



Scholars Research Library

Archives of Applied Science Research, 2014, 6 (3): 142-153
(<http://scholarsresearchlibrary.com/archive.html>)



Flood hazard mapping of the Lohar Nala Basin, West Tripura

Moujuri Bhowmik and Nibedita Das

*Department of Geography and Disaster Management, Tripura University, Suryamaninagar
West Tripura*

ABSTRACT

Floods are probably the most recurring, widespread, disastrous and frequent natural hazards of the world. This geomorphic hazard is common in West Tripura District as it is situated in a tropical monsoon region. Lohar Nala flows for 22.53 km distance in Mohanpur Rural Development Block, West Tripura District. About 20-25% of the total basin area (102.51 km²) is flood affected. This study aims to identify the flood affected mouzas and to prepare Flood Hazard Map of the Lohar Nala Basin, where flood pose a recurrent danger. An additive model was utilized to create a composite flood hazard index of this basin. A composite flood hazard index was prepared incorporating variables of near distance to the Lohar Nala, population density, number of households in each mouza, agricultural losses and availability of high ground (shelter). Flood hazard zones were mapped in a GIS environment. Three flood hazard zones have been identified in the basin according to these five variables among which Bamutia falls under High Flood Zone. Fatikchhara and Kalkalia mouzas fall under Moderate and Low Flood Zone respectively. The study demonstrates the potentials of GIS application in flood hazard mapping.

Key words: Lohar Nala, Flood Hazard Zone, Flood Hazard Index, GIS modeling.

INTRODUCTION

River and river systems are very important to man. In the historical times, the entire civilization grew around or near the rivers. River and their adjacent floodplain corridors fulfill a variety of functions both as part of the natural ecosystem and for a variety of human uses. The rivers and river systems also have negative values; they often cause great damage and death due to flood. Flood hazard is the probability of occurrence of a potentially damaging flood event of a certain magnitude within a given time period and area [7]. It is one of the most devastating natural hazards which lead to the loss of lives, properties and resources. Lohar Nala is the smallest and un-gauged river with 22.53 km length of West Tripura District. About 20-25 % of the total basin area (102.51 sq. km) is flood affected. Flood Hazard Mapping is a vital component for appropriate land use in flood plains. It creates easily readable, rapidly accessible charts and maps [4] which facilitates the identification of risk areas and prioritize their mitigation effects.

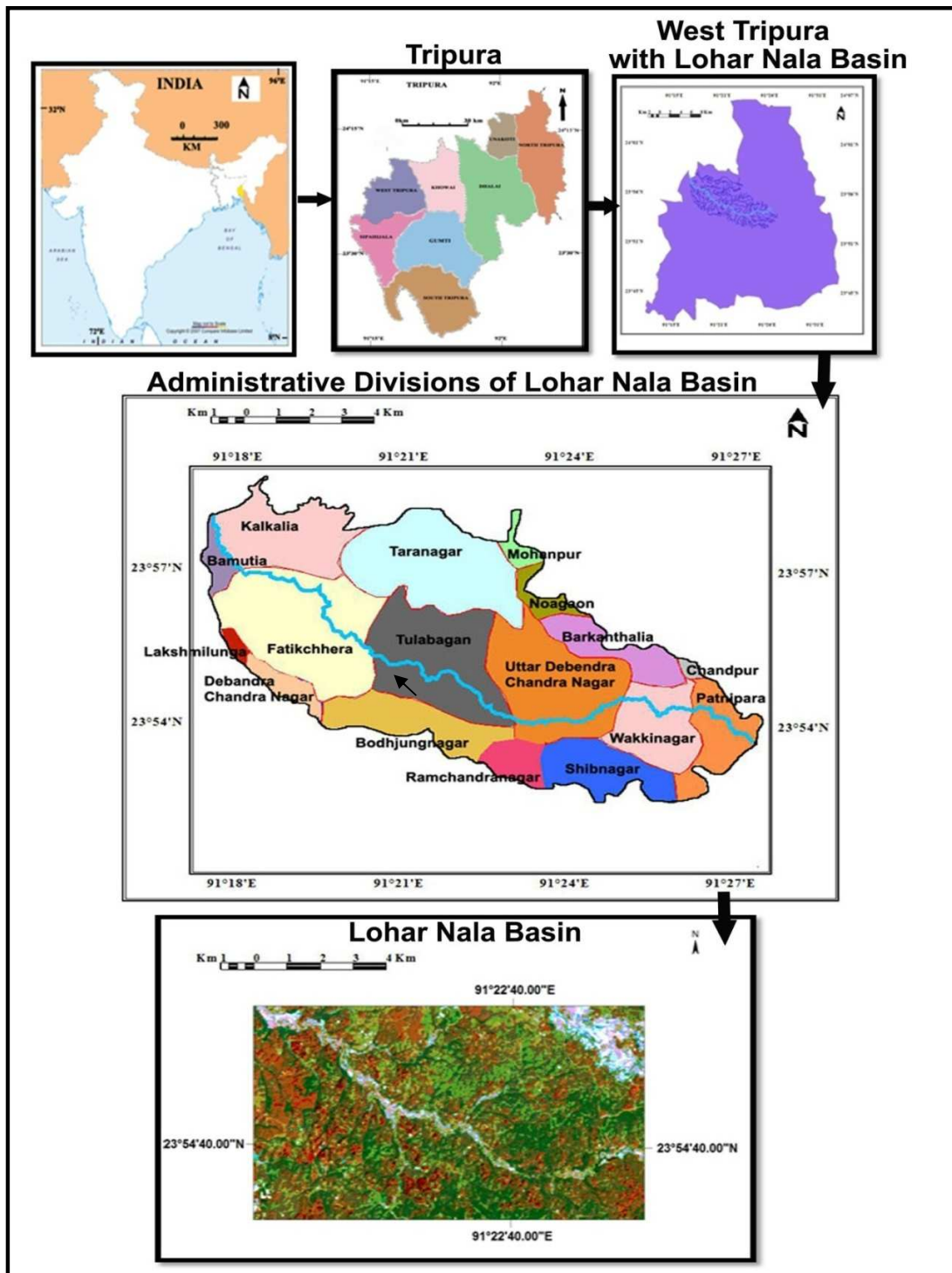


Fig.1: Location Map of the study area.

2. Study Area:

This basin extends from 23°52'N to 23°58'N latitude and 91°17'30"E to 91°27'50"E longitude (Fig.1). Geologically, the study area falls under Dupitilla series and Tipam group of rocks which is characterized by sand rocks with shale and fossil woods. Tropical monsoon type of climate prevails here. The area is characterized by

piedmont slopes and uplands, terraces and tillas and flood plains where red loam and sandy loam soils and older and younger alluvial soils are found respectively.

3. Objectives:

Main objective of this research work is to prepare Flood Hazard Map of the basin.

MATERIALS AND METHODS

In order to carry out this study Geomatica V 10.1 (for GIS mapping), Adobe Photoshop V 7, GPS tool, SOI topographical map No. 79 M/5 (1:63360 scale) of 1932-33, Land sat Imagery of 1989 and 2006 (LISS III) have been used.

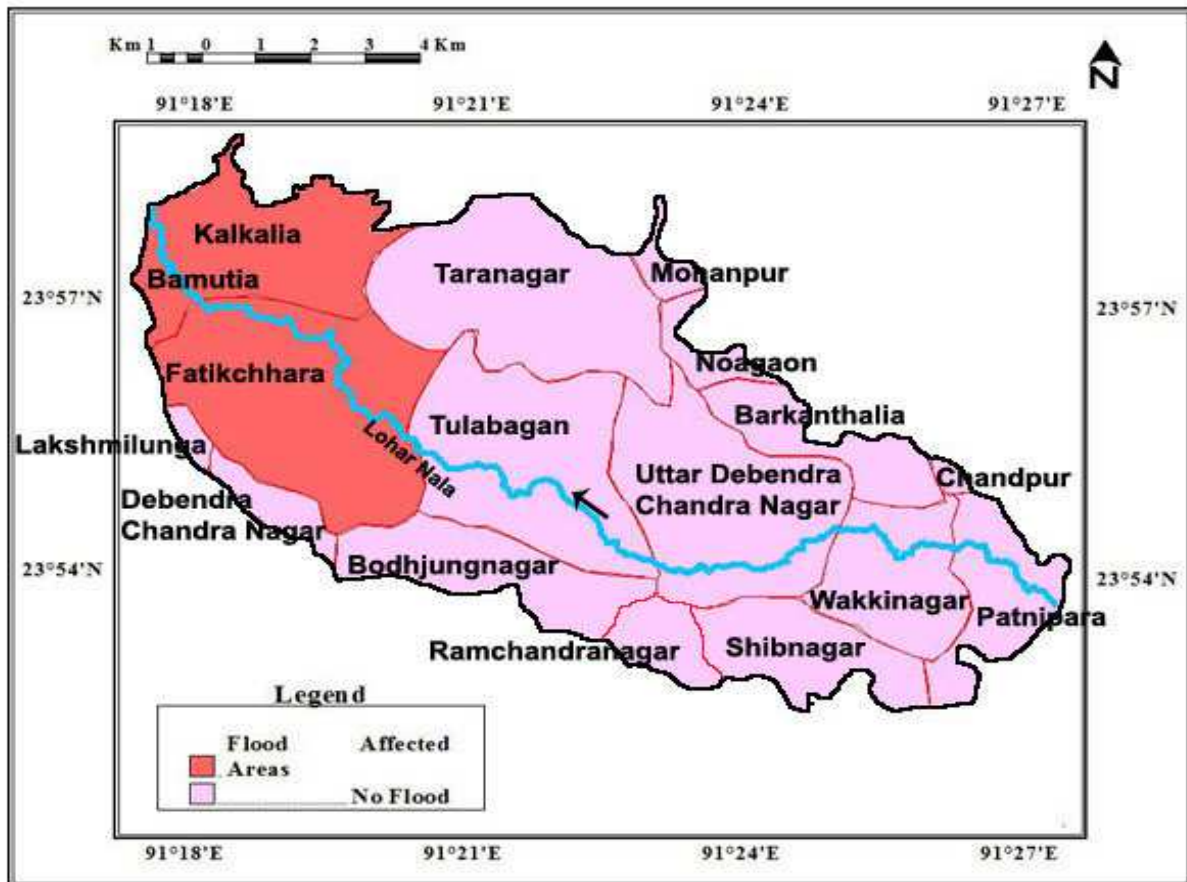


Fig. 2: Flood affected areas of the Lohar Nala basin, West Tripura.

The present study is mainly based on intensive field survey and observations. Intensive field work has been carried out to collect the information regarding flood inundation and related problems in the flood affected areas. No satellite data was available for flood period; therefore, for inundation data the researcher had to depend on field survey and the information collected from the Tehsil Offices of respective mouzas. Then, flood inundation layer has been prepared on the basis of the GPS (Global Positioning System) reading. Inundation depth has also been recorded during field visit. No secondary data was available for preparing Flood Hazard Map. Thus, this map has been prepared following Forkuo's Method. For preparing Flood Hazard Map five variables, namely, (i) distance of the affected mouzas from the catchment, (ii) population density, (iii) land elevation, (iv) number of houses, (v) agricultural losses of those affected areas have been taken. Questionnaire survey has been carried out in the affected mouzas to find out the amount of loss, available government or non-government relief, diseases, other sufferings during flood etc.

RESULTS AND DISCUSSION

5.1 Flood affected areas:

Flood is a very common hazard in Lohar Nala Basin. Here majority of the victims are poor people living in flood plain. The lower reach of the Lohar Nala is densely populated and during field visit it has been noticed that the people have built settlements within the river channel. Out of 17 mouzas only three mouzas namely Kalkalia, Fatikchhara and Bamutia are flood affected which are situated in the lower reach of the Lohar Nala (Fig. 2).

In the study area flood occurred twice (June and September) in the year 2004, once in July 2007 and September 2010 and due to which Kalkalia, Fatikchhara and Bamutia were adversely affected. In the year 2004, there was a havoc flood due to prolonged duration of rainfall of 20 days in the month of June (900mm) and 21 days in the month of September (555.9mm) (Fig.3). Because, in this year rainfall started to occur from the pre-monsoon season which lead to the saturation of soil, all storage capacities became satisfied as a result of which the monsoon shower of June increased the discharge from 15 cumec to 30.63 cumec in June and 21 cumec to 31.33 cumec in September (Fig.4). Consequently, excessive amount of water spread over the surrounding area and inundate vast area of the Lohar Nala basin. In the year 2007, there was continuous rainfall for 21 days in the month of June (745.4 mm) and 23 days in the month of July (908.6 mm) when discharge was 29 cumec and 31.33 cumec respectively. In the year 2010, these three mouzas were affected in the month of May due to high discharge (25.72 cumec) because of long duration of rainfall (671.6mm) for 20 days. Generally, river maintains very low flow and low velocity of water during most part of the year and hence, sudden torrential rainfall causes sudden increase in the volume of water which cannot be disposed off by the river immediately and thus the river banks are overtopped by swelling of water and instantaneous floods are caused [8].

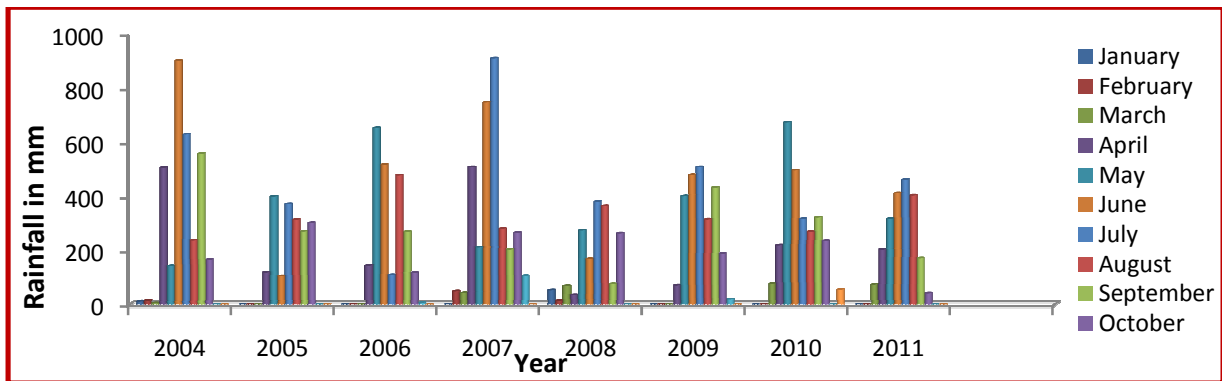


Fig. 3: Temporal variation of rainfall in the Lohar Nala (2004 – 2011), West Tripura.

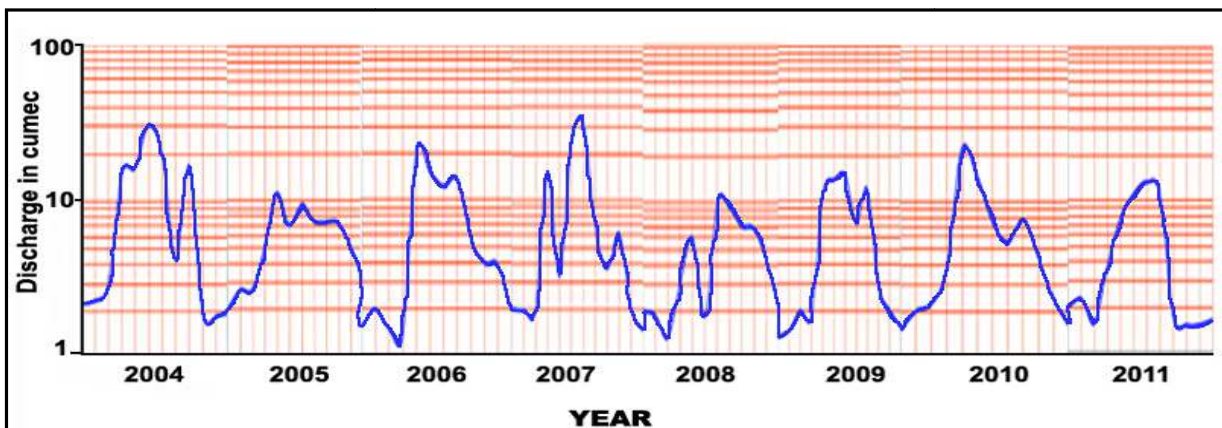


Fig.4: Monthly discharge hydrograph of the Lohar Nala during 2004-2011 (based on rainfall-temperature data provided by the ICAR, Lembuchhara).

These floods damaged houses, standing crops, destroyed schools, roads and livestock of these three villages. Many families were displaced and mostly seek shelter in school buildings, relative's house etc.

5.2 Flood hazard Mapping:

The purpose of flood hazard mapping is to identify the areas within a development plan that are at risk of flooding based on factors that are relevant to flood risks. Managing and analyzing flood hazard is one of the most important factors. A flood Hazard Map based on administrative units is a quick, accurate and cost effective means for planners and administrators to formulate remedial strategy. In addition, it makes the process of resource allocation simple resulting in a smooth and effective implementation adopted flood management strategy. A small scale leads to identification of the higher hazard zone upon which a large scale and a detailed mapping eventually identifies the high hazard areas [5].

For this study, SOI topographical map (79M/5) covering the study area at a scale of 1: 63360, Digital Elevation Model (DEM), digitised contour map, administrative map of the basin, population census data, household data, supervised classification map were used. However, this hazard map is very much data intensive in nature.

5.2.1 Digital Elevation Model and its applications in Flood Hazard Mapping:

To prepare Flood Hazard Map, Digital Elevation Model of Lohar Nala has been prepared (Fig.5). A Digital Elevation Model (DEM) is a digital representation of the Earth's relief that consists of an ordered array of elevations relative to a datum and referenced to a geographic coordinate system [2]. DEM is the main source to produce information of land topography. Today, the advancement in both information technology and computing power and graphics visualizations capabilities have led to the rapid growth of DEM usage in many fields, such as landscaping, mapping and GIS [1]. It provides elevation information that is useful for many environmental applications including hydrologic modelling and flood management planning [6]. They provide the opportunity to model, analyze and display phenomenon related to topography and other surfaces.

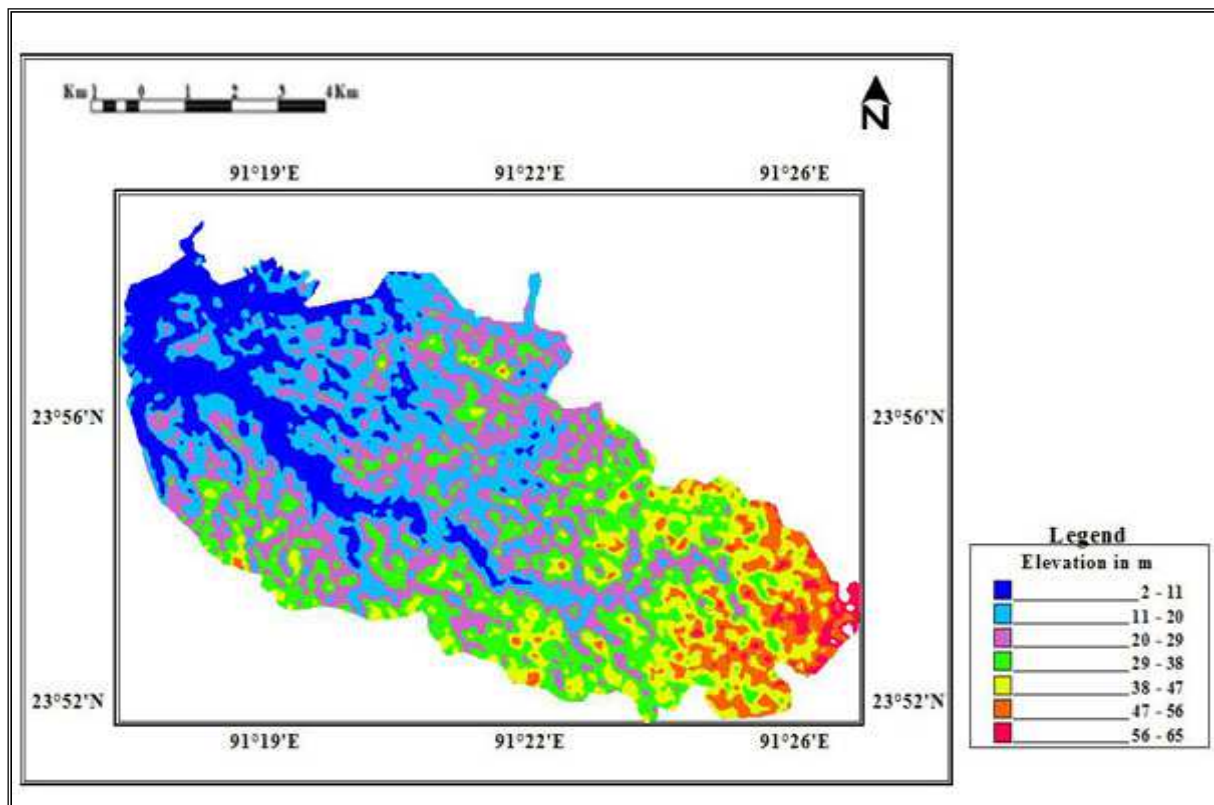


Fig.5: Digital Elevation Model (DEM) of the Lohar Nala basin, West Tripura.

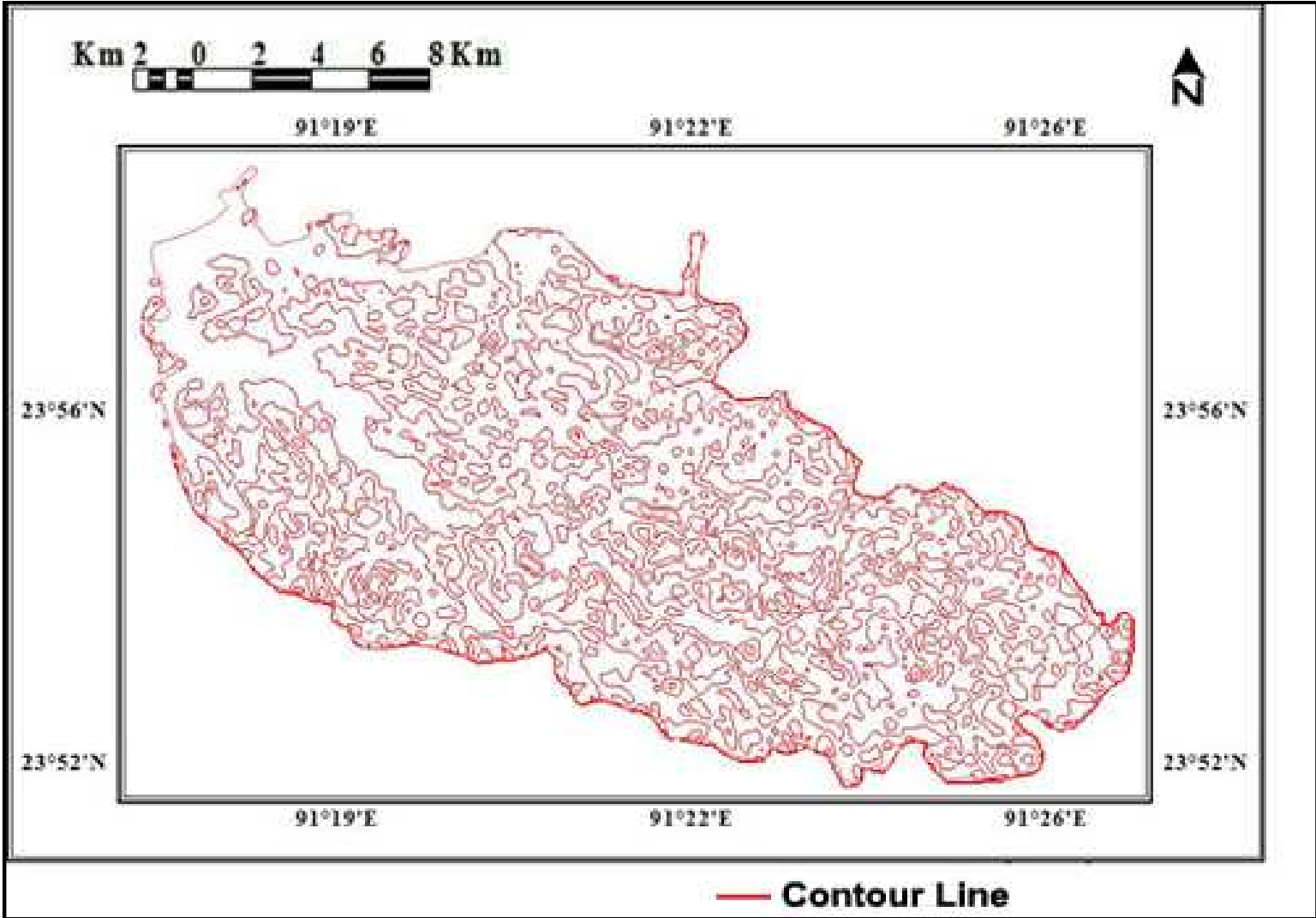


Fig.6: Contour map of the Lohar Nala basin, West Tripura.

From DEM, contour has been generated at an interval of 10 m using GIS technique and this contour map has been used to extract the highest point for each flood affected mouzas (Fig.6). The mouza boundary layers have been overlaid and highest elevation for each mouza has been extracted using Geomatica 10.1 software.

5.2.2 Land Use Classification:

To identify and measure agricultural area land use of the Lohar Nala basin has been classified using GIS technique (Fig. 7). The method for land use classification includes two steps: (a) geo-referencing and (b) image classification.

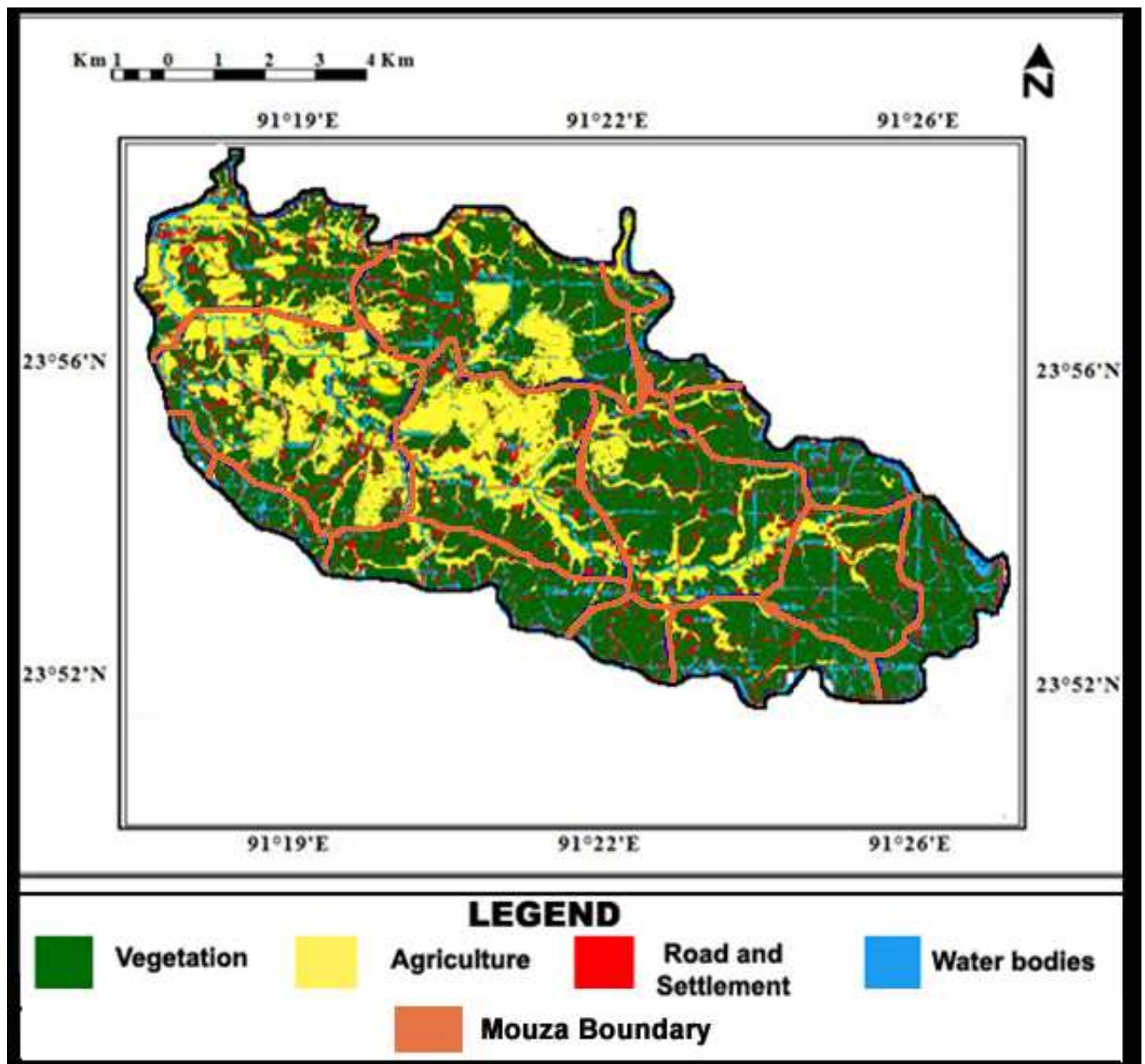


Fig.7: Supervised Classification of the satellite image of the Lohar Nala basin, West Tripura.

5.2.3 Proximity to the river:

For the analysis, various mouza's distances from the Lohar Nala were determined. The midpoints of the mouzas were considered. Since the mouzas were digitised into polygons, it was firstly converted into point feature, as shown in Fig.8, to define the midpoints of the affected mouzas. The distances of the various mouzas in kilometres were then extracted.

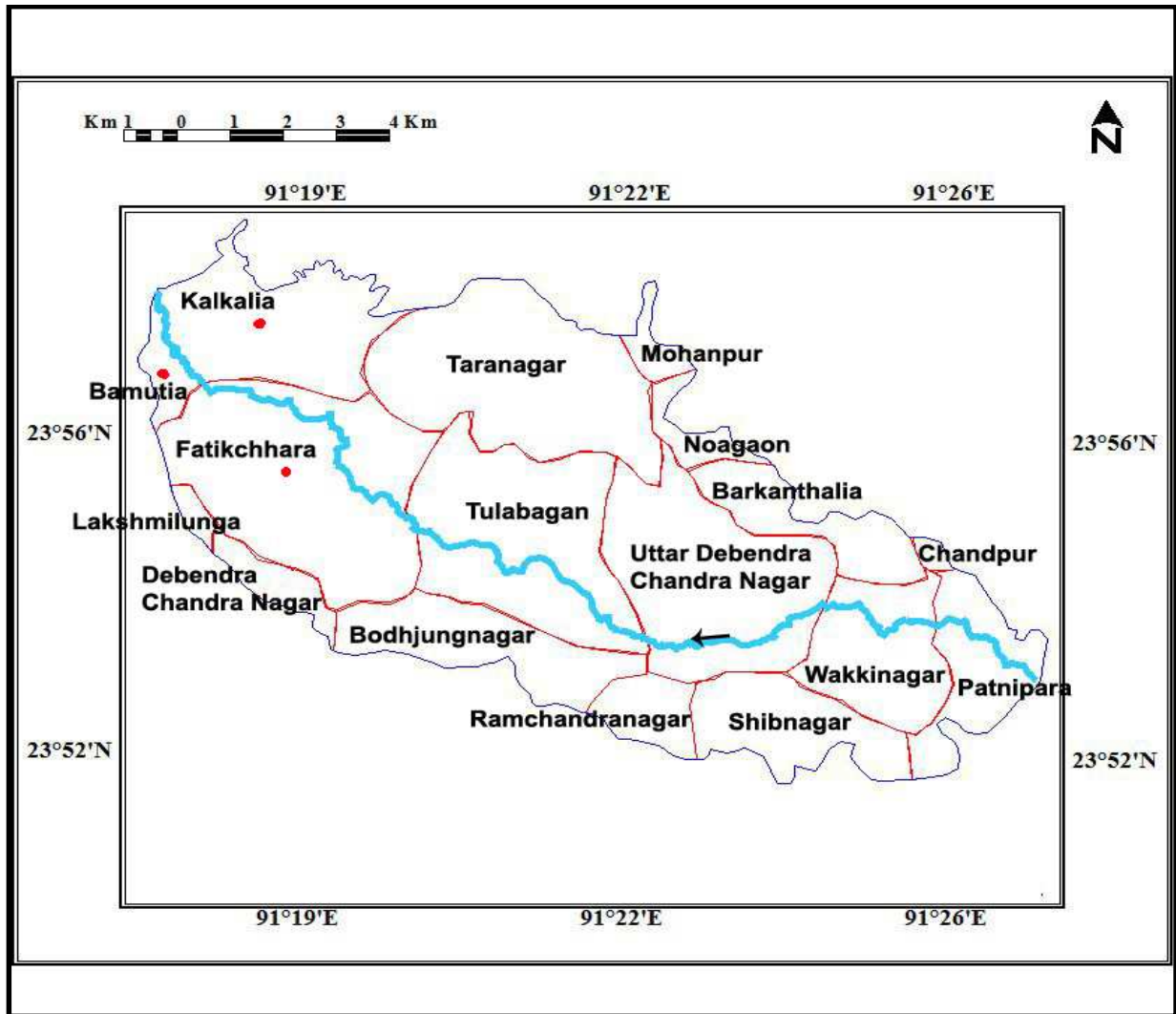


Fig.8: Point feature class of flood affected mouzas of Lohar Nala basin, West Tripura.

5.3 Flood Hazard Index (FHI):

An additive model has been adopted for creating a composite flood hazard map. It is recognised that the principle of assigning rank to the variables is very crucial in this entire process of hazard mapping. In this paper the process of assigning rank to the flood hazard indicators is primarily knowledge based. The variable ‘Near_Mouza’ which is the proximity to the river has been attached high importance because where the risk of inundation is very low other variables do not contribute anything to the element of flood hazard [3]. The ranking scheme for flood hazard indicators is presented in Tables 1 according to Forkuo’s Method.

Table 1: Ranking scheme for flood hazard indicators

Adjective	Distance from the catchment (km)		Population Density (persons/km ²)		Highest Elevation (m)		Number of Houses		Cultivated Cropped Land (km ²)	
	Range	Rank	Range	Rank	Range	Rank	Range	Rank	Range	Rank
Negligible	>3.60	0	0-300	0.25	>60	1	1000-1300	0.20	0.01-1	0.02
Very Low	3.00 – 3.60	1.50	301-600	1	51-60	1.5	1301-1600	0.52	1.01-2	0.04
Low	2.41 – 3.00	1.80	601-900	1.5	41-50	2.5	1601-1900	0.68	2.01-3	0.06
Moderate	1.81-2.40	2.63	901-1200	2.5	31-40	3	1901-2200	0.88	3.01-4	0.08
High	1.21 - 1.80	4.50	1201-1500	4	21-30	4	2201-2500	1.14	4.01-5	0.10
Very High	0.61-1.20	6.75	1501-1800	6	11-20	4.5	2501-2800	1.50	5.01-6	0.12
Extreme	0-0.60	8.80	>1800	8	0-10	5	>2800	1.68	>6	0.14

This ranking scheme clearly displays that very low or 0 ranking has been applied at very high 'Near_Mouza' (Table 2) value and at very high elevation value (Table 4) to prevent the far mouzas from getting a higher flood hazard index on the basis of other factors. On the other hand, ranking has been increased at rate with higher risk of other factors namely population density, number of houses, agricultural losses of those affected areas (Table 3, 5 and 6). That means very low 0 ranking has been applied at very low value of population density, number of houses and agricultural losses area.

Table 2 : Proximity to the catchment ranks

Name of the Mouza	Distance(km) from the catchment (Near_Mouza)	Hazard Rank (R_Mouza)
Bamutia	1.90	2.63
Fatikchhara	1.73	4.50
Kalkalia	1.94	2.63

Table 3 : Population density ranks

Name of the Mouza	Population Density (persons/km ²) (2011)	Hazard Rank (R_Pop)
Bamutia	1,259	4
Fatikchhara	735	1.5
Kalkalia	481	1

Table 4 : Highest Elevation ranks

Name of the Mouza	Highest Elevation in m (Shelter)	Hazard Rank (R_Shelter)
Bamutia	20	4.5
Fatikchhara	40	3
Kalkalia	20	4.5

Table 5: Property ranks

Name of the Mouza	Number of Houses (Property) (2011)	Rank (R_Prop)
Bamutia	2,376	1.14
Fatikchhara	2,913	1.68
Kalkalia	2,321	1.14

Table 6 : Cultivated Cropped land ranks

Name of the Mouzas	Cultivated Cropped land (km ²)	Rank (R_Crop)
Bamutia	5.11	0.12
Fatikchhara	2.36	0.06
Kalkalia	1.59	0.04

5.3.1 Flood Hazard Index (FHI) model:

For preparing a flood hazard index (FHI), a model is normally adopted. The variables and the principles of assigning ranks to the variables are very crucial in arriving at a flood composite index in process of hazard mapping. Mostly, the process of assigning ranking of flood hazard indicators is knowledge based.

$$FHI = (R_Mouza + R_Pop + R_Shelter + R_Prop + R_Crop)$$

Where R_Mouza is rank for the mouzas proximity to the river, R_Pop is rank for mouza's population density, R_Shelter is rank for mouza's highest elevation, R_Prop is rank for properties and R_Crop is rank for agricultural produce at risk. The attribute tables bearing the various indicators ranking were added and calculations performed to obtain the index for the mouzas (Table 7).

Table 7 : Flood Hazard Index (FHI)

Name of the Mouzas	R_Mouza	R_Pop	R_Shelter	R_Prop	R_Crop	FHI
Bamutia	2.63	4	4.5	1.14	0.12	12.39
Fatikchhara	4.50	1.5	3	1.68	0.06	10.74
Kalkalia	2.63	1	4.5	1.14	0.04	9.31

5.3.2 Hazard categories:

Hazard values have been divided into 3 classes on the basis of two quartile measurements (Table 8). Table 9 shows the hazard categories of affected mouzas of Lohar Nala. After the final flood hazard index was derived, it has been represented in a graduated coloured map using Geomatica Software.

Table 8: Classification of composite hazard ranks into qualitative hazard intensity classes

Index Value Range	Hazard Category
9.31–10.61	Low
10.62 – 11.91	Moderate
11.92 – 13.21	High

Table 9: Hazard Categories of affected mouzas

Name of the Mouzas	FHI	Hazard Category
Bamutia	12.39	High
Fatikchhara	10.74	Moderate
Kalkalia	9.31	Low

5.3.3 Analysis of Results:

Five indicators have been taken into consideration for developing the composite flood hazard index. Each of the factors has been assigned different ranking to quantify the severity of hazard. In Fig.9, the final flood hazard map is represented in a graduated colour map. Proximity of the mouzas to the Lohar Nala has been considered as the measure of flood proneness of a particular mouza. To quantify the lives under potential flood threat, population density of each was taken as another important variable. Elevation takes into account as the aspect of flood emergency management. During the time of inundation, affected population are required to be evacuated to a safe place for temporary shelter, not likely to be submerged by flood water. Agricultural land was the indicator that takes into account agricultural production that will be affected in times of flood. Number of houses in each mouzas was considered to quantify the economic assets under potential flood threat. Bamutia, Fatikchhara and Kalkalia are located in close proximity to the Lohar Nala and these areas are characterized by very low to low elevation due to which excessive amount of water overtops the river bank and spreads over these areas. Population density and agricultural losses are highest at Bamutia in comparison to Fatikchhara and Kalkalia. Population density and area under agriculture are moderate at Fatikchhara and low at Kalkalia. Thus, Bamutia mouza falls under high hazardous zone, Fatikchhara mouza under moderate hazardous zone and Kalkalia mouza under low hazardous zone.

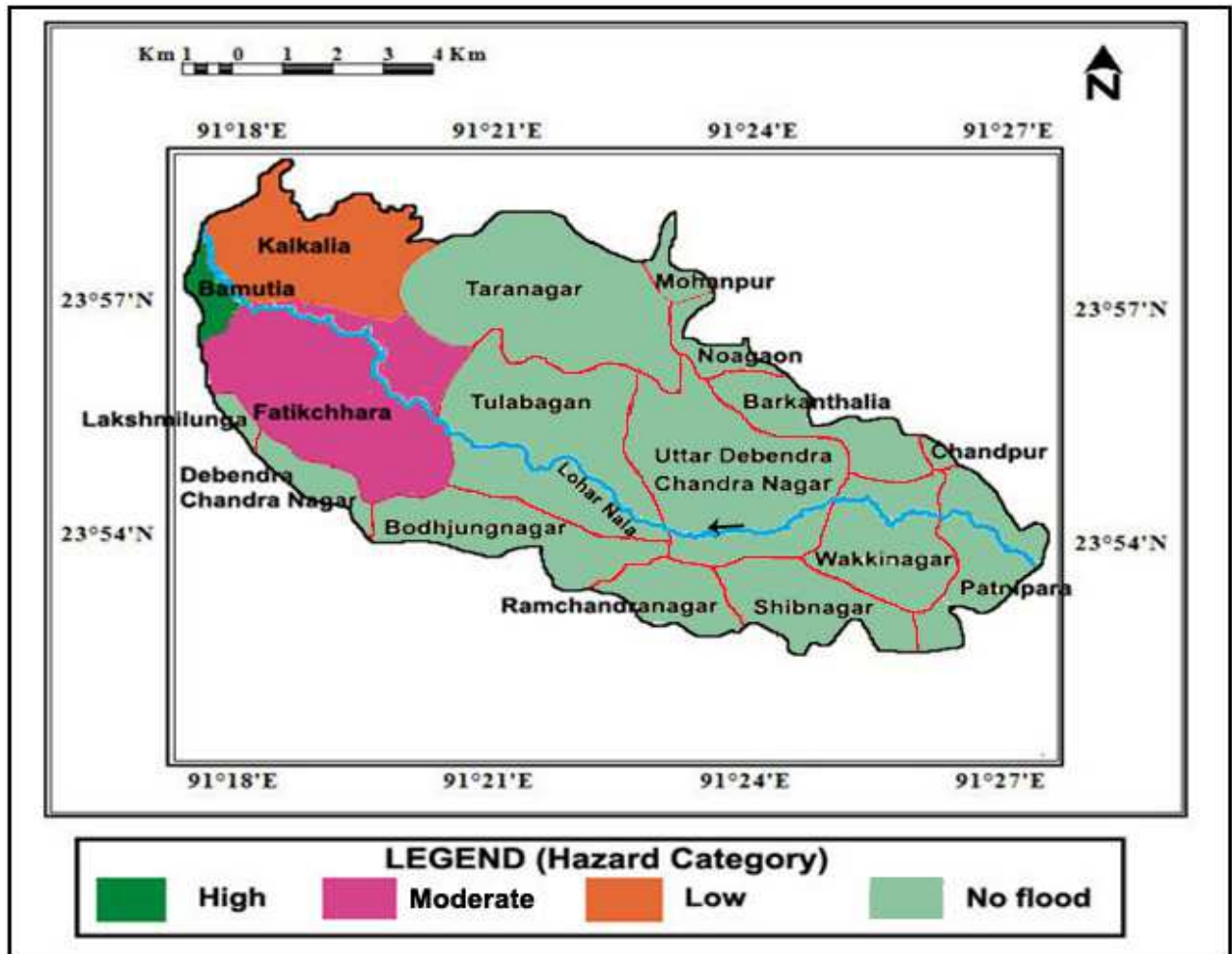


Fig. 9: Flood Hazard Map of the Lohar Nala Basin, West Tripura.

CONCLUSION

From the above discussion it can be concluded that three mouzas namely Kalkalia, Bamutia and Fatikchhara are flood affected mouzas of Lohar Nala Basin. Because these three areas are situated in the lower reach of the Lohar Nala. Three flood hazard zones have been identified in the basin according to these five variables among which Bamutia falls under High Flood Zone. Here population density, the main resource of any area, and agricultural losses, the main source of income of this area, are highest in comparison to Fatikchhara and Kalkalia mouzas. These two fall under Moderate and Low Flood Zone respectively.

REFERENCES

- [1] E Forkuo, *Remote Sensing and Spatial Information Sciences*, **2008**, 37, B2, 1023-1029.
- [2] E Forkuo, *Journal of Environmental Science and Engineering*, **2010**, 52, 2, 81-92.
- [3] E Forkuo, *International Journal of Geomatics and Geosciences*, **2011**, 1, 4, 932-950.
- [4] G Bapalu, R Sinha, *GIS Development Weekly*, **2005**, 1, 13, 1-3.
- [5] J Sanyal and X Lu, *Hydrological Processes*, **2005**, 19, 3699-3716.
- [6] K McDougall, X Liu, B Basnet and A Apan, *Evaluation of current DEM Accuracy for Condamine Catchment*, Proceedings of the 8th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences Shanghai, P. R. China, June 25-27, **2008**, 71-78.

[7] N Brooks, *Vulnerability, Risk and Adaptation- A Conceptual Framework*, Tyndall Centre for Climate Change Research, Norwich, **2003**, 1-16.

[8] S Singh, *Environmental Geography*, Prayag Pustak Bhawan, Allahabad, **2008**, 425-432, 331-334, 308-316.