PREFACE

Water is one of the greatest assets under the possession of mankind. It is a source of life but when challenged, it also has ability to destroy the whole life structures. Throughout the history of mankind, floods have brought untold wealth and prosperity to civilizations. Expansion of human settlements and cultivation in the floodplains hinders free movement of flood water and thereby creating a disaster like situation.

Sub-Himalayan Alipurduar district is endowed with an intensive network of river systems. The majority of the rivers originates in the Himalayas and enters from a north to northwestern direction and flows south to southeastern direction. As many of the rivers originate at the same hill, flood often occurs simultaneously, and the rivers coalesce to form a single vast sheet of water. Deforestation via-a-vis environmental degradation in the watersheds indeed plays the decisive role in contemporary increased frequency and magnitude of flood hazards in Alipurduar district.

The entire theme of project has been organised in chapter including objectives and methodology in general, general introduction of Falakata Block causative factor of Mujnai river lastly present existing situation and ending with future possibilities with a hope.

ACKNOWLEDGEMENT

In the accomplishment of this project successfully, many people have best owned upon me their blessings and the heart pledged support, this time I am utilizing to thank all the people who have been concerned with this project.

First of all, I am highly indebted to my supervisor Mr. Pranoy Dey, Assistant Professor of Geography department, whose valuable guidance has been the ones that helped me patch this report and make it full proof success. His suggestions and his instructions have served as the major contributor towards the completion of the report.

The I would like to thank my friends and my classmates who have helped me with their valuable suggestions and guidance has been very helpful in various phases of the completion of the report.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

A flood is an overflow of water on land. Sometimes a river might receive extra water, either from heavy rains or other natural disasters. When this happens, the water overflows from its normal path in the riverbed and onto the dry land. During a flood, people should move themselves and their most precious belongings to higher ground quickly. The process of leaving homes in search of a safe place is called evacuation. Floods occur at irregular intervals and vary in size, duration and the affected area. Water naturally flows from high areas to low lying areas. This means low-lying areas may flood quickly before it begins to get to the higher ground. Floods can also occur in rivers when the flow rate exceeds the capacity of the river channel, particularly at bends or meanders in the waterway. Floods often cause damage to homes and businesses if they are in the natural flood plains of rivers. Floods are the most frequent type of natural disaster and occur when an overflow of water submerges land that is usually dry. Floods are often caused by heavy rainfall, rapid snowmelt or a storm surge from a tropical cyclone or tsunami in coastal areas.

Floods can cause widespread devastation, resulting in loss of life and damages to personal property and critical public health infrastructure. Between 1998-2017, floods affected more than 2 billion people worldwide. People who live in floodplains or non-resistant buildings, or lack warning systems and awareness of flooding hazard, are most vulnerable to floods.

1. Flash floods are caused by rapid and excessive rainfall that raises water heights quickly, and rivers, streams, channels or roads may be overtaken.
2. River floods are caused when consistent rain or snow melt forces a river to exceed capacity.
3. Coastal floods are caused by storm surges associated with tropical cyclones and tsunami.

Between 80-90% of all documented disasters from natural hazards during the past 10 years have resulted from floods, droughts, tropical cyclones, heat waves and severe storms. Floods are also increasing in frequency and intensity, and the frequency and intensity of extreme precipitation is expected to continue to increase due to climate change. Flood in any particular area can be predicted by the flood probability analysis. The probability of flood event has analysed through the nature of flood level cross by the river.

Flood occurrences at Mujnai River in Alipurduar district can be seen from the early history. Falakata is an administrative block of Alipurduar in Indian state of West Bengal. There are various rivers in the block like Torsha , Raidak , Kaljani , Sankosh , Gadadhar etc. Danger level of Mujnai is 80.20 ft. It is a trans-boundary river with a length of 62.45 km that originates from the Hantapara.The meandering tendency of the river Mujnai has resulted inverse erosion in river bank, forming low laying shoals on opposite bank. The river bank erosion due to meandering is one of the major problems in the Mujnai basin. The meandering nature of Mujnai river often allow to flow along the concave banks and thereby invites large scale banks failure devastating arable land, villages, infrastructures such as bridges, railway line, roads, buildings.

1.2 Objectives

1. To look into the causes and effect on Mujnai river flood.
2. To study the evolution and characteristics of Mujnai basin and its role in flood in nearby areas.
3. Discuss the amount of intensity of rainfall and its effects on flood.
4. Identify the vulnerable areas.

1.3 Methodology of the study

Four steps have been taken to accomplish the survey:

- ❖ First step (pre field work): After selecting the study area, the required maps are prepared and a questionnaire was prepared for the perception study to know about the damage and cause by the flood in the study area.
- ❖ Second step (field work): Collection of primary data through the questionnaire from random sampling implemented by interviews.
- ❖ Third step (field work): Collection of secondary data from various govt. Offices.
- ❖ Fourth step (post field work): Analysis of data and map have been completed, correlated evaluated spatial pattern and characteristics of existing situation and condition have been represented by different cartographic techniques and interpretation have been made on the complete work.

1.4. Data Sources:

The project report is about the flood condition in the villages around Mujnai River. For collecting the data, surveyed the different areas of Mujnai River. Various secondary data about the overview of the study area, flood damage,various climatic and river parameters and various flood management programmes are collected from the govt offices. Also, I have taken the help from internet, journals & different books.

1.5. Processing of Data:

After the entire work of survey, the data have been processed, tabulated and analysed and interpreted supported by suitable diagrammatic representation.

1.6 Analysis of Data:

Different types of questions are prepared to designs a proper questionnaire for the flood condition in the villages around Mujnai River after collecting various data from door-to-door survey, the data are classified on the basis of the questions. And then they are tabulated in various tables for doing the survey. As here random sampling method is used to collecting the data therefore most of the collected data are primary data through interviews of the local people and also some of secondary data from various offices.

1.7. Data Presentation:

All the collected data have been presented through different tables and charts with their respective percentage distribution. And the tables and charts are explained by various suitable diagrams and maps. And also, to explain the flood condition in the villages around Mujnai River some photographic evidences are given to interpret the conditions very easily. Last but far from least a master chart is given to describe the whole primary data which are collected at a time of the survey work.

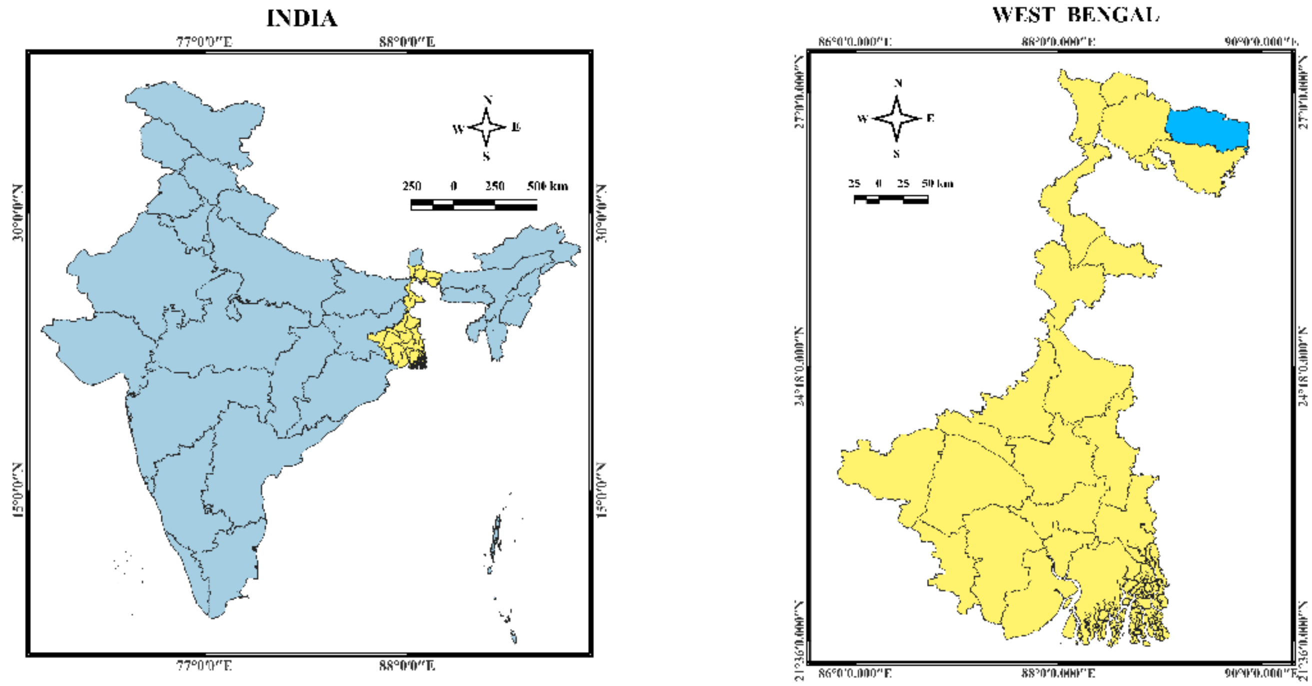
1.8. Data Base

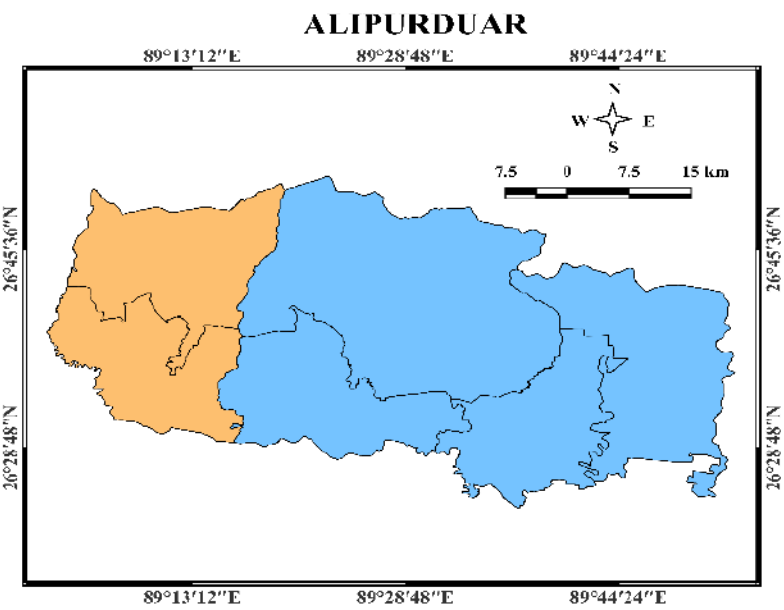
The scheme for data collection has been carried out in two stages. Firstly, different relevant data has been collected from primary source i.e., from direct measurement at the field. Secondary data will he collected from different organizations. Primary data will he collected from field surveys. Mainly questionnaire surveys will he initiated in the flood-affected areas to assess the cost of flood hazard. Secondary data will be collected from Disaster Management Office of Alipurduar, Irrigation and waterways department books, newspapers, google and other web sites.

1.9. Location of the Study Area

Mujnai basin area has been chosen as a study area, which is under Falakata Block, in Alipurduar district. The district is bounded on the Bhutan, Darjeeling, on the south by and Coochbehar and the east by eastern Dooars. The latitudinal location of Falakata block is 26º29’00’’N to 26 º43’00’’N and the longitudinal location of Falakata block is 89º02’24’’E to 89º16’48’’E.

LOCATION MAP OF THE STUDY AREA





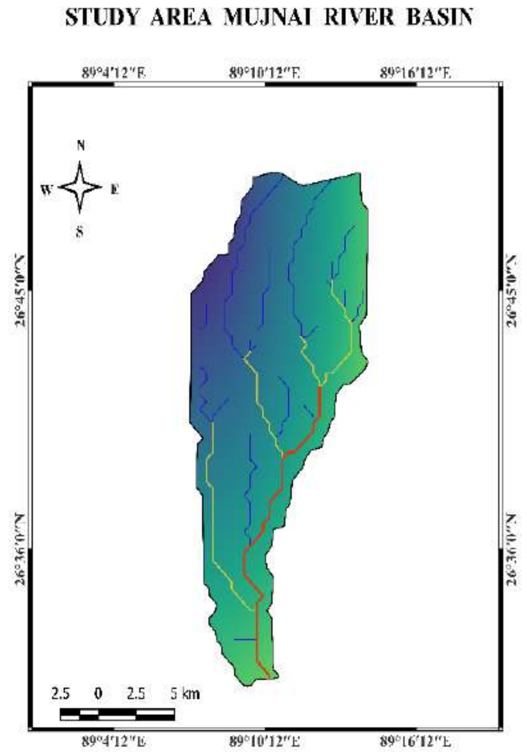


Fig1.1 Location Map of Study Area

CHAPTER - 2

GEOGRAPHICAL BACKGROUND OF ALIPURDUAR DISTRICT

2.1 Introduction

Mujnai regards the geographical area of Dooars. So, here physiographical all the characteristics of Tarai region are found. The elevation of Falakata from main sea level is BM88 metre. This block is under Alipurduar District which is a district of North Bengal covering an area of 3383 km^2. The district was established in 2014. Alipurduar has the special importance in respect of tourism, forest, hills, tea garden, scenic beauty and wide variety of tribes. Presently Alipurduar is the part of West Bengal and shares international border with Bhutan and district border with Jalpaiguri and Cooch Behar.

2.2 Administrative set up

The administrative set up of Alipurduar District consists of one sub-division i.e. Alipurduar with District headquarter at Alipurduar municipal town which has 7 police stations under this jurisdiction. There are 6 CD blocks (Falakata-Madarihat, Falakata, Kalchini, Kumargram, Alipurduar-I and Alipurduar-II) or panchayat samities and 2 municipalities (Alipurduar and Falakata) in the District where 3 blocks and 1 municipality belongs to Alipurduar sub-division, other 3 blocks and 1 municipality in proposed Falakata sub-division. But according to the forest administration there are three forest divisions fallen in this District and these are Alipurduar forest division, Alipurduar forest division and Coochehar forest division.

Table 2.1 The Administrative particulars of Alipurduar District.

Geographical area (sq. km)	**2526.30 sq. km**
Geographical location	Between 26°23'11" and 26°52'30" North latitudes and 89°02'30" and 89°53'07" East longitudes
District headquarter	Alipurduar
Parliamentary constituency	1
Assembly area	1
Sub-Division	1
Blocks	6
Panchayat samities	6

Gram panchayat	66
Gram samsad	902
Municipality	2
Mouza's	340
Police Station	7
Police outpost	3
Inhabited villages	338
Forest villages	39

Source: District planning & Development office, DM, Alipurduar,2018

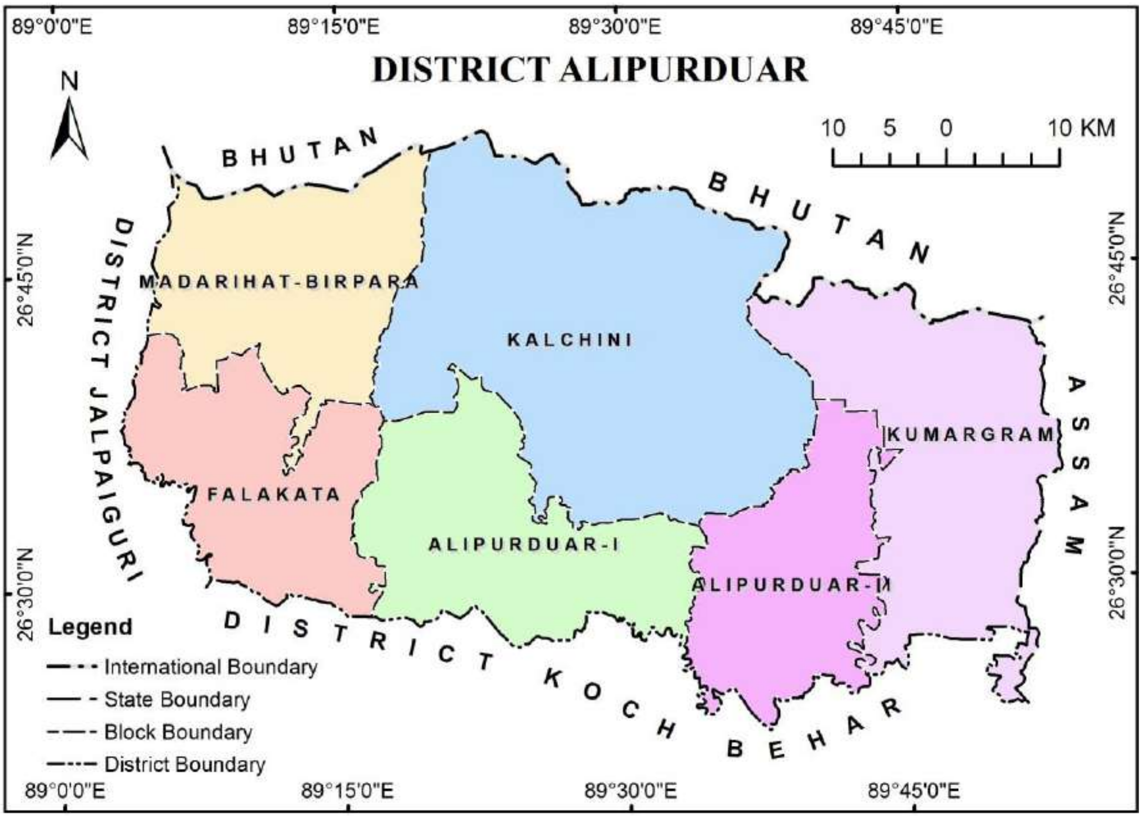


Figure 2.1 Alipurduar District (Block-wise).

2.3 Relief

The surface of the District is wavy plain at the foot of the Eastern Himalayas where slope gradually declines from north to south. The District covers entire 'duars' which means doors to the Bhutan/ or mountain (Grunning, 1911). It refers to the area at the immediate foot of the Bhutan hills and the tract forms a very irregular belt, scantily clothed and intersected by innumerable rivulets from the Bhutan hills. A rough plain part from north to south resembles it as a gigantic staircase running step by step down from the lofty Eastern Himalayas to the south of the District. The formation and geological development of 'Duars' have been summarized by Dr. B. Banerjee in 'Morphological Regions of West Bengal,' in Geographical Review of India, vol. 26, as follows-'There is another type of plain lying at the foot hill of the Himalayas. This is the typical piedmont plain or the alluvial fan surface of the Himalayan foot hills. This tract is known as the Duars, the general elevation of which is over 250 feet'. A major parts of this plain is built up of debris washed down from the Himalayan slopes. The immense loads of materials carried down by the rivers are gathered as soon as the streams get down to the plain region. The erosion and deposition is occurred repeatedly every year. A general southerly slope of 2 to 3 feet per mile is characteristics feature of the landscape where the rivers came down from the hill; huge number of semi-circular fans also formed by the deposition of boulders and coarse sandy soil particles.

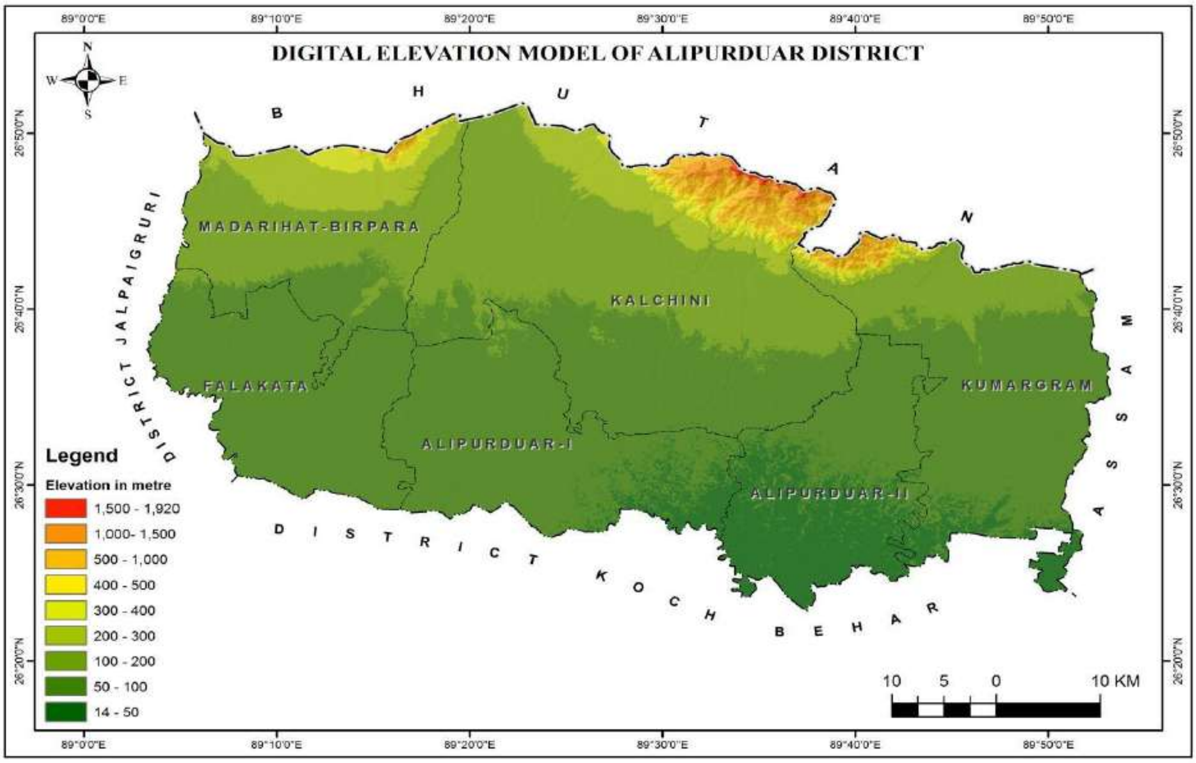


Figure 2.2 Digital elevation model (DEM) of Alipurduar District.

2.4 Drainage

The forest area is intercepted by many rivers, streams and jhoras of varying sizes which normally originate in the hills of the Bhutan and flow southwards. They rise and fall with great rapidity and frequently change their course which causing damage of forest. Drainage system is one of the important components of the physical environment which affects the agriculture directly and indirectly (Chauhan, 1987). The principal rivers that flow through this District are Sankosh, Rydak, Phaskhawa, Jayanti, Bala, Dima, Mujnai, Pana and Gaburbasra. The rivers become full and fierce with torrents in the rainy season (July to September) but are shallow and tame in the dry season (December to April).

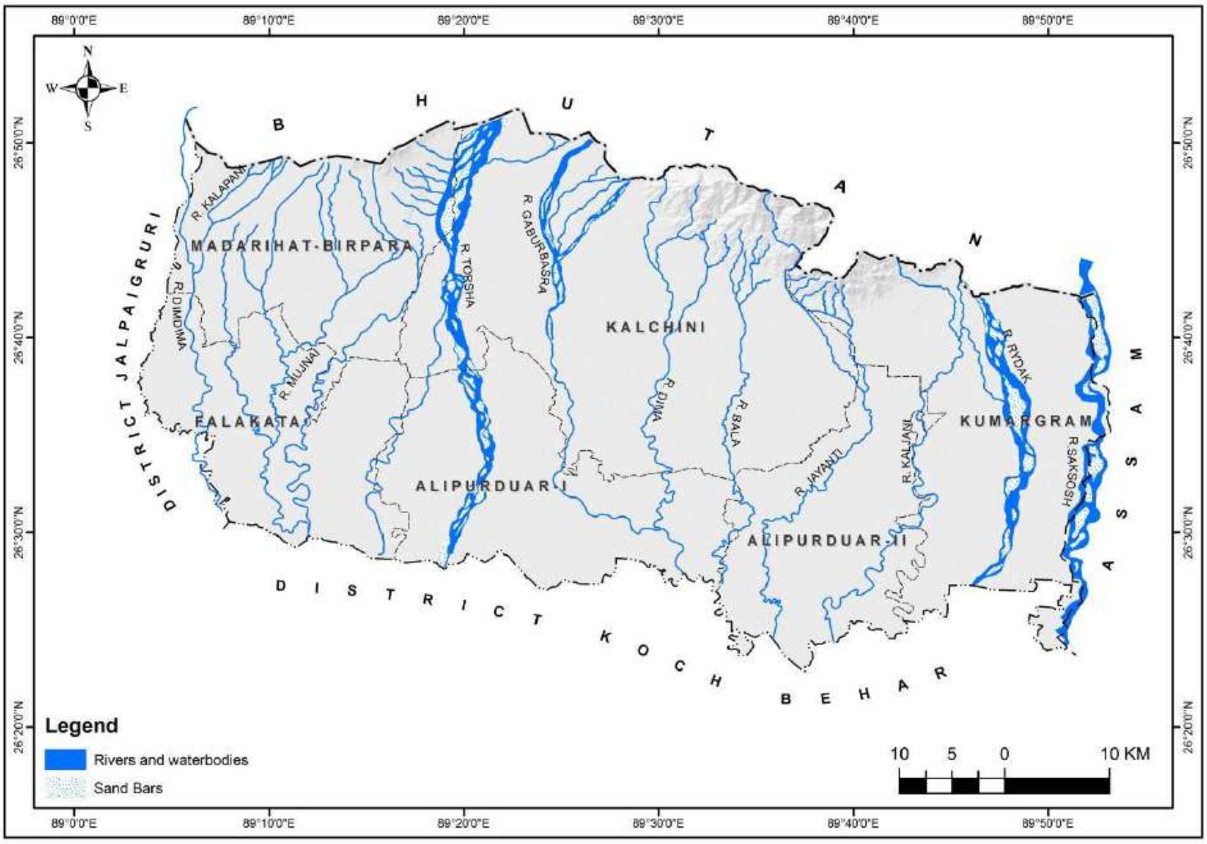


Figure 2.3 Rivers in Alipurduar District.

2.5 Climatic characteristics

The seasons in Alipurduar District follow the course of those of other Districts in the plains but, owing to its proximity to the Bhutan hills, the rainfall is much heavier and the temperature is rarely excessive. Oppressive heat, high humidity and heavy precipitation are the principal characteristics of the climate of this District.

2.5.1 Seasons

The Alipurduar District experiences five dominant seasons with altitudinal variations both in duration and extent. The important seasons are as follows:

i. Summer season (May to June)

ii. Rainy season (July to September)

iii. Autumn season (October to November)

iv. Winter season (December to February)

v. Spring season (March to April)

The summer is tropical and hot, rainy season is severe with high amount of rainfall and sometimes flood occurs due to sudden heavy rain in the Bhutan hill. The autumn is experienced for a very short period. The sky remains clear in this season and temperature is mild and gradually decreases. This is a favorite season for inhabitants and within this period several festivals are celebrated them. The winter season is again severe and coldly. A short period of spring season also developed after ending of winter where temperature again gradually increases.

2.5.2 Temperature

Temperature is lowest in January; by April the temperature rises and it gradually increases till it reaches its highest point in July and August in 2018 (table 2.2). The mean minimum temperature is lowest in January which is recorded 12^{o}c in 2018 and the mean maximum temperature is highest in May which is recorded 33^{0}c in 2018 (table 2.3). At Buxa-Jainty hill forests and other forests of the District the climate is somewhat exceptional; the rainfall is heavier and even in the hottest weather fans are not used and blankets are necessary at midnight. The north of the region is generally cooler than southern plains area.

Table 2.2 Maximum and Minimum Temperature (^{o}C) by month in the District of Alipurduar.

Month	2014		2015		2016		2017		2018	
	Maxi	Mini	Maxi	Mini	Maxi	Mini	Maxi	Mini	Maxi	Mini
January	27	9	27	11	28	9	28	8	27	9
February	31	9	32	12	30	12	28	10	28	9

March	37	16	34	16	35	15	35	13	33	15
April	35	19	34	17	37	17	36	18	35	17
May	37	20	35	20	37	20	37	20	36	20
June	37	23	37	21	36	23	28	22	36	23
July	35	23	37	23	36	23	36	23	36	23
August	37	24	36	23	37	23	38	23	37	23
September	35	23	37	23	36	21	36	23	36	22
October	35	18	34	17	35	17	35	20	35	18
November	33	14	33	14	33	13	32	14	33	13
December	31	8	29	10	29	11	29	10	31	12
Average	**34.17**	**17.17**	**33.75**	**17.25**	**34.08**	**17**	**33.17**	**17**	**33.58**	**17**

Source: India Meteorological Department, Govt. of India (2018) & District Statistical Handbook, Alipurduar District.

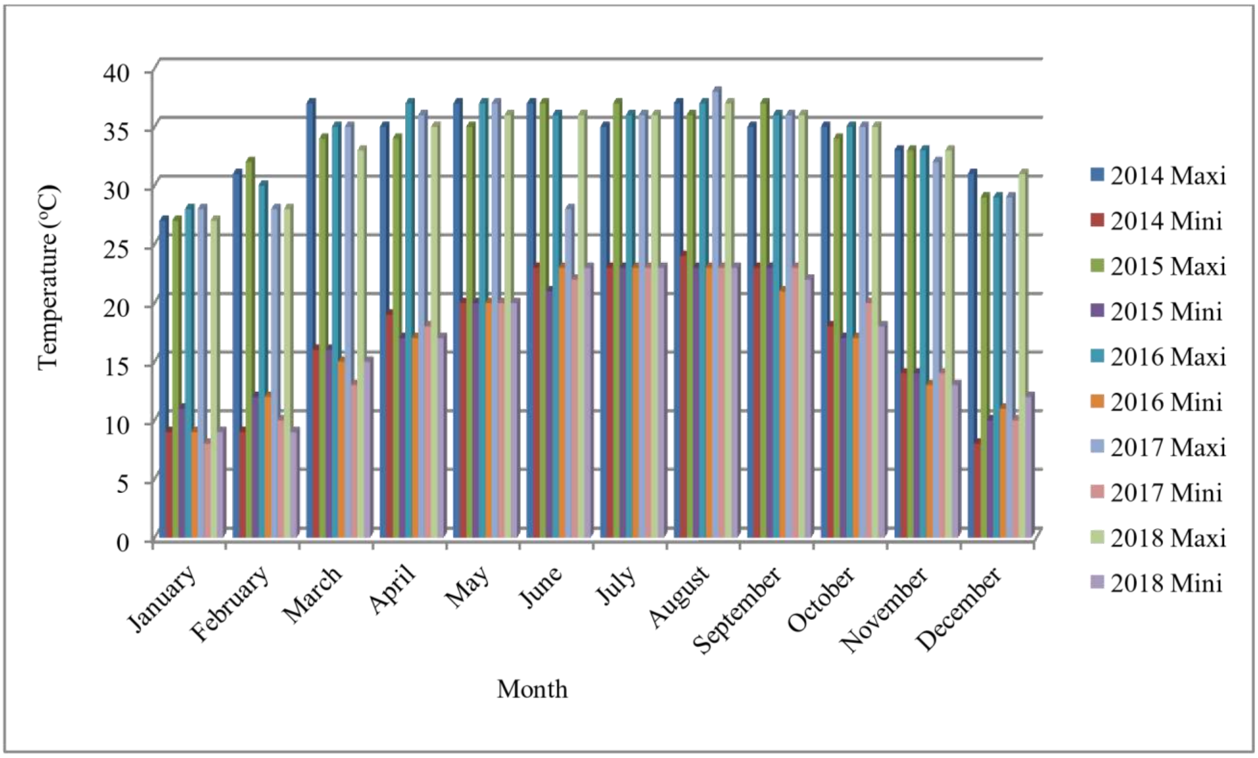


Figure 2.4 Maximum and Minimum Temperature (°C) from 2014-18 (Ref. table 2.2)

Table 2.3 Mean Maximum and Mean Minimum Temperature (ºC) by Month in the district of Alipurduar

Month	2014		2015		2016		2017		2018	
	Maxi	Mini	Maxi	Mini	Maxi	Mini	Maxi	Mini	Maxi	Mini
January	23	12	24	12	24	12	23	11	23	12
February	27	14	27	15	29	16	24	14	24	12
March	31	20	30	18	31	17	30	17	29	19
April	30	21	32	21	32	21	31	21	32	21
May	32	23	31	23	33	23	34	24	33	23
June	32	25	33	24	32	25	32	25	32	25
July	31	25	32	25	33	25	32	25	32	25
August	34	26	32	25	34	25	33	25	32	25
September	32	25	34	25	32	24	32	25	33	25
October	31	22	30	21	32	21	32	23	32	22
November	30	16	30	16	28	17	31	18	30	16
December	27	14	28	13	26	13	26	13	26	15
Average	**30**	**20.25**	**30.25**	**19.83**	**30.50**	**19.92**	**30**	**20.08**	**29.83**	**20**

Source: India Meteorological Department, Govt. of India (2018) & District Statistical Handbook, Alipurduar District.

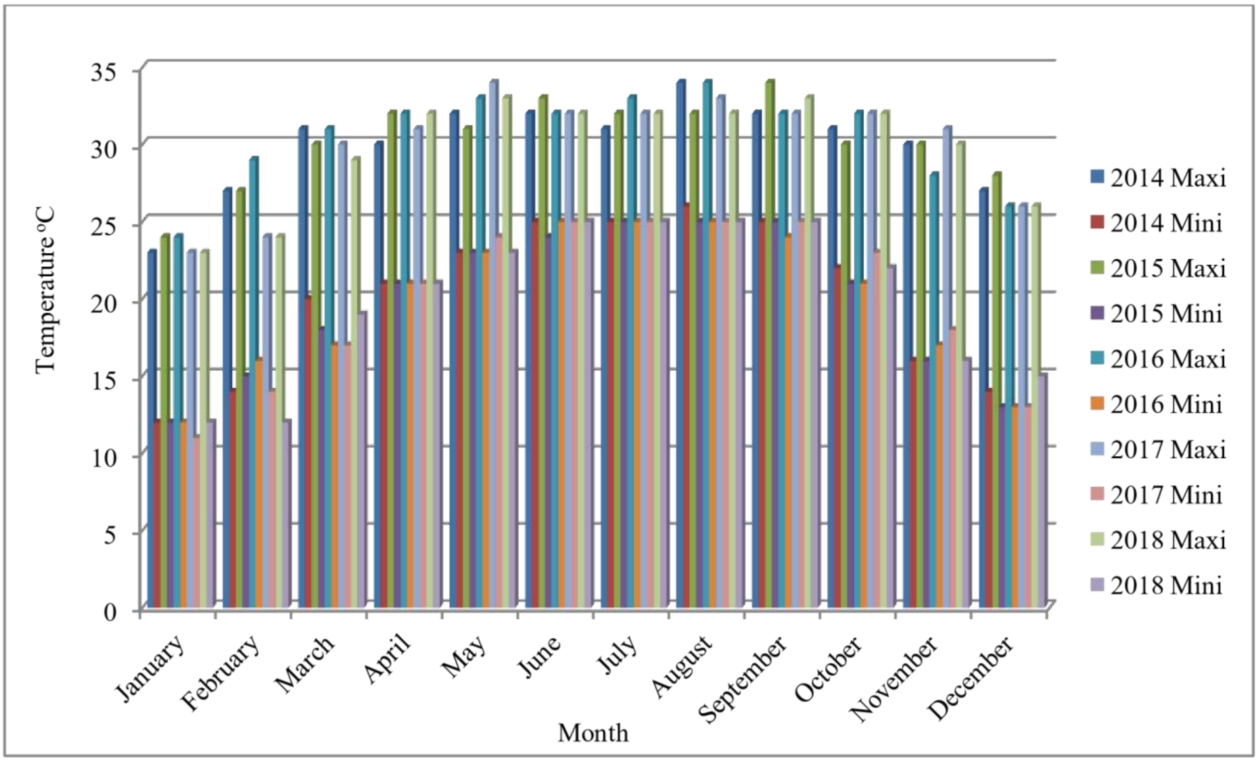


Figure 2.5 Mean Maximum and Mean Minimum Temperature (ºC) by Month from 2014-18 (Ref. table 2.3).

2.5.3 Rainfall

The rainfall is the single dominant weather parameter that affects plant growth, plant production, location of farming system and farmers selection of crops. Failures of rains or excessive of rainfall in a short period have brought repeated crop failures (Vyas, 1994). The heaviest rainfall in this District is at the foot of the Bhutan hills, and the lowest in the south on the plain of Falakata, Alipurduar. November, December, and January are the driest month although in these months rainfall sometimes occurred due to western disturbance. In consequence of this heavy rain and widespread rainfall the area never dried up and is always green and the growth of vegetation is most luxuriant.

The rainfall is lightest in the cold weather months, but more in April and increases considerably in between May to October in every year. From June to September the monsoon wind flow north-east wards and is deflected towards in North Bengal which is responsible for heavy rain. During this period the rainfall at this area is 1195 mm in July which was highest recorded in 2018, 1109 mm in August, 597 mm in June, 273 mm in September, 167 mm in May (table 2.4). The lowest recorded rainfall was 9 mm in February of 2018.

Table 2.4 Monthly Rainfalls (mm) of the District Alipurduar.

Months	Actual					Normal
	2014	**2015**	**2016**	**2017**	**20108**	
January	15	17	0	0	12	9
February	8	5	7	63	9	17
March	35	132	17	45	49	54
April	208	207	98	201	132	172
May	416	230	404	222	167	305
June	647	438	625	511	597	606
July	1307	782	760	946	1195	989
August	436	648	242	717	1109	600
September	668	254	637	701	273	461
October	171	353	201	82	72	224
November	9	7	15	0	73	23
December	4	0	11	0	0	5
Total	**3924**	**3073**	**3017**	**3488**	**3688**	**3465**

Source: India Meteorological Department, Govt. of India (2018) & District Statistical Handbook, Alipurduar District.

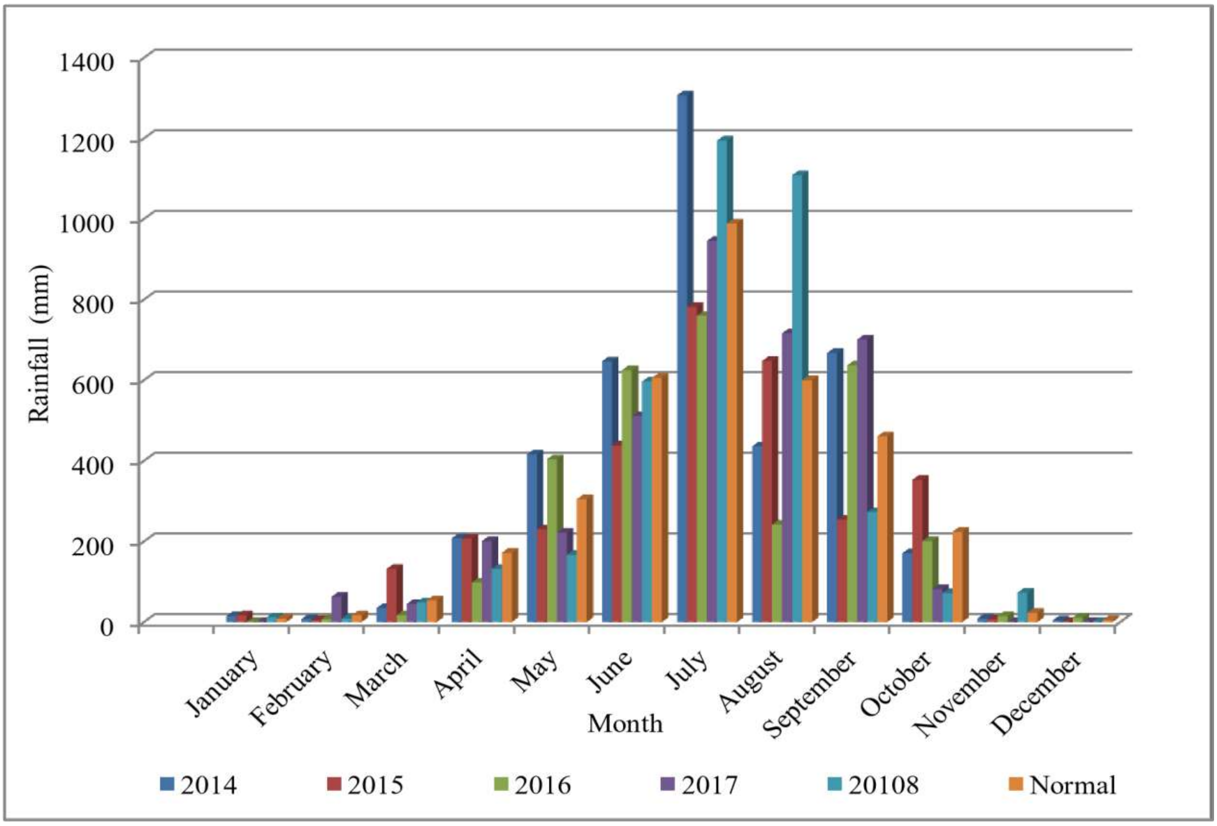


Figure 2.6 Monthly Rainfall (mm) from 2015-18. (Ref. table 2.4)

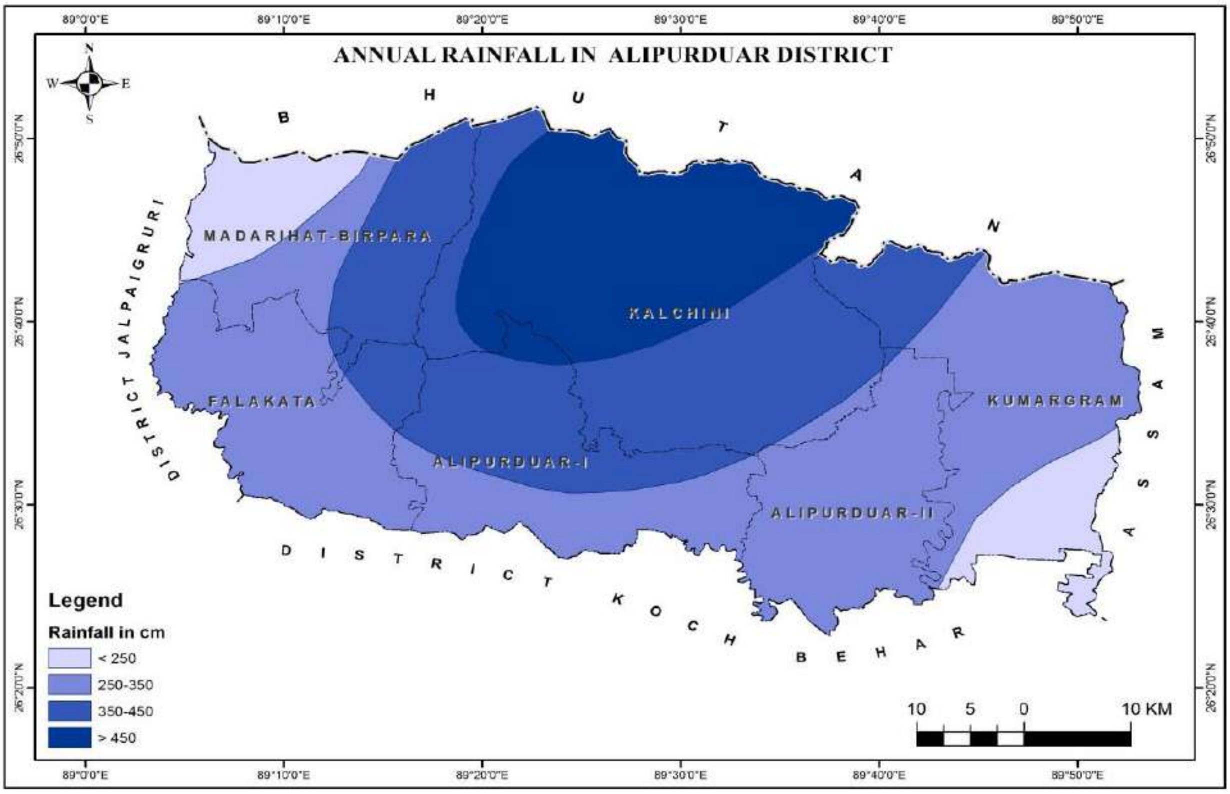


Figure 2.7 Annual Rainfall zones, 2018

2.6 Soil and Rock

The greater part of the district is covered with alluvium ranging from pure sandy to clay. Over most of the area the soil is sandy loam but in the river basin areas such as the Torsa, Raydak, Kaljani, Dima, Pana and Sankosh it is bard, black, and clay (Das, 2000); excellent bricks and earthenware can be made in this part of the soil and the land furnishes good pasture and fine crops of paddy, wheat, and tobacco. In the north of the district the soil is ferruginous clay and is particularly well suited to the growth of the tea plants. The district contains numerous old river beds which have been deserted by the streams which used to flow along them; near the hills they are strewn with stone and boulders, lower down they contain gravel, and in the pains sand. These deserted river-beds are unprofitable wastes, of little use to anyone. The north of the hill portion are composed of a series of beds, which consists of variegated slates, quartzite and dolomites, and are fringed on the south by low hills of upper tertiary strata. Limestone occurs in considerable amount in the Buxa hills and masses of calcareous tufa are found along their base (Grunning, 1911). Copper are occurs in greenish slate with quartzite layers to the west of Buxa.

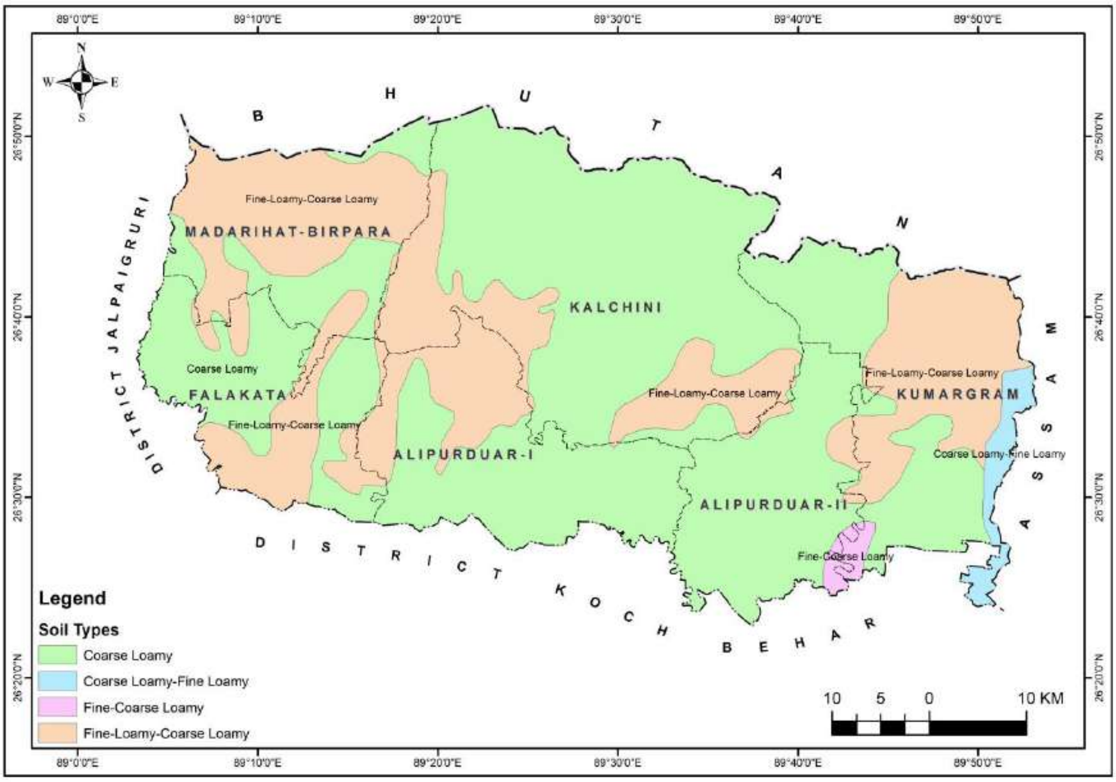


Figure 2.8 Soil map of Alipurduar District.

Source: NBSS & LUP, Regional Centre, Kolkata.

2.7 Vegetation

A major part of Alipurduar District is covered by forests. Even today this area remains one of the most prominent wildlife areas of the country and bears the best sal, teak and other forest in India. The main forest cover comprises of semi-moist-deciduous vegetation. Apart from this high rise forest, there are floodplains of rivers like Kaljani, Pana, Torsa etc. covered with grasslands which nourish a wide spectrum of wildlife. The forests of this region are home to many rare and endangered species of mammals and birds. The Indian one horned rhinoceros is found in Jaldapara National Park. Near extinct species like the hispid hare, pygmy hog, floricanan endangered bird have been reported from the Jaldapara National Park and Buxa Jayanti Forest. Apart from this species like tiger, leopard, Asian elephant, gaur, wild boar, sambar, cheetah, hog deer, barking deer are also found in the various forest tracts of Alipurduar. A number of divisions of Forest Department of Govt. of West Bengal are working over this area. Forests like Jaldapara, Buxa Jayanti are declared as sanctuaries and national park to protect wildlife. The forests of this area extend from south of the plains to north of the Duars regions of the Bhutan hills and is located in the flood plains of different main hill rivers and other medium and small rivers and rivulets which have created a pocket of grass land. Apart from national parks and sanctuaries a significant small forests area of this District is covered by forest such as Dalgaon, Titi-Rehti, Dhumpara, Bhakla, Raidak, Sankosh forest etc. Some where it has such a luxurious growth that even the sun light finds it difficult to reach the surface of land. The forest of this district are predominately sal (Shorea robusta) with associates viz., schima wallichii, michelia champaca and chukrasia tabularis (State Forest Report, 2012-2013).

The forest of the District may be classified into the following main types:

i. Riverine forests
ii. ii. Plains forests
iii. iii. Hill forests
iv. iv. Savannah forests

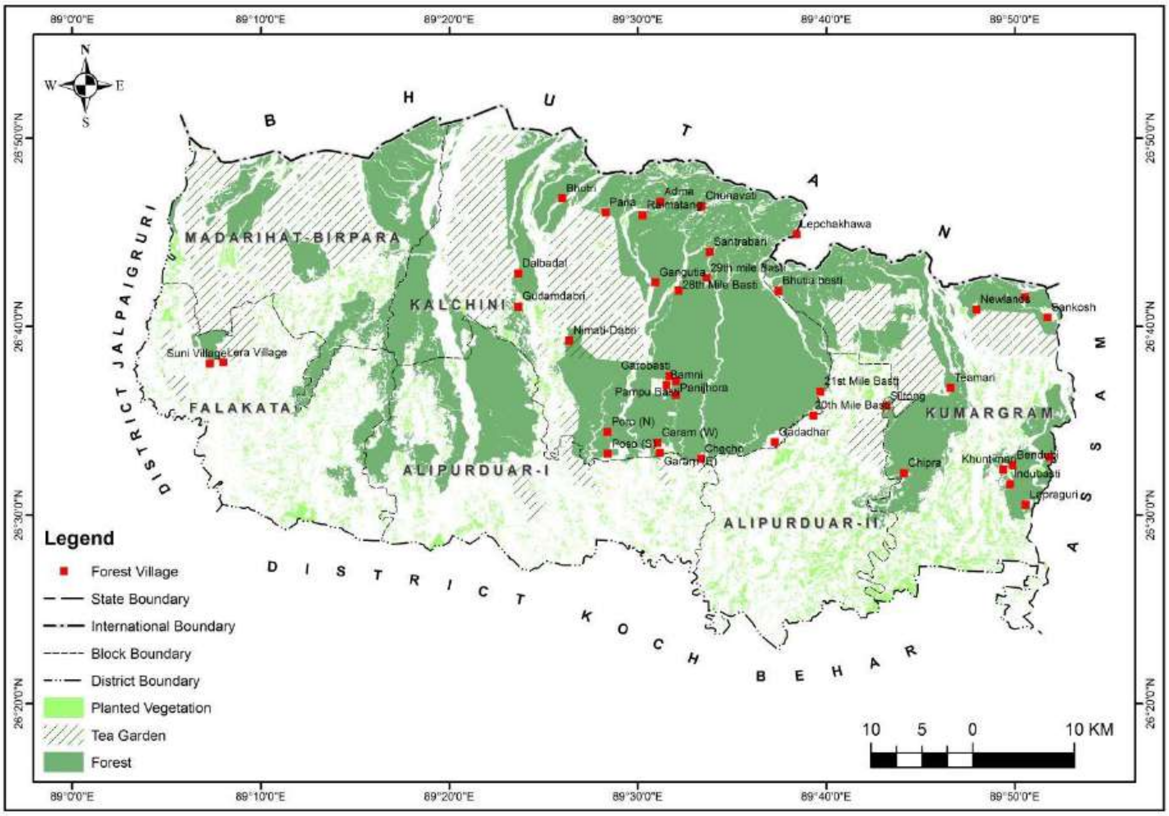


Figure 2.9 Vegetation cover and tea gardens of Alipurduar District.

The riverine forests are of mixed type, main trees are khair (acacia catechu), sissoo (dalbergia sissoo), premna species, salmalia malabarica, albizzzia species, and gmelina arborea etc. Besides bauhinia, wrightia tomentosa, toona ciliate and grewia species are found in the riverine forests areas (Roy, 1961). At some places odal and sidha are found in good proportion.

The plains forests are semal, khair, asathwa (ficus religios), neem (melia azadirachta), amlaki (phyllanthus emblica), radha chura (poinciana regia), debdaru (polyalthia longifolia), guava (psideim guyava), Arjuna (terminalia Arjuna), hartaki (terminalia Arjuna) etc.

Close to the streams and moist pockets occurs a type of evergreen forests known as tropical evergreen forests, typical trees of which are aesculus assamica, Eugenia Formosa, dillenia indica, castanopsis species, talauma hodgsoni, pinanga gracilis, and myristica species (Forest survey of India, Eastern Zone, Calcutta, 1999).

The hill forests of this District include some important species of toona ciliate, castanopsis specia, acrocarpus fraxinifolius, durabanga sonneratioides and ailanthus grandis and mours laevigata. These are sporadic in nature.

Savannah forests are covered small area in the district. Common savannah forests species of grasses that are found include the saccharum species, erianthus species, imperata cylindrical, phragmites karka, and arundo donax and neyraudia reynaudiana. Apart from these, numerous other species are surrounded by thickets of trees and shrubs, partly planted and partly of spontaneous growth, in which mango, jack, papal and tamarind trees frequently occur; bamboos thrive luxuriantly and the numerous clumps of these form a conspicuous feature in the landscape and add greatly to its beauty (Grunning, 1911).

CHAPTER - 3

MORPHOMETRIC ANALYSIS OF MUJNAI RIVER BASIN

3.1 Introduction

This chapter has attempted to share the extent of variation in landforms contrasts & their magnitudes of the Mujnai basin by adopting advanced techniques of fluvial Geomorphology. The quantitative study of form characteristics of the earth's surface and any landform unit is referred to as morphometric analysis. This is the most commonly used technique in basin analysis, as morphometry forms an appropriate areal unit for the interpretation and analysis of fluvial-originated landforms, demonstrating open systems of action. The quantitative makeup of a drainage basin's stream system is expressed as stream order, drainage density, bifurcation ratio, and stream length ratio (Horton, 1945). It includes a quantitative examination of the many components such as stream segments, basin length, basin parameters, basin area, height, volume, slope, and land profiles that reveal the nature of the basin's growth.

Mujnai river catchment are the sub basins of Torsa River Basin and It has been delineated from Hydrosheds .1n general the entire 4th order sub basins are selected for the morphometric analysis in following heads:

Here variations of profiles and curves have been presented from the analysis of landform development & drainage basin dynamics. The basin has been suitably divided into grids of 2cm each for preparing maps of various Morphometric attributes.

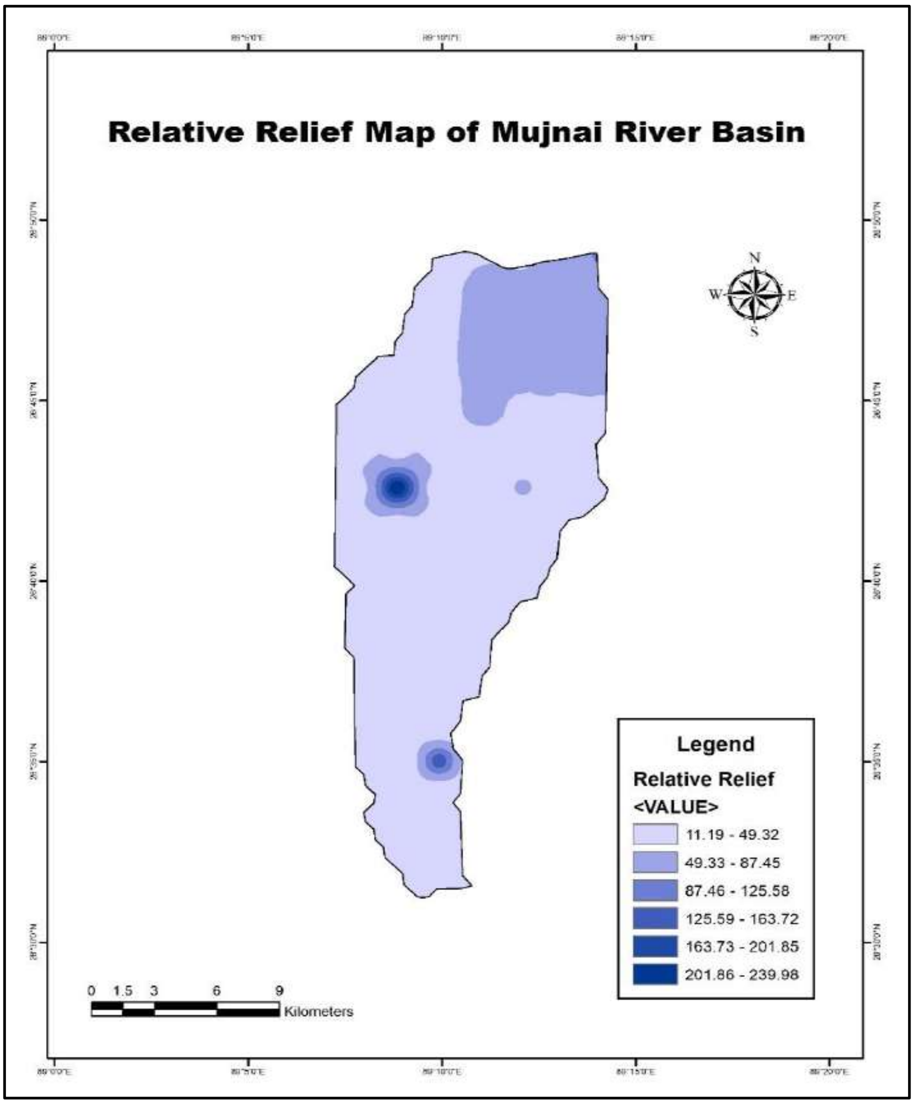
Table 3.1: Method of Calculating Morphometric Parameters of Drainage Basin

Morphometric Parameters	**Methods/ Formulae**	**Author**	**Year**
Relative relief (RR)	(Highest — lowest) elevation	G.H Smith	1935
Absolute Relief (AR)	Highest Elevation	G.H. Smith	1935
Dissection index (DI)	Relative relief/ Absolute height	Dovnir	1957

Average Slope	Slope angle = tan+ = average no. of contour crossing /unit area* contour interval/constant (636.6 for km grid map)	C.K Wentworth	1930
Stream order (Nu)	Hierarchical order	A.N Strahler	1952
Stream length (Lu)	Length of the stream	R.E Horton	1945
Drainage density (Dd)	Dd=L/A; where, L= total length of the stream; A=area drained	R.E Horton	1945
Stream frequency (Fs)	Fs=N/A where, N=total no. of stream; A = area drained	R.E Horton	1932

3.2 Relative Relief

Melton (1957) coined the word. It is obtained in the current study region through a visual examination of the digital elevation model created from SRTM data. The difference between the highest and lowest points in a unit area is defined as relative relief, often known as 'amplitude of accessible relief' or "local relief. " It is a critical morphometric variable that is used to measure the general morphological properties of terrain and the degree of dissection. Here maximum height difference in each grid of I sq. km. of 78B/[16] toposheet of G.S.I has been used as the control for plotting of isopleths, to show varying relative relief of the basin. On the basis of above mention method, a relative relief map has been prepared.



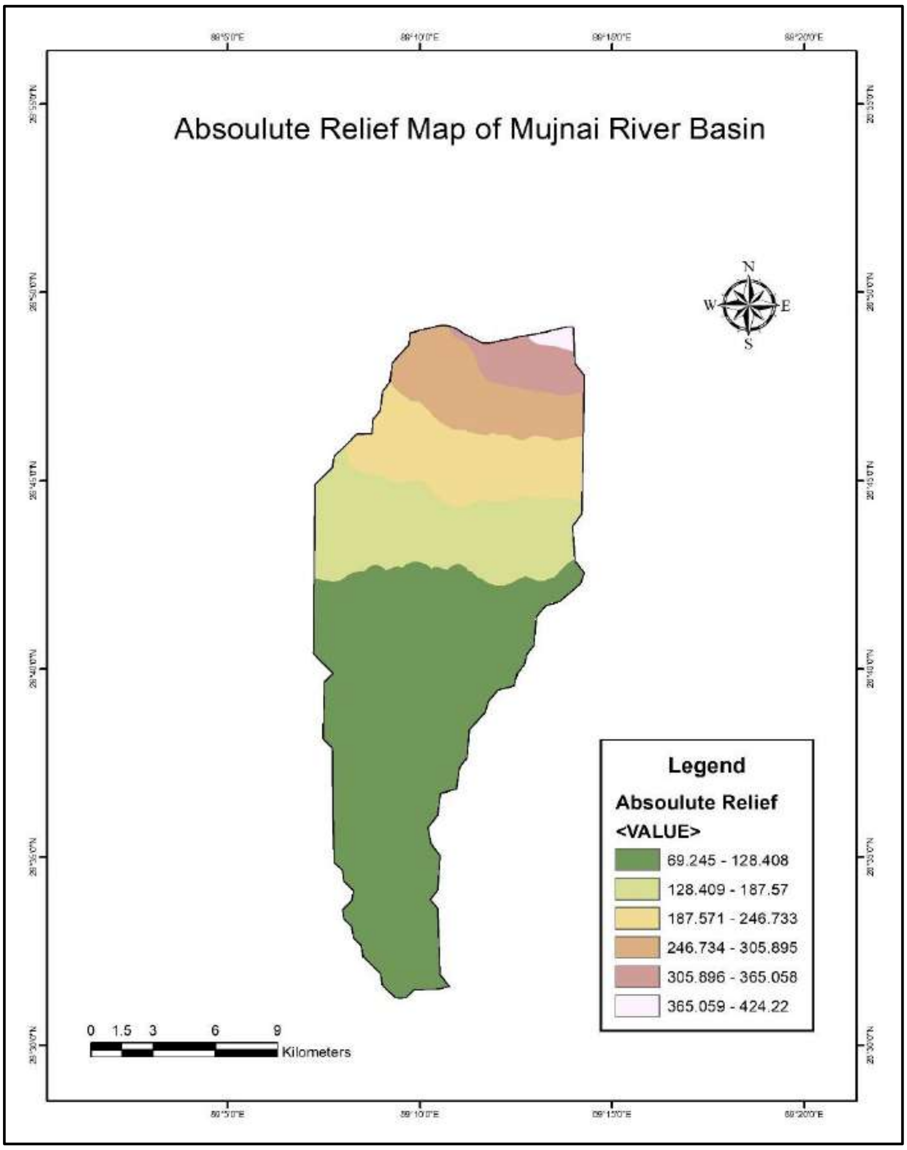
Map No.3.1: Relative Relief Map of Mujnai River Basin

Source – SRTM,Dem

From the table it is clearly understood that the region of Mujnai Basin vary between <100m to >400m. The southern part of the study area has lowest value means foot hill region where central, western and most of the northern part is under hilly region. High relief is found in the central part 7 western part of the map.

3.3Absolute Relief

It is obtained in the current study region through a visual examination of the digital elevation model created from SRTM data. The highest points in a unit area is defined as absoulute relief, often known as 'amplitude of accessible relief' or "local relief. " It is a critical morphometric variable that is used to measure the general morphological properties of terrain.



Map No.3.2: Absolute Relief Map of Mujnai River Basin

Source – SRTM,Dem

3.4 Dissection Index

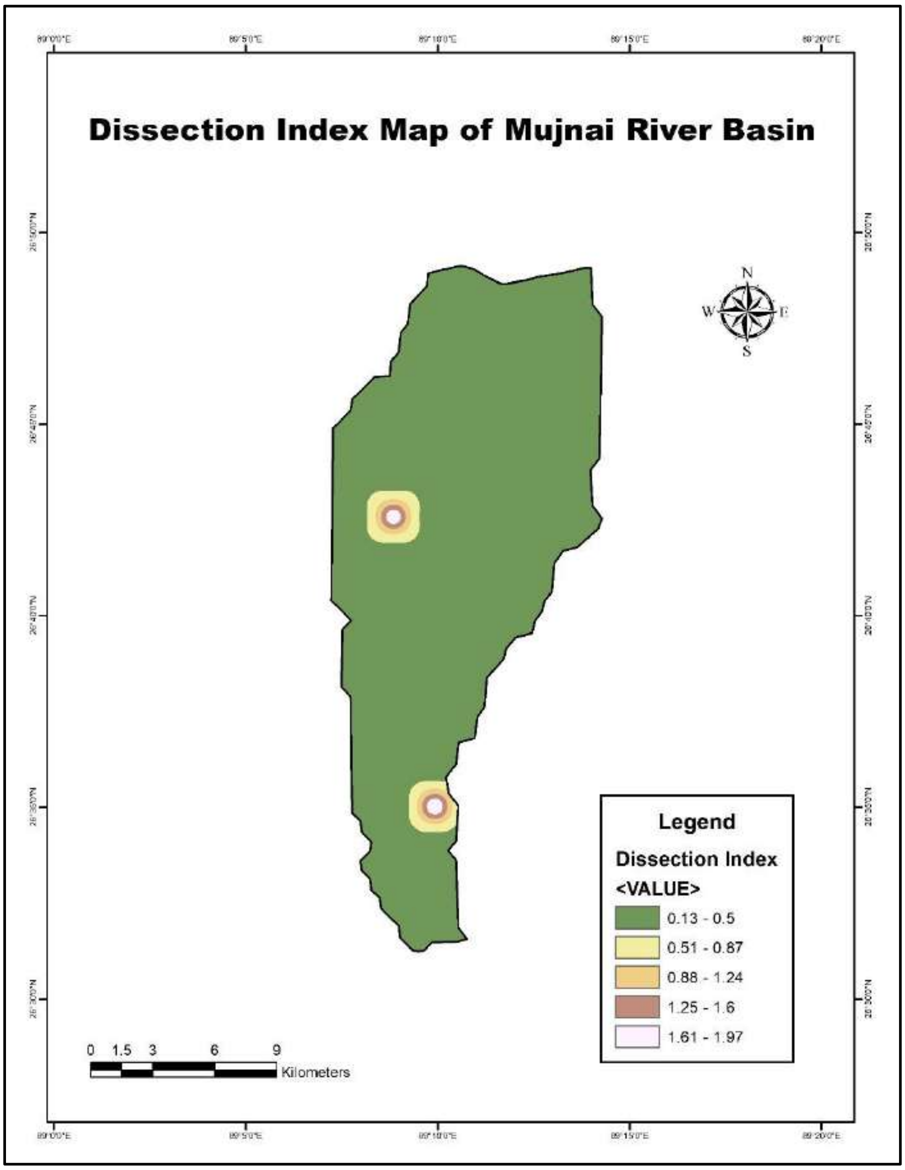
The dissection index, which is expressed as a ratio of maximum absolute relief to maximum relative relief, is an essential morphometric indicator of the nature and amount of terrain dissection. Dov-Nir (1957) developed a rapid method for calculating the dissection index that 'takes into account the dynamic potential state of the area- the ratio between relative height and perpendicular distance from the erosion base'. In this basin analysis, the grid method was used to outline the calculative fractions of the dissection index, and these values were altered between 0 and I to grasp the frequency or size of the dissected regions based on the relative relief and area ratio.

Dissection Index (D.I) =

Relative Relief [Absolute Relief or (Maximum altitude — Minimum altitude) / Maximum altitude

The value of D.I ranges between 0-1.0. It attains the highest when minimum altitude is 0.

Therefore, the greater the value, the greater is the degree of dissection.



Map No.3.3: Dissection Index Map of Mujnai River Basin

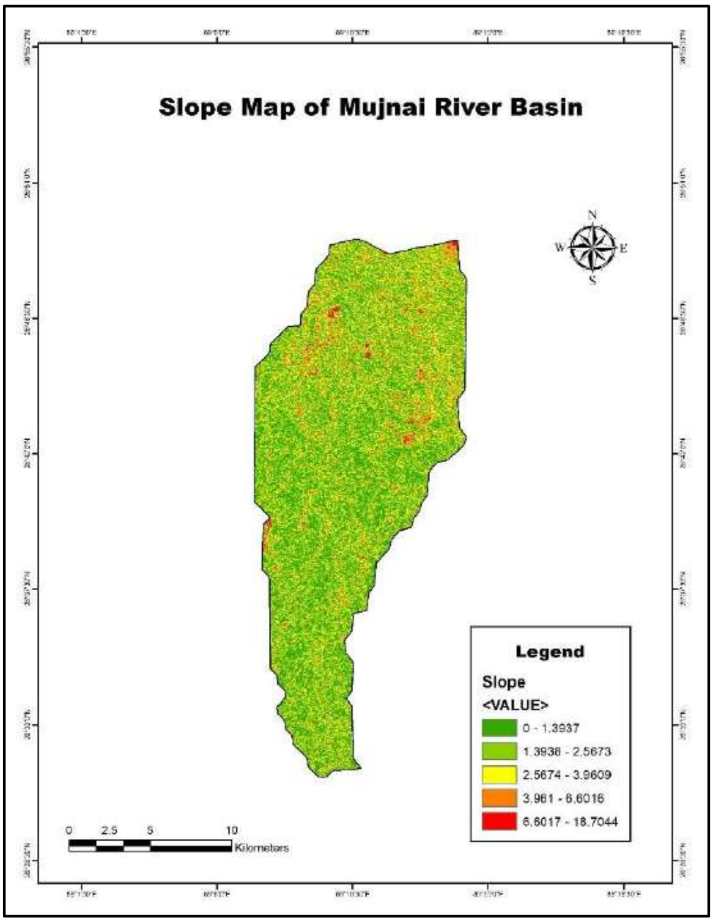
Source – SRTM,Dem

Here the calculated values are varied from 0.06 to 0.10 that means there the dissection index of Karatoya river basin is extremely low categorized from the map it is clear the Southern part is least dissection and highest dissections are found in Western & Central part of the map.

3.5 Average Slope

Slopes, defined as angular inclinations of terrain between hill-tops and valley bottoms, resulting from the combination of many causative factors like geological structure, absolute and relative reliefs, climate, vegetation cover, drainage texture and frequency, drainage texture etc. are significant morphometric attributes in the study of landforms of the drainage basin.

Wentworth has put his forth formula in his scheme of calculation of average slopes in degrees wherein the contour map of the region is divided into grids and calculated the average number of contour crossing per unit area. Using this method in the study the magnitude of average slope is from 2^0 30' to 4^0 30'towrads the upstream. That is indicating the inclinations along with the basin from source to the mouth are very low.



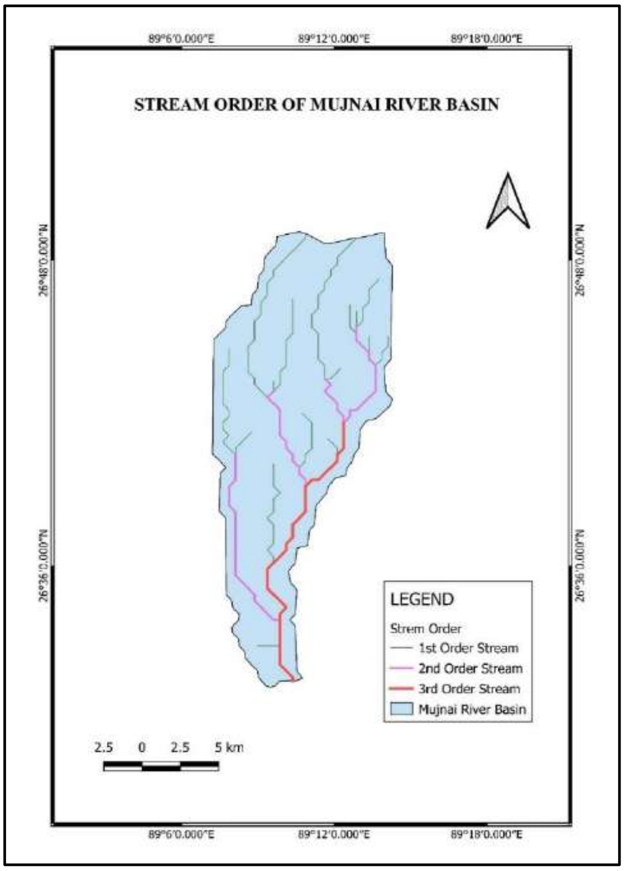
Map No.3.4: Average Slope Map of Mujnai River Basin

3.6 Stream Order

There are four different system of ordering streams that are available Horton (1945), Strahler (1952) and Schideggar (1970)]. Strahler's system, which is a slightly modified of Horton[ee]s system, has been

followed because of its simplicity, according to him where the smallest, unbranched „each finger-tip streams are designated as 1st order, the confluence of two 1st order channels give a channels segments of 2nd order, two 2nd order streams join to form a segment of 3rd order and so 4tlf. When two channel of different order join then the higher order is maintained. The trunk stream is the stream segment of highest order. trahlers scheme is popularly known as **'stream segment method'**.

Basically the stream ordering system is analysing the different drainage network system as well as the geomorphic characteristics of the basin. It is found that Upper Karatoya river tributaries are of 4th order. In all 35 streams were identified of which 26 are 1st order, 7 are 2nd order, 2 are 3rd order, and 1 is 4th order. Drainage patterns of stream network from the basin have been observed as mainly of dendritic type which indicates the homogeneity in texture and lack of structural control. The properties of the stream networks are very important to study basin characteristics.



Map No.3.5: Stream Order Map of Mujnai River Basin

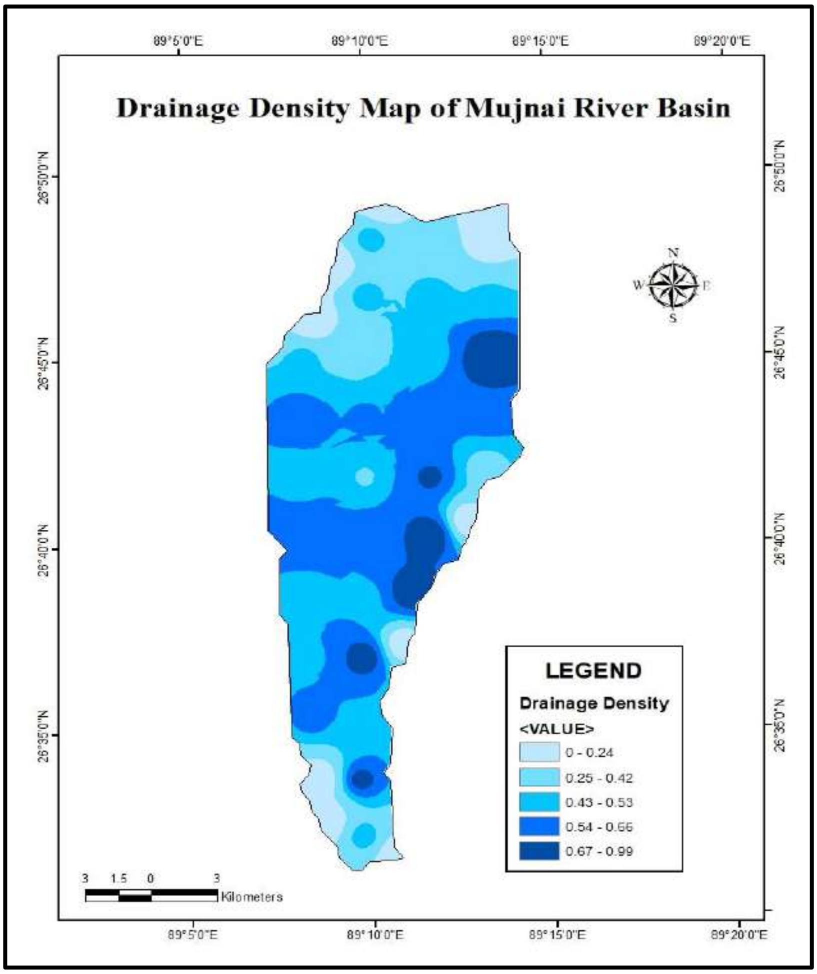
Source - Hydrosheds

3.7 Stream Length (Lu)

The stream length (Lu) has been computed based on the law proposed by Horton. Stream length is one of the most significant hydrological features of the basin as it reveals surface runoff characteristics. The stream of relatively smaller length is characteristic of areas with larger slopes and finer textures. Longer lengths of streams are generally indicative of flatter gradient. Generally, the total length of stream segments is maximum in first order stream and decreases as stream order The number of streams is of various orders in a watershed are counted and their lengths from mouth to drainage divide are measured with the help of GIS software. The length of 1st order stream is 115.91km, 2nd order stream is 81.03 km, 3rd order stream is 43.23 km, and 4th order stream is 5.67km. The change may indicate flowing of streams from moderate altitude, lithological variation and moderately level slopes. The observation of stream order verifies the Hortons law of stream number i.e. the number of stream segment of each order forms an inverse geometric sequence with order number.

3.8 Drainage density (DD)

Horton (1932), introduced the drainage density (Dd) is an important indicator of the linear scale of land form elements in stream eroded topography. It is the ratio of total channel segment length cumulated for all order within a basin to the basin area, which is expressed in terms of km/km2.The drainage density, indicates the closeness of spacing of channels, thus providing a quantitative measure of the average length of stream channel for the whole basin. It has been observed from drainage density measurement made over a wide range of geologic and climatic type that a low drainage density is more likely to occur in region and highly resistant of highly permeable subsoil material under dense vegetative cover and where relief is low. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture (Strahaler, 1964).The drainage density (Dd) of study area is varies from 2 to 4 km/km2 indicating moderate drainage densities. The Moderate drainage density indicates the basin is highly permeable subsoil and vegetative cover.

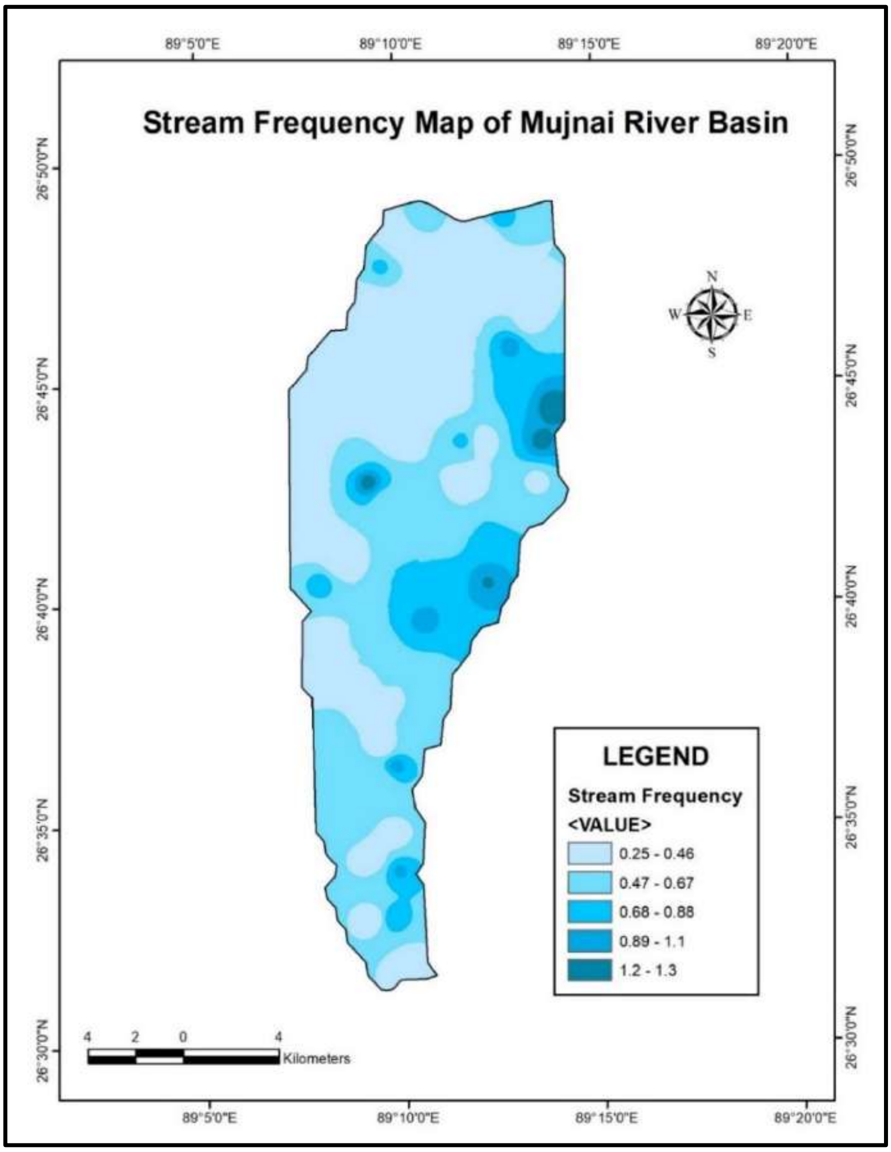


Map No.3.6: Drainage Desity Map of Mujnai River Basin.

Source - Hydrosheds

3.9 Stream Frequency (SF)

Stream frequency (SF), is expressed as the total number of stream segments of all orders per unit area. It exhibits positive correlation with drainage density in the watershed indicating an increase in stream population with respect to increase in drainage density. The SF for the basin is varies from 2 to 3. (Horton, 1932). It indicates that the number of streams in the basin per unit area is moderately low.



Map No. 3.7: Stream Frequency Map of the Basin.

Source - Hydrosheds

CHAPTER-4

CAUSES & IMPACTS OF FLOOD OF MUJNAI RIVER

4.1 Introduction

Flood is a natural disaster where the situation water temporarily covers lands that usually dry, and then get filled with water. This natural disaster frequently happened in Malaysia during monsoon season that can affecting Malaysia from the perspective of their financial cost, frequency and most importantly the impacts on the population and the disruption to the socio-economic activities. There are few events that can causes a flooding which is rainfall, river overflow, dam breaking ice snow melts and tsunami. Flood that causes by rainfall can occur when heavy rainfall for a short time or light rainfall for several days or weeks. The water will naturally flow from high areas to low lying area. As a result, the lowlying area will rapidly fill with water before it begins to get high area. In term of positive effect flood can enhance and restore biodiversity in floodplains particular, restoring nutrient-rich soil conditions where it is suitable for agriculture and natural vegetation, clear debris and sediment from flooded areas and recharges groundwater. Instead of that, negative effect flood can risk life threatening, disturbing social and economic activities and destroy property, because inconvenience and cost recovery can be high for the government or individuals and prevent new investment in flood prone areas. Throughout the human history, floods have been part of his destiny. They are widely discussed today as a result of increased public awareness and greater destruction caused by them. Perhaps, flood is one of the most dramatic interactions between man and his environment. Emphasizing both the sheer force of natural events and man's inadequate efforts to control them. The holy bible has an account of the greatest flood to ever happen.

4.2 Definition of Flood

According to WHO/UNESCO the “food is a rise usually brief, in the water level in a stream to a peak from which the water level records at a slower rate, According to International Commission on Irrigation and Drainage “flood is a relatively high flow or stage in a river, marked higher than a mass of water which is rising swelling and overflowing.”

4.3 Causes of Flood on Mujnai River and its Surrounding Area

Alipurduar district is endowed with an intensive network of river systems. Most of the rivers are highly notorious for their unpredictable nature. Letting loose fury tiff floods and problem of extensive and regular bank erosion. Course shifting and rendering. Thousands of people homeless during the rainy reason. The majority of the rivers of Terai and Dooars originate in the Himalayas and enter from north to north-westerly direction and flow south to south-easterly direction. The lateral gap between the two major rivers is in between 3 to 30 km. i.e., Mujnai and Gadadhar - Raidak respectively. As many of the rivers originate from the same hill, flood often occurs simultaneously in many rivers and the rivers coalesce to form a single vast sheet of water.

4.3.1 Natural Causes

A. High Intensity Rainfall

High intensity rainfall is the mother of all problems, particularly the flooding of the Alipurduar district. Sudden maximum downpour creates the situation of flood in the district. The nature of the flood is mainly flash flood. Cloud burst or maximum rainfall in a short span always aggravates the situation of flooding in the district since long past. The flood history of the district gives no clean conception of because that is high intensity rainfall or cloud burst is the main cause behind the major floods of the district. Floods of 1922 are due to cyclonic rainfall in one week was about 10times of the normal rainfall and other Major floods are 1954. 1968. 1993. 1999 and 2000 and 2017 all are caused due to unprecedented highly intensive rainfall.

B. Shifting of River Courses

This is the most significant hazard of the district. Avulsion is often found in the foothills and dooars area of Alipurduar district. Avulsion not only causes the floods of severe nature but also defoliates the flood situation and flood havoc of the district significantly. Shifting of river courses in the Alipurduar district is so often due to the rise of riverbed levels high deposition of silts and coarse materials in the riverbeds, soil erosion and landslides in the upper catchment of the rivers and bank erosion. Rivers are very closely flowing in the district. So, the lateral gap of the rivers of the foothill areas is very small and the river coalesces makes the shifting quite normal. Shifting of the rivers creates prolonged flood condition and gave birth of the high of flooding and havocs. River Tista, Mujnai ,Sankosh and many other rivers shifted their channels in the past.

C. Cloud Burst

Cloud burst occurs due to intense precipitation in a short duration which can sometimes be accompanies by hail and storm and can cause a flood. These natural incidents occur at a mountain slopes and water runs down towards the plains, causing a flood. Due to cloud burst flood occur in Mujnai River and the nearest region.

D. Landslide

Compared to the mountains in the Deccan plateau or central India, the Himalayan ranges experience serious landslides. No systematic or reliable data are available on the extent of the problem and the amount of sit contributed from this source. With the increasing activities of road construction in the Himalayan region, road engineers annually face the land slide problems for clearing the debris and keeping the roads open. Therefore, the volume of debris contributed by the slides along the Himalayan roads may furnish a first approximation of the silt estimates contributed from this source, though numerous landslides occurring in inaccessible areas will remain beyond any possible estimation. Under the circumstances, an effort may be made to give a partial view of the serious problem of landslides infesting the entire stretch of the upper catchments of the flood prone rivers of the Brahmaputra River systems. Due to its characteristic geological formations and being in the seismic region, the problem in the upper catchments is however, quite complex.

4.3.2 Manmade Causes

A. Surface Mining

People in state have their free rights to grazing and extracting minor forest produce. Overloading degrades the watershed sediment discharge (like Jalpesh, Teesta spur etc.) and overland flow volume increases from such degraded catchments. The situation becomes more acute in places where livestock population is very high. Some areas are having this problem of the district and the upper catchments of the main rivers of the Alipurduar district facing the problem. This is the major problem of floods in Alipurduar district.

B. Deforestation

Deforestation has several environmental affects like air pollution, soil pollution, Climatic change and soil erosion etc. But flood occurrences are very prominent due to the deforestation in the upper and lower catchments of the river basin in the recent years. Alipurduar district is famous for the vast forest tracks and for their luxuriant growth of natural vegetation is facing the problem of large scale deforestation or forest clearings due to the expansion of agricultural lands, tea gardens, roadways, railways, rapid urban isotones or settlements etc. these causes landslides, sheet erosion, slope failure and top soil erosion in the upper catchment areas of the leading river of the district, which enhance the debris flow and large scale sedimentation in the riverbeds of all the rivers of the district and acute the flood problem of the district. This reckless deforestation also affects the climate of the study area.

C. Urbanization

Rapid urbanization in the Alipurduar district is experienced since long back. Alipurduar town is a divisional town from the British period and the district as a whole is well connected with Bangladesh before partition. After independence the district witnessed huge infiltration from Bangladesh. It is most important factor for the rapid urbanization in the district. The towns of the district are also very closely spaced like Alipurduar, Maynaguri, Falakata, Falakata, Malbazar.

D. Drainage Congestion

Here the network of the drainage is very high and the lateral gap between the two rivers is very less in this region. Only 3 to 30 km are the lateral gap of the rivers in this district. So, rivers are very closely spaced which may create a problem of the river coalesces in the floods or heavy discharge in the rainy season.

E. Over Grazing

The rules and regulation of grazing rights, privileges, and concessions for forest produce, Minor timber etc., are generous and vary from state to state. Forest regulations admit such rights. Tribal people in the state have their free rights to grazing and extracting minor forest produce. Overloading degrades the watershed sediment discharge and overland flow volume increases from such degraded catchments. The situation becomes more acute in places where livestock population is very high. Some areas are having this problem of the district and the upper catchments of the main rivers of the Alipurduar district facing the problem. This is the major problem of floods in Alipurduar district.

4.4 Impacts of Flood on Mujnai River and its Surrounding Area

In India, every year, loss and damage of property are recorded due to flood, which causes damage to village sand houses, loss of human life, loss of castles, loss of crops, and so on. In the Mujnai river basin, floods occur due to sudden, incessant, excessive and ultimately sudden dropdown of showers in the upper catchment areas. It has significantly impacted people, livestock, houses, and villages over the years.

4.4.1 Impacts of flood

A. Loss of Forest

During a major rainfall event, especially after prolonged periods of preceding rainfall the forest soil becomes saturated water no longer filters into the soil but instead runs of along the soil surface. River Mujnai is in the Bhutan Himalayan Range. Landslide sand heavy rainfall are the standard features of these areas. Due to this forest covers lose their stability.

B. Effect on the River System

Monsoons high density of rainfall occurs and innumerable Landslides and dropdowns transport massive loads from the upper catchment of the river bed, which are incapable to transport by the present hydrological cycle. Due to this, river beds are rising. The mining queries are unscientific, producing a massive quality of mineral loss on the slope. During

C. Loss of Bio-Diversity

Flooding can have negative effect on wildlife causing drowning, desease proliferation, and habited destruction. Although Alipurduar is full of vegetal cover, a study regarding LULC prevails that 1993-2020, a considerable amount of dense forest lands ware destroyed. Over 2 Million trees destroyed, a market price of over 15,000 million rupees.

Table 4.1: Houses Damaged by Flood in Alipurduar District

Year	No of Damaged Houses
2008	220
2009	580
2010	340
2011	420
2012	438
2013	396
2014	380

Source: Department of Disaster Management, Alipurduar

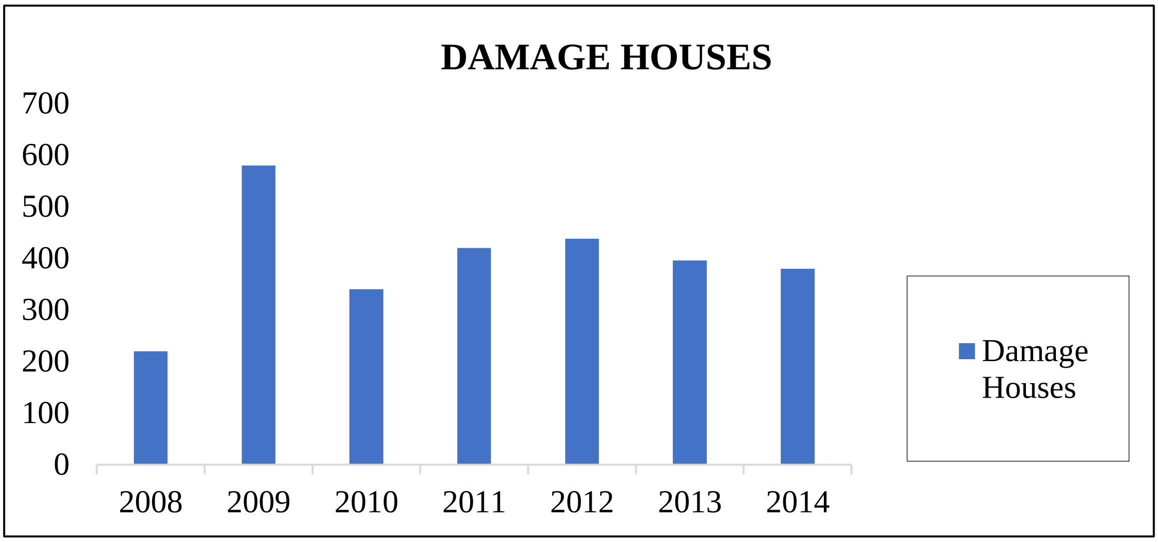


Fig. 4.1: Houses Damaged by Flood in Alipurduar District

Table 4.2: Loss of Human Lives by Flood in Alipurduar District

Year	**No of Lives**
2008	9
2009	12
2010	15
2011	16
2012	11
2013	10
2014	14

Source: Department of Disaster Management, Alipurduar

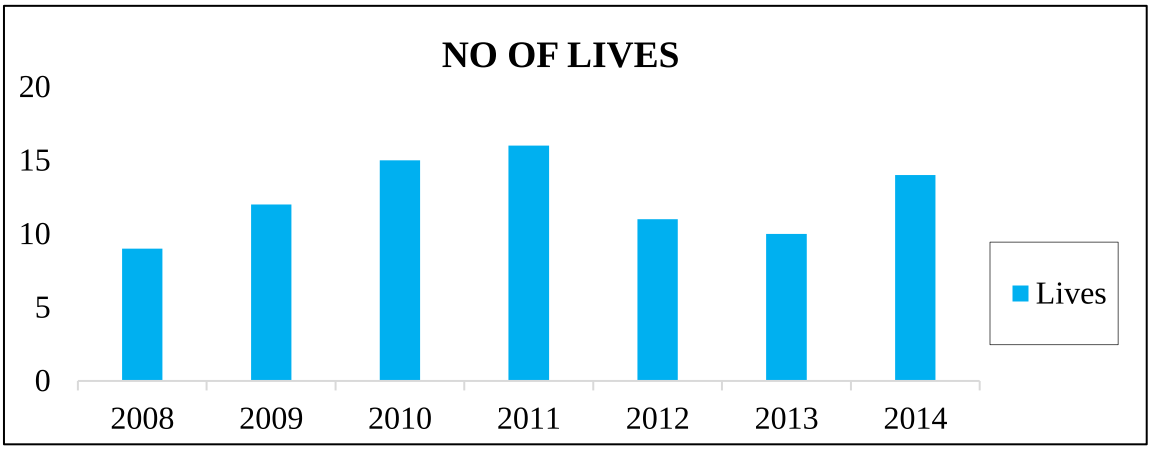


Fig4.2: Loss of Human Lives by Flood in Alipurduar District

Table 4.3: Loss of Crops by Flood In Alipurduar District

Year	No of Cattle's
2008	255
2009	370
2010	260
2011	260
2012	240
2013	260
2014	245

Source: Department of Disaster Management, Alipurduar

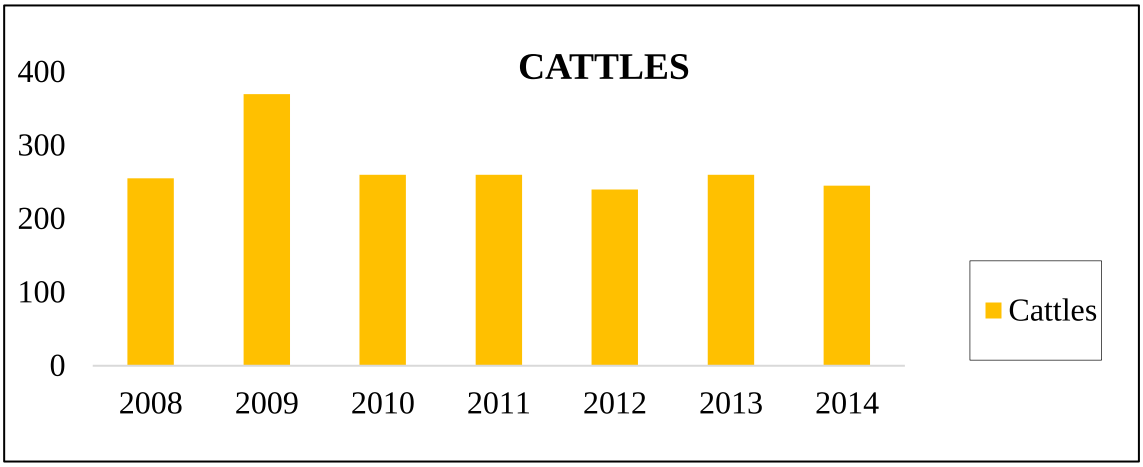


Fig. 4.3: Loss of Cattle by Flood in Alipurduar District

Table 4.4: Loss of Crops by Flood in Alipurduar District

Year	Crop (in hectare)
2008	7300
2009	8289
2010	8270
2011	8300
2012	8898
2013	7800
2014	7900

Source: Department of Disaster Management, Alipurduar

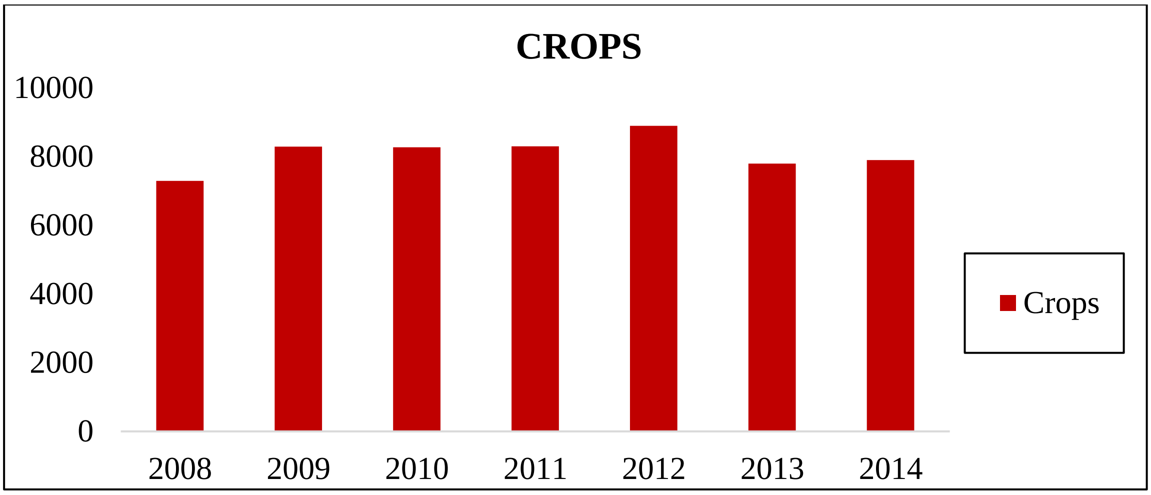


Fig. 4.4: Loss of Crops by Flood in Alipurduar District

D. Loss of Tea-Garden, Arable Land

Tea gardens are threaded like forests due to this region's mining activity. In between 1993-2020 at about 75 hectares of Tea-Garden were lost permanently due to the Bank failure. Accumulation of calcium on the tea garden soil has detrimental effects both in terms of productivity and quality. Productivity is decreasing in many tea gardens and the quality is also deteriorating.

E. Air & Noise Pollution

Mining activities often cause air pollution, which harms wild life. Fine Dolomite dust also causes air pollution, which deteriorates the balance.

F. Deterioration of surface & sub—surface water quality

Dolomite mining in the Bhutan Himalayan foothill region allows the dissolving of the calcium in the Mujnai basin which ultimately harms the Bio-Diversity. It allows the river water thereby deteriorating the Mujnai basin's water quality. Its leads to the deterioration of the aquatic diversity of the river. Unscientific mining also alters the soil-water relationship dramatically. It reduces the lag time significantly and increases surface runoff and the probability of floods. Dissolving calcium also moves through the sub-surface through the soil pores, thereby deteriorating sub-surface water quality.

G. Soil p^h Balance

Dissolving the calcium in the Mujnai river basin increases the amount of calcium in the basin area and its surroundings. Due to this very reason, soil p also increases. Unlimited release of Dolomite through the air and water cause accumulation of calcium on the soil surface. This increases the p value which have detrimental effects on many traditional crops like Tea. In some extreme cause, calcium crust may also develop and thereby. Once fertile, soil may turn sterile.

H. Health Hazard

The immediate health impacts of floods include drowning, injuries, hypothermia, and animal bites. In the long term, chronic deasease, disability, poor mental health and poverty _related desease including malnutrition are the potential legacy. Dolomite mining gives rise to health problems in the Sub-Himalayan, West Bengal and Bhutan regions. Study reveals that kidney stone is 2 times faster among people residing around Jyanti, Rajavatkhawa, Mujnai basin, Chamurchi, Makrapara, Lankapara, etc.

CHAPTER-5

PERCEPTION STUDY OF FLOOD AT ALIPURDUAR DISTRICT: A CASE STUDY ON HARINATHPUR VILLAGE, FALAKATA BLOCK

5.1 Introduction

A perception survey is a research study carried out to understand the opinion of the target audience, be it employees, customers, student or patience. Floods, being natural phenomena, represent a hazard only with respect to human society. Therefore, the human response and attitude are no less important in flood risk assessment. In Falakata block, there is a great lack of data on social aspects and public response to flood mitigation measures and information management. The number of flood victims are still high in the area, mainly due to the lack of implementation of structural flood control measures. The objective of this study is people's perception of flood risks in the Falakata block and their attitudes and perceptions about causes and impact of flood and flood management. The study revealed a few important factors about the interactions between people and floods. In depth interviews is the most effective data collection tool because it focused on psycho-social factors and drew out in depth responses from respondents about what they think and how they feel about the flood hazard.

5.2 Methodology of perception survey

In the present study, the methods employed constituted of interviewing people living in the chronic flood prone area with structured questionnaires. There were few households with our survey contact. Secondary data were also collected from local B.D.O office. Special questionnaires with asking about floods in this village and what are the effect in their life, perceived frequency and characteristics of flood. Secondary data, questionnaires, focus group discussion and data collection methods were applied. A list of frequently flooded areas in the region was drawn with a view to accommodate risk level variability.

Table 5.1: Calculation Table for Types of Floods

Types of Floods	No. of Household	No. of Household (%)
Flash flood	52	66.67
River flood	26	33.33
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows, Harinathpur Village is mainly affected by two types of floods, Flash flood and river flood. The diagram shows that 66.67% of areas are affected by flash flood and 33.33% of areas are affected by River flood. From the above scenario, it can be said that Harinathpur village is mostly affected by Flash flood.

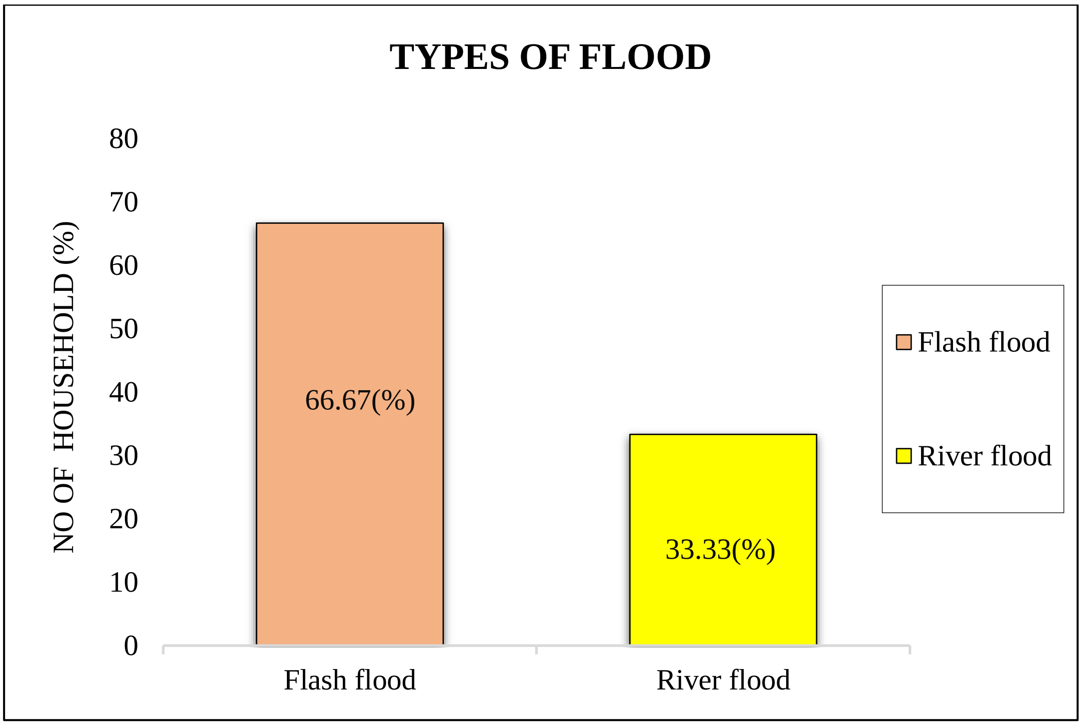


Fig-5.1: Types of Floods

Table 5.2: Calculation Table for Home Relocation System

Home relocation	No. of household	No. of household (%)
Yes	26	33.33
No	30	38.46
Don't know	22	28.21
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows that 33.33% of households of Harinathpur village are ready to relocate and 38.46% don't want to relocate, while rest 28.21% are not sure whether they want to relocate or not due to the flood.

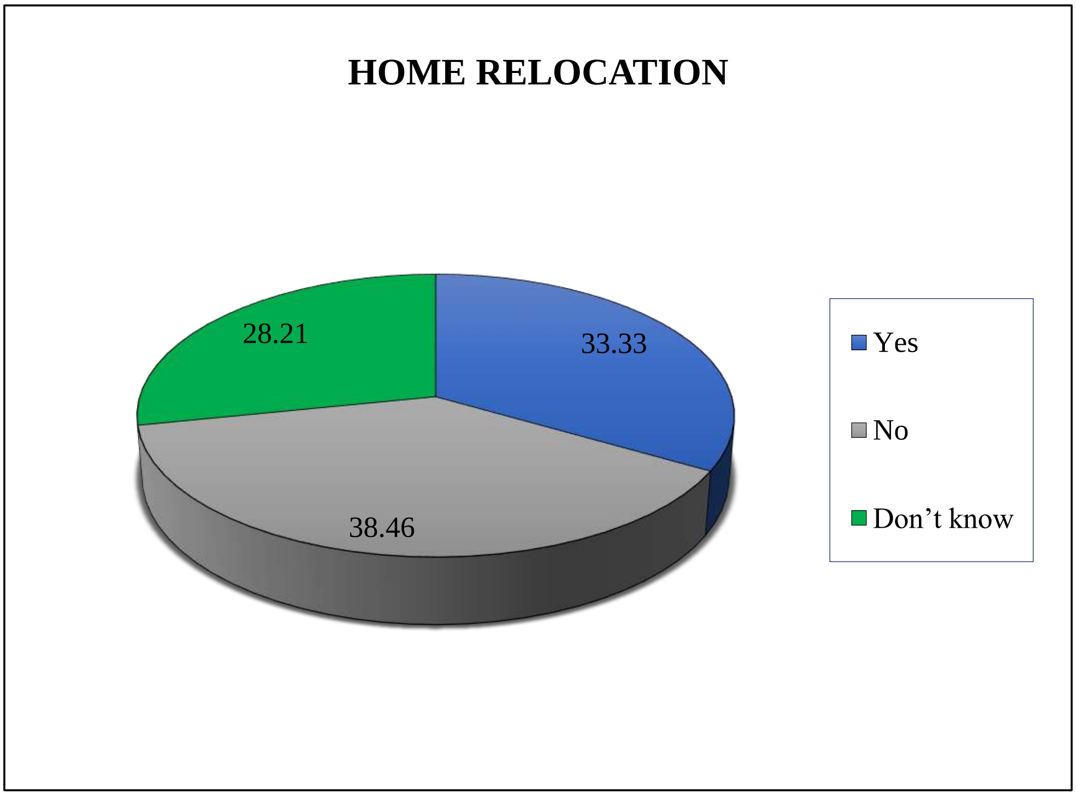


Fig-5.2: Home Relocation System

Table 5.3: Calculation Table for Improvement of Early Warning System

Improvement of early warning system	No. of household	No. of household (%)
More maintenance	28	35.90
More information	18	23.08
Don't know	32	41.02
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows that 35.90% of households of Harinathpur wants more maintenance to the early warning system for the flood caused by the rivers and 23.08% of households wants more information about it while, 41.02% don't know anything about it.

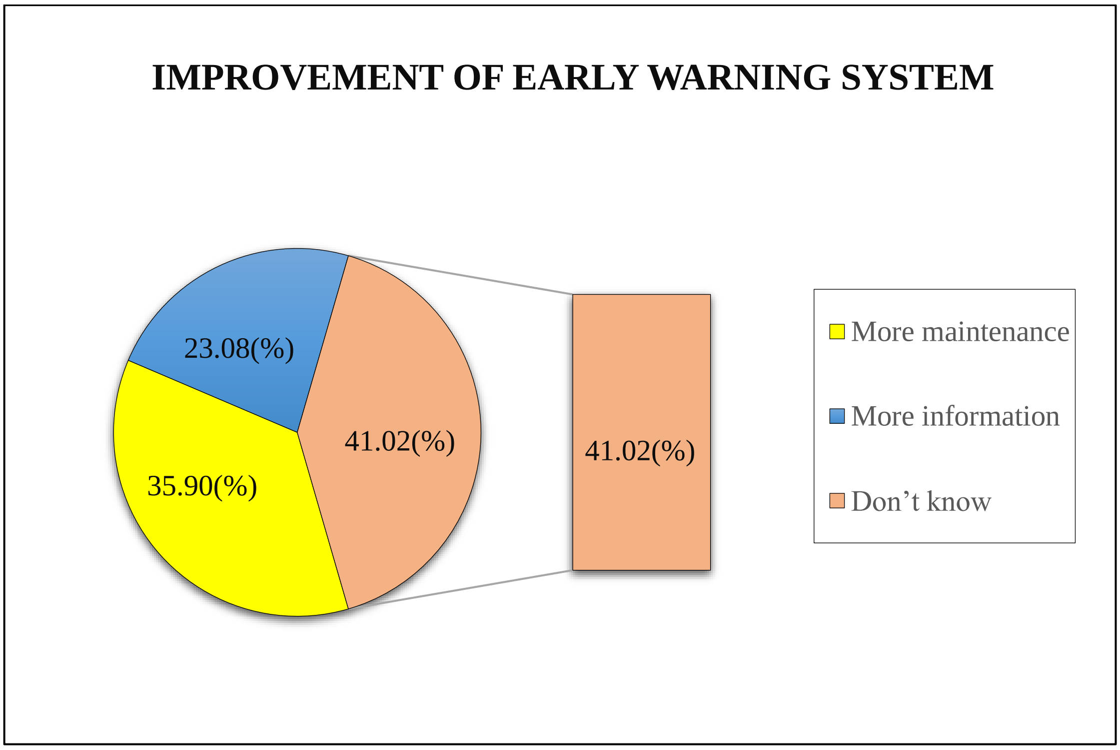


Fig 5.3: Improvement of Early Warning System

Table 5.4: Calculation Table for Institutional Dealing with Emergency Managemant

Institutional dealing with emergency management	No. of household	No. of household (%)
No	57	73.08
Don't know	21	26.92
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows that 73.08% of households of Harinathpur village says that there is no institutional dealing with emergency management during flood situation while 26.92% of households don't know anything about the emergency management.

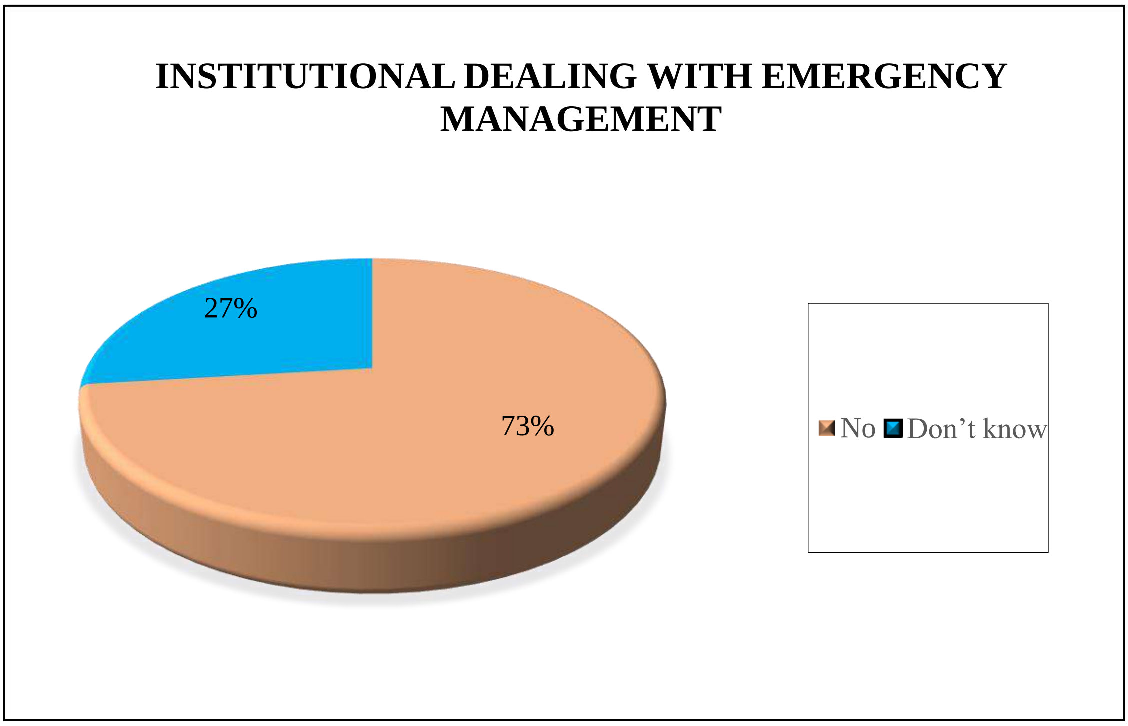


Fig 5.4: Institutional Dealing with Emergency Management

Table 5.5: Calculation Table for Information About Flood Risk

Information about flood risk	No. of household	No. of household (%)
Yes	54	69.23
No	24	30.77
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows that the information of flood given by the municipality. According to 69.23% of people that they found information of flood risk from the municipality and rest 30.77% of people said that they are not found any information of flood risk.

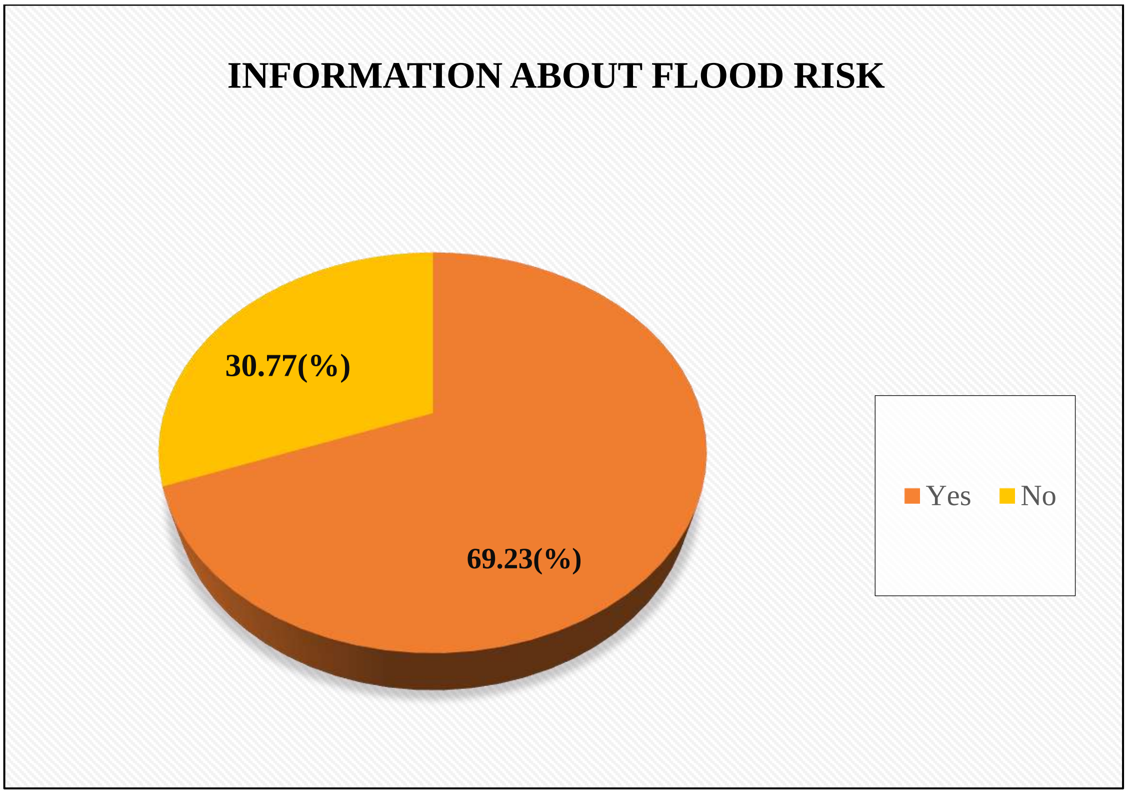


Fig5.5: Information About Flood Risk

Table 5.6: Calculation Table for Home Damage by Flood

Home damage by flood	No. of household	No. of household (in %)
Yes	50	64.10
No	28	35.90
Total	**78**	**100**

Source: Field Survey,2024

The above table shows the home damages in Harinathpur village due to floods. We found that 64.10% of houses are damaged during the flood and rest 35.90% of houses are safe. It shows that mostly houses of village are destructed during flood.

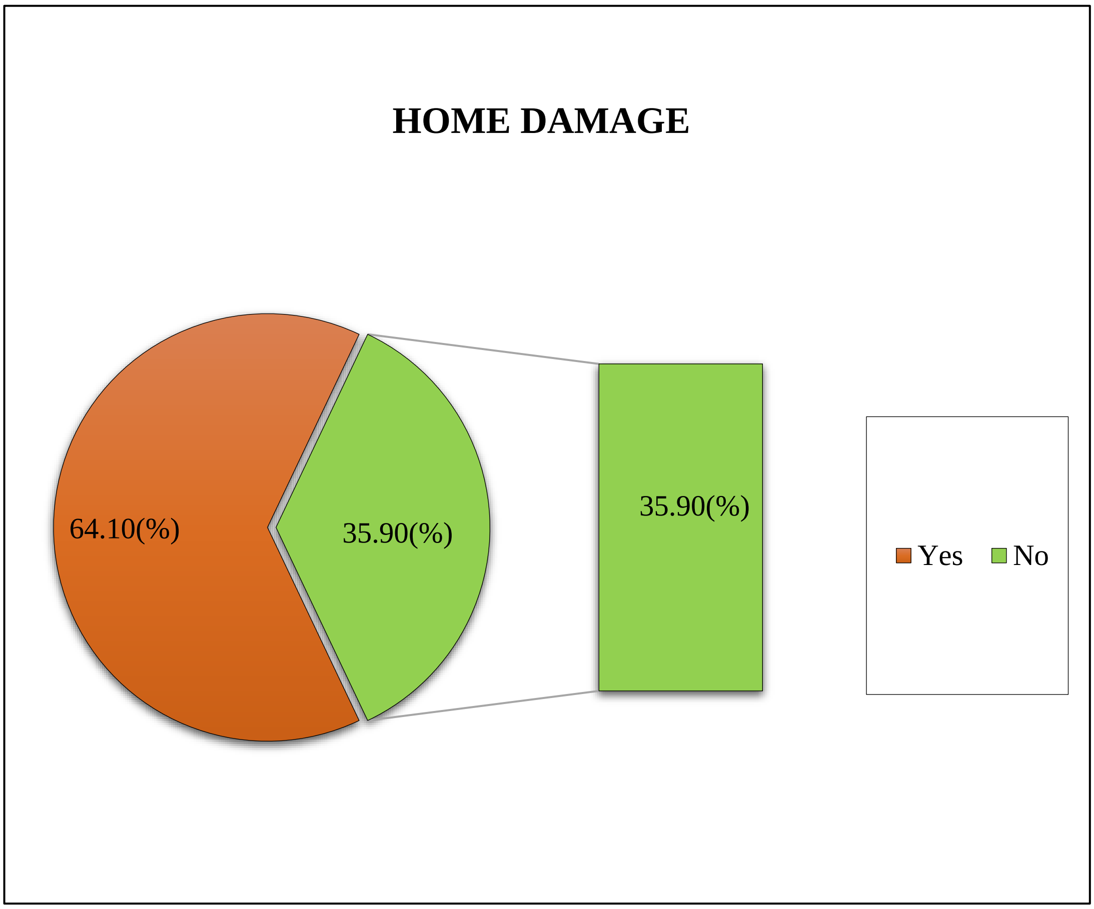


Fig 5.6: Home Damage by Flood

Table 5.7: Calculation Table for Early Warning System

Early warning system	No of household	No of household (in %)
Yes	54	69.23
No	24	30.77
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows the usefulness of early warning system to villagers of Harinathpur village for decrease the effects of floods. According to 69.23 % households that the early warning system is useful for decrease the effects of flood, rest 30.77 % households said that the early warning system is not useful for them.

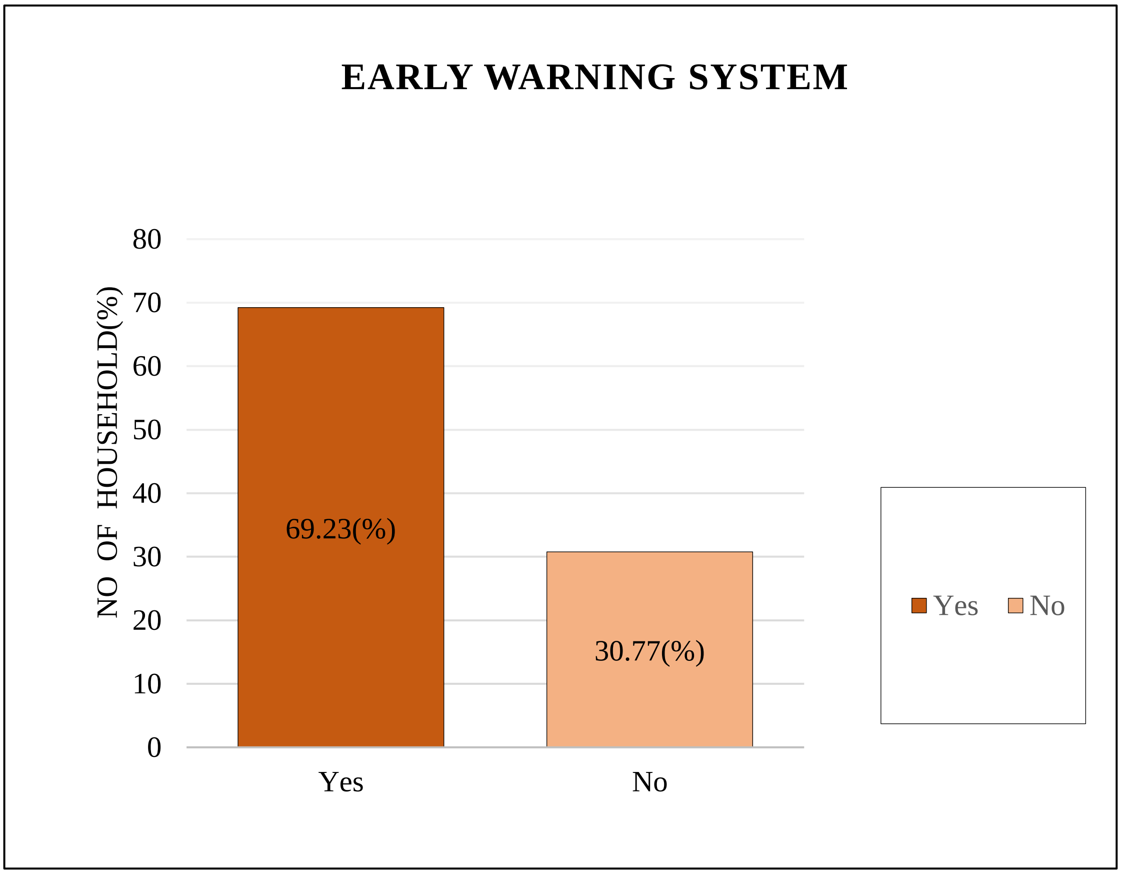


Fig5.7: Early Warning System

Table 5.8: Calculation Table for Financial Compensation

Financial compensation	No. of household	No. of household (%)
Yes	22	28.21
No	56	71.79
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows about the receiving adequate financial compensation by villagers to relocate to new home in safer area. According to 28.21% of households that they received financial compensation to relocate to new safer area, rest 71.79% households not received financial compensation.

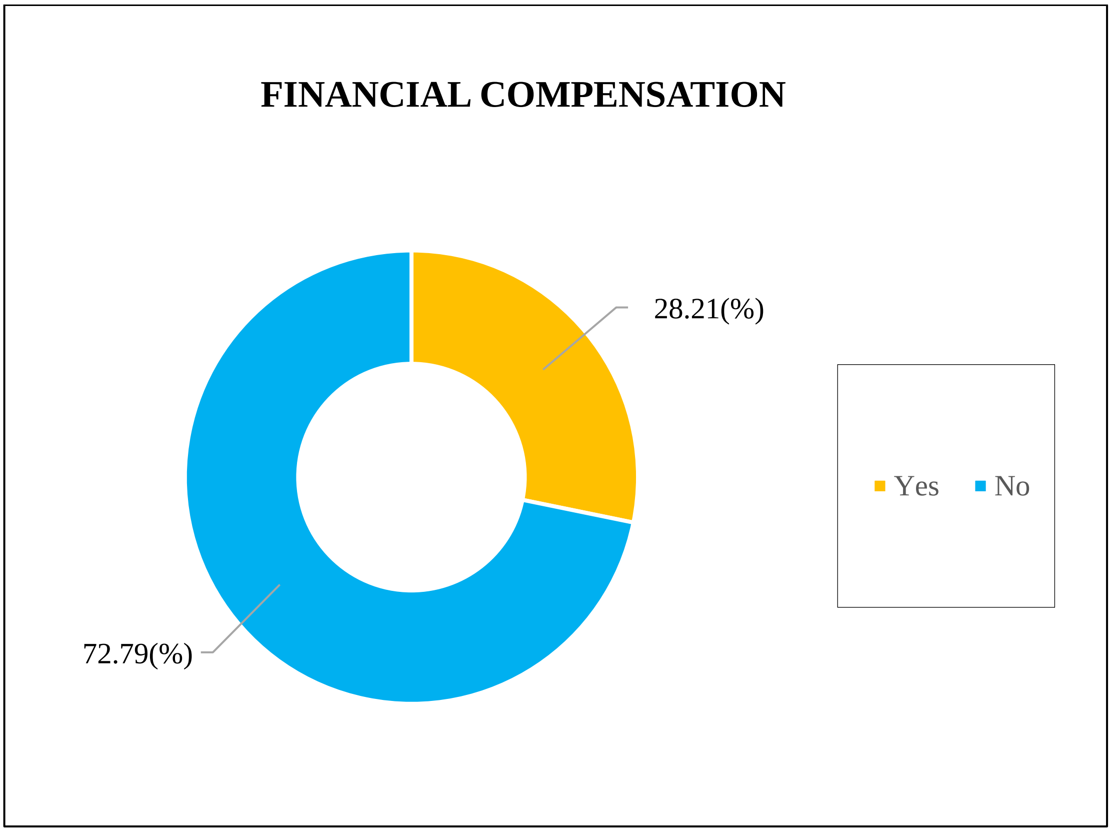


Fig 5.8: Financial Compensation

Table 5.9: Calculation Table for Loss of Personal Victim in Last Flood

Loss of personal victim in last flood	No. of household	No. of household (%)
Yes	40	51.28
No	38	48.72
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows the personal victim during the flood in Harinathpur Village. According to 51.28% of households that they are personal victim in last flood, and rest 48.72% of villagers are not suffer during the last flood.

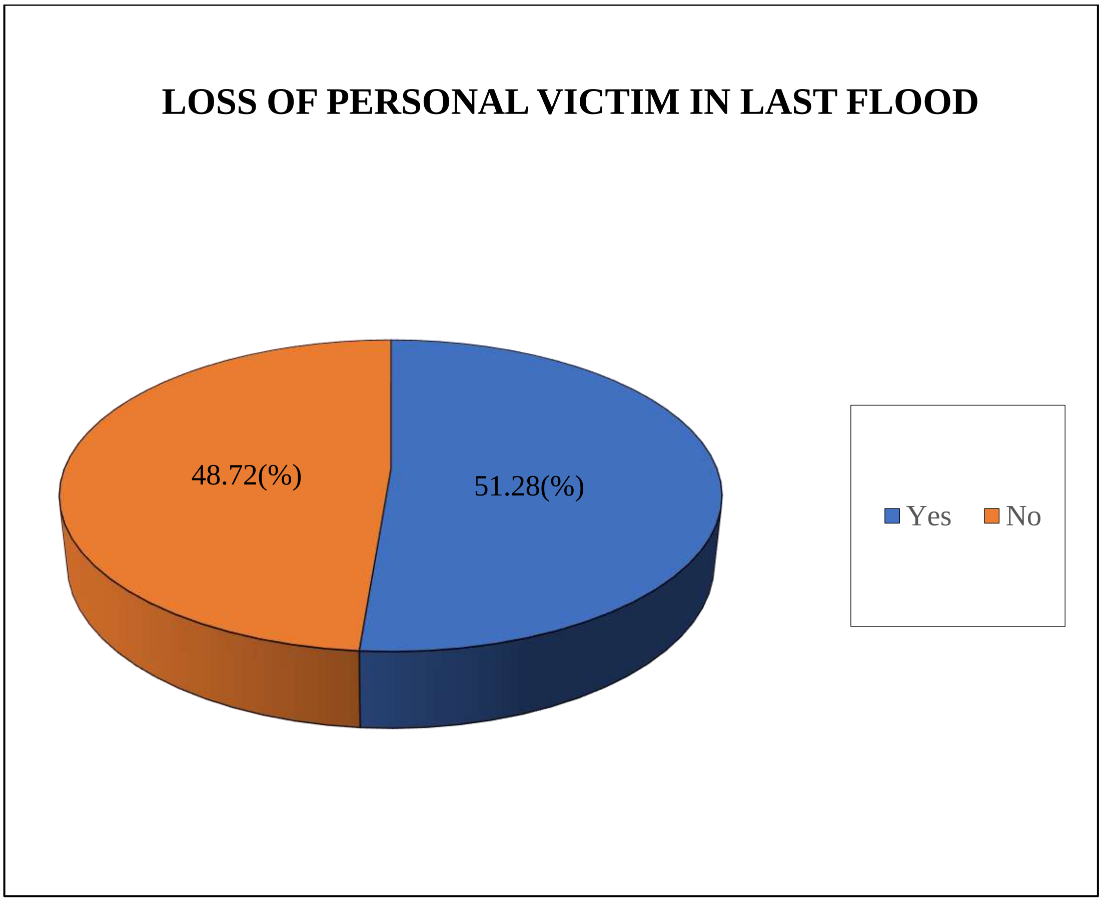


Fig5.9: Personal Victim in Last Flood

Table 5.10: Personal Evolvement in Last Flood

Personal evolvement in last flood	No. of household	No. of household (%)
Yes	57	73.08
No	21	26.92
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows the personal evolvement of people in last flood which occurred in the Harinathpur village. According to 73.08% of people that they are evolve in last flood, rest 26.92% of households not evolved in the last flood.

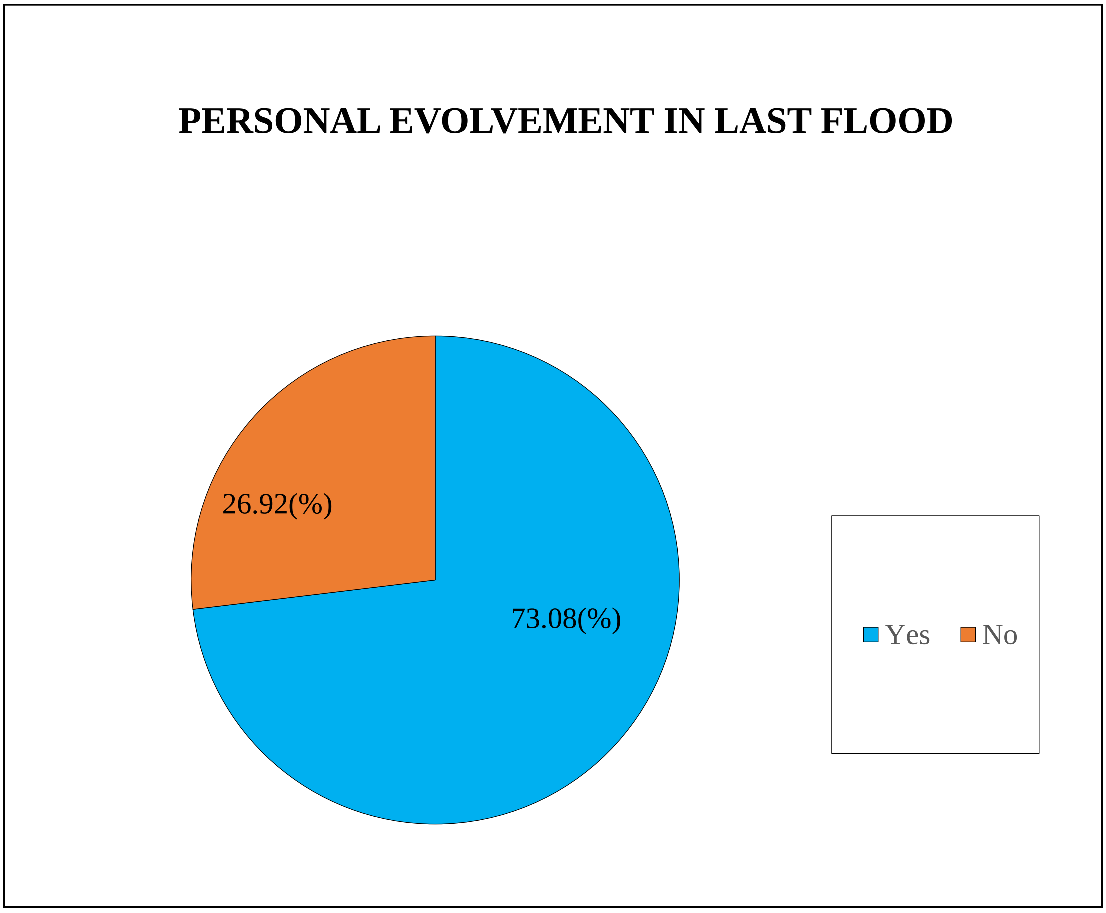


Fig 5.10: Personal Evolvement in Last Flood

Table 5.11: Calculation Table for Flood Management Tools

Flood management tool	No. of household	No. of household (%)
Structural work	30	38.46
Construction of flood embankments	35	44.87
Afforestation	13	16.67
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows about the flood management tools for mitigate flood in Harinathpur village. According to 38.46% people structural work should be used as the flood management tool, 44.87% people are said that construction of flood embankments should be used as the flood management and rest 16.67% of villagers are said that afforestation may be helpful for mitigate flood.

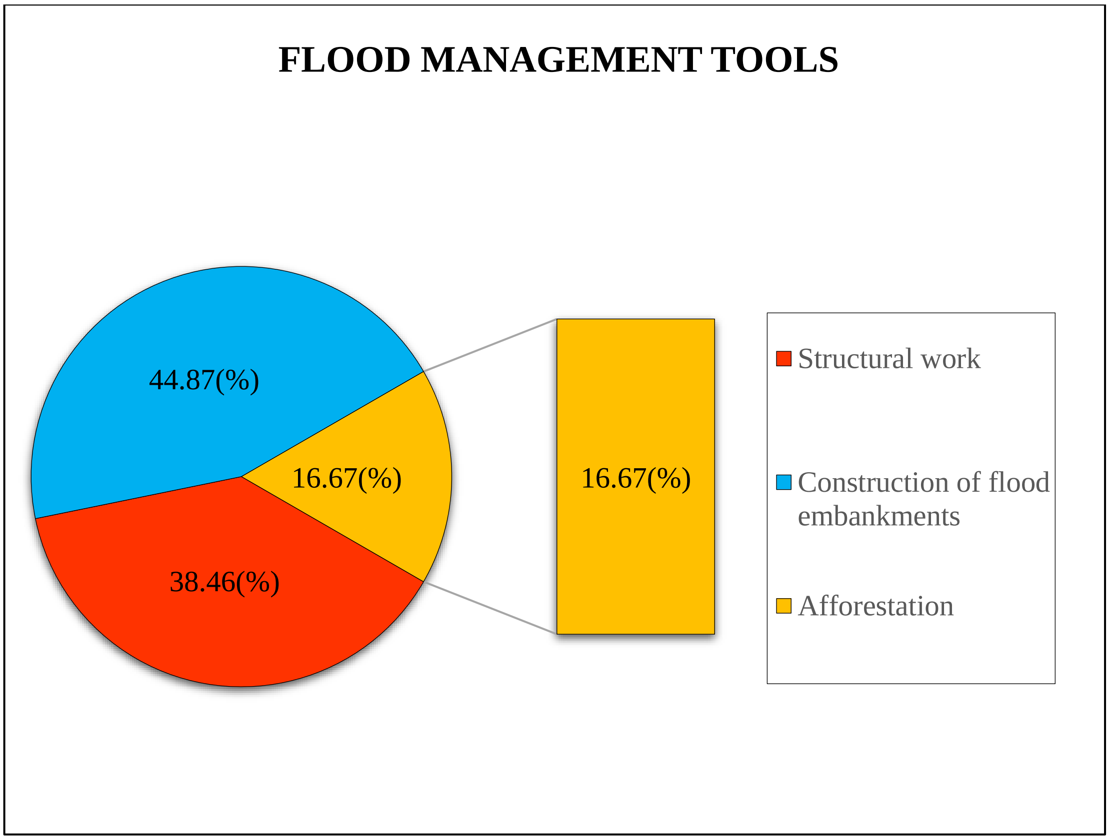


Fig 5.11: Flood Management Tools

Table 5.12: Calculation Table for Cost of Emergency Plan

Cost of emergency plan	No. of household	No. of household (in%)
Lots of money	28	35.90
Amount specified	10	12.82
Don't know	40	51.28
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows about the cost of the emergency plan which is provided by government. According to 51.28% of the households they don't know about it and 35.90% of the households are said that lots of money are required for this.

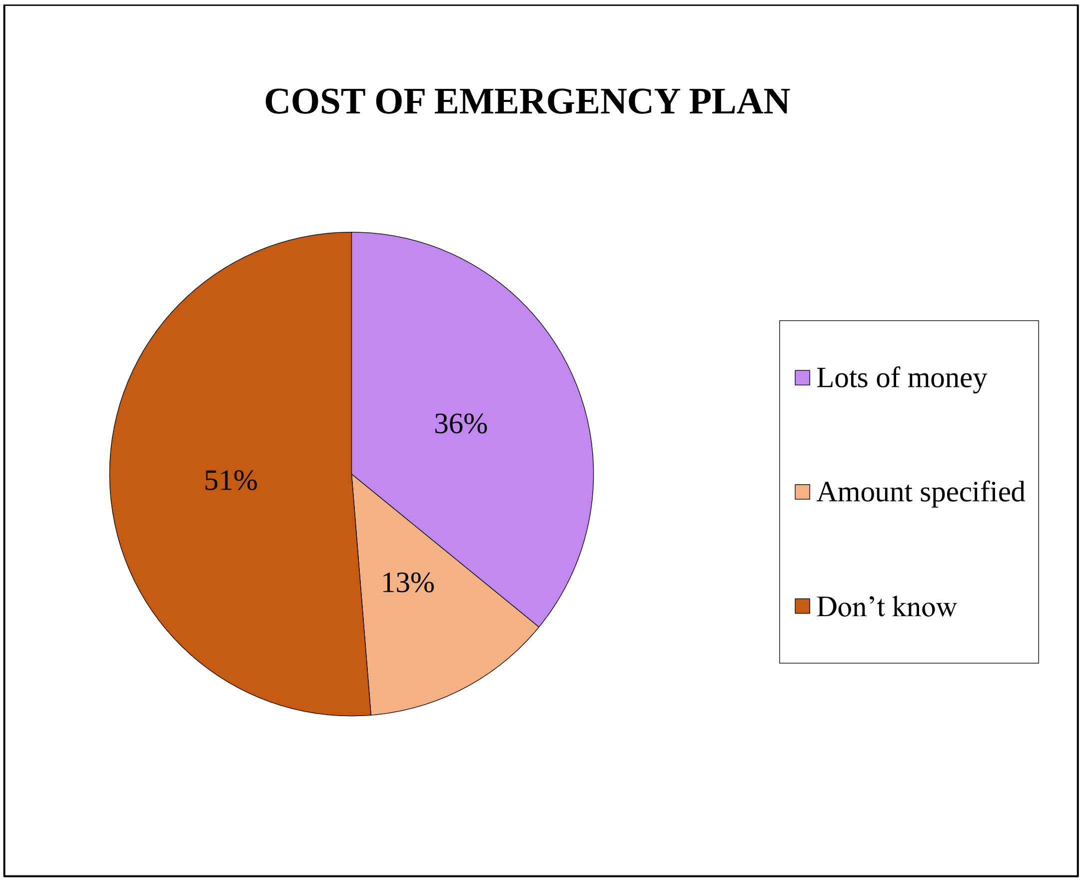


Fig5.12: Cost of Emergency Plan

Table 5.13: Calculation Table for The Responsible Institution to Cope with Emergency Plan

Rating (1-10)	No. of household	No. of household (In%)
1	0	0
2	0	0
3	0	0
4	19	24.36
5	33	42.31
6	7	8.97
7	19	24.36
8	0	0
9	0	0
10	0	0
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows the rating given by households of Harinathpur village about the responsible institution to cope with the emergencies. Where most of the households have rated 5 and least of them has rated 6, which clearly shows that most of households want changes in responsible institution.

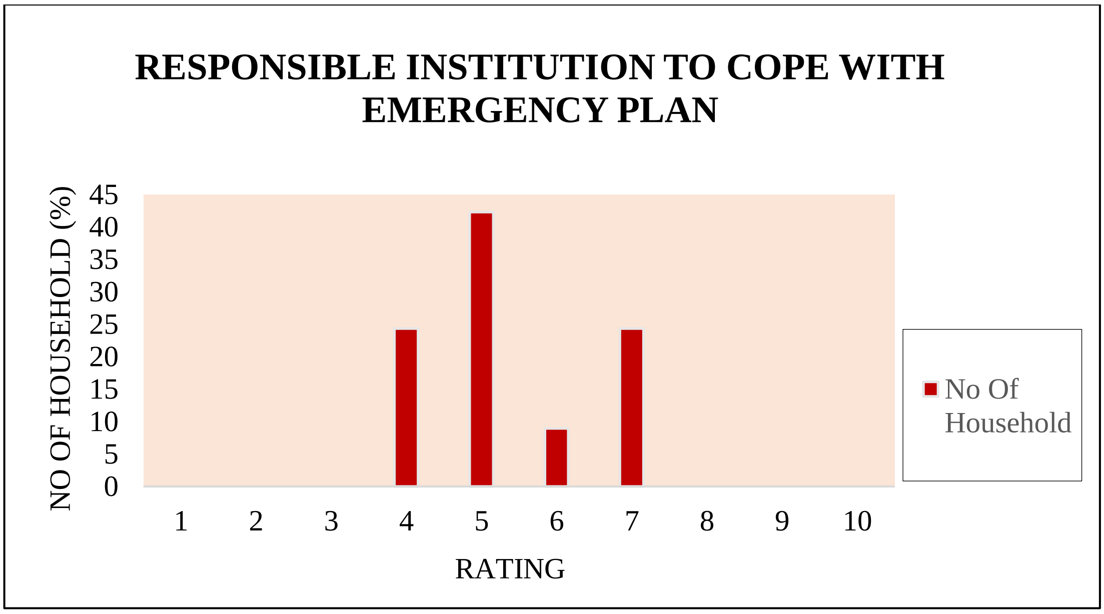


Fig5.13: Responsible Institution to cope with emergency plan

Table 5.14: Calculation Table for The Structural Work Carried Out

Rating (1-10)	No. of households	No. of households (in %)
1	0	0
2	0	0
3	19	24.36
4	19	24.36
5	33	42.31
6	0	0
7	7	8.97
8	0	0
9	0	0
10	0	0
Total	**78**	**100**

Source: Field Survey, 2024

The above table shows the rating given by the households of Harinathpur village about the structural work carried out in the area. Here most of the households have rated 5 and least of them has rated 7, which clearly means that people are not liking the structural work carried out in the area.

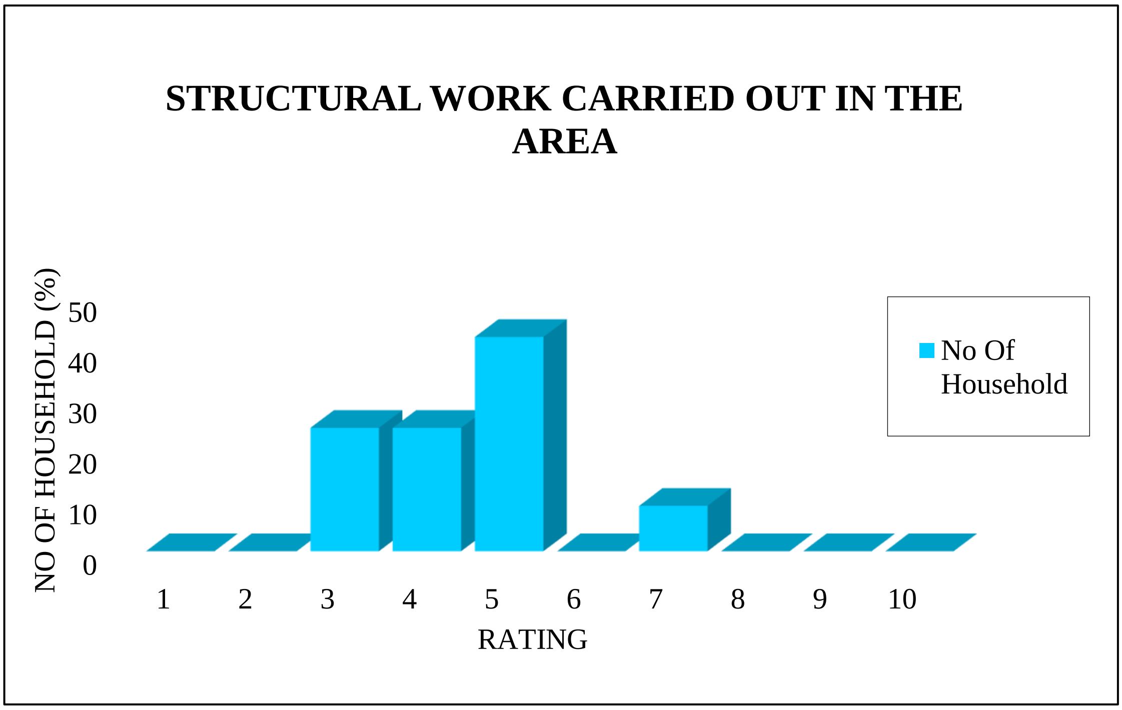


Fig5.14: Stuructural Works Carried Out in the Area

Table 5.15: Calculation Table for Management of Emergency Planning

Rating (1-10)	No. of households	No. of households (In%)
1	0	0
2	0	0
3	19	24.36
4	19	24.36
5	40	51.28
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
Total	**78**	**100**

Source: Field Survey, 2024

The above tables show the rating given by households of Harinathpur village about the emergency planning. Here we can see that maximum no, of households has rated 5 and least of them has given 3 which, clearly shows that the emergency planning of the village is not good.

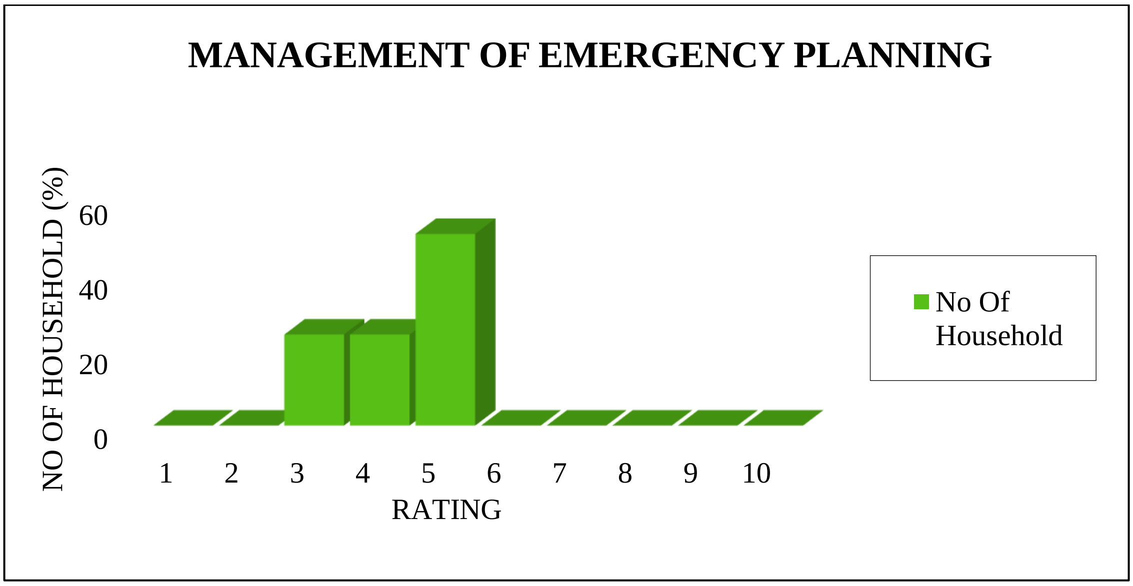


Fig5.15: Management of Emergency Planning

CHAPTER 6

Suggestions and Recommendation

6.1. Introduction

Suggestions and recommendations are needed for the stabilization and sustainable development of the Mujnai River Basin.

6.2 Treatment of slope confirmation

The slope plays a vital role in causing floods. Stability can be maintained by reducing the angle of the slope.Local people should do this treatment of susceptible slope. Also additional mining in commercial areas in mujnai river basin should be stocked.

6.3 Surface drainage

Sub surface drainage is the removal of water from the rootzone.Surface drainage of this area is affected by deep fissure and depressions, of which water accumulate and create wet ground.So the ground surface should be levelled, and depressions be filled up along with the filling up of all cracks. During such operations, the grass cover must not be disturbed unnecessarily.

6.4 Sub-Surface Drainage

Prevention of percolation in the hilly area of Mujnai Basin by covering up the slope portion by a river of impervious material like Clay, Mud etc.

6.5 Retaining walls

In the Mujnai Basin and its surrounding areas, buildings and roads are protected by retaining walls built of reinforced concrete that have failed due to inadequate design and weep holes. So the retaining walls should have proper outlet draining for the drainage water without intervention. Periodic maintenance especially during monsoons and weep holes in the wall, should be chocked with fine-grained materials.

6.6 Restrictions of Settlements

To successfully manage susceptible tracts under study, restrict the existing population to the geologically and topographically more stable part of the hill, setting apart the unstable area, which must be carefully demarcated for forestation by quick-going trees and also avoid campaign or parking during flood.

6.7 Agronomic measures

Plants protect soil from erosion.Generally, row crops are least effective and give rise to more erosion hazards.More scientific and logical cropping patterns should be adopted to protect them. In designing a conservation strategy based on agronomic measures, row crops must be combined with protection-effective cover crops in a logical cropping pattern of various agronomic measures. Cover crops, strip cropping, and mulching are essential and recommended as protective measures against soil erosions in Mujnai Basin.

6.8 Soil management

Soil conservation aims to obtain the maximum sustained production level from a given land area while maintaining soil loss below a threshold level.The maximum acceptable erosion rate is known as the soil loss tolerance estimated by various scientific research as ranging between 0.01 in semi-desert environments.Soil management aims to maintain the fertility and structure of the solid, resulting in high crop yields and good plant cover, reducing the erosive effects and runoff.

6.9 Mechanical method

Mechanical methods are used widely to control the movement of water and the decision to adopted, depending on whether the objectives are to reduce the runoff velocity and increase surface water storage capacity or safety depose of excess water.

6.10 Duties of flood disaster management

Although this measure cannot control floods, the flood policy can be necessary to the flood victims in the post floods period. Hence this measure should be implanted with immediate effects.

After the devastation of 1968 flood and the disaster management of Jalpaiguri, has been taken various policies to control the flood effects. To control flood the best policies is to contrast embankment besides the rivers. This should be constructed along all the flood porn areas of the rivers & adequate numbers and large buildings like lock gates should also be provided in the right place for passing the surplus drainage water.

6.11 Duties of health department

To tackle the situation, preparatory measures have been proposed and undertaken. From experience,some of the connecting roads become disrupted and communication from H.Q to the blocks becomes challenging.

Following measures have been taken such as -

a. District health control room will be overall in charge of the operational system.

b. Arrangements will be made for storing medicine during flood period at Jateswar health centre, Falakata health centre, Dalimpur health centre etc.

c. Control room at district headquarters and block headquarters should be opened for running regular reporting system and flood health relief measures.

d. Medicine and movement of rapid action team are needed throughout the entire region.

CHAPTER 7

CONCLUSION

With the advent of British occupation, tea plantation extensive deforestation, unscientific terrace cultivation haphazard, constructional work, inadequate drainage situation,and unplanned land use has led to various cycle of degradation .The Mujnai Basins' mountain landscape show phases of human interaction with nature.

Mining activities are one of the leading causes of floods in this region. This cause loss of villages, human life, cattle and crops. Not only in a materialistic way has it had a devastating effect on the country's economy.

It is a significant concern for all of us, especially those living in and around the Mujnai Basin of the Falakata region.lt is also a threat for the environment; such landslides damage the biodiversity and may cause a change in the Bhutan Himalayan foot hill region.

Due to this reason, we all have to take adequate measures to prevent such damages, more than the government must have to play a smooth and active role in this area to prevent mining activities, scientific measures have to be applied to prevent geophysical balance, damages caused by floods every year. They have to pay the attention to local tribal people to ensure the environment's security on their way. If such measures are taken, it can be hoped that we will be able to prevent the damage more appropriately in the near future.

Plate 1: Group Picture at our Survey Area

Plate 2: Group Picture at District Magistrate Disaster Management in Alipurduar.

Plate 3: Some Pictures at our survey Area

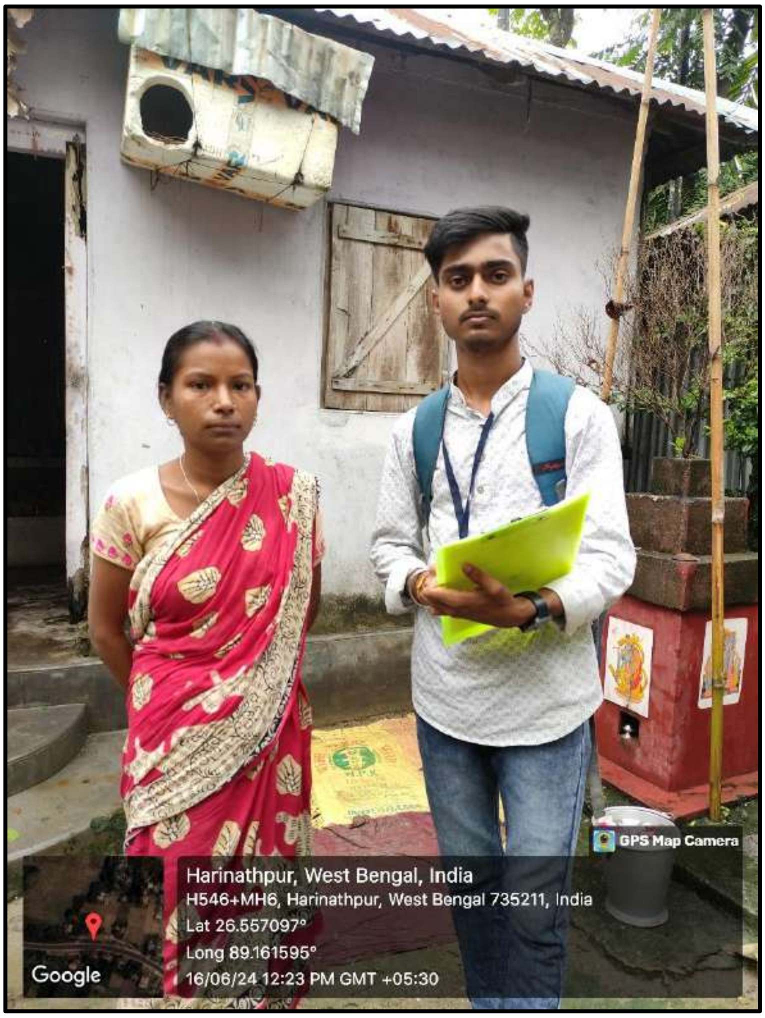


Plate 4: Individual Photograph in the Survey Area

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APPENDIX

BIRPARA COLLEGE

DEPARTMENT OF GEOGRAPHY

SCHEDULE FOR COLLECTION OF PRIMARY DATA ON

FLOOD

(INDIVIDUAL REPORT)

Name of the Respondent:

Gender: Age:

Cd Block: District:

State:

1. Name of the Village/Town:
2. What Is the Disaster Risk of Your Region?

A. Flood B. Riverbank Erosion C. Earthquake D. Landslide E. Others

3. Which Type of Floods You Can See in This Area?
4. In Your Opinion What Are the Most Effective Flood Risk Mitigation Tool?
    a. Structural Work
    b. Construction Of Flood Protection Embankments
    c. Afforestation
5. Do You Think Home Relocation from High-Risk Area Towards Safer Area Is a Good Idea?

    A. Yes B. No C. Don't Know
6. If Needed, Would You Be Personally Available Upon Receiving Adequate Financial Compensation to Relocate to New Home in Safer Area? A. Yes B. No C. Don't Know

7. Is The Flood Early Warning System Useful for The People Living in This Region?

8. A. Yes B. No C. Don't Know

9. What Improvements Would You Like to Make to The Current Warning System?

A. Don't Know B. More Information C. More Maintenance

10. In Your Opinion, How Could One Safeguard People Living in Flood prone Areas?

A. More Information B. Relocation C. Emergency Plans D. Others E. Don't Know

11. Tell Me, How Much You Agree with The Following Statement, "Current Management Can Prevent Floods"

A. Completely Agree

B. Don't Know

C. Agree

D. Disagree

E. Completely Disagree

11. Rate 1 To 10 To the Availability of The Responsible Institutions to Cope with The Emergencies:

12. Rate 1 To 10 To the Structural Works Carried Out in The Area:

13.Rate 1 To 10 To the Management of The Emergency Plan and The Early Warning System:

Risk Assessment

14.How Much Do You Think You May Be Exposed to Flood Risk in The Future?

A. A Lot Of

B. Quite A Lot Of

C. Somewhat

D. Not at All

15.Rate 1 To 10, How Much Do You Think Floods Are Hazard to Your Home?

16.Rate 1 To 10, How Much Do You Think Floods Are Hazard to Your Life?

17.Do You Have Any Personal Evolvement in Last Flood That Occurred?

A. Yes B. No

18.Do You Have Any Personal Victim from Last Flood That Occurred?

A. Yes B. No

19.Was Your Home Damaged? Yes/No

20.Whether You Were Evacuated from Your Home Earlier? Yes/No

21. Do You Currently Live in An Area Classified as Flood Prone Area?

A. Yes B. No C. Don't Know

22.Do You Know, What Are the Institution Dealing with Flood Prone Areas?

A. Yes B. No C. Don't Know

23. Do You Know, What Are the Institution Dealing with Emergency Management?

A. Yes B. No C. Don't Know

24. Did You Ever Receive Information of Flood Risk in Your Community?

A. Yes B. No C. Don't Know

25. Do You Know the Cost of The Structural Works Carried Out in The Area?

A. Don't Know B. Lots of Money C. Amount Specified

26. Do You Know the Cost of The Emergency Plan?

A. Don't Know B. Lots of Money C. Amount Specified

27. What Is Your Suggestion to Minimize the Flood Problem in Your Area?

28. Will You Be Interested to Get the Training Related to Flood Disaster Management Skill?

Signature of the supervisor

Signature of the student