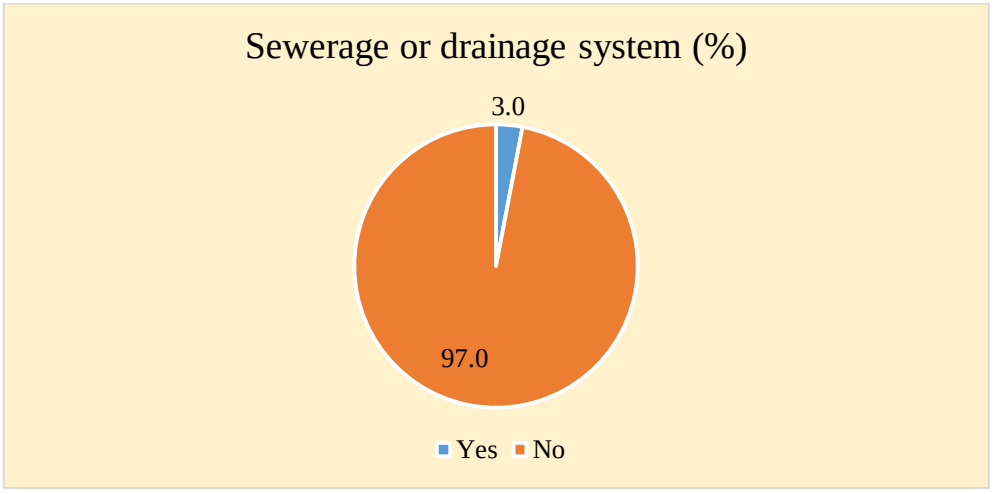


Figure 6. 29 Sewerage or drainage system (%) (Source: Field survey 2019)

6.8 Comparative analysis of social service and resource

Figure 6.30 shows the response of the 300 people to the comparative analysis of the changes in the study area. According to respondents, road network, the distance of the source of drinking water, income status, health centers/treatment facilities, education facilities, Bazar/market facilities, social security, and other service centers have rapidly increased in the study area. Land availability, forest cover, and agricultural land have decreased in the study area. The reasons are rapid urbanization, population growth, migration from plain land, unplanned development, and development of the tourism industry. 66.3% respondent think that the social bondage has increased, and 30% respondent think it has decreased.

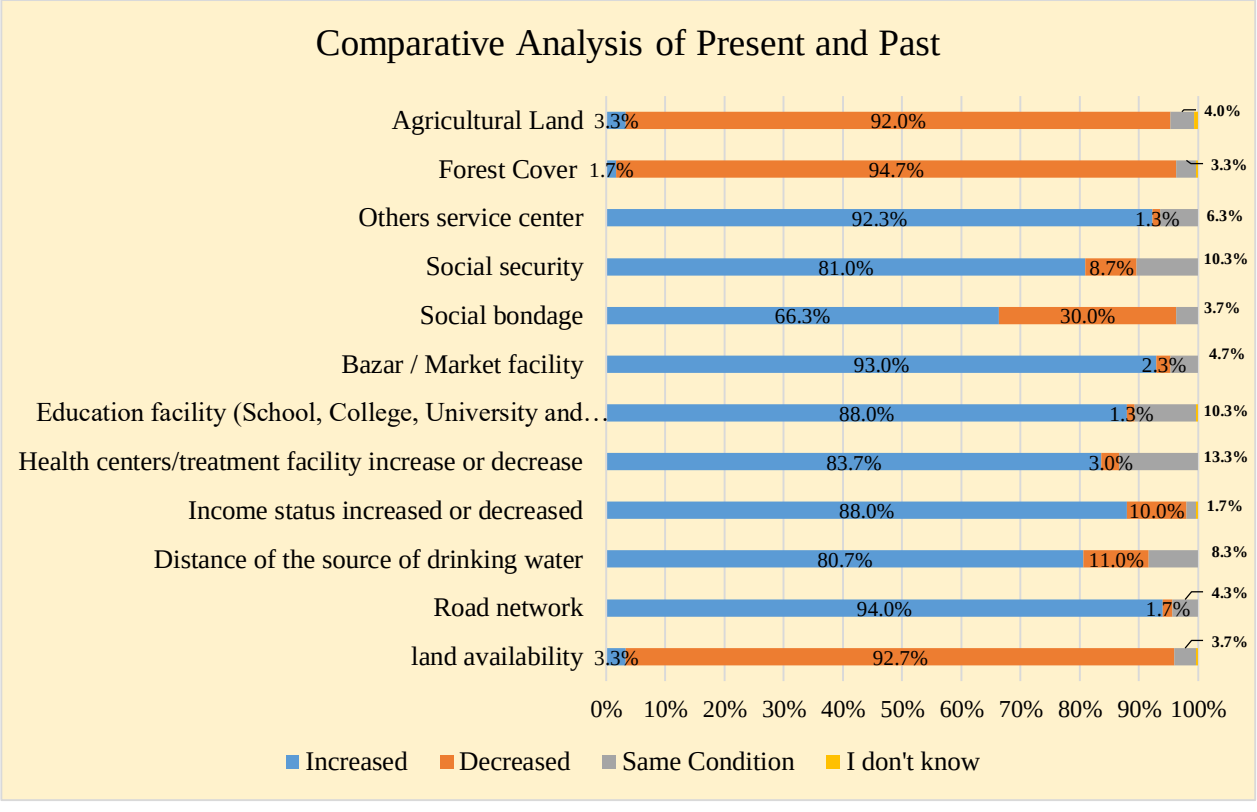


Figure 6. 30 Comparative Analysis of Present and Past (Source: Field survey 2019)

6.8.1 Social Vulnerability

According to 300 respondents, Social vulnerability in the study area is induced by the main flood (21.5% of the respondent think that) and landslide (19.20% of the respondent think that). Drugs (8.30% of the respondent think that), extortion (11.80% of the respondent think that), and social conflict (11.50% of the respondent think that) are also responsible for social vulnerability. 17.80% of respondents said there is no significant vulnerability in society.

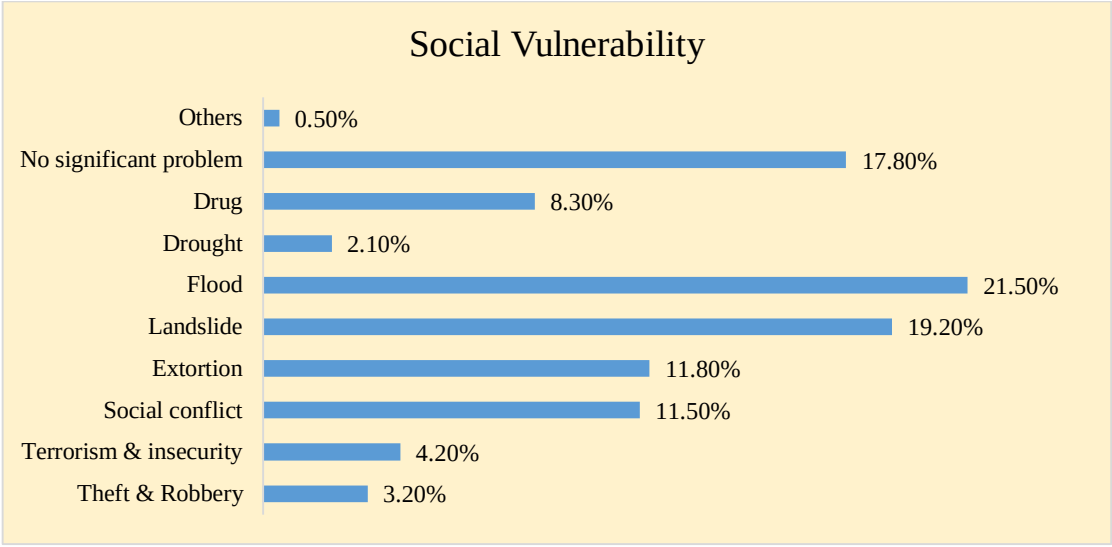


Figure 6. 31 Social vulnerability (Source: Field survey 2019)

6.8.2 Problems of Locality

The main problems of the locality identified by the 300 respondents are Terrorism and insecurity (7% respondents response among 300 respondents), drugs (10.2% respondents response among 300 respondents), extortion (11% response among 300 respondents), gas (2.9% response among 300 respondents), medical (11.5% response among 300 respondents), educational institution (8% response among 300 respondents), road and transport problem (12.90% response among 300 respondents), water problem (16.80% response among 300 respondents). 19% of respondents think there is no significant problem in the locality.

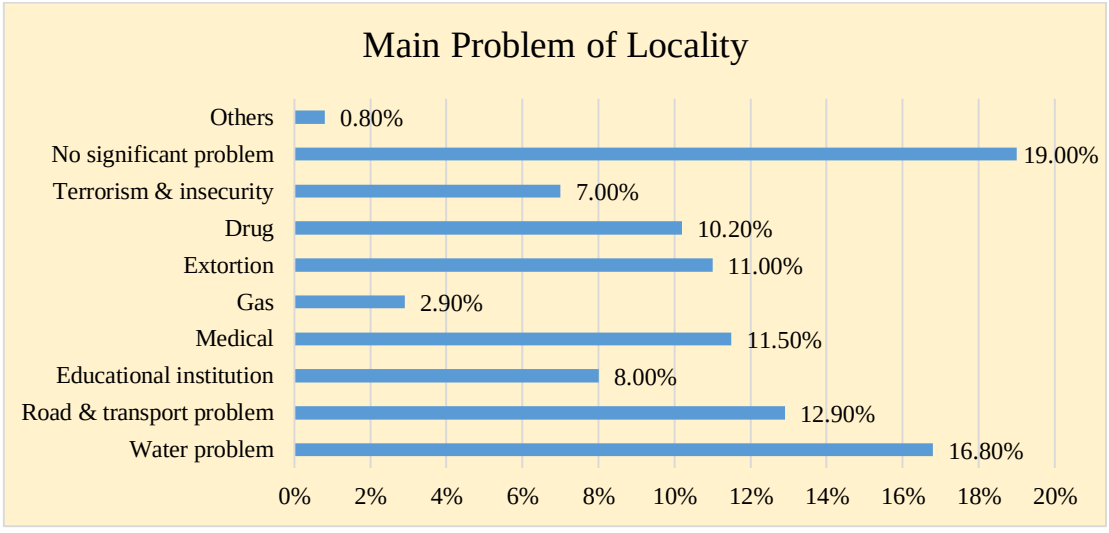


Figure 6. 32 Main problems in the locality (Source: Field survey 2019)

6.9 Conclusions

Analysis of the household survey results revealed that population growth, Migration from plain land, rapid urbanization, Kaptai Dam, the migration policy of the government, high land price, unplanned development, development of the tourism industry, firewood collection and poverty were identified as the significant drivers of LULC changes in the study area.

Chapter Seven

Environmental Analysis

7.1 Introduction

To observe the land-use change, the environmental profile study is significant. It helps in identifying and assessing the environmental effects. The study area in Rangamati includes the disaster and hazards, cause and effects, pollution status, etc.

7.2 Temperature

The temperature in the Rangamati district was between 11.6 to 24.1 degrees Celsius in 1989, 12.9 to 27.5 degrees Celsius in 1999, 12.6 to 27.7 degrees Celsius in 2009, and 12.2 to 26.9 degrees Celsius in 2014. As a result, it indicates an upward tendency. According to the Bangladesh meteorological department's statistics, the temperature in the Rangamati district has been rising over the years. So, the research study's finding is an increasing temperature trend. The maximum and minimum temperatures are both trending increasing.

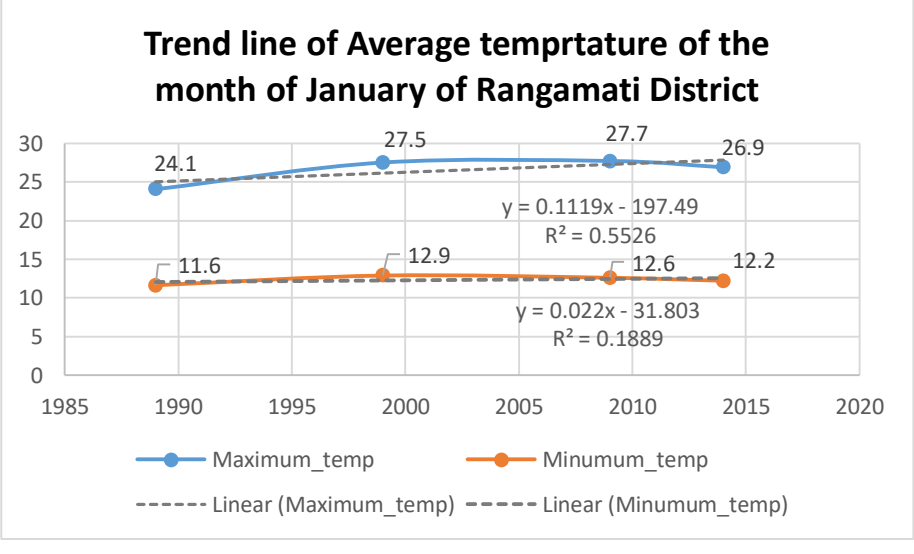


Figure 7. 1 Trend line of the average temperature of January in different years (Source: BMD data)

7.3 Rainfall

Rainfall volume and intensity are the main determinants of rainfall erosivity. Most of the study locations saw precipitation between June and October, and it was essentially consistent throughout the area (Hossain, 2005). Most of the landslide occur in the study area during over rainfall. Landslide is the important causes of land use land cover change. A graph line is called a "trendline" or "best-fit line." This line on the graph shows the data's overall pattern or direction in a straight or curved shape. Analytical tools like this one are often used to show how data changes over time or how two variables are linked together. In the present observation, the rainfall maximum was recorded as 3800 mm. in 1993 inthe Rangamati district. In contrast, the rainfall was noted as 3300 mm in 2015 at Rangamati. An irregular rainfall pattern is visible. But the trend line is downward.

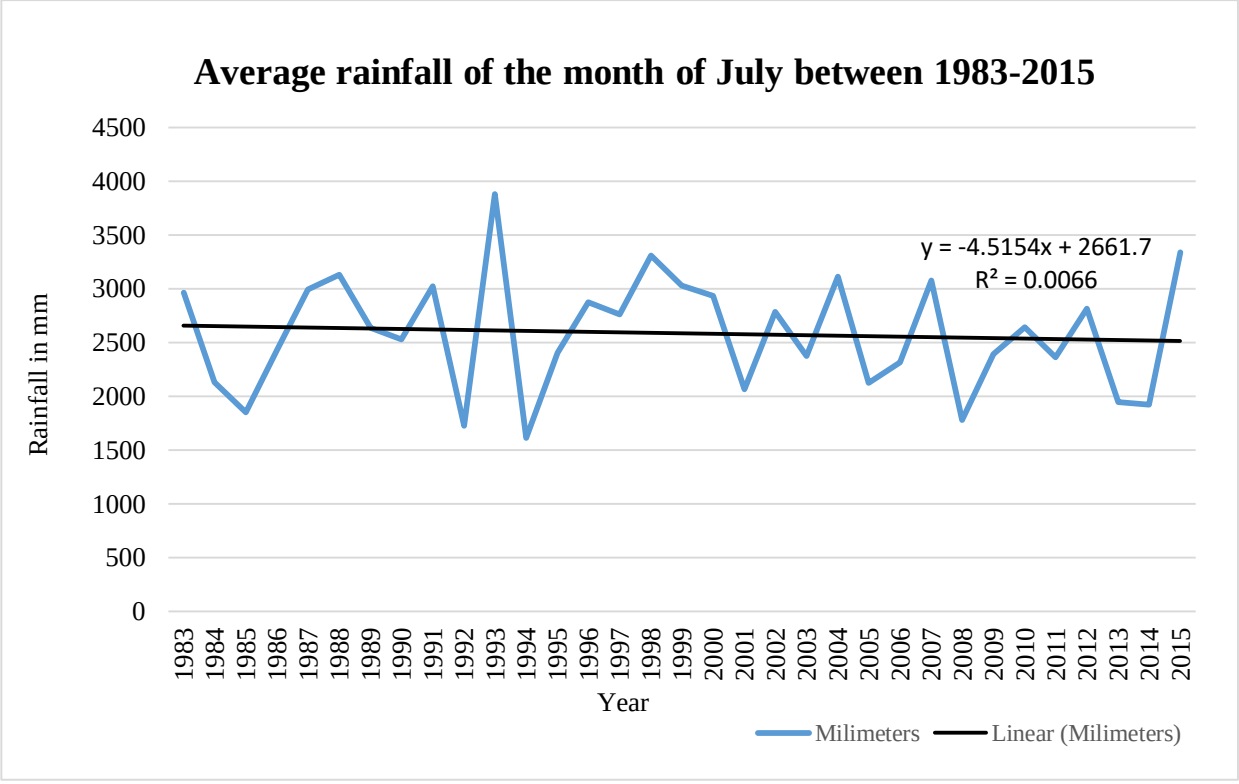


Figure 7. 2 Average Rainfall of July between 1983 and 2015 (Source data: BMD)

7.4 Humidity

A trendline, also known as the best fit line, is a straight or curved line on a graph that depicts the data's overall pattern or direction. This analytical tool frequently displays data movement over time or a correlation between two variables. The average humidity for different years between 1983 to 2015 is given below, where the minimum humidity

was highest in 2000 and lowest in 2006 and the trend line is downward. Likewise, the maximum humidity ranged from 80 to 90% between 1983 and 2015.

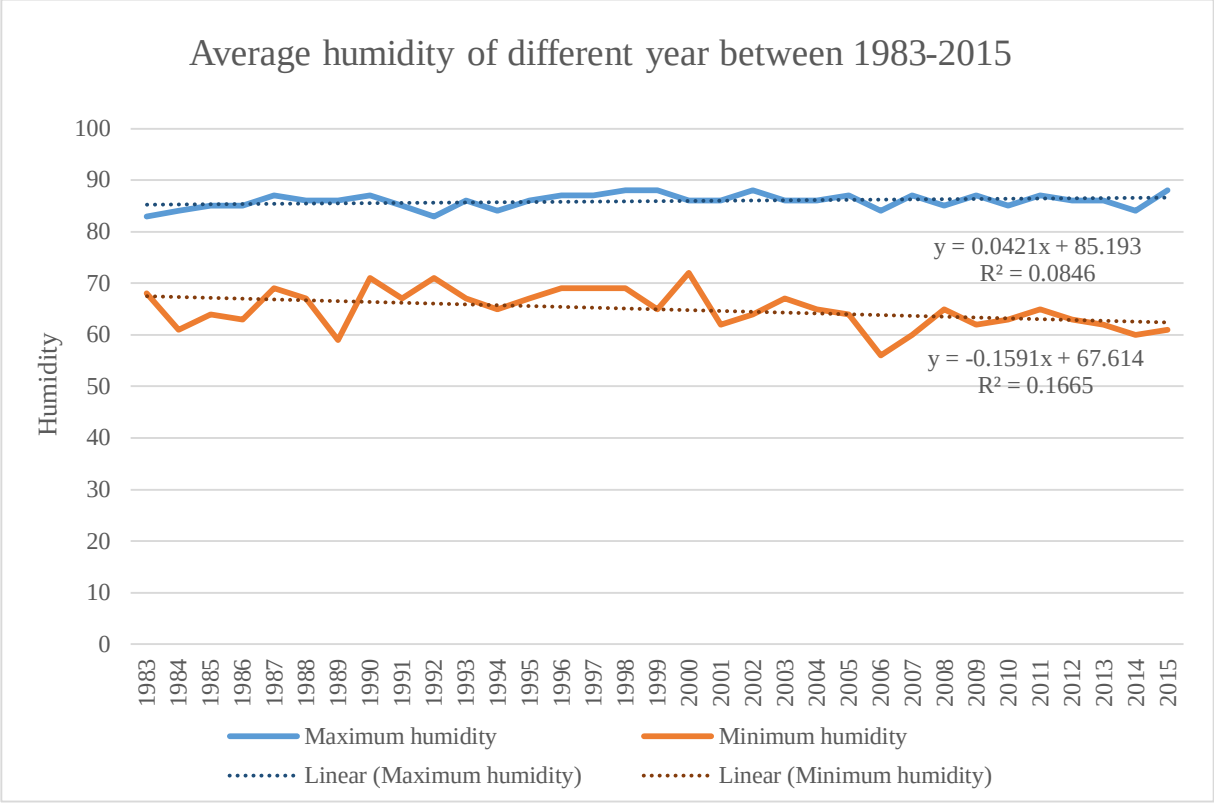


Figure 7. 3 Average Humidity of different years between 1983 and 2015 (Source: BMD data)

7.5 Change in Land Surface Temperature:

Figure 7.4 shows how LST changes over time in the four-time periods shown in 1989, 1999, 2009, and 2019. Those results show that in 1989, the land surface temperature was 21.9 °C. In 1999, it was 24.5 °C, 25.8 °C, and 23.7 °C in 2009 and 2019. No parts of Rangamati had a temperature above 30 °C during these 30 years. The maximum temperature was identified in 2009, and the lowest temperature was identified in 1989, which was 9.47°C. The Satellite image used to calculate the LST was taken in January (dry season). So, the Temperature of the surface area is overall showing a lower value than during the summer season.

7.6 The relationship between LST and LULC

The figure 7.5 below depicts the variance of the surface temperature as a consequence of the different responses of the vegetation index. Regression analysis is performed to accurately assess the effects of land use between mean LST and mean NDVI associated

with land-use type, where Y is mean LST and X is NDVI. In any instance, the distinct components of the land surface alter depending on the amount of heat that is radiated and transported. The number of types, proportions, and spatial featureinfluencesce the land surface temperature for various geomorphological parameters (Yue 2007). It is clear from the regression analysis that the mean LST and NDVI values have a significant inverse relationship (Ghobadi et al. 2014). More forest cover (higher NDVI) in some land-use zones results in lower surface temperatures.

The linear regression was highly negative in 1989. The figure 7.5 depicts the LST and various indices' relationships and linear regression equations from 1989 to 2019. According to the correlation and regression analysis findings, LST has a negative relation with NDVI in 1989, 1999, and 2019, and nearly no relationship with NDVI in 2009.

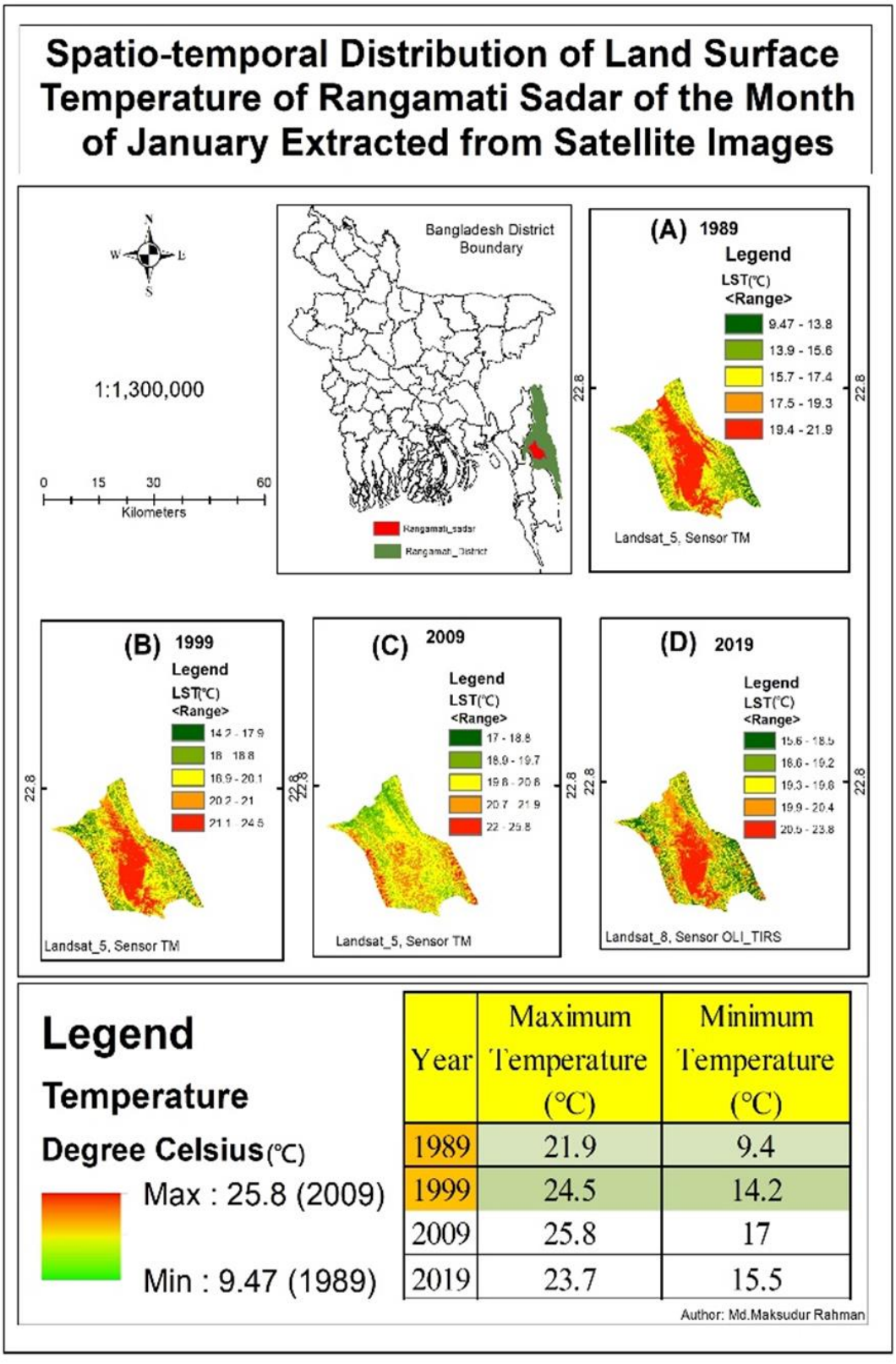
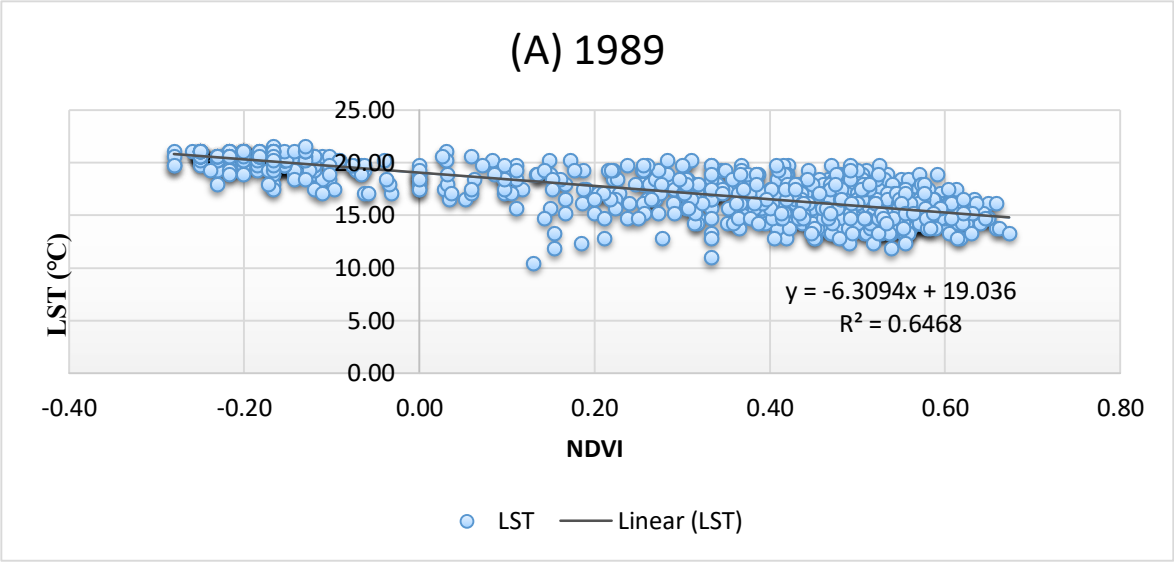
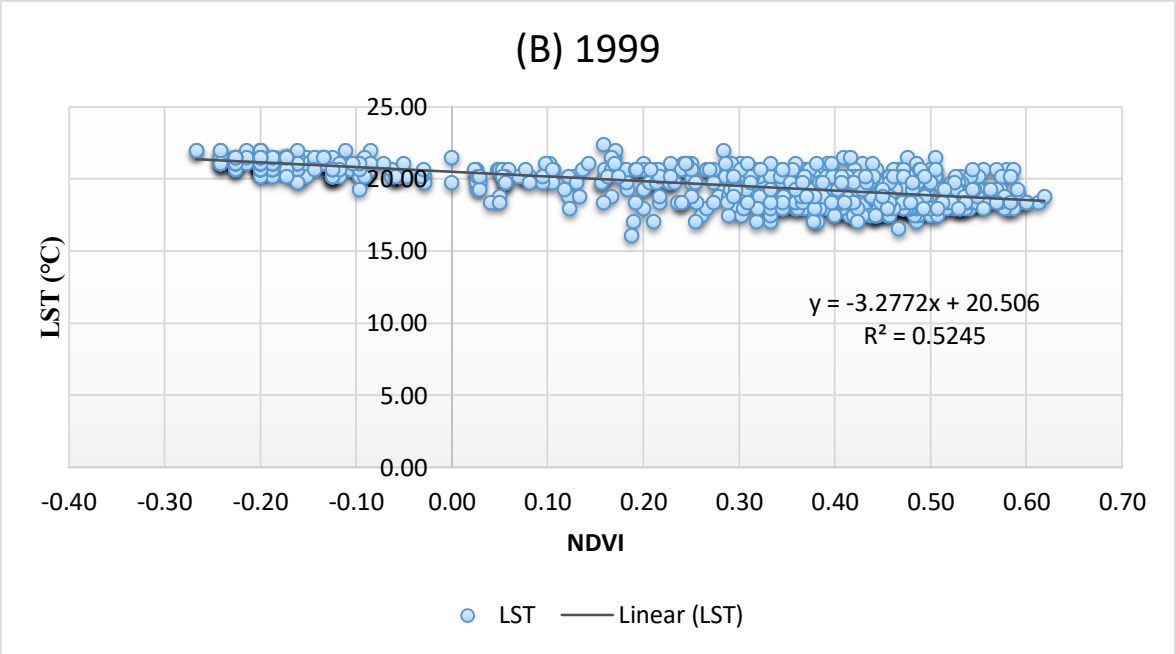
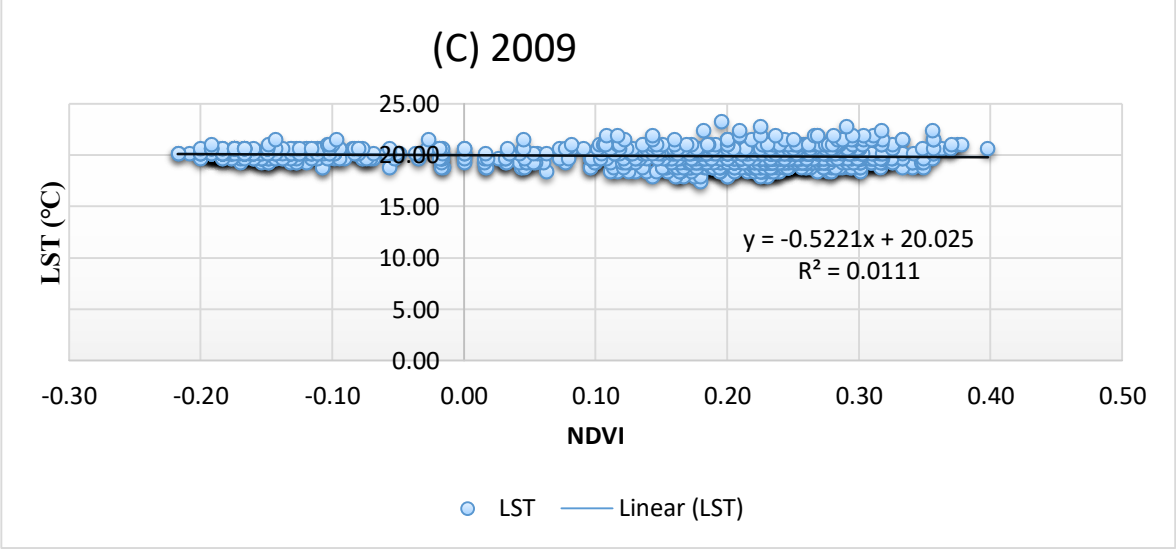


Figure 7. 4 Spatial-temporal distribution of land surface temperature of Rangamati for the month of January


(A) 1989
25.00
20.00
15.00
10.00
5.00
0.00
LST (°C)
-0.40
-0.20
0.00
0.20
0.40
0.60
0.80
NDVI
y = -6.3094x + 19.036
R² = 0.6468
LST
Linear (LST)


(B) 1999
25.00
20.00
15.00
10.00
5.00
0.00
LST (°C)
-0.40
-0.30
-0.20
-0.10
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
NDVI
y = -3.2772x + 20.506
R² = 0.5245
LST
Linear (LST)


(C) 2009
25.00
20.00
15.00
10.00
5.00
0.00
LST (°C)
-0.30
-0.20
-0.10
0.00
0.10
0.20
0.30
0.40
0.50
NDVI
y = -0.5221x + 20.025
R² = 0.0111
LST
Linear (LST)

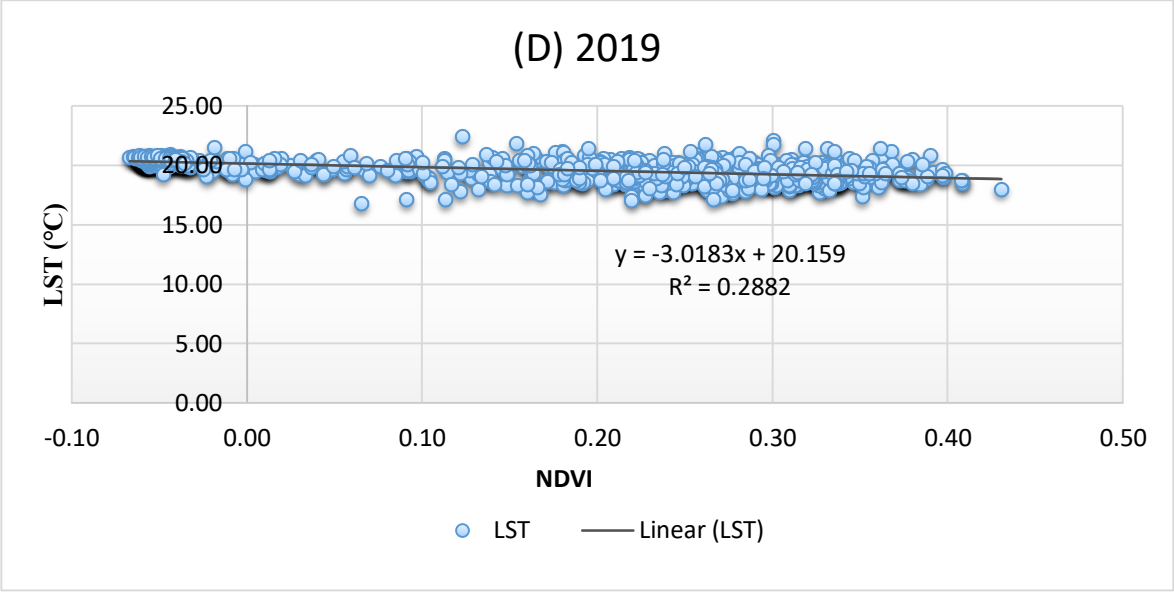


Figure 7. 5 Scatter plot of linear regression of LST and NDVI in a different year of Rangamat Sadar Upazila (Source: Satellite image extraction data)

7.7 Disaster and hazards

A disaster is an event that happens quickly or unexpectedly in most cases, and it usually has a significant impact on the usual way of life in the area where it happens. It is terrible for your health, your home, or the environment. This loss is too much for the people who live in the area where it happened, so they need help from outside the area. A hazard is an event that could cause someone to get hurt, lose their life, or damage their property or the environment.

Figure 7.6 shows the types of disasters and hazards in the study area. According to the 300 respondents, Over rainfall (27% responded), landslides (26% responded), and cyclones (19% responded) are the major disasters. Earthquakes (12% responded), floods (10% responded), the outbreak of Malaria (2% responded), flash flood (2% responded) and drought (2% responded) are also common in the study area.

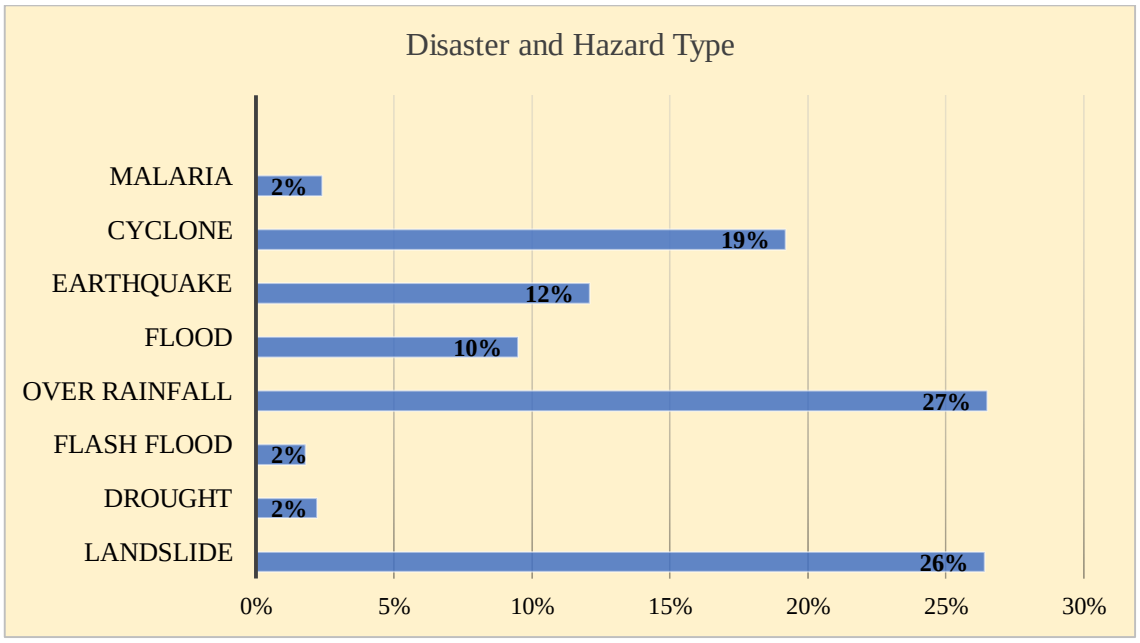


Figure 7. 6 Disaster and Hazard Type (Source: Field survey 2019)

According to the total respondent significant disasters in the locality are landside (among the 300 respondents, 66% responded) and flood (28.3% responded among 300 respondents). Since Rangamati is a hilly area, a landslide is very common there, and the overflow of the hilly rivers and over rainfall (4.3% responded) cause a flood.

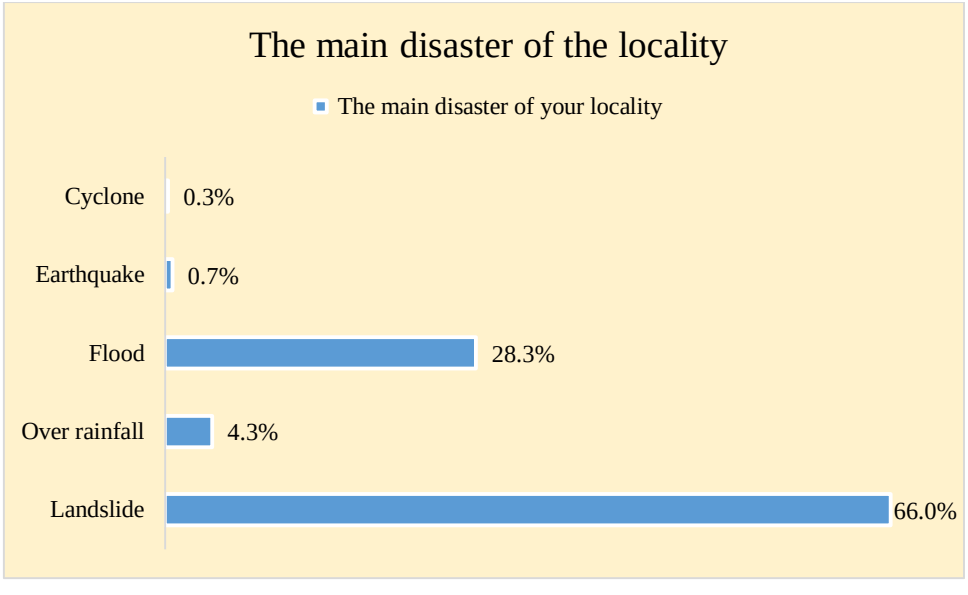


Figure 7. 7 The primary disaster of the locality (Source: Field survey 2019)

7.8 Landslides in Rangamati

Landslides are common in Bangladesh's mountainous regions (Alam et al., 2005), particularly in the Chattogram region in the southeast (Ahmed et al., 2014). Landslides have grown in densely populated cities located in hilly locations due to rapid urbanization and human development activities such as building and road construction via deforestation and excavation of hill slopes (Galli and Guzzeti, 2007; Schuster and Highland, 2007). On June 12, 2017, strong monsoon showers of rain prompted a series of landslides in Bangladesh's Rangamati, Chattagram, and Bandarban districts, killing at least 152 people (The financial express,2017). Rangamati was the worst-affected area, with landslides burying hillside buildings while residents slept (BBC NEWS, 2017). As of 15 June, there had been at least 20 distinct landslides in the region (The Financial Express, 2017), with up to 105 deaths recorded (The Daily Star, 2017); 5000 dwellings had been destroyed (The Weather Channel, 2017). Rangamati's roads were impassable until June 15 (BDnews24.com, 2017), severely damaging the district's electricity system. Many of the district's roadways were washed away, creating craters up to 15 meters (50 feet) deep or debris heaps (The Daily Star, 2017). Although not very old, the geological formation of hills in such locations is still undergoing deterioration and reformation due to weathering and other natural processes. Increased gravity stress due to rainfall and other natural or manmade processes on the hill slope might cause destabilization.

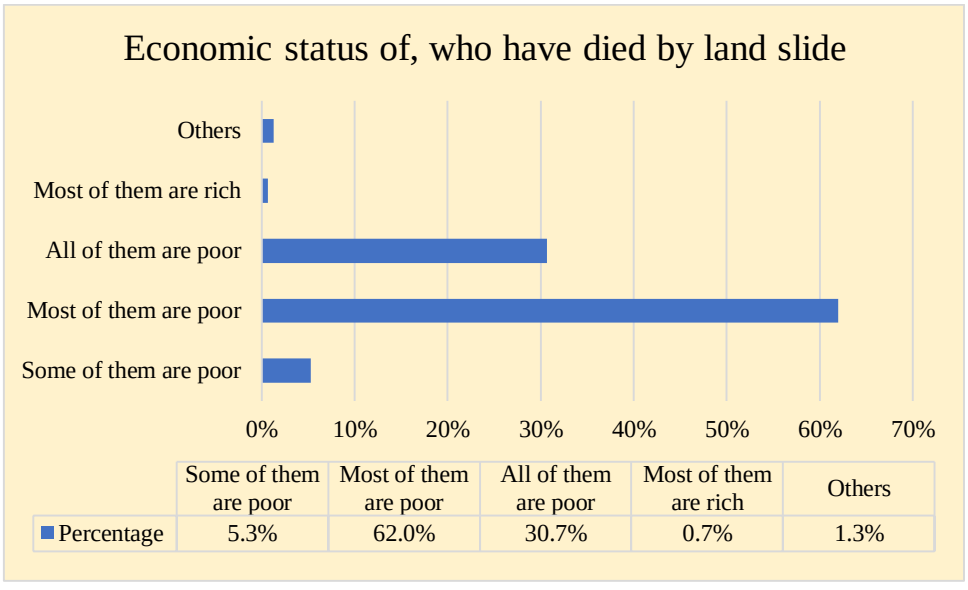
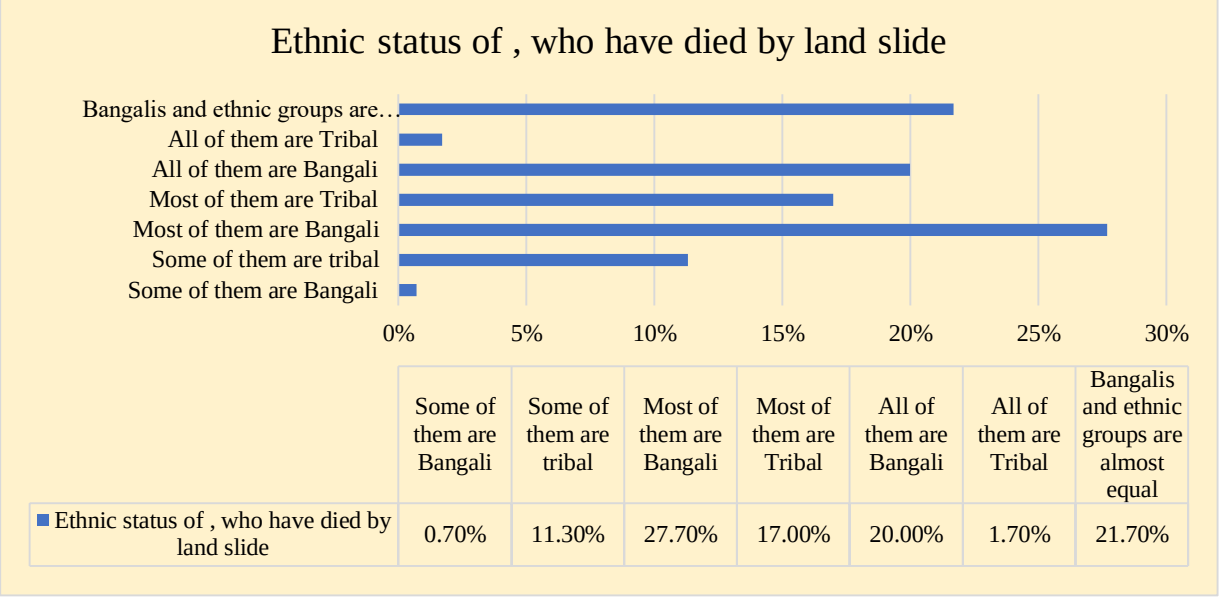


Figure 7. 8 Economic status of those who have died by a landslide (Source: Field survey 2019)

Figure 7.8 Shows the economic status of those who have died from the landslide. According to the respondents (62%), most of them were poor, and 30.7% respondent think that all of them were poor.



	Some of them are Bangali	Some of them are tribal	Most of them are Bangali	Most of them are Tribal	All of them are Bangali	All of them are Tribal	Bangalis and ethnic groups are almost equal
Ethnic status of , who have died by land slide	0.70%	11.30%	27.70%	17.00%	20.00%	1.70%	21.70%

Figure 7. 9 Ethnic status of those who have died by a landslide (Source: Field survey 2019)

Figure 7.9 shows the ethnic status of those who died from landslides. According to 27.70% of respondents, most of them are Bengali, 21.70% said Bengalis and ethnic groups are almost equal, 20% said all are Bengali 17% said most of them are tribal, and 11.3% said some of them are tribal.

7.9 Causes and effects

Figure 7.10 shows the causes of disasters and hazards. According to the most of respondents (20.5%), over rainfall is the cause of disasters and hazards. 9.20% of respondent think disasters and hazards are just natural things, and 11.90% respondent think these as both natural and human-made. They also think that thunderstorms (12.20%), unplanned settlements (9.70%), unplanned land use (9.70%), deforestation (11.80%), and cutting hills (11.70%) are responsible for disasters and hazards. 2.10% of respondents think it is their fate given by God.

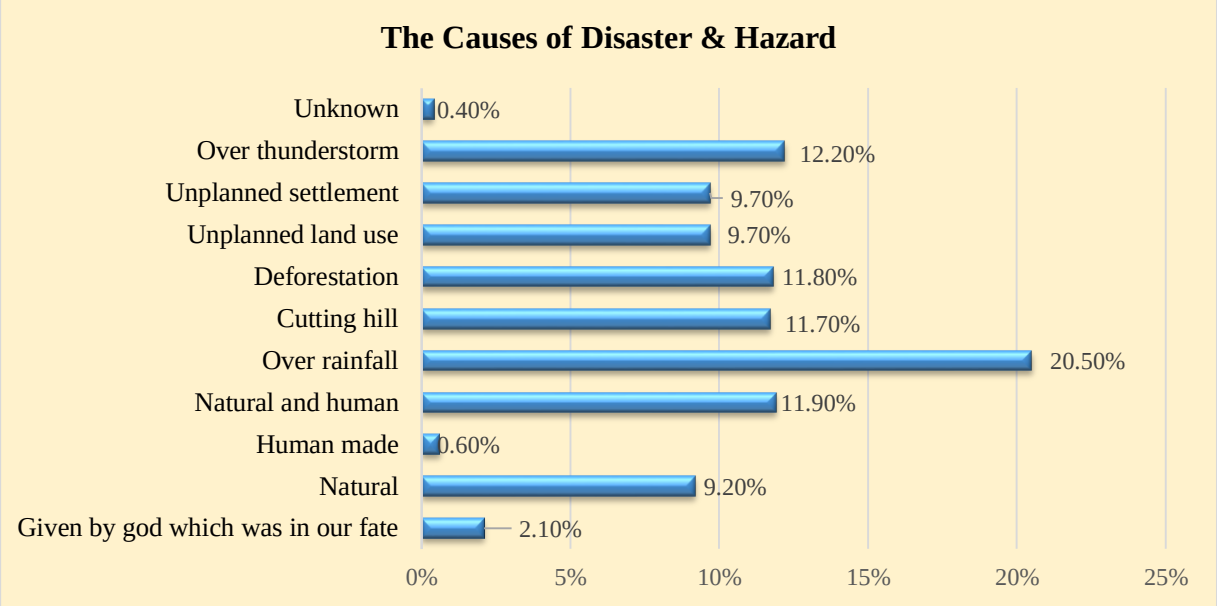


Figure 7. 10 The Causes of Disaster & Hazard (Source: Field survey 2019)

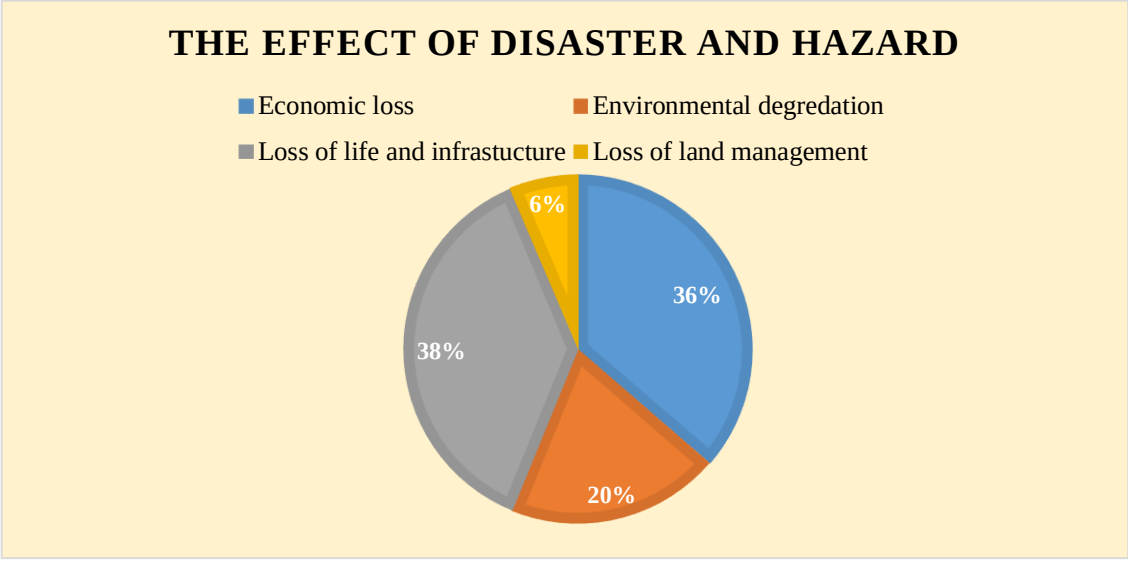


Figure 7. 11 The effect of disaster and hazard (Source: Field survey 2019)

Figure 7.11 shows the effects of disasters and hazards. According to the 300 respondents, The main effects are the loss of life and infrastructure (38%), economic loss (36%), degradation of the environment (20%), and loss of land management (6%).

7.10 Pollution

A certain amount of dangerous compounds being introduced into the ecosystem is referred to as pollution. These harmful substances are known as pollutants. According to the land use map (Figure 4.1), open water bodies are still the second-largest land use after vegetation, which still makes up nearly 70% of all land use. The freshwater supply of the Kaptai Lake (KL) is now being negatively influenced by land use changes, urban human settlement, inland navigation, tourism activities, as well as big development programs in terms of roads, bridges, and other building works (Rahman et al., 2014). In the field survey, the majority of participants cited the Kaptai Lake contamination as an example of environmental pollution. Participants in FGD and KII have also taken the issue of lake pollution and siltation seriously. According to them, the lake is being contaminated by the dumping of various trash and debris. Additionally, landslides regularly silt Kaptai Lake with debris and pollute it. In rural regions, several respondents prioritized pesticides and fungicides used in agriculture as a source of rain-induced lake contamination. 73% of respondents think that the area is polluted, 21.7% respondent think the area is not polluted, and 5.3% don't know about this.

Table 7. 1 Status of Rangamati Sadar (Polluted or not)

Response	Polluted Area responded (%)
Yes	73.0
No	21.7
unknown	5.3

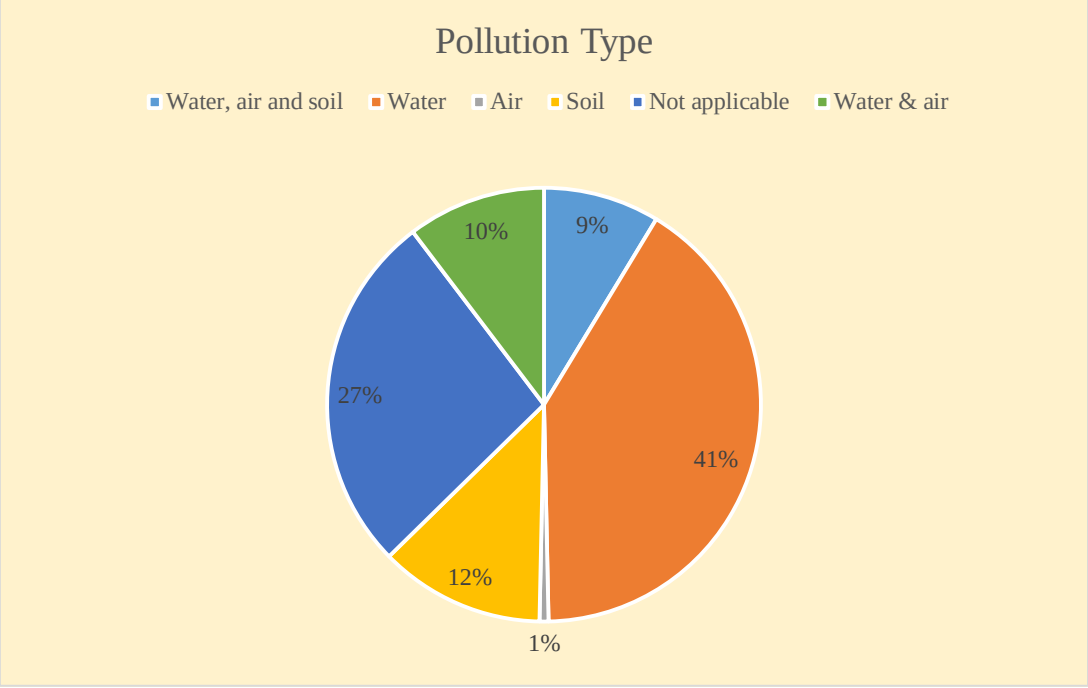


Figure 7. 12 Pollution type (Source: Field survey 2019)

Figure 7.12 shows the type of pollution in the study area according to the respondents. 41% respondent think that the water is polluted in the area, 12% respondent think that the soil is polluted, 10% respondent think that both water and air are polluted, 9% respondent think air, water, and soil are polluted and 1% respondent think the air is polluted.

Most of the FGDs and KIIs on water pollution show that, pollution in the Kaptai Lake (KL) is becoming severe due to the open defecation of slum dwellers adjacent to the lake, and the constant influx of city garbage and waste into the lake water, resulting in the loss of suitability for domestic use and loss of water quality. This spreads water-borne diseases and destroys the ecosystem of the lake. Also driving forces such as pesticides used in agriculture, landslides and sedimentation have been cited by many as causes of water pollution and Lake siltation. Due to intense siltation over the years, the water level of the lake has dropped abnormally. Along with the results from the field study, FGD, and KII mentioned above, several literature evaluations about Kaptai Lake pollution are included below.

IUCN Bangladesh statistics show that sedimentation has decreased the lake's total volume by 25% during the past 30 years (IUCN Bangladesh, 2015b). The effects of land use and other watershed features on sediment would change throughout time and

space as well as in response to local dynamics (Hoque et al., 2021). According to SSO, the current lack of rainfall adds to the list of problems (Rayhan., et al 2021). Every year thousands of people visit KL for a pleasure trip to the lake. They throw plastic bags, packets, plastic boxes, paper, masks, and food waste into the lake. Traveling vessels such as motorized boats, launches, and speed boats, spill engine oil which harms aquatic biodiversity (Rayhan, N. et al 2021). Water pollution due to the prevalence of pathogenic bacteria (Enterococcus spp., Salmonella spp., Pseudomonas spp., and Vibrio spp.) and excessive quantities of harmful metals, such as lead, cadmium, and nickel, the water in KL has been described as being unsafe to drink and domestic use (Barua et al., 2016).

The Halda River, which is close to the Kaptai Lake and is regarded as a special breeding ground for carp in Southeast Asia, has already lost 26 of its fish species (Bashar et al., 2007; Bhuyan and Bakar, 2017) as a result of chronic water pollution brought on by municipal sewage, industrial waste, and agricultural waste that is either discharged directly into the river or through seepage and runoff (Karim et al., 2019; Moula et al., 2020). One of the poisonous aquatic weeds present in temperate, tropical, and sub-tropical nations, including Bangladesh, is the water hyacinth, which was once endemic to South America. (Ndimele, 2012). It grows in large quantities, shelters dangerous germs, reptiles, and poisonous snakes, and severely impairs fisheries, tourism, and navigation (Patel, 2012; Ndimele, 2012). Similarly, over the last two decades, the mass and rapid growth of water hyacinths and their extensive use as a brush fishery to lure all types of fish have negatively impacted the KL fishery (Suman et al., 2021). According to Suman et al., 2021, certain parts of the Kaptai Lake regularly undergo eutrophication, high turbidity, oxygen depletion, and unexpected fish death during the period of their research period as a result of pollution. According to experts, the availability of Rui, Katal, and Mrigel accounted for 82 percent of the entire catch in 1965–1966 but less than 5 percent in 2014–2015. On the other hand, today over 90% of the entire fish capture is made up of small fish, up from 5% in 1965–1966. IUCN Bangladesh reported that of all species, 14% were considered vulnerable, 11% were endangered, 3% were severely endangered, 11% were near threatened, and 51% were considered to be of least concern. Extensive siltation, increasing exploitation, brush fishing, habitat degradation, pollution, water level fluctuations, and climate change may all be contributing factors to the larger number of vulnerable species (Ahmed et al., 2006; Rahman et al., 2017).

According to Hoque et al., (2021), the analysis of these lake sediments can provide valuable information regarding the patterns and modifications of upland land use. At least a few of the sediment characteristics, such as clay, moisture, organic matter (OM), and organic carbon (OC), demonstrated a clear relationship with the land use pattern and settlement intensity in the nearby catchment regions. Greater effects on the sediment characteristics and, ultimately, the reservoir ecosystem would result from intensive habitation in the watershed. The sustainability of this hydroelectric lake would eventually be impacted by the alteration in the sedimentation process in the reservoir, which would impact navigation, fisheries, and the way of life of the catchment's residents.

According to Karmakar et al. (2011), the most concerning finding was the presence of excessive suspended solids in the reservoir, which were caused by debris eroded off the nearby desolate hills. They attribute the alarming occurrence to excessive human activities in the hills, such as logging, excessive and illegal felling, shifting cultivation, frequent burning, and improperly constructed roads and infrastructure, as well as the lack of forest cover in the majority of the hills of the Chittagong Hill Tracts. Disposal of solid trash by locals and visitors around the lake and fecal contamination by fishermen and other boaters that frequent any area of the lake were additional aspects of water pollution.

In light of the circumstances, community-based fisheries management, preservation of carps' natural breeding grounds, revision of current fishing laws, and cooperative research are crucial to reducing the lake's adverse environmental effects and maintaining a comprehensive, long-term system for pollution control. community-based fisheries management, conservation of natural carp breeding sites, pollution control, reform of current fishing legislation, and collaborative research are necessary to reduce the lake's negative environmental effects and maintain the lake's viability.

7.11 Proposal for disaster reduction

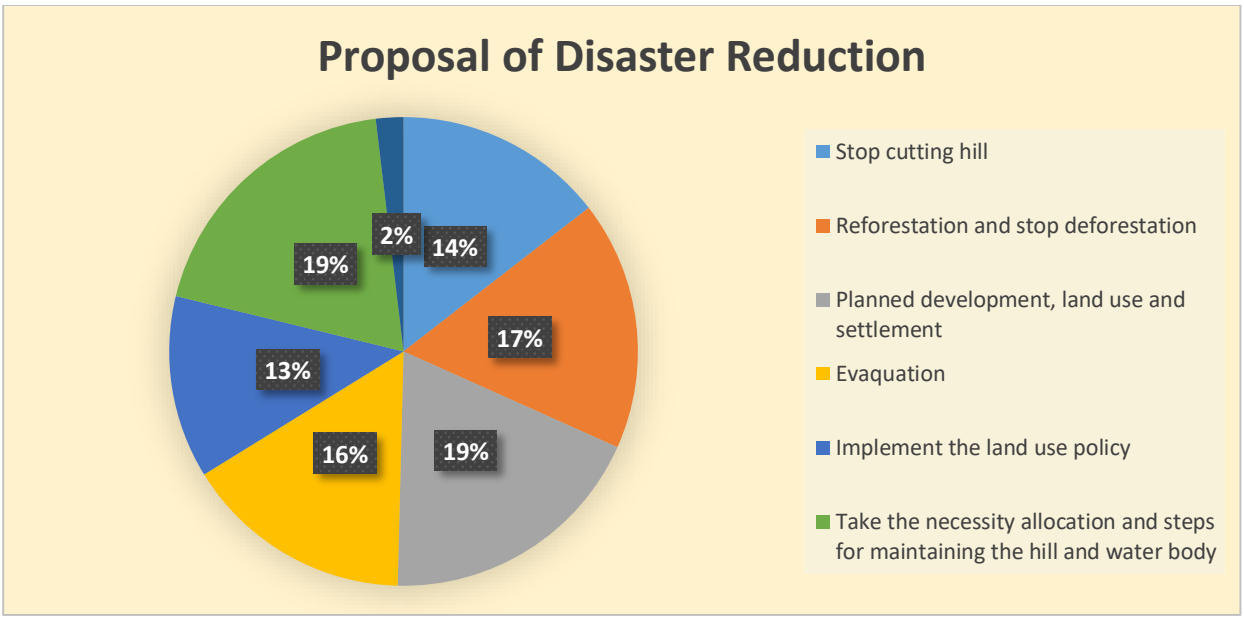


Figure 7. 13 Proposal of Disaster Reduction (Source: Field survey 2019)

Figure 7.13 shows the proposed way of disaster reduction by the respondents. 19% proposed planned development, land use, and settlement, 19% proposed taking the necessary allocation and steps for maintaining the hill and water body, 17% proposed reforestation and stopping deforestation, 16% proposed evacuation, 15% proposed stopping cutting hill, 13% proposed implementation of the land use policy and 2% proposed other ways.

7.12 Soil Degradation:

Long-term productivity, environmental conservation, and a healthy ecosystem, as well as sustainable development, are all dependent on soil and water conservation. Soil erosion in sloping fields has a negative influence on the physical, chemical, and biological aspects of soils, resulting in decreased agricultural productivity (Salahin, et al. 2013). The Chittagong Hill Tracts (CHT) had been governed by the CHT Regulation, 1900, and further measures were taken in response to government requests for modifications to the Regulation. Take, for example, the CHT (Amendment) Regulation of 1920 or P.O. No. 48 of 1972 (Amin, 2000). This regulation covers the Circle Chiefs, Dewans, and Headmen's authority and jurisdiction, land leases/transfers, registration of papers relating to land ownership, and revenue collection, and is

particularly focused on the types of land or crops (Shoaib, 2002). The conservation of natural resources of the mouza was committed to Deputy Commissioners and Headmen by notice No 7848 E.A. dated 15-07-1939 (Calcutta Gazette, 1939). The problem was made worse by the construction of the Kaptai hydroelectric project. The amount of land available for Jhuming has drastically decreased, resulting in fast soil deterioration and marginalization of the Jhumias (Anon, 1929; Dewan, 1990; Mey, 1984).

Since the turn of the twentieth century, there have been several legal and regulatory consequences on the CHT community and its natural resources. Language, habits, religious beliefs, and socio-political organization distinguish the various ethnic groups from one another (Shoaib, 2002). They chose various portions of the hills to live in as well. For example, Chakmas, Marmas, and Tripura are valley dwellers who were categorized by Lewin (1869) as 'Khyongtha' meaning 'children of the river,' while Khumi, Mro Murang, Lushai, Bawn, and Pankus, Kukis, Tanchangya, chak, and Riag live on ridges and were categorized as 'Toungtha' meaning 'Children of the hills (Mohsin,1997).

Soil erosion is a common phenomenon as a result of landslides and changes in land use land cover. In addition to tuber crops including ginger, turmeric, aroid, and jhum rice cultivation on hill slopes and other development activities, tribal peoples rely on shifting agriculture on around 3,200 ha each year, which results in topsoil erosion of roughly 1.5 million tons/year (Shoaib, 2002). As a result of the siltation of Kaptai Lake and other water sources, the filling of valleys and reservoirs, and the construction of deltas along with coastal areas, deltas are being formed. Erosion is followed by the deposition of alluvial materials, which occurs as a result of floods and the filling of valleys, streams, or the extension of coastal plains and deltas to the sea (Salahin, et al. 2013). Brookfield and Blaikie (1987) go to considerable lengths to stress "that land degradation should by definition be a social concern," arguing that:

Net degradation = (Natural degrading processes and human interference) - (Natural reproduction and restorative management).

Physical factors such as soil texture, bulk density, soil moisture content, and field capacity did not alter greatly in experimental plots, according to Salahin, et al. (2013), while chemical properties such as macro and micronutrients showed significant depletion. Erosion cannot be completely avoided since it is a natural process; however,

it may be reduced to an acceptable pace by cultivating across the slope with little soil disturbance up to a 15% to 20% hill slope (Salahin, et al. 2013).

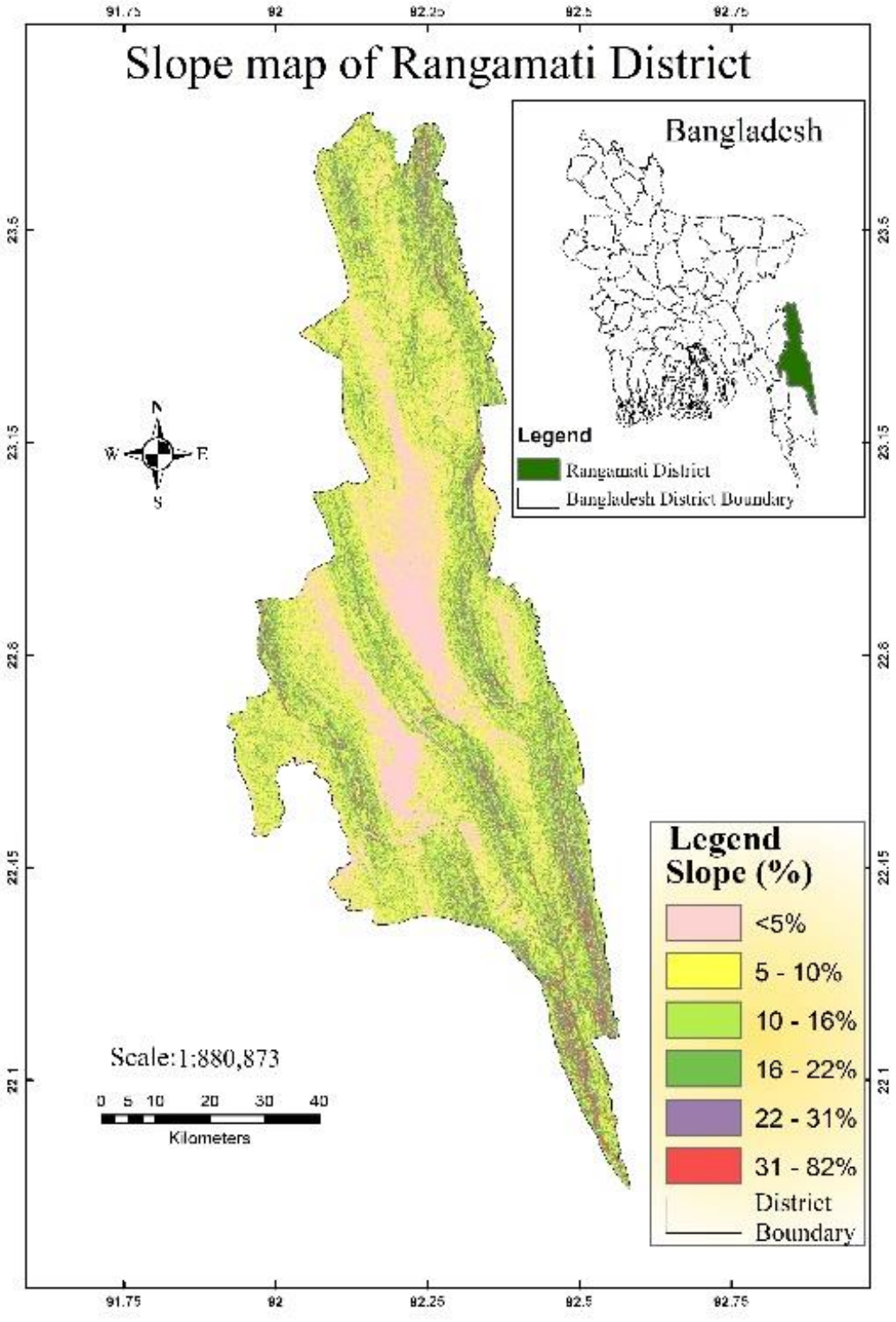


Figure 7. 14 Slope map of Rangamati District (Source: Extraction from DEM data from: https://www.usgs.gov/)

7.13 Conclusions

The environmental profile study reveals that the major disasters of the locality are landside and floods. According to most respondents, rainfall is the cause of disasters and hazards. The main effects of disasters and hazards are the loss of life and infrastructure, economic loss, degradation of the environment, and loss of land degradation and management. Deforestation must be halted immediately to safeguard the ecosystem, and afforestation must be done in a well-planned and scientific way.

Chapter Eight

Results from Field Surveying

8.1 Introduction

This chapter deals with the survey result and field visit analysis of the research area. The results include the study area's questionnaire survey, FGD, and KII.

8.2 Questionnaire survey

A socio-economic and environmental survey was conducted in the rural, semi-urban, and urban areas of the Rangamati district (Photograph 59 to 64). Individuals from households are selected based on poverty and education. 300 Households were selected. (Pourashava and its adjacent union of Sapchhari based on age and education). The main theme was identifying changing land use pattern and demographic profile and livelihood choices, agricultural production, and their impact on socio-economic and environmental conditions.

8.3 Key Informants Interview (KII) and Focus Group Discussion (FGD)

KII and FGD with the ethnic and Bengalee community both group, Slum area was conducted to identify the core problems of that society. Four discussions were made. One in an urban area, two in a rural area, and one in a tourist spot (Pada Ting Ting). Key informants were chosen using a purposive sampling method based on their knowledge of the topic matter. All of the specialists from the Rangamati District who were knowledgeable about the issues in the study area served as key informants. The main topic of discussion was the relationship between land-use change and socio-economic and environmental conditions, impact on socio-economic and environmental status, agriculture and livelihoods, existing vulnerability and interventions, and possible solutions.

Key Informant Interview was done with the Responsible local officials and leaders, Forest officials, Land record and agriculture officials, and NGO personnel (Photograph 41-58). The discussion topic was Major driving forces of inappropriate and destructive

land use practice and its impact on the socio-economic and environmental condition, agricultural production and livelihood options and their possible solutions

8.3.1 Focus Group Discussion (FGD)

Desctiption of all focus group discussions (FGD) are given bellow (Photograph 38 to 40) .

Focus group Discussion Serial No: 1

Name and age of group members:

Total 10 People-Md. Humayun Kabir (24), Md. Rejaul Karim (17), Md Monir Hossain Rony (16), Md. Abdullah al Naim (21), Md. Hasan Ali Moon (22), Md Jisan Uddin (16).

Location: Urban area, South Omdamia hill

Education level:

Secondary education-2, Graduation-1, Post-graduation-1, Engineer-1

Occupation: Student and Jobseeker

Description closes to the statement:

Engineer Hassan Ali Moon said thatOmdamia Hill was once isolated and was connected by this road about 30 years ago. This is the crucial point of changing the landscape here. This is because forests have to be cut down to improve communication systems and settlements, hills have to be modified, and human pressure has increased at one stage. And to meet this growing demand, land has been continuously eroded, greening has decreased, and environmental pollution has increased, leading to environmental catastrophes.

Md. Humayun Kabir said that the primary disaster of Rangamati was a landslide. The cause of landslides is to clear the hills by cutting down the trees of the hills and making the hills unbalanced by cutting down the hill and building houses. Rezaul Karim said that when the hills are cleared by fire to cultivate the land, the soil of the hills becomes crumbly, and the land collapses in the rain. Abdullah Al Naeem said deforestation erodes the soil, the hills lose their fertility, and soil structure changes. And if this situation continues, the disaster will increase, and Rangamati will become completely uninhabitable.

Focus group Discussion Serial No: 2

Name and age of group members:

Total 10 people- ChandramuniKarbari (45), Chandrasekhar Chakma (34), Shashi Mohon Chakma (48), Khemo Kumar Chakma (48), Balram Chakma (50), Chandralal Chakma (47), Nirob Chakma (56)

Location: Rural area, Shapchari union, Karbaribari

Education level: Mostly illiterate, Primary and secondary education-2/1

Occupation: Agriculture

Income: Better than before

Description closes to the statement:

Shashi Mohon Chakma said deforestation is teak garden planting which causes desertification in the hills and drying up of the canals. Others said that planting teak does not require labor, time, and care like other crops, and there is no maintenance cost.

ChandramuniKarbari said teak orchards are growing in the hills due to decreasing jhum cultivation. The number of human resources required to produce and care for various fruits, crops, and vegetables is not present in agriculture. Also, once the teak is planted, the leaves may be loosened once a year while the tree is still young. Again, a teak tree absorbs water from soil more than any other tree, so the humidity of the hills decreases, and the dryness increases. As a result, the canals and the fountains are drying up. Another person said teak is being planted because of high demand, high market prices, and land grabbing.

Khemo Kumar Chakma, a farmer who received National Agriculture Medal, said, in terms of fertility, they divide the hills into three parts - 1) very fertile, low elevation 2) less fertile, medium height 3) rocky, barren and very high. Third-grade hills can be designated for teak cultivation. First and second-class hills should be cultivated without destroying the slope.

Focus group Discussion Serial No: 3

Name and age of group Member:

Total 6 People-Md. Kamal Hossain(45), Sumon sheikh (25), Chayan Hossain (26) Md Kabir Mia(27), KifatHossen (22) and Imran Hossain (25)

Location: Pada Ting Ting (A renowned tourist spot of Rangamati).

Education level: All are under secondary school level.

Occupation: Restaurant stuff of Peda Ting Ting tourism spot and Boatman

Description closes to the statement:

Md. Kabir Mia said, "At one time, we saw the deep forest in the surrounding upazilla so that it was almost impossible to enter during the day. It was scary. And now, you will not see any dense forest anywhere. This is a big change. Today, our ecosystem has changed. There is no water in many fountains, and the springs have dried up. Today, there is a drinking water crisis, and now we have to buy drinking water here, which was unimaginable.''

Md. Kamal Hossain said what else do you hear about land-use change? You can see that the surrounding islands are now completely bare, whereas they were covered with green at one time, and the forest was whole. Once upon a time, deer could be seen in the forest, but now deer are far away, now you will not find a single monkey. Do you want to see any change?'' The major disaster of Rangamati is a landslide. The leading causes of landslide are to clear the hills by cutting down the trees of the hills and to make the hills unbalanced by cutting down the hill and building unplanned houses."

Sumon Sheikh said that "Indeed, as the construction of the Kaptai Dam flooded the lowlands, the people of the lower settlements climbed all the hills. Then cut down of the hills or destroyed the hill vegetation and to meet the demand of this increased population, environmental catastrophe and destructive land use start gradually."

Focus group Discussion Serial No: 4
Name and age of group Member:

Total 6 People-Md. Mozammel Hossain (52), Nazrul Islam (45), Nurul Afsar (65), Alfat Rahman (72), Mir Ahmad Sikdar (55) and Ismail Hossain (50)

Location: Puran Para/PuranBosti/ Old Slum (Situated beside Reserved Bazar).

Education level: Illiterate, signature knowledge, and primary education.

Occupation: Timber business, boat business, Labor leader, and fishing.

Description closes to the statement:

Alfat Rahman said, "Then there was the time (Before the construction of Kaptai Dam) of the golden age. Although the number of people was less the land was much more. The land was rich in crops including paddy. Then there were a lot of cattle but now have nothing, somehow I am living by working with a place to stay. "

8.3.2 Key informants Interview (KII)

The KII was interpreted by a framework named GraneheimLundman Framework. As Graneheim & Lundman (2004) explain, qualitative content analytical approaches focus on analyzing both the explicit or manifest content of a text as well as interpretations of the 'latent content' of texts - that which can be interpreted or interpolated from the text but is not explicitly stated in it. So with that KII is interpreted here (Photograph 41 to 58).

The total overview of the interviewees (Table 8.1) and the main output discussion of KII (Table 8.2) are shown below:

Table 8. 1 Brief overview of interviewees and their affiliation (source: Field survey 2019)

Interviewee	Affiliation/Designation	Representative
1	Senior scientific officer, Bangladesh fish research institute, Rangamati	Governmental representative of fish research
2	Headman, Bakchori Mauza	Political leader
3	Assistant Headman, Shapchori Mauza	Political leader
4	Headman, Shapchori Mauza	Political leader
5	Executive Engineer, Department of Public Health Engineering, Rangamati	Governmental representative of public health
6	Professor, Department of the Botany, Rangamati Gov't College	Representative of Academia
7	Principal, Rangamati Gov't College	Representative of Academia
8	Assistant Professor, Rangamati Gov't College	Representative of Academia
9	Advocate	Representative of law personnel
10	Headman, Jhagrabil Mauza	Political leader
11	Assistant Director, Fire Service Civil Defense, Rangamati	Governmental representative of civil defense
12	Chairman, Hill District Council	Political leader
13	Additional Director, Department of Agricultural Extension	Governmental representative of agricultural extension
14	Town Planner, Rangamati Municipality	Governmental representative of town planning

15	Councilor, Ward No 5	Political leader
16	Panel Mayor, Rangamati Municipality	Political leader
17	Senior Scientific Officer, Bangladesh Forest Research Institute, Rangamati	Governmental representative of forest research
18	Omdamia Hill, Tourism, Rangamati.	Representative of tourism in Omdamia hill
19	KathalToli	Representative of general people

Table 8. 2 Discussion about the land use change and its socio-economic and environmental impacts and consequences (Source: Field survey 2019)

Statements	Condensed meaning unit Description closes to the statement	Condensed meaning unit (Interpretation of the underlying meaning)	Sub-theme	Theme
1.'In Kaptai lake, many fish species are disappearing because there is no pecific sanctuary for fish shelter, feeding, and breeding. Also, water pollution by settlements adjacent to the lake and the siltation of the lake are threats to the lake's ecosystem.'	Lack of water resource management	Proper management of the water resource and the ecosystem of the lake area should be protected	Formulation of the proper scientific way for the protection of the various fish species	Implementation of integrated practical initiatives by the Lake Authority
2.'One of the major causes of landslides and environmental pollution is that the rainwater falls directly on the soil due to the baldness of the hills. As a result, the soil is easily eroded, and due to the excessive absorption of rainwater, the soil becomes loose and slides. The water level has gone down a lot, and there is no water in the well or even in the tube well below 100 feet. As a result of population growth and development, we have seen a lot of deforestation.'	Environmental degradation	Hill is cutting and over rainfall cause soil erosion and landslides. Drinking water scarcity is severe due to water pollution, and population growth and development are responsible for deforestation.	Protection of water & forest resources and disaster preparedness are required	Proper environmental management

Statements	Condensed meaning unit Description closes to the statement	Condensed meaning unit (Interpretation of the underlying meaning)	Sub-theme	Theme
3.‘People used to drink water directly from this lake (Kaptai, but now it is unsuitable for domestic use due to pollution.’	Severe water pollution	‘The lake's water is getting polluted from the macha and tong house on the side of the lake & kerosene and diesel from the vessels of the lake.’	Awareness needs to be created to reduce water pollution	Water resource management
4. ‘The land cover here is not flat but hilly. So the land use here is different from the plain district. The livelihood of the tribals is mainly based on agriculture. When it rains continuously for a long time in this area, the soil on the top of the hill becomes completely soft and loose, so it becomes one of the causes of landslides. It can be said that the housing pattern of hill people and Bengalis is different. The hill people are mountain friendly, and the Bengalis' activity is harmful. The hill people built houses on the four pillars without destroying the slope of the hill. On the other hand, the Bengalis built houses by destroying the slope of the hill. The social problem is the conflict between the hilly people and Bengalis. There is a conflicting situation among the students that needs government forces' help to control.’	Different land cover and land use in a hilly region	Due to different land cover and land use in hilly areas, the disasters are also different, and housing patterns should also be different	Use of hilly areas in an environment-friendly way	To take initiatives for maintaining peace and overall development
5. ‘Deforestation has been accelerated due to setting up many mills and factories that depend on raw materials from the forest, especially Karnafuli Paper Mill, Pulp Wood Mill, etc.’	Deforestation	‘Overexploitation of forest resource for	Reducing deforestation and increasing	Forest resource management

Statements	Condensed meaning unit Description closes to the statement	Condensed meaning unit (Interpretation of the underlying meaning)	Sub-theme	Theme
		collecting raw materials.'	social plantation	
6. 'Basically, we got new Rangamati due toKaptai Dam, and nature has undergone a massive change, both good and bad. Jhum cultivation is changed into orchards and houses, per capita land has decreased, disaster has increased, the occupation has changed, deforestation, hill-cutting and major changes in the migration issue.'	Environmental and social impacts of the Kaptai dam	Kaptai dam is one of the primary reasons for the land-use change in Rangamati	Impact assessment of constructing dams	Proper land-use management
7. 'The socio-economic impact of changing land use is huge as people change their primary occupations, biodiversity, forests decline, floods, landslides, and other disasters increase.'	Impacts of land-use change	Land-use change is affecting both the environment and the socio-economic condition	Land-use zoning	Land use planning and management
8. 'Deforestation is increasing because of timber traders. As a result of deforestation, the streams are drying up, and desertification is taking place.'	Deforestation	Timber traders are indirectly responsible for desertification	Monitoring and proper law enforcement are required for protecting forest resources	Forest resource management

Statements	Condensed meaning unit Description closes to the statement	Condensed meaning unit (Interpretation of the underlying meaning)	Sub-theme	Theme
9. 'The great change started with creating artificial Kaptai Lake through a dam on the Kornafuli river. As a result, the homes of millions of people have been submerged, resulting in the loss of their ancestral homes. However, we do not own land like the plain land. The 1997 peace agreement has not yet been fully implemented. With the increase in population, the amount of land per capita has also decreased, and the value of land has increased by almost 100% compared to 20 years ago. As a result, Jhum cultivation has been reduced to a great extent, and instead, fruits, including ginger, turmeric, and some vegetables, are being cultivated on a large scale. However, even if the situation is better than before, we would have been better off if there were no internal quarrels between different (4 major) regional political parties.'	Different types of land ownership	Land-use change is different in hilly areas than the plain land because of different types of land ownership.	Maintaining political stability	To take initiatives for maintaining peace and overall development .

Statements	Condensed meaning unit Description closes to the statement	Condensed meaning unit (Interpretation of the underlying meaning)	Sub-theme	Theme
10. Due to overpopulation, increasing human literacy rate, change of occupation, and unplanned urbanization, the Jhum trend has diminished with the drastic change in natural land use and land cover. Orchards and a few timber gardens are now replacing it. However, cropping intensity has increased more than before, now 156%. Deforestation has increased a lot after the Peace Accords (1997). As a result, biodiversity has changed dramatically. So the planned urbanization should start now. Otherwise, disasters, including landslides, will increase, water problems will become more widespread, and the environment will be severely disrupted.	Impacts of land use change	Unplanned land use affects both the socio-economic condition and the environment	Land-use zoning, planned urbanization, and development	Planned urbanization and planned land use
11. 'Population distribution depends on what type of area we want to see? Do you want to see it as a tourism area or a growth center of economic activity? Otherwise, the reserve market, which was once known as just a launch ghat, is now a commercial hub, and Banarupa, a residential area, has become a commercial hub. That is why the living standards of our population are declining, and house rents are rising.'	Land-use change	Population growth and distribution are affecting the land use	Equitable distribution of population	Land use planning and management

Statements	Condensed meaning unit Description closes to the statement	Condensed meaning unit (Interpretation of the underlying meaning)	Sub-theme	Theme
12. ‘Population of the municipal area has increased almost two to three times compared to the past, and the environment here is becoming increasingly uninhabitable and polluted. For example, under the pressure of the population, many tong/hut houses have been built on the shores of the lake. As the beauty of the lake is lost, the lake's pollution is constantly increasing. As a result, big fish are not available in the lake like before. If this situation continues, the tourism industry here will be destroyed.’	Environmental degradation	Planned urbanization, controlling population growth, and reducing pollution are necessary to protect the environment	Protecting the tourism industry	Adaptation and implementation of a beautiful, integrated, and effective plan

Statements	Condensed meaning unit Description closes to the statement	Condensed meaning unit (Interpretation of the underlying meaning)	Sub-theme	Theme
13. 'Construction of Kaptai Dam has changed the land use. With the continuous increase in population and the need for their increasingly different needs, adverse changes in nature have begun. Examples, are deforestation, hill cutting, housing, Jhum farming, teak gardening, etc. As a result, the soil is being eroded and has lost nutrients. The eroded soil of the mountains creates 4-5 inches of sediment at the bottom of the lake every year which is dangerous for the ecosystem of the lake and the overall environment. So as we are torturing nature, sometimes nature is also taking its revenge through landslides. That is why we should rescue and rehabilitate the people living along the lakes and rivers in the risky places of the hills. If the government acquires the hills and makes them suburbs, then perhaps the environment here can be easily maintained and become economically self-sufficient. People at risk can be protected from risk.'	Using hills in an environment-friendly way	Reducing deforestation, pollution, and hill cutting to protect the overall environment of the hilly areas	Disaster preparedness, conservation of water bodies, planned housing, and urbanization	Environmental management through proper land use management
14. 'Rapid urbanization and development are major factors of land-use change. Unplanned land use and over rainfall cause landslides. Land-use changes are affecting the agricultural sector, environment, and socio-economic condition. Hill cutting and deforestation should be reduced to protect the environment.'	Environmental degradation	Unplanned land use affects both the socio-economic condition and the environment	Land-use zoning, planned urbanization, and development	Proper land-use planning and management

Statements	Condensed meaning unit Description closes to the statement	Condensed meaning unit (Interpretation of the underlying meaning)	Sub-theme	Theme
15. ‘There used to be three or four houses on this hill, and now it is around 50-60. The number of trees that used to be there is no more, I once saw many wild deer here, but now there is no place for people to live.’	Population growth, biodiversity loss	Environmental degradation due to lack of land use management	Planned housing	Land use management
16. ‘The nature of disaster has changed. Once upon a time, there was terrible malaria. Now there are landslides. I have seen a massive change in land use. Due to the obstruction in different parts of the lake, the current of the Kornfuli channel has changed, and navigability has been lost. For example, the connecting road from Fisarighat to the reserve market was never there. This has stopped the flow of the inner margins of the lake. This has further increased the pollution of the enclosed part of the lake and has ruined the lake's environment.’	Environmental degradation	Land-use change and the construction of dams and roads are affecting the environment	Disaster preparedness and conservation of water bodies are required	Environmental management

8.4 Conclusions

This chapter showed the FGD and KII information of the study. Rangamati is the biggest district in Bangladesh. So, urban and rural areas have been included in this study fieldwork to gain accurate information about that region to better my research study.

Chapter Nine

Analysis and Discussion

9.1 Introduction

This chapter is all about analyzing the land use research and the field survey. The overall discussion of the NDVI analysis, questionnaire survey, FGD, and KII analysis gives some crucial insights into land use change socio-economic and environmental impact.

9.2 Changes in Land use

The NDVI values of these land use land cover classes differ significantly from 1977-to 2019 (Nath and Acharjee 2013). Figure:3 shows that the highest NDVI value was found in 1977 (0.88), representing healthy vegetation. After 1977, the highest NDVI value was found in a decreasing trend (0.79 in 1989, 0.74 in 2000, 0.71 in 2011, and 0.53 in 2019), representing the study area's rapid vegetation cover change. Slightly changed or an irregular change trend was observed in the Kaptai Lake (Parveen et al. 2002) and bare or char land areas due to the seasonal variation of water like scarcity and availability. Results confirmed that the forest or dense vegetation area is decreased. On the other hand, Settlement areas and the sparseness of vegetation are increased gradually, which may be considered a significant threat to proper ecosystem functioning and climate change. Agricultural and forest areas have dropped in seventeen of the world's 200 countries, according to the condition of the global forest 2016 study. The country of Bangladesh is at the top of the list (FAO 2016).

Figure: 5.2 and Table: 5.3 show the spatial representation of LULC types from 1977 to 2019. The trend is changing land-use patterns is a dynamic process. It depends on different times and spaces. This research has found a significant variation in settlement areas, and sparse vegetation and forest area were changed gradually (Nath and Acharjee 2013). The water body and bare or char land were found slightly irregularly changed due to seasonal variation of water bodies. Dense forest & sparse vegetation played a significant role in many conversions to settlement and bare land areas. This conversion could be related to the rapid increase in population and faster economic development in the Rangamati District. It is impossible to declare Level-2, and Level-3 land-use features by Landsat image in the hilly area (Singh 2012).

Between 1977 and 2019, the land use pattern in the Rangamati district changed a lot. This conclusion is similar to that of Abedin (2020). The amount of forest land has gone down, then the amount of water. Also, the land and settlement area grew from 1.01 to 18.06 percent. From 2011 to 2019, the forest land change rate value was -44.43 percent of the change in total land use. It also showed that the change rate of forest land was the largest, with sparse vegetation accounting for 27.64 percent of the change in total land use. Water bodies and bare land changed less, accounting for 0.55 percent of a change in total land use, respectively. It's essential to look at survey data to see how overpopulation affects the spatial distribution of land use, which can result in massive changes in a short amount of time.

More than 60% of people that live in semi-urban areas think that economic activities, not population, drive land-use change. About 65% of people living in the urban area said that, after population, urban growth affects land use over time. Rasul (2004) used the same idea of what causes the land cover to change. Figure 5 shows the main factors that have led to land-use changes and forest degradation in the Rangamati area. This has led to less natural beauty in the area. Today, eco-tourism is the most popular type of vacation out there. People thought that eco-tourism could be a good alternative to cutting down forests and habitats for environmentally-friendly development. People who do land-use change studies should use tools like remote sensing and GIS.

9.3 Socio-economic and environmental impact due to land-use change in Rangamati

According to the study in Rangamati, significant land-use changes have occurred in urban areas due to high population pressure. The forest and agricultural lands are being used for building new settlements. Urban land-use changes very fast because of high population pressure, different centers for providing service, industrialization, etc. Figure 9.1shows the most significant change in urban land use deforestation (39.40%). Other changes are barriers (19.4%), hill cutting (9.70%), changed farming (10.4%), and decreasing cultivation of land (21.10%).

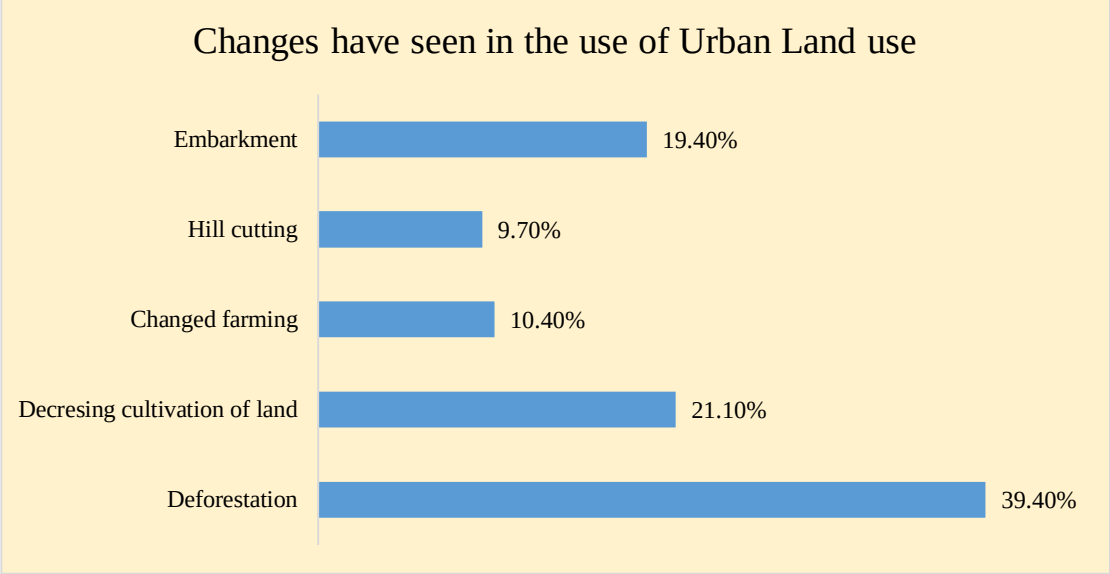


Figure 9. 1 Changes in urban land use (Source: Field survey 2019)

The study reveals that the forest cover in the study area is decreasing at an alarming rate. Figure 6.34 shows that overpopulation (26.7%) is the main reason for reducing forest and agricultural land. Overpopulation creates pressure on existing land for settlement purposes. A large population requires more food production, which requires more arable land for cultivation. Lack of law enforcement (15.2%), business farms (7.8%), development activities (17.2%), Bazar shops (10.5%), housing (16.8%), mill factory (5.70%) are also responsible for the reduction of forest and agricultural land in the study area according to the respondents.

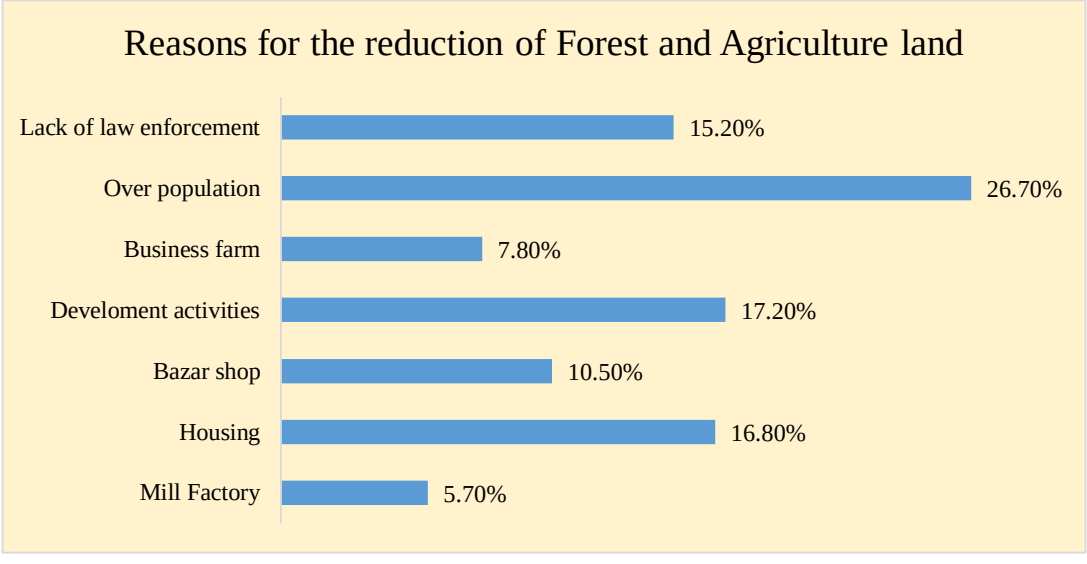


Figure 9. 2 Reasons for the reduction of Forest and Agriculture land (Source: Field Survey 2019)

Planned land-use practices are essential in a locality. According to the respondents, there are some major driving forces of destructive and unplanned land-use practices in

the study area. The main force is lack of proper administrative role (39.7%), lack of necessary allocation of hill maintenance (28.1%), degradation of proper land use policy (16.1%), land grabber of local influential (7.9%), and misuse of political power (6.8%).

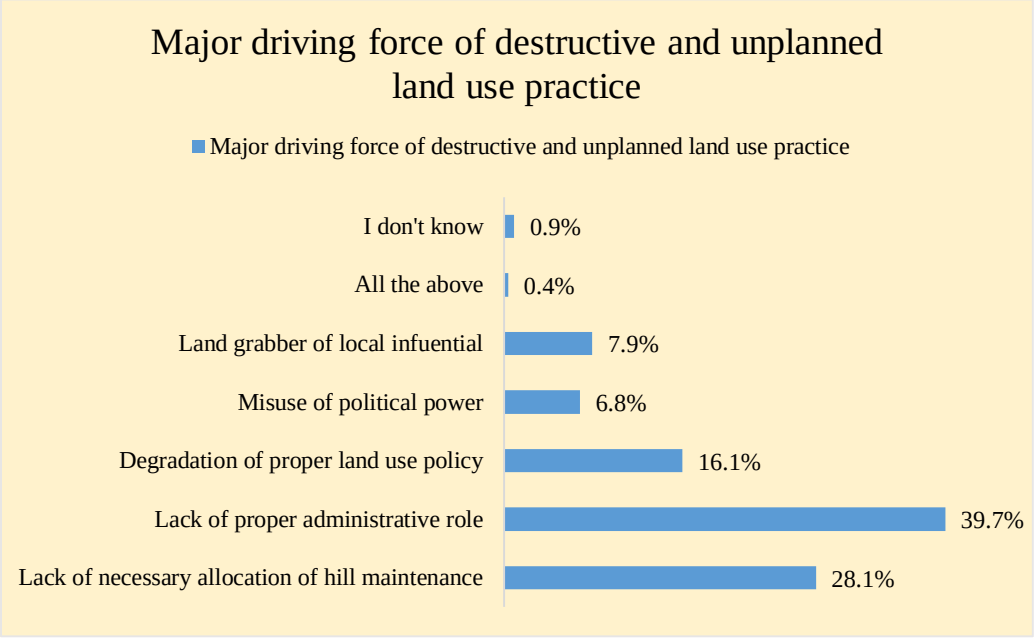


Figure 9. 3 Major driving force of destructive and unplanned land use practice (Source: Field Survey 2019)

The unplanned land-use change affects both the environment and society. Figure 6.36 shows the environmental impacts due to land-use change. According to most respondents (21.60%), forest and agricultural land will be reduced. Already from the study, it is seen that forest cover and agricultural land are decreasing in the study area. 17.60% respondent think that natural resources like soil, air, and water have been polluted, 16.10% respondent think flood rate will increase, 13.30% respondent think the habitat of flora and fauna will be damaged, hazards will increase (12.20%), loss of biodiversity (5.90%), loss of ecosystem (5.80%), climate change will occur (5%).

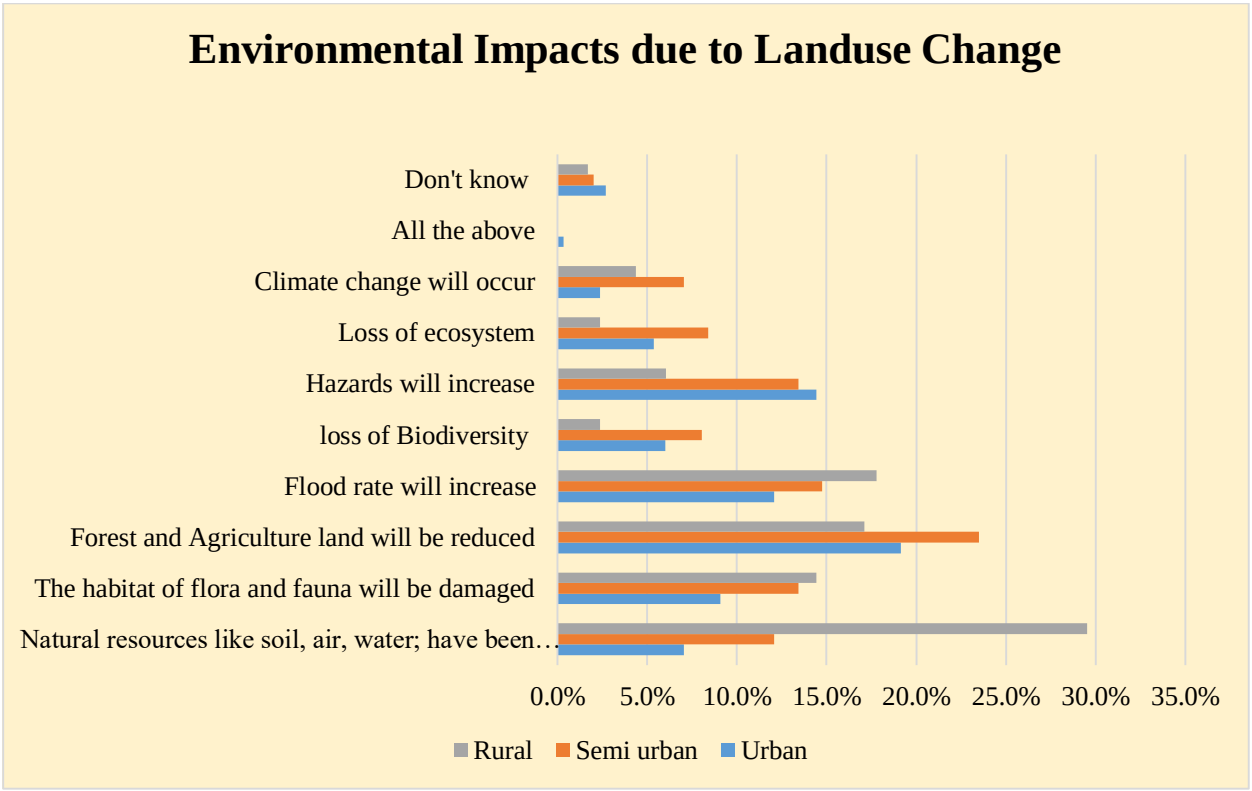


Figure 9. 4 Environmental impacts due to land-use change (Source: Field Survey 2019)

Land-use change affects the environment and the society and economic condition of people. According to the respondents, figure 6.37 shows the socio-economic impacts of land-use change in the study area. They think the tourism industry will be damaged (24.20% respondent), agriculture and forestry resources will be reduced (22.9%), people will change their primary profession (13.60%), production of cash crops will be reduced (12%), flash flood, landslide, and hazard will increase (10.50%), loses of Bio-diversity (8.4%), fisheries production may be reduced (7.50%).

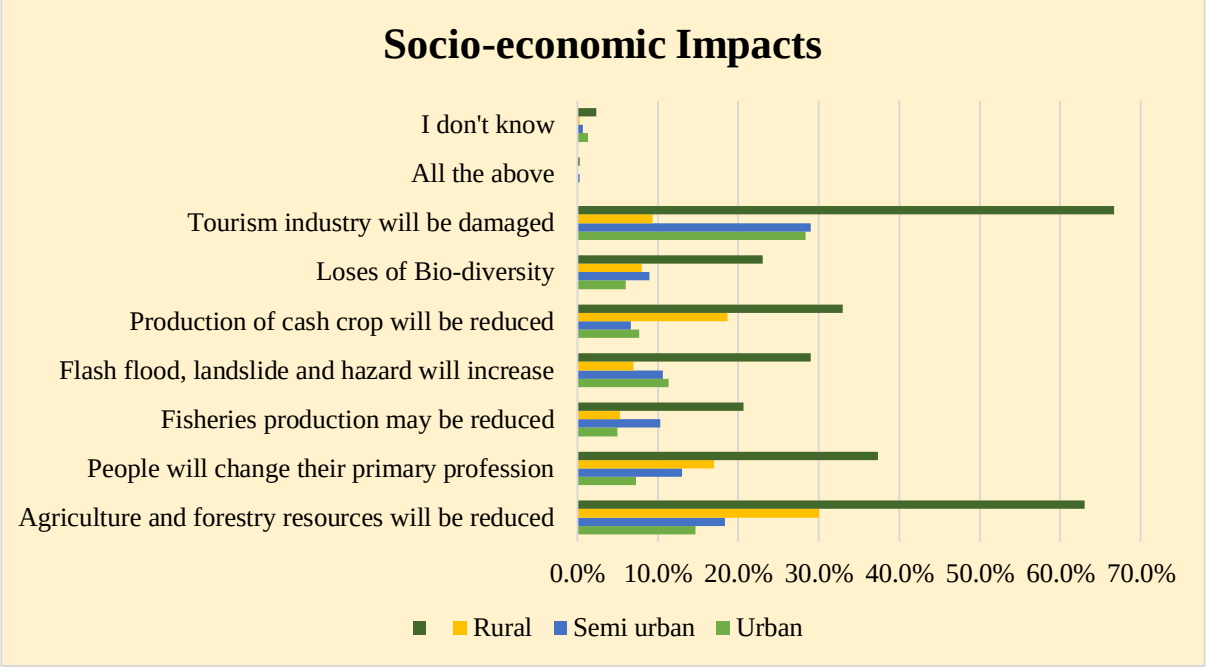


Figure 9. 5 Socio-economic impacts due to land-use change (Source: Field Survey 2019)

Figure 6.38 shows the major driving forces of rapid land-use change. In urban and rural areas, the main driving force of land-use change is population growth. In the rural area, major driving forces are migration from the plain land, rapidly increased development of urban areas and construction of the Kaptai dam. In the semi-urban area, the major driving forces are increasing economic activities, rapidly increasing land prices, migration from plain land, and the construction of the Kaptai dam. In the Urban area, the major driving forces are rapidly increased development of an urban area, development of the tourism industry, rapidly increasing land price, migration from plain land, the government's migration policy, increasing economic activities, and unplanned development.

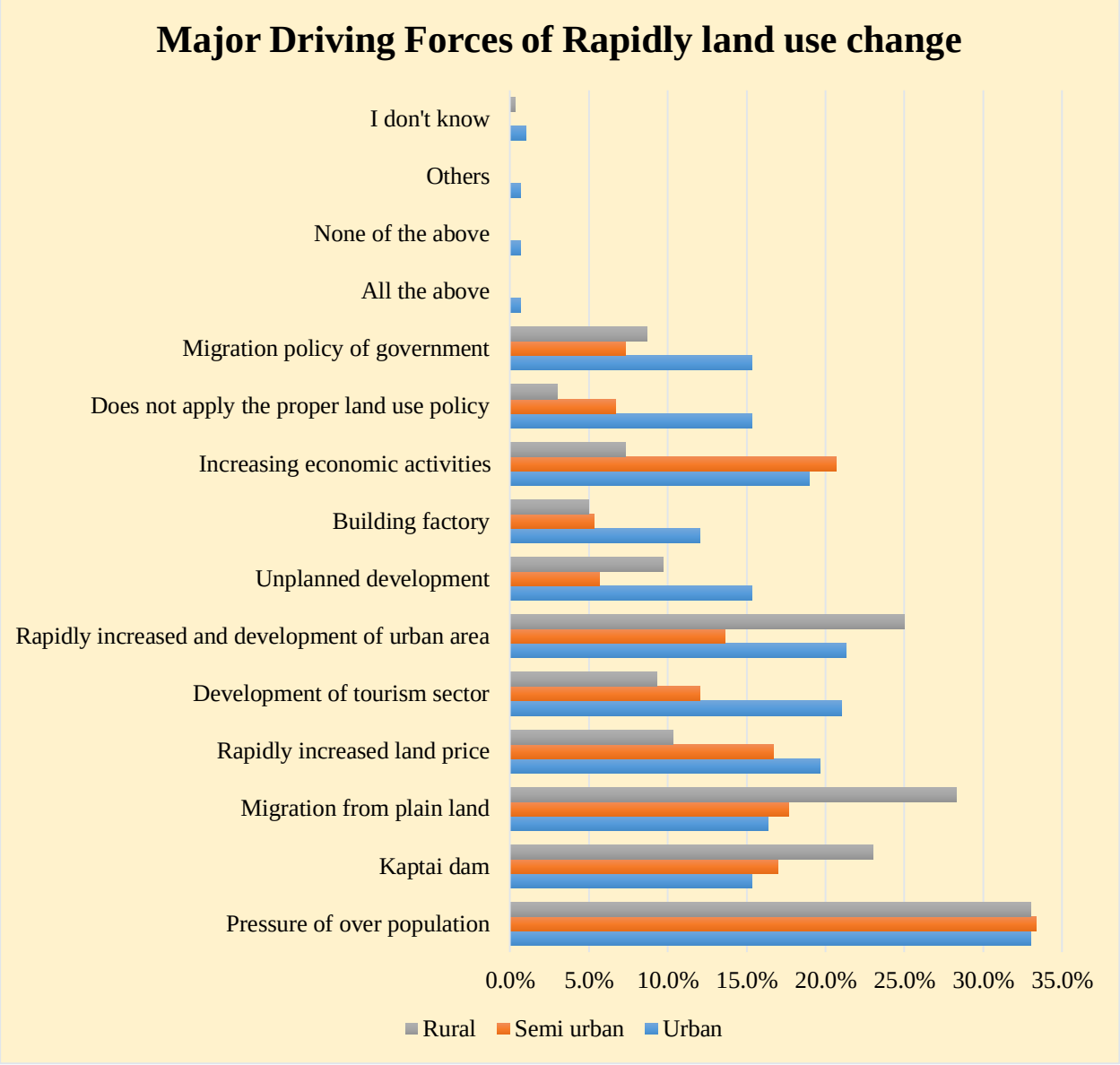


Figure 9. 6 Major Driving Forces of Rapid land-use change (Source: Field Survey 2019)

9.4 Output of KII

- Proper management of the water resource and the ecosystem of the lake area should be protected
- Hill cutting and over rainfall cause soil erosion and landslides. Drinking water scarcity is severe due to water pollution, and population growth and development are responsible for deforestation.
- The lake's water is getting polluted from the macha and tong house on the side of the lake & kerosene and diesel from the vessels of the lake.

- Due to different land cover and land use in a hilly area, the disasters are also different, and housing patterns should also be different
- Overexploitation of forest resources for collecting raw materials.
- Kaptai dam is one of the primary reasons for the land-use change in Rangamati
- Land-use change is affecting both the environment and the socio-economic condition
- Timber traders are indirectly responsible for desertification
- Land-use change is different in hilly areas than the plain land because of different types of land ownership.
- Unplanned land use affects both the socio-economic condition and the environment
- Population growth and distribution are affecting land use.
- Planned urbanization, controlling population growth, and reducing pollution are necessary to protect the environment.
- Reducing deforestation, pollution, and hill cutting to protect the overall environment of the hilly areas.
- Unplanned land use affects both the socio-economic condition and the environment
- Environmental degradation due to lack of land use management.
- Land-use change and the construction of dams and roads are affecting the environment

9.5 Output of FGD

FGD at urban area, South Omdamia hill, Rangamati

Students, service holders, and educated people.

Road construction changed the landscape of the urban area of Rangamati; due to population pressure and growing demand, forest areas have been depleting rapidly. Environmental pollution has increased leading to environmental catastrophe. Occurrences of Landslides are one of the major disasters.

FGD at rural area, Shapchari union, Rangamati

Agriculture and most people were illiterate.

Due to a lack of competent and scientific management, agricultural practices have shifted from jhum cultivation to commercial planting, and sustainable agricultural techniques have yet to be established. As a result, soil moisture is dwindling as the majority of canals dry up, particularly during the winter months. A local farmer made an important insight on developing a commercial plantation economy in third-grade hills with a high elevation and rocky and barren soil.

FGD at tourism spot of Rangamati, Pada Ting Ting, Rangamati

Boatman and most of the associates of the restaurant of Peda Ting Ting tourism spot were illiterate but one respondent was highly educated. (no tourist was present at that time).

Significant change throughout the years was the depletion of forest areas. Spring water is being dried out, so local people have to buy water. The biodiversity of that area was also impacted by hill cutting. Landslides are a common occurrence as a result of forest change and the uncontrolled settlement of the Building. Because the Kaptai Dam inundated low-lying areas, locals began chopping down hills and settling there.

The concentration of excessive population forced a change in the land use pattern of Rangamati. Some of the respondents said the construction of the Kaptai Dam was responsible for changing the land use pattern and socio-economic and environmental status of the Rangamati District.

FGD at Reserved Bazar of Rangamati, Puran Para/PuranBosti/ Old Slum, Rangamati

Illiterate, signature knowledge, and primary education. Their occupations are Timber business, boat business, Labor leader, and fishing.

Before the construction of the Kaptai Dam, there were fewer people and more bare lands and forests. There were many cattle in the fields, and the lands were rich in harvesting crops, including paddy.

9.6 Conclusions

This chapter was all about analyzing the land use research and the field survey. The present review of the NDVI study, questionnaire survey, focus group discussion, and KII analysis provides valuable information on land-use change's overall socio-economic and environmental consequences.

Chapter Ten

Conclusions

10.1 Introduction

This chapter is all about the conclusions of the research study. The overall summary and significant findings of the study are presented in this chapter. Some of the recommendations have been added to this for further research work.

10.2 Summary of the study

From 1977 to 2019, the NDVI index was used to investigate the temporal variation of the trend in land use patterns in the Rangamati District. Each year, it looks at land usage and changes in the Rangamati district. In the preceding section, land-use change is presented as a dynamic process. From 1977 to 2019, the settlement area expanded steadily, the thick forest area decreased steadily, and the vegetation sparseness area increased steadily. A small or irregular change trend has been seen in the Kaptai lake and barren or char land region due to seasonal fluctuations in water such as shortage and availability. The normalized difference vegetation index technique extracted features with different threshold levels. Consequently, the current study describes the temporal land use pattern in the Rangamati District.

10.3 Major findings of the study

The study was about the land-use change and the socio-economic and environmental impact due to land use change. The objectives mentioned in chapter one have been proved by statistical data in chapters four to nine. Below are the significant findings of the research study:

- The settlement has expanded disproportionately in the study period 1977-2019.
- The conversion of dense forest to sparse vegetation and sparse vegetation to bare land.
- The conversion of bare land to settlement, urban development, and desertification reduce the amount of available land for food and timber production.
- Rapid deforestation or dense forest is almost finished.

- Deforestation has led to a scarcity of sources of natural drinking water.
- Demographic change, economic growth, migration land use policies, and regulations are the major driving factors of land use land cover changes in Rangamati.
- Soil erosion, desertification, and other soil degradations reduce land fertility and productivity.
- Land use change overall affects the environment and the society and economic condition of people.
- According to satellite image processing results, forests constituted the most significant area in 1977. The rate of deforestation in four decades of the study was -15.71%, -12.26%, -13.75% and -44.43% respectively. Between 1977 and 2019, waterbodies decreased from 7.32 to 6.91%, while bare land and settlement areas expanded from 1.14 to 4.67% and 1.01 to 18.06%. Sparse vegetation has been increased by 3.66 to 69.64%.
- More than 60% of people that live in semi-urban areas think that economic activities, not population, drive land use change. About 65% of people living in the urban area said that, after population, urban growth affects land use over time.
- In urban and rural areas, the main driving force of land use change is population growth. In the rural area, major driving forces are migration from the plain land, rapidly increased development of urban areas and construction of the Kaptai dam. In the semi-urban area, the major driving forces are increasing economic activities, rapidly increasing land prices, migration from plain land, and the construction of the Kaptai dam. In the Urban area, the major driving forces are rapidly increased development of an urban area, development of the tourism industry, rapidly increasing land price, migration from plain land, the migration policy of a government, increasing economic activities, and unplanned development.
- The findings of the LST and NDVI correlation and regression study from 1989 to 2019 demonstrate that LST and NDVI were closely connected in 1989, with higher NDVI values indicating greater vegetation and lower surface temperature. On the other side, it steadily diminishes in 1999, 2009, and 2019, implying that vegetation declines and surface temperatures rise.

- Hazards and catastrophes differ in a hilly terrain due to differences in land cover and land usage.
- Timber traders are indirectly responsible for desertification.
- Land use change in Rangamati differs from that in plain land due to the varied types of property ownership and distinct topography.
- Unplanned land use affects both the socio-economic condition and the environment.

10.4 Conclusions

Studying land use change processes is crucial for projecting socioeconomic and environmental changes. An analysis of Landsat images and a field survey to track land use changes are part of the technique used in this study. Land use change patterns must be studied, and changes must be monitored for economic planning and country growth. When it is feasible to perceive distinct economic and social systems inhabiting the same or comparable surroundings, land use patterns reveal the character of a society's interaction with its physical environment. The benefit of remote sensing is that it provides a sophisticated and trustworthy instrument for quickly and accurately surveying any region. This is essential for making long-term land use decisions and forecasting potential future changes in population trends.

10.5 Recommendations

This study shows that this is true. Here are some ideas for future research based on the results of this study:

- Expansion of indiscriminate settlement must be regulated.
- Emphasize to be given for environmental sustainability.
- Deforestation must be stopped, and more afforestation programs should be introduced and implemented scientifically.
- Social practice, social education, awareness-raising, and effective legal enforcement should all help reduce deforestation.
- Any new project must consider how to protect the land through a sustainable environment & land management system and by halting land degradation.
- Prioritization of investment in the protection of land and water resource management to be considered.

- The public interest and private investor's interest must be balanced in the line of sustainable land use planning regulations.
- Enforce Land use policy very strictly with all compliance factors.
- Hazards and catastrophes differ in a hilly terrain due to differences in land cover and land usage. So housing patterns should also be different.
- Although the Landsat satellite data is consistent, allowing for a comprehensive comparison of images, change analysis and, modeling but for the better output this analysis requires equal intervals of image acquisition. Moreover, there is an unequal distance and temporal unavailability of images for the need of cloud and noise-free quality images.
- Provision to be made for using high-resolution imageries (like IKONOS and Quick Bird is critical) for producing high-quality land use maps. This would provide greater information by mapping the hilly areas along with varied features.

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Appendix I: Questionnaire for Socio-economic and Environmental Survey

Institute of Disaster Management and Vulnerability Studies

University of Dhaka

Socio-economic and Environmental Survey Questionnaire (Household survey)

All data collected through this questionnaire are confidential and will be used for research work

Supervised by

Professor Dr. Khondoker Mokaddem Hosen, Dr. Dilara Zahid

and Professor Dr. Tarekul Islam

Subject: Socio-economic and Environmental impacts of changing land use pattern of Rangamati District

Section-1: Identity

1.1: House no:			

Date: / / 2019

1.2: Name (Head of the family):	Total family member:
Name of Father/Husband:	
Mobile number:	
1.3: Name of the informer: (If not head of family)	
Mobile number:	

1.4: Description of Sample area:

Area	Name of Area (Tick union or write the ward no in case of Municipal area)		
District	Rangamati		
Upazilla	Sadar		
Union	3 no Shapchhari / Municipality's Ward no:-		Road:
Mouza		Village:	Mahalla:

1.5: Information of data collector:

Name	Profession	Educational qualification	Mobile number	Signature

No	**2.1: Name of the family member**	**2.2: Relationship with head of the family:** Head of Family-1 Husband/ Wife-2 Son/ Daughter-3 Father/ Mother-4 Others-5	**2.3: Gender:** Male-1 Female-2 Others-3	**2.4: Age (In year)**	**2.5: Marital Status**: Unmarried-1 Married-2 Widow/ Widower-3 Divorced-4	Not applicable under six year	
						2.6: Education: (write down the code of the highest class of study)	**2.7: Work activity:** Involved in Job-1 Job seeker-2, Household work-3 Students-4
1	2	3	4	5	6	7	8
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

2: Household Characteristics (Applicable for all family member)

Education code: No education-0, Class one-1, Class two-2, Class three-3, Class four-4, Class five-5, Class six-6, Class seven-7, Class eight-8, Class nine-9, Secondary or equivalent -10, Higher Secondary or equivalent-12, Honors or equivalent -13, Masters or equivalent -14, Others-15.

2.8: Religious and ethnic identity of the head of the family

(Please tick (√) on applicable code)

Religion	Name of ethnic group
Islam-1, Hindu-2, Buddist-3, Christians-4, Others-5	Bangali-1, Chakma-2, Marma-3, Tripura-4, Khumee-5, Rakhaine-6, Khyang-7, Lushai-8, Bawm-9, Pankho-10, Chak-11 and Tangchangya-12

Section-3: General information of Household (Please tick (√) on applicable code)

3.1: Types of household		**3.2: Location of Kitchen**	
Present	Past (Before 25/30 years ago)	Present	Past (Before 25/30 years ago)
Pucca-1 Semi Pucca-2 Katcha-3 Jhupri-4	Pucca-1 Semi Pucca-2 Katcha-3 Jhupri-4	In House (Individual Room)-1 Individual Kitchen-2	In House (Individual Room)-1 Individual Kitchen-2

3.3: Types of Fuel		**3.4: Source of Drinking water**	
Present	Past (Before 25/30 years ago)	Present	Past (Before 25/30 years ago)
Gas/LP Gas-1 Electricity-2 Coal-3 Biogas-4 Wood/Bamboo-5 Cow dung /Straw/Leaf-6 Others-7	Gas/LP Gas-1 Electricity-2 Coal-3 Biogas-4 Wood/Bamboo-5 Cow dung /Straw/Leaf-6 Others-7	Deep/Shallow Tubewell-1 Wasa-2 Fountain/Charra-3 Well-4 Karnaphuli river-5 Others-6	Deep/Shallow Tubewell-1 Wasa-2 Fountain/Charra-3 Well-4 Karnaphuli river-5 Others-6

3.5: The main source of Light		3.6: If the source of light is Electricity, then monthly average electricity bill	3.7: Type of Toilet	
Present	Past (Before 25/30 years ago)	Present	Present	Past (Before 25/30 years ago)
Electricity-1 Solar-2 Kerosine-3 Others-4	Electricity-1 Solar-2 Kerosine-3 Others-4	150-300 tk-1 301-500 tk-2 501-1000 tk-3 More than1000 -4	Sanitary-1 Pit Latrine-2 Katcha-3 Open Space-4	Sanitary-1 Pit Latrine-2 Katcha-3 Open Space-4

3.8: Is there any sewerage and drainage system? Yes-1 No-2	
3.9: Transportation system	
Present	Past (Before 25/30 years ago)
CNG-1, Private Motor Cycle-2, Bus/Chander Car-3, Private Car-4, All-5, Others-6	CNG-1, Private Motor Cycle-2, Bus/Chander Car-3, Private Car-4, All-5, Others-6

Section-4: Economic activities of the family

4.1: What is the profession of the head of household?
Government Job-1, NGO/Private Job-2, Business-3, Agriculture-4, Day labourer-5, Pensioner-6 and Others-7

4.2: Present Cattle status of family: Many in the past but 1 or 2 at present-1, Not available both before and now-2, Available before but not available now-3

4.2.1: What is the reason of decreasing or not having the cattle? Lack of natural food and pasture-1, Lack of cattleman-2, Economic Problem-3, others-4, Not applicable-5.

4.3: What is the monthly expenditure of your family?

Expenditure issue	Monthly Expenditure at now (Please tick (√) on applicable code)	
Food, Clothing, Shelter, Education, Medical, Festival, Entertainment and others.	Below 5000/-taka -1	>25,000/- and <30,000/- -6
	>5000/- and <10,000/- -2	>30,000/- and <35,000/- -7
	>10,000/- and <15,000/- -3	>35,000/- and <50,000/- -8
	>15,000/- and <20,000/- -4	>50,000/- -9
	>20,000/- and <25,000/- -5	-

4.4: Can you save any amount of money in every month? Yes-1, No-2,

If answer is yes, how much can you save? ……..Tk.

4.5: What is your monthly income?

(If income source is more than one please tick (√) on each of the applicable code)

Present Monthly Income (Please tick (√) on applicable code)		Source of income May be one or more (Please tick (√) on applicable code)	
Below 5000/-taka -1	>25,000/- and <30,000/- -6		
>5000/- and <10,000/- -2	>30,000/- and <35,000/- -7	Service-1	1 and 2 -5
>10,000/- and <15,000/- -3	>35,000/- and <50,000/- -8	Business-2	1 and 3 -6
>15,000/- and <20,000/- -4	>50,000/- -9	Agriculture-3	2 and 3 -7
>20,000/- and <25,000/- -5	-	Day labour-4	Others -8

Section-5: The information of dwelling, land and land use

5.1: Where is the birth place of the head of household?

Rangamati-1, Out of Rangamati-2

5.2: Why and how have you moved here?

Reason (Please tick (√) on applicable code)
Migration related to Kaptai embarkment-1, Service-2, Business-3, As a settler-4, Agricultural purpose-5, For comparatively better living-6, Buying land was available easily here-7,
Service, Business and child education-8, For the residence of relatives and friends here-9,
Not applicable-10, Others-11

5.3: When did you come here?.....Year. **How long have you been living here?**.....years.

5.4: What had been the landform before you started to live here? Forest-1, Agricultural land/Jumming land-2, Pasture Land-3, Orchard-4, I don't Know-5

5.5: Here you- Tenant-1, Own house-2,

(If answer is 2, fill 5.6 and If you are tenant then monthly house rent…….taka.)

5.6: How much land do you have?

(1 Acre = 100 Decimal = 100 Satak, 1Kani =33.5 Decimal/Satak)

Type of land	Your/Own	Father or Grandfather (Before 25/30 years ago)
Plain agri land	..... Decimal/Satak	..... Decimal/Satak
Mixed land	..... Decimal/Satak	..... Decimal/Satak
Hilly land	..... Decimal/Satak	..... Decimal/Satak
Fringe Land	..... Decimal/Satak	..... Decimal/Satak
Dwelling land	..... Decimal/Satak	..... Decimal/Satak
Total land	..... Decimal/Satak	..... Decimal/Satak

5.7: Source of ownership of land and amount (1 Acre=100 Decimal/ Satak, 1Kani =33.5 Decimal/Satak)	
(i) Inherited…...Acre…..Year (ii) Buying……...Acre…..Year (iii) Inherited & buying…...Acre……..Year (iv) From Lease……...Acre……..Year	(v) From Govt……...Acre……..Year (vi) Other…...Acre…..Year (vii) Not Applicable

5.8: Present and previous (Before 25/30 years ago) price of land

(1 Acre=100 Decimal/ Satak, 1Kani =33.5 Decimal/Satak)

Type of land	Present Price	Previous price (Before 25/30 years ago)
Plain agri land	..... tk/Per decimal/satak	..... tk/Per decimal/satak
Mixed land	..... tk/Per decimal/satak	..... tk/Per decimal/satak
Hilly land	..... tk/Per decimal/satak	..... tk/Per decimal/satak
Fringe Land	..... tk/Per decimal/satak	..... tk/Per decimal/satak
Average per decimal at Present =.....tk		Average per decimal (Before 25/30 years ago)=.....tk

About the information of the document of land

(Please tick (√) on applicable code)

5.9: Do you have any legal document of your own or dealing land? Yes-1 No-2	5.10: If the answer of 5.9, is yes then types of legal document (May be one or more) Permission of circle chief /Headman-1 Deed/ Registration of land office-2 Name enforcement -3	5.11: Do you have any rights for handover or selling of your own or dealing land? Yes-1 No-2 Don't Know-3	5.12: Do you have any rights to give occupancy right of others of your own or dealing lands to others? Yes-1 No-2	5.13: Have there any ownership or occupancy right of women member in your family? Yes-1 No-2

Don't Know-3	Will / Heba Deed-4 Applicant of Demesne-5 Lease-6 Tax receipt/ Dakhila-7 Others-8		Don't Know-3	Don't Know-3

Section-6: Information about fertilization and irrigation of land

(Only where applicable)

6.1: Do you have any agricultural land? Yes-1, Had before, not now-2, Never-3

6.2: Do you cultivate your land or get them cultivated by others?

(Please tick (√) on applicable code)

Yourself or by others-1, If not-2 , Not applicable-3

If you cultivate yourself or get them cultivated by others then fill the below table. If they are not cultivated- What is the present condition of your land? Fallow land-1, Segun Garden -2

Present		Previous (Before 25/30 years ago)	
Necessity of chemical Fertilizer	Yes-1, No-2 Not Applicable-3	Necessity of chemical Fertilizer	Yes-1, No-2 Not Applicable-3
Production: Good-1, Avarage-2, Not satisfactory-3, Not Applicable-4		Production: Good-1, Avarage-2, Not satisfactory-3, Not Applicable-4	

6.3: How many years of the fallow period of Jum land? (If applicable)

If there have Jum-1, There haven't Jum-2, Had before but not now-3

Present	Previous (Before 25/30 years ago)
……..Years	……..Years

6.4: What are the fruits of crops garden in your family?

There was before but not now-1, There was never-2, Not-applicable-3

Name of Crops	Name of Fruits and others Garden with area

6.5: Do you need to irrigate the agricultural land? Yes-1, No-2

Section-7: Environment and Disaster: (Please tick (√) on applicable code)

7.1: What kinds of disaster occure here? Landslide-1, Drought-2, Rat flood, insect and attack of wild animal-3, Over rainfall-4, Flood-5, Earthquake-6, Cyclone-7, Malaria-8.

7.2: In your opinion which is the most harmful disaster ? Landslide-1, Drought-2, Rat flood, insect and attack of wild animal-3, Over rainfall-4, Flood-5, Earthquake-6, Cyclone-7, Malaria-8.

7.3: In your opinion what are the causes and effects of the disasters?

(Please write down the applicable codes for cause and effect in table)

Name of Disaster	Causes (Only code number)	Effects (In your opinion, write down the two important effects)
Landslide		
Drought		
Over rainfall		
Rat flood, insect and attack of wild animal		
Malaria		

Causes: The disaster is the reason given by God, which was in our fate-1, Natural-2, Human made-3, Human made and Natural-4, Over ranifall-5, Cutting Hill or destroying Hill slope-6, Deforestation-7, Rapidly unplanned land use-8, Unplanned settlement-9, Over thunderstorm and its vibration-10, Unknown-11.

Effects: Economic loss-1, Environmental degradation-2**, Loss** of life and infrastructure-3, Loss of land management-4, All of the above-5, others-6.

7.4: What do you think to do for disaster reduction?

Stop cutting hill-1, Reforestation and stop deforestation-2, Planned development, land use and settlement-3, Evacuation-4, Implementation of the land use policy-5, Giving necessary allotment and taking necessary steps for the maintenance of hills and water bodies-6, All of the above-7.

7.5.1: Is your area polluted? Yes-1, No-2, I don't know-3. If yes then fill 7.5.2

7.5.2: What types of pollution occur in your locality?

Water, air and soil-1, Water-2, Air-3, Soil-4, Not applicable-5, Water & air-6

7.6: Those who have died by landslides:	**7.7:** Those who have died by landslides:	7.8: What are the main problems of your locality?
Some of them are poor-1 Most of them are poor-2 All of them are poor-3 Most of them are rich-4 All of them are rich-5 Others-6	Some of them are Bangali-1 Some of them are Tribal-2 Most of them are Bangali-3 Most of them are Tribal-4 All of them are Bangali-5 All of them are Tribal-6 Bengalis and ethnic groups are almost equal-7	Water problem-1 Road & Transport problem-2 Educational institution-3 Medical-4, Gas-5, Electricity-6, Extortion-7, Drug-8, Terrorism & insecurity-9, There is no significant problem-10, Others-11

7.9: What are the reasons of your falling in danger?	**7.10: What type of changes have you seen in the use of land for the urban development?**	**7.11: What are the reasons for the reduction of forest and agricultural land?**
Theft/Robbery-1, Terrorism/insecurity-2, Social conflict-3, Extortion-4, Landslide-5, Flood-6, Drought-7, Drug-8, No significant problem-9, Others-10.	Deforestation-1, Decreasing the land of cultivation-2, Changed Farming-3, Cutting hill-4, Embarkment-5, Others-6.	Urbanization-1, Demand for timber-2, Collection of Fuel wood-3, Population Growth-4, Shifting cultivation-5, Poverty-6, Lack of law enforcement-7, All the above-8.

7.12: In your opinion, what are the major driving forces of destructive and unplanned land use practice?	**7.13: What are the economic and social impacts of such land use?**	**7.14: What are the environmental impacts of such unplanned land use practice?**
Lack of necessary allotment of hill maintenance-1, Lack of proper administrative role-2, Lack of the application of the proper land use policy-3, Misuse of Political power-4 Hill or Land grabbing of local influential person-5, All the above-6, I don't know-7.	Agricultural and forestry resources will be reduced-1 People will change their primary profession-2, Fisheries production may be reduced-3 Disaster along with flash flood and landslide will increase-4, Production of cash crop will be reduced-5 Biodiversity will be destroyed-6, Tourism industry will be damaged-7, All the above-8, I don't know-9.	Natural resource, soil, air, water are being polluted-1, The habitat of plants and wild fauna will be damaged-2, Environmental balance is being destroyed by decreasing forest and agricultural land-3, Lake and river siltation and flood-4, Lose of Biodiversity-5, Flash flood, landslide and disaster will be increased-6, Ecosystem will be destroyed-7, Climate change-8, All the above-9, I don't know-10.

7.15: In your opinion, what are the main reasons of the rapid changes of land use pattern? (One or more codes can be ticked(√))		
Pressure of over population-1, Construction of Kaptai dam-2, Migration from plain land-3, Increasing land price -4 Development of tourism industry-5,	Rapid increase and development of urban area-6, Unplanned development-7, Building Factory-8, Increasing economic activities-9, Lack of proper application of the proper land use policy-10	Migration policy of Government-11, All of the above-12, None of the above-13, Others-14, I don't know-15.

8: Comparative analysis of present and past (Before 25/30 years ago) life style of this area**:**

(Please tick (√) on applicable code)

	Characteristics	Presently good/ Increased	Good in the past/ Decreased	Same Condition/ Unchanged	I don't know
8.1	Availability of land	1	2	3	4
8.2	Road network	1	2	3	4
8.3	Distance of the source of water	1	2	3	4
8.4	Income	1	2	3	4
8.5	Health Centers /Medical	1	2	3	4
8.6	Education/School/College/University	1	2	3	4
8.7	Bazar/Marketing	1	2	3	4
8.8	Social bondage	1	2	3	4
8.9	Social security	1	2	3	4
8.10	Other Service Center	1	2	3	4
8.11	Forest Cover	1	2	3	4
8.12	Agricultural land	1	2	3	4

Thank you for giving valuable time and information

Appendix II: Checklist for Key Informants Interview (KII)

Institute of Disaster Management and Vulnerability Studies
University of Dhaka
Socio-economic and Environmental Survey Questionnaire
(KII)

All data collected through this questionnaire are confidential and will be used for research work

Supervised by

Professor Dr. Khondoker Mokaddem Hosen, Dr. Dilara Zahid
and Professor Dr. Tarekul Islam

Subject: Socio-economic and Environmental impacts of changing land use pattern of Rangamati District

Information about Interviewee:

Name	Profession	Educational qualification	Mobile number	Signature

1. Please say something about the present and past status of Jum cultivation? And its impacts of society and environment?
2. What are the reasons for the reduction of forest and agricultural land?
3. What type of changes have you seen in the use of land for the urban development?
4. What are the main problems of your locality?
5. What kinds of disaster occure here?
6. In your opinion what are the causes and effects of the disasters?
7. What do you think to do for disaster reduction?
8. What types of pollution occur in your locality?
9. In your opinion, what are the major driving forces of destructive and unplanned land use practice?
10. What are the economic and social impacts of destructive land use?
11. What are the environmental impacts of unplanned land use practice?
12. In your opinion, what are the main reasons of the rapid changes of land use pattern?
13. Have there and conflict related to land between hilly people and migrants?

Thank you for giving valuable time and information

Appendix III: Checklist for Focus Group Discussion (FGD)

Institute of Disaster Management and Vulnerability Studies
University of Dhaka
Socio-economic and Environmental Survey Questionnaire
(Focus Group Discussion)
All data collected through this questionnaire are confidential and will be used for research work

Supervised by

Professor Dr. Khondoker Mokaddem Hosen, Dr. Dilara Zahid
and Professor Dr. Tarekul Islam

Subject: Socio-economic and Environmental impacts of changing land use pattern of Rangamati District

Information about members of Focus Group:

Serial no	Name	Profession	Educational qualification	Mobile number	Signature
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

1. Please say something about the present and past status of Jum cultivation? And its impacts of society and environment?
2. What are the reasons for the reduction of forest and agricultural land?
3. What type of changes have you seen in the use of land for the urban development?
4. What are the main problems of your locality?
5. What kinds of disaster occure here?
6. In your opinion what are the causes and effects of the disasters?
7. What do you think to do for disaster reduction?

8. What types of pollution occur in your locality?
9. In your opinion, what are the major driving forces of destructive and unplanned land use practice?
10. What are the economic and social impacts of destructive land use?
11. What are the environmental impacts of unplanned land use practice?
12. In your opinion, what are the main reasons of the rapid changes of land use pattern?
13. Have there and conflict related to land between hilly people and migrants?

Thank you for giving valuable time and information

Appendix IV: Photograph

Photograph of Agriculture

Photograph: 01
Bringal cultivation in hill valley

Photograph: 02
Vegetables cultivation in hill valley

Photograph: 03
Capsicum cultivation hill valley in Sapchari

Photograph: 04
Mango Grafting in Shapchari

Photograph: 05
Mango garden on hill slope

Photograph: 06
Malta cultivation at Shukorchari in Shapchari

Photograph of Agriculture

Photograph: 07
Plum garden after pruning
in Shapchari

Photograph: 08
Paddy seedbed on the shores of the lake
near Rangapani

Photograph: 09
Paddy cultivation on valley of hill slope

Photograph: 10
Paddy cultivation on valley of hill slope

Photograph: 11
Spices

Photograph: 12
Production of Vermi Compost
(Organic fertilizer)

Photograph of Environmental Issues

Photograph: 13
Deforestation process-1

Photograph: 14
Deforestation process-2

Photograph: 15
Timber wood processing
beside Kathaltoli

Photograph: 16
Timber wood processing

Photograph: 17
Sign of old tree beside the char land

Photograph: 18
Sign of old tree on the char land

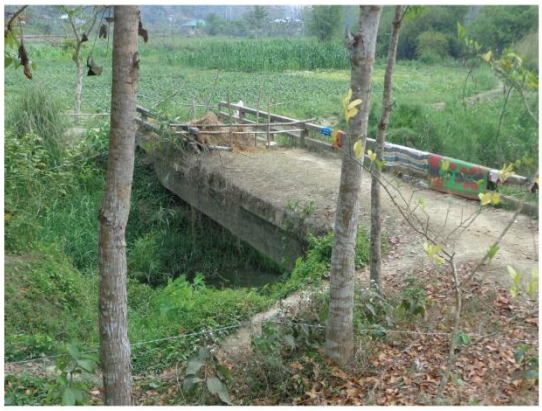
Photograph of Environmental Issues

Photograph: 19
Slus and Burn

Photograph: 20
Hill without tree

Photograph: 21
Shegun garden on hill

Photograph: 22
Manikchari Canal almost filled
(Causes of Flood)



Photograph: 23
Unplaned bridge on Manikchari canal
Which is causes of flood

Photograph: 24
Unplaned bridge cause by flood on
Manikchari

Photograph of Environmental Issues

Photograph: 25
Construction work in the lake

Photograph: 26
Dumping dust on the open space

Photograph: 27
Dust in open place

Photograph: 28
Furniture dust dumping
in the Kaptai Lake

Photograph: 29
Polluted lake behind kathaltoli

Photograph: 30
Soil erosion adjacent to housing in
Rangapani

Photograph of Environmental Issues

Photograph: 31
Vulnerable housing pattern near Public Library

Photograph: 32
Water level near fishary ghat

Photograph of Development Work

Photograph: 33
Government building on the hill

Photograph: 34
Office of the BFRI

Photograph: 35
Public Library on the top of hill

Photograph: 36
The house under construction adjacent to the lake on the side of the road in the old slum.

Photograph: 37
Three Bridge: Right one is connect Kaptai, Left one is connect Brammanpara, Straight one is connect Rangapani to Asambosti

Photograph of Focus Group Discussion (FGD)

Photograph: 38
FGD of Karbari Bari of Shapchari

Photograph: 39
FGD of Shapchari

Photograph: 40
FGD of Peda Ting Ting

Photograph of Key Informants Interview (KII)

Photograph: 41
KII of the chairman of the Rangamati Zilla Parishad

Photograph: 42
KII with mayor of Rangamati Pourashava

Photograph: 43
KII of Professor Maniklal Dewan

Photograph: 44
KII of the Principle of Rangamati Govt College

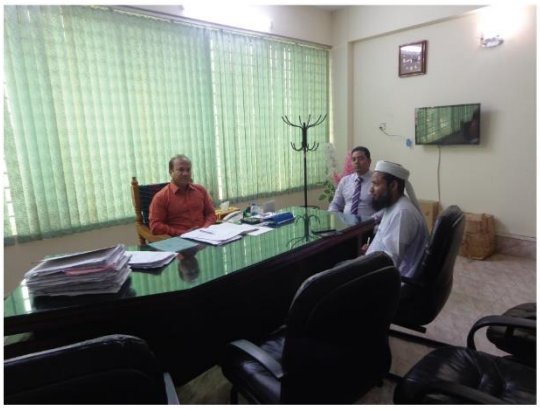
Photograph: 45
KII of the Professor of Botany of Rangamati Gov't College

Photograph: 46
KII of the Senior Citizen-1

Photograph of Key Informants Interview (KII)

Photograph: 47
KII of the Senior Citizen-2

Photograph: 48
KII of Headman of Jhagrabil Mouza



Photograph: 49
KII of CEO of Zillaparishad

Photograph: 50
KII of Senior Scientific Officer of BFRI

Photograph: 51
KII of Fire Service Officer

Photograph: 52
KII of Research officer of CHTDB

Photograph of Key Informants Interview (KII)

Photograph: 53
KII of the Administrative Officer of BFDC

Photograph: 54
KII of the secretary of Zillaparishar Chairman

Photograph: 55
KII of UNDP Officer

Photograph: 56
KII of Administrative Officer of Paurashava

Photograph: 57
KII of Town Planner Suborna Chakma (Left) & Councellor Md. Helal-Uddin

Photograph: 58
KII of assistant headman of Shapchari

Photograph of Questionnaire Survey

Photograph: 59
Survey of Assam Bosti-1

Photograph: 60
Survey of the traders of Assam Bosti

Photograph: 61
Survey of Assam Bosti-2

Photograph: 62
Survey of Assam Bosti-3

Photograph: 63
Survey of Assam Bosti-4

Photograph: 64
Survey of Bodipur, Shapchori

Photograph of Social Aspect

Photograph: 65
Hapazard & unplaned housing in urban area

Photograph: 66
House of Mud

Photograph: 67
Housing Pattern Adjacent to lake near Tabalchari

Photograph: 68
Housing Pattern of different elevation in Rangapani

Photograph: 69
Housing Pattern in hill slope

Photograph: 70
Housing Pattern of a muddy house

Photograph of Social Aspect

Photograph: 71
Housing Pattern of different elevation

Photograph: 72
Housing adjacent to Lake

Photograph: 73
Researcher infront of a headman house

Photograph: 74
Housing Pattern of Semi Pucca

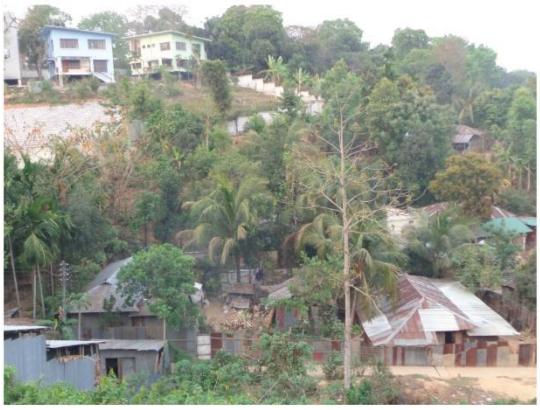
Photograph: 75
Housing Pattern of Semi Pucca & Katcha

Photograph: 76
Housing Pattern Manikchari

Photograph of Social Aspect

Photograph: 77
Diforestation around the house

Photograph: 78
Housing Pattern adjacent to lake



Photograph: 79
Housing Pattern near Public Library

Photograph: 80
Housing Pattern road side of Manikchari

Photograph of Economic Activities

Photograph: 81
Fishing in Kaptai lake

Photograph: 82
BFDC Fisharighat

Photograph: 83
BFDC Fish Processing

Photograph: 84
BFDC Fish Processing Drum

Photograph: 85
Boat of goods transportation (Fist, Fruits, Bamboo & others)

Photograph: 86
Hand Loom

Photograph of Economic Activities

Photograph: 87
Poultry farm

Photograph: 88
Turmaric processing by sun heat in Shapchari

Photograph: 89
Turmaric grading Bodipur in Shapchari

Photograph: 90
Seasonal fruits infront of Rangamati Gov't College

Photograph of Tourism Activities

Photograph: 91
Hanging Bridge, Rangamati

Photograph: 92
Peda Ting Ting

Photograph: 93
Peda Ting Ting a important tourism spot

Photograph: 94
An Isoleted Island of Puran Bosti

Photograph: 95
Some Isoleted Island near Peda Ting Ting

Photograph: 96
Boat for enjoying Lake