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Application of Analytical Hierarchy Process Model for Flood Risk Zonation of Sunamganj, Bangladesh: A GIS and Remote Sensing Based Study

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Abstract: Flood is one of the most common and destructive natural hazards in Bangladesh. It is the most frequent hazard in Sunamganj District and occurs once or twice in every year. It wreaks havoc on people and property in the area. Remote sensing and geographic information systems are powerful tools for assessing hydrological studies and hazard management in today's environment. Analytical Hierarchy Process is a time-consuming and cost-effective decision-making approach. In order to model and estimate the flood risk zones in Sunamganj District, Bangladesh, an integrated Analytical Hierarchy Process (AHP) and Geographic Information System (GIS) analysis technique is used in this research. Total eight spatial factors were assessed using GIS and AHP model to investigate the flood risk zones in Sunamganj. The factors such as slope, elevation, topographic weighted index (TWI), drainage density and distance from river were derived from SRTM DEM using Arc map. Landuse land cover (LULC), normalized difference vegetation index (NDVI) were assessed using landsat 8 imageries. The LULC map was created using supervised image classification method. The lithology of Sunamganj district was generated using world geological shapefiles from USGS Certmapper. In the final map, flood susceptibility of Sunamganj was categorized in five zones including Very High, High, Moderate, Low and very Low flood risk zones. As a result, about 4.827% of the total area is found to be very high flood risk zone, 17.584% of total area of high flood risk zones and 27.126% of total area of moderate flood risk zones are found. On the other hand, 33.786% of low flood risk zones and 16.321% of extremely low flood risk zones are detected. It is concluded that the integration of AHP and GIS in flood risk assessment can give useful comprehensive outputs and information for flood risk management.

Keywords: AHP, GIS, Remote Sensing, Flood Susceptibility, LULC, NDVI, TWI

1. Introduction

Flood is an overflow of water which merges lands and water bodies like river, pond, ocean, reservoirs etc. The reasons behind flood are heavy rains, overflowing rivers, broken dams, urban drainage basins, storm surges and tsunami, channels, lack of vegetation, melting snow and ice etc. The number of floods has been increased since last three decades and that floods are considered as a major natural disaster due to their

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devastating effects that lead to socio-economic losses (Souissi et al., 2020). It is known that future flood threats won't go away, and the start of climate change will increase flood strength and frequency, endangering many parts of the world (Das, 2011). Climate change, changes in land use, and other anthropogenic activities are the main causes of increases in flood risk (Kourgialas et al., 2011). Flood risk assessments are used to evaluate flood risk management (FRM) techniques (Koks et al.,2015). The main causes of the floods are typically attributed to the intense monsoon rains and the timing of the major rivers' flood peaks (Khalequzzaman, 1994). The North-Eastern region of Bangladesh becomes flooded in every year. Sunamganj District is frequently flooded from March to September each year. The main reason of flood in Sunamganj is excessive rainfall. Sunamganj District recorded the highest rainfall in Bangladesh due to its geographical location which is adjacent to Cherapunji having the highest rainfall in the monsoons. Heavy downpours in the Meghalaya and Assam regions result in the unexpected rise of the water level and water flow speed in streams and rivers that bring a large number of debris, boulders, trees, obliteration of infrastructure and constructed buildings and cause life loss, property damage and infrastructure destruction in the majority of cases (Das et al., 2018).

In recent decades, remote sensing and geographical information system have become evolutionary tools to perform hazard management and geospatial mapping through multi-criteria decision models (Pourghasemi, 2012). Many studies on flood risk are conducted at various scales using remote sensing and GIS. Every researcher employed some appropriate method to determine what caused the flooding and what harm it caused. In present, multi-criteria decision making (MCDM) based flood risk assessment has gained popularity. For example Lai et al., 2015 used Fuzzy model to estimate flood risk while (Yang et al., 2013) used an integrated Fuzzy and AHP model. According to (Saaty, 1980**),** Through multi-criteria analysis techniques like AHP, which resolves complicated problems by organizing the components into a hierarchical framework, decision makers might research and comprehend the problems.

AHP model can be used in different purposes. The model was used in agricultural fields. For example AHP was used in farmers' adoption on irrigation and suitable crop land selection (Karami, 2006 ; Uyan, 2013). Bunruamkaew et al., 2011 used this method to determine the site suitability for ecotourism.

Flood is one of the major natural calamities of Sunamganj. It is frequently brought on by long periods of rainfall, precipitation and drainage systems that fail to handle excessive runoff. The aim of this study is to find the potential flood susceptibility zones in Sunamganj and map them accordingly using AHP method and GIS.

2. Study Area

Sunamganj is a district in the Sylhet Division in north-eastern Bangladesh (Figure 01). The district has a total area of 3,669.58 square kilometers and is located between 24°34' and 25°12' north latitudes and 90°56' and 91°49' east longitudes.. It is bordered on the north by the Indian state of Meghalaya, on the south by the habiganj and kishoreganj districts, on the east by the sylhet district, and on the west by the netrokona district. It is bounded Meghalaya a state of India which supposed to have the most rainfall in the world. Sunamganj District is a low lying area consists of numerous haors and wetlands. A maximum elevation of 22 meters above mean sea level can be found in Sunamganj. According to the recent census Sunamganj District has the total population of 246,968. Population density is 660 per sq.km.

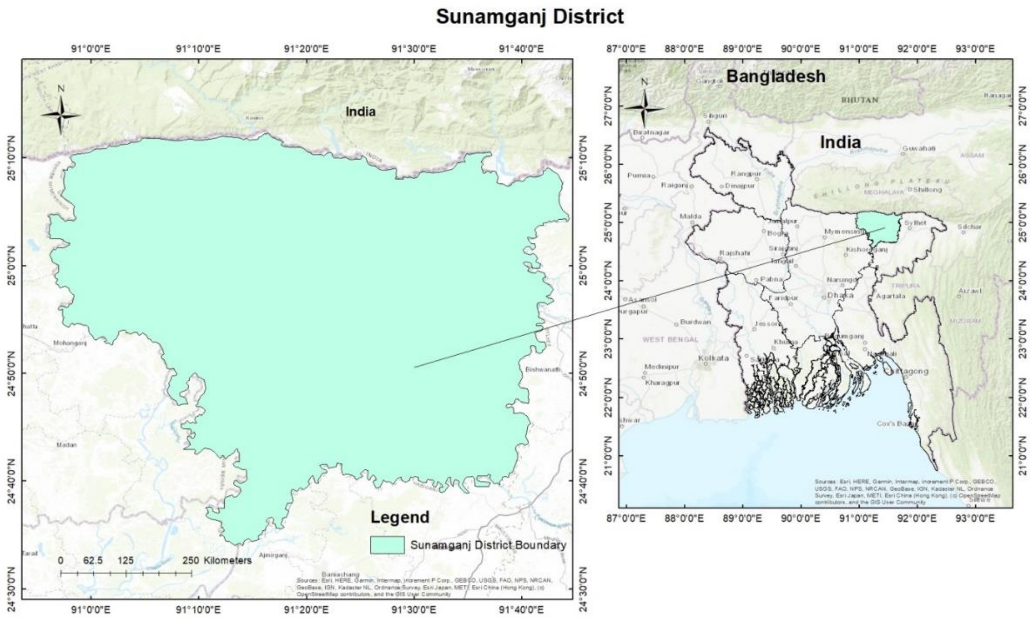

Figure 01: Represents the study area of this research. Source: compiled by Author, 2022

3. Data and Methods

The methodology considered for this study is shown in figure 2. The data collected for this study were all secondary. SRTM DEM, Landsat 8 Imegary and world geologic shape file was collected for making the variable maps of flood zoning.

- **DEM (SRTM):** The Shuttle Radar topographic Mission (SRTM) DEM (Digital Elevation model) was collected of 30 m resolution from USGS earth explorer. Elevation map was extracted from the original DEM. Other variables like Topographic weighted Index (TWI), Slope, Drainage Density, and Distance from river were also directed from the digital elevation model. The slope was derived with the spatial analyst tool using the DEM. Topographic weighted index (TWI) was calculated using raster calculator and spatial analyst tool. Streams and drainage density was calculated by using the DEM on ARC map spatial analyst tool. Distance from river also made with DEM by using ring buffer tool on ARC map.

- **Landsat 8 Imegery (year 2021**): Landsat 8 Imegery were also collected from USGS Earth Explorer. The acquisition date was 20-06-2021and the resolution was 30 m with less than 10% cloud cover. LULC and NDVI map was derived from this**.** The LULC map was generated using supervised image classification method. It was classified in f classes, settlements, water bodies, agricultural land, barren land and vegetation cover. NDVI was derived using the formula: NDVI = (NIR-RED) /

(NIR+RED), where in landsat 8 the near infrared (NIR) is band 5 and the red is band 4. That means the formula used here was: (Band 5 -Band 4) / (Band5 +Band 4).

- **World Geologic Shapefile:** The USGS Certmapper website provided this shape file. This was used to create the study area's geology map. The lithological map of the study area was directly derived from the shapefile, then it was converted into raster in order to reclassify.

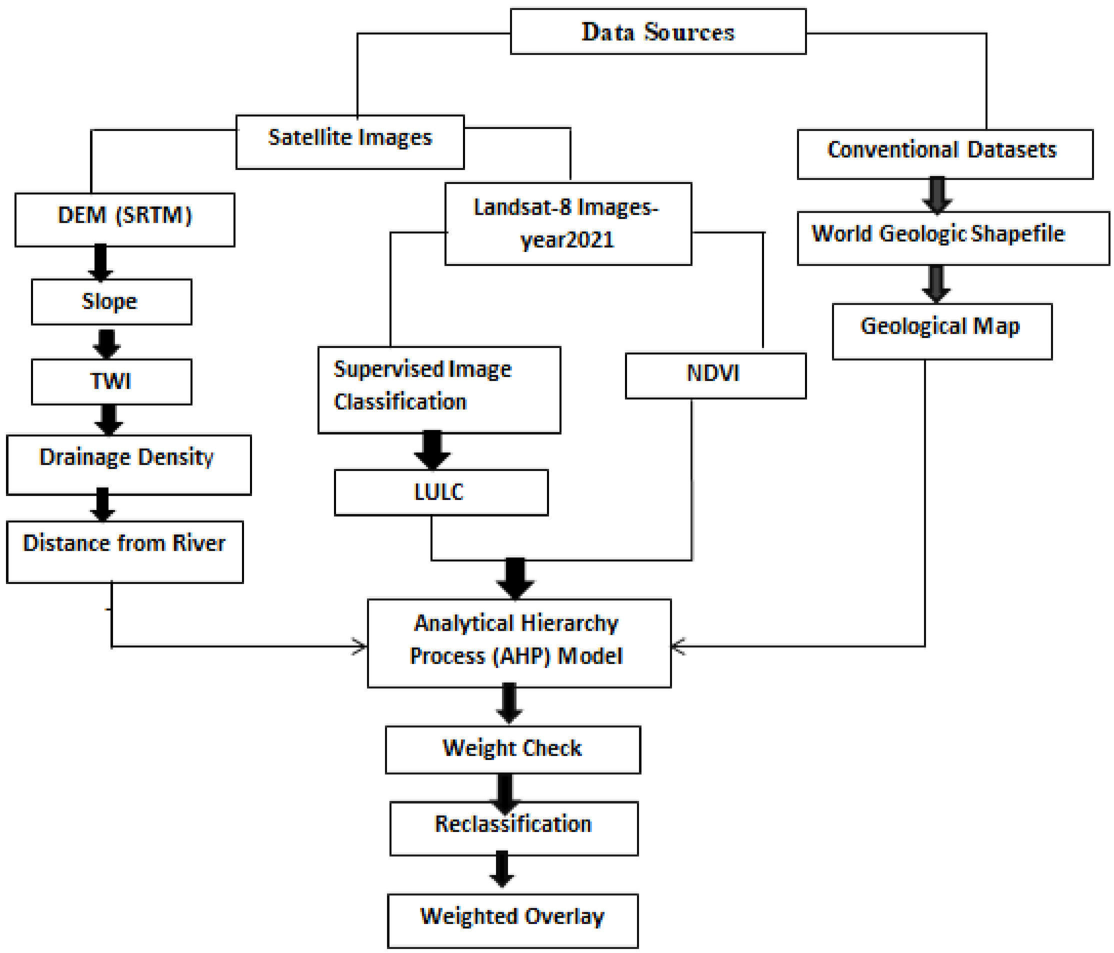

Figure 02: Represents the Methodology of this study. Source: compiled by author, 2022

4. Analytical Hierarchy Process (AHP) Model

The Analytic Hierarchy Process (AHP) is a method for organizing and analyzing complex decisions, using math and hypothesis. It was established by T.L Saaty is a method to solve multiple criteria decision making problems by setting their priorities (Pourghasemi et al.,2012). A hierarchy is a mechanism for comparing several possibilities according to importance. The AHP is designed in a way that represents human mind and nature. Therefore, AHP provides the possibility of searching and evaluating the cause and effect relationship between goal, factor, sub-factor, and alternatives using breaking down the structure of the problem (Yang et al., 2013).

The analytical hierarchy process is a very flexible and systematic method for solving complicated decision issues with various components (Saaty, 1980). The weights and rankings of 8 spatial factors have been calculated in this study using the AHP model to identify the flood hazard zones. In this study, the likelihood of a flood occurring was calculated using the flood susceptibility model, and the resultant map was divided into five groups: very low, low, moderate, high, and very high. The flood susceptibility model can be defined as following equation :

$$\mathbf{Fs} = \sum_{1}^{n} \mathbf{W} * \mathbf{R} \quad \textbf{(1)}$$

Here, **Fs** means flood susceptibility, **W** indicates the weights of the parameters and R indicates the ranks. A pairwise comparison matrix (Table 01) was built where the weighted categories were divided into sub categories and comparison was done by pair to pair of each category. The following equation was used to make the pairwise comparison matrix:

$$A = aij \begin{bmatrix} a11 & a12 \ldots\ldots & a1n \\ a21 & a22 \ldots\ldots & a2n \\ a31 & a32 \ldots\ldots & a3n \end{bmatrix} \quad \textbf{(2)}$$

Where, **A** = pair wise comparison and **aij** =numerical comparison between the values **i** and **j**.

At the last step of AHP, the mathematical process commences to normalize and find the relative Weights (Table 02) for each matrix. The relative weights are given by the right eigenvector (w) corresponding to the largest eigenvalue max (L) as in equation:.

Max L Aw = w ....(3)

The matrix A will have rank 1 and max equal to n if the results of the pairwise comparisons are totally consistent. In this particular scenario, weights can be generated by normalizing any of the rows or columns of A.

The relationship that exists between A's entries is what determines the consistency.

The formula of consistency index CI is given below:

CI = (Max L - n) / (1 –n) ....(4)

The final consistency ratio (CR), which allows to determine whether the evaluations are sufficiently consistent, is calculated as the ratio of the consistency index (CI) and the random index (RI), as indicated in Equation 5.

The formula of consistency ratio is given below:

CR = CI / RI ....(5)

Here, CR stands for consistency ratio, CI represents consistency index and RI represents random index. If the CR in > 10% the AHP model would not be validate and AHP ranking should be re adjusted then. In this study, CR was 9.5%. Every aspect taken into account in this study has been evaluated independently and divided into various subcategories. Each subcategory has received a different rank and weights (Table 03) as a result of relative scoring using the AHP approach.

Table 01: Represents the Pairwise comparison Matrix

Parameters	TWI	Slope	LULC	NDVI	Distance From River	Drainage Density	Geology	DEM
TWI	1	1	1	1	1	1	3	1
Slope	1	1	3	1	1/2	1	1	3
LULC	1	1/3	1	2	1/3	1	1	1
NDVI	1	1	½	1	1/5	1/3	3	1
Distance From River	1	2	3	5	1	1	3	3
Drainage Density	1	1	1	3	1	1	3	1
Geology	1/3	1	1	1/3	1/3	1/3	1	3
DEM	1	1/3	1	1	1/3	1	1/3	1

Source: The pairwise comparison matrix was created using equation (2) by taking account into the eigenvalue (equation 3); consistency index (equation 4) and consistency ratio (equation 5)

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Table 02: Normalized and the weight values in the standardized pairwise comparison matrix

Parameters	TWI	Slope	LULC	NDVI	Distance From River	Drainage Density	Geology	DEM
TWI	0.14	0.13	0.09	0.07	0.21	0.15	0.20	0.07
Slope	0.14	0.13	0.26	0.07	0.11	0.15	0.07	0.21
LULC	0.14	0.04	0.09	0.14	0.07	0.15	0.07	0.07
NDVI	0.14	0.13	0.04	0.07	0.04	0.05	0.20	0.07
Distance From River	0.14	0.26	0.26	0.35	0.21	0.15	0.20	0.21
Drainage Density	0.14	0.13	0.09	0.21	0.21	0.15	0.20	0.07
Lithology	0.05	0.13	0.09	0.02	0.07	0.05	0.07	0.21
DEM	0.14	0.04	0.09	0.07	0.07	0.15	0.02	0.07

Table 03: Represents the weighted values and Flood Potential Classes

parameters	Class	Potentiality	Flood Potential Class	Weights %
TWI	-5.374933 **to** - 1.63267	Very Low	1	13
	1.632674 - 0.048929	low	2	
	0.048929 - 1.918418	moderate	3	
	1.918418 - 4.323706	High	4	
	4.323706 - 10.359936	Very High	5	
Slope	0 - 0.493066	Very High	5	14
	0.493066 - 0.91532	High	4	
	0.91532 - 1.47282	Moderate	3	
	1.47282 - 2.500146	Low	2	
	2.500146 - 10.200527	Very Low	1	
LULC	Settlement	High	4	10
	Agriculture	Moderate	3	
	Vegetation	Very Low	1	
	Water Body	Very High	5	
	Bare lands	Low	2	
NDVI	-0.125858 - - 0.011446	Very High	5	9.0
	-0.011446 - 0.102965	High	4	
	0.102965 - 0.217376	Moderate	3	
	0.217376 - 0.331788	Low	2	
	0.331788 - 0.446199	Very Low	1	
Distance From River	0.5- 1.8	Very High	5	23
	1.8-3.1	High	4	
	3.1-4.4	Moderate	3	
	4.4-5.7	Low	2	
	5.7-7.0	Very Low	1	
Drainage Density	0 - 1581.123657	Very High	5	15
	1581.123657 - 4253.557617	High	4	
	4253.557617 - 7628.37988	Moderate	3	

parameters	Class	Potentiality	Flood Potential Class	Weights %
	7628.379883 - 12397.974609	Low	2	
	12397.974609 - 25455.349609	Very Low	1	
Geology	Tila Uplands	Very Low	1	8
	Limestone	Low	2	
	Young Gravelly Sand	Moderate	3	
	Alluvial Silt and Clay	High	4	
	Marsh Clay	Very High	5	
DEM	-27 - 7	Very High	5	8
	7 - 10	High	4	
	10 - 13	Moderate	3	
	13 - 18	Low	2	
	18 - 63	Very Low	1	

Source: The table is derived from the flood variables and their weights using Analytical hierarchy Process model.

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5. Flood Potential Variables Analysis

The analysis of spatial features and variables as components in the development of AHP-GIS decision making is covered in this section.

In this Study, eight topographic criterias were chosen to evaluate according to their significance in flood occurring. The factors considered are TWI, Slope, LULC, NDVI, Distance from river, Drainage density, Geology and DEM (elevation).

5.1 Topographic Wetness Index

A popular method for describing wetness conditions at the catchment scale is the topographic wetness index (TWI) (Grabs et al., 2009). The Topographic Wetness Index is a typical tool for quantifying the amount of moisture in the soil. If the wetness index is high, this indicates that the soil moisture content is likewise high. This indicates that areas with a high wetness index are not able to absorb a greater quantity of water. They store a bigger quantity of water than other regions.

The topographic wetness index is defined as:

w = ln (A/ tanβ).....................................(6)

Where **w** means the wetness index, A means the specific catchment area, β means the downright inclination direction of the terrain in degrees**.** Higher TWI regions are more vulnerable to flooding. Lower TWI zones, on the other hand, are less vulnerable. Calculation of the TWI of the study area (Figure 03a) has done directly through processing of SRTM DEM .On a scale from 1 to 5, the ranks progress from lower to higher in the reclassification map (Figure 03b).

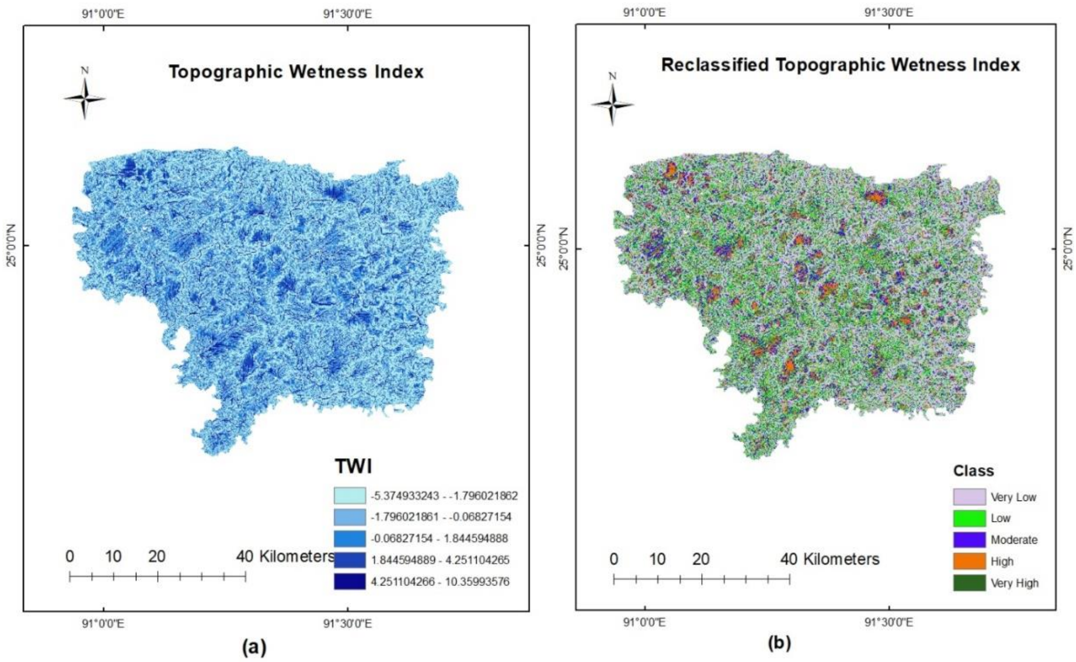

Figure 03: (a) Topographic wetness index (b) Reclassified Topographic Wetness Index.

Source: The topographic weighted Index (TWI) was prepared with SRTM DEM using the equation 6. The reclassified map was created on a scale of 1-5 ranking from very low to very high Compiled by author, 2022.

5.2. Slope

A landscape's angle, inclination, steepness, or gradient are all distinct ways of referring to the concept of slope. Flooding is significantly more common on slopes with a lower gradient than on slopes with a higher gradient. A location with a low slope gradient will constantly attract rain or additional river water. As a result, slope is the most commonly used parameter in the generation of flood maps.

In this study, the digital elevation model (DEM) was used to create the slope map (Figure 4a).Low gradient slopes are highly vulnerable to flood occurrences compared to high gradient slopes. So, on the scale of 1-5, lowest gradient slope is considered as the highest flood risk zone. That is why reversed reclassification was used make the reclassified map (Figure 4b).

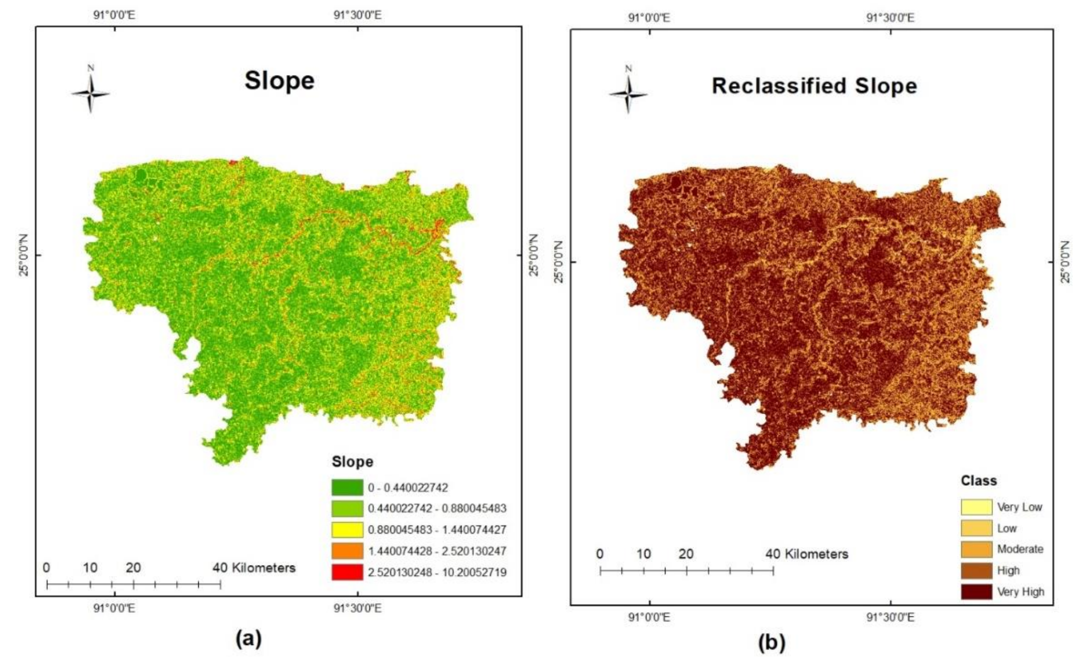

Figure 04: (a) Slope map of Sunamganj District. (b) Reclassified slope of Sunamganj district.

Source: The slope was prepared with and spatial analyst tool on Arc Map using the SRTM DEM. The reclassified map was created on a scale of 1-5 ranking from very low to very high.

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5.3. LULC

Land use land cover (LULC) is a component of the physical composition and features of land elements on the earth's surface. LULC systems contain complex dynamics that include ecological, social, and economic factors. Changes in the availability and distribution of use of land have substantial consequences for climate, environmental issues, and natural ecosystem conditions (chihlar, 2000). Land use and Land cover classification generally gives the idea about how permeable or non-permeable the land is to the water. That is why LULC map plays an essential role in flood mapping.

The research area's LULC map (Figure 05a) is created utilizing Landsat 8 OLI TIRS level 1 data sets and the supervised image classification technique. Landsat 8 dataset were of year 2021.

In reclassified map (Figure 05b), the water bodies are given the scale 5 which is very high flood zone, followed by the settlement and agricultural lands are given 4 and 3. The bare soil and vegetation cover were given 2 and 1 respectively. Because it is obvious that the River and wetlands will be flood the most. That is why in the reclassified map it is given the highly risk value. Also built areas do not let the water to infiltrate. They will be also highly flooded. On the other hand, agricultural lands always situate near river and settlements. it can be moderately flooded. it is given the rank 3. Water doesn't not stay longer in vegetated area, that is why these regions are less flooded.

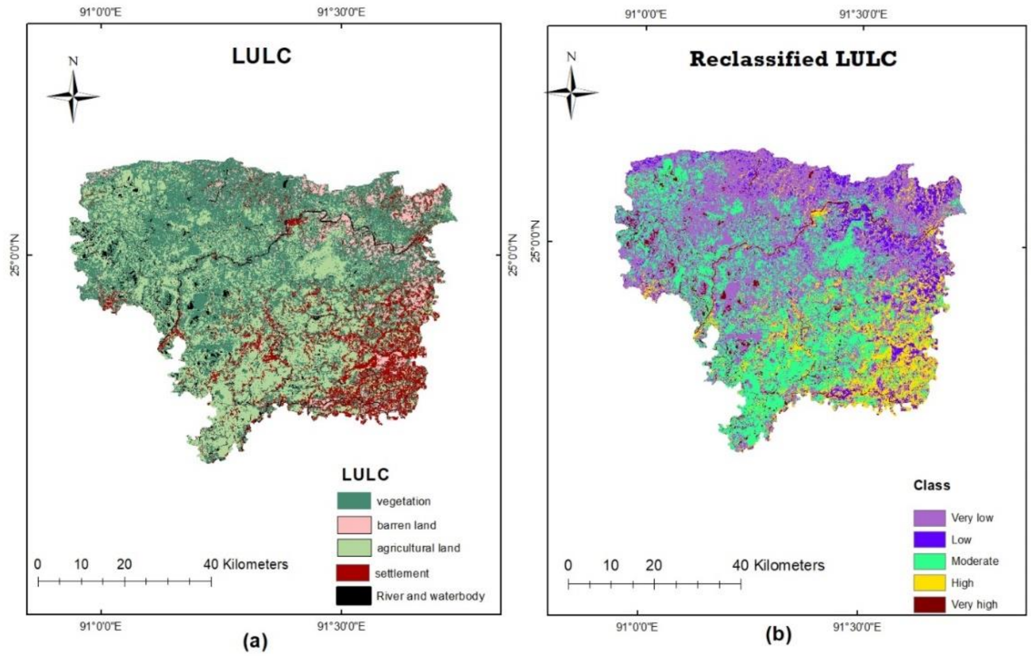

Figure 05: (a) Landuse and Land cover map of Sunamganj. (b) Reclassified Landuse Land cover Map of Sunamganj.

Source: A supervised image classification technique was used to create the LULC map using Landsat 8 imageries. It was divided into five categories: vegetation, barren land. agricultural land, settlement and water bodies. Reclassified map was prepared based on the infiltration of the Landuse.

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5.4. NDVI

NDVI (Normalized Difference Vegetation Index), a simple numerical indicator and powerful tool that can be used to assess spatio-temporal changes in green vegetation (Pettorelli et al., 2013). The normalized difference vegetation index (NDVI) is an easy-to-understand graphical indicator that can be applied to the analysis of remote sensing measurements, which are typically acquired from a space platform. These measurements are used to establish if the target area under observation is covered in living, green vegetation. The NDVI index can detect and quantify the presence of living green vegetation by using reflected light in the visible and near-infrared wavelengths.The NDVI value is always in the range of -1 to +1.The normalized difference between red and near infrared bands in an image is calculated by calculating the ratio of red and near infrared bands on a per-pixel basis from a remotely sensed image.

The formula of NDVI is:

NDVI = (NIR-RED)/(NIR+RED)...............................(7)

This formula is applied differently with different satellite Imagery. In this study landsat 8 imageries are used. The formula of NDVI using Landsat 8 imageries is following:

NDVI = (B5-B4) / (B5+B4) .... (8)

Here, B4 means band 4 and B5 means band 5.

In the study area, the NDVI (Figure 06a) ranged from –0.9 to 0. 39 that means there is abound of low lying physical settings in the study area with some sparse vegetation and crops. That means the area is more likely to be flooded with very high to moderate intensity.

As NDVI ranks from -1 to 1 and lowest value indicates the lower area, so lower the rank the higher the probability of flood. That is why reversed reclassification method was used to prepare the reclassified NDVI map (Figure 06b).

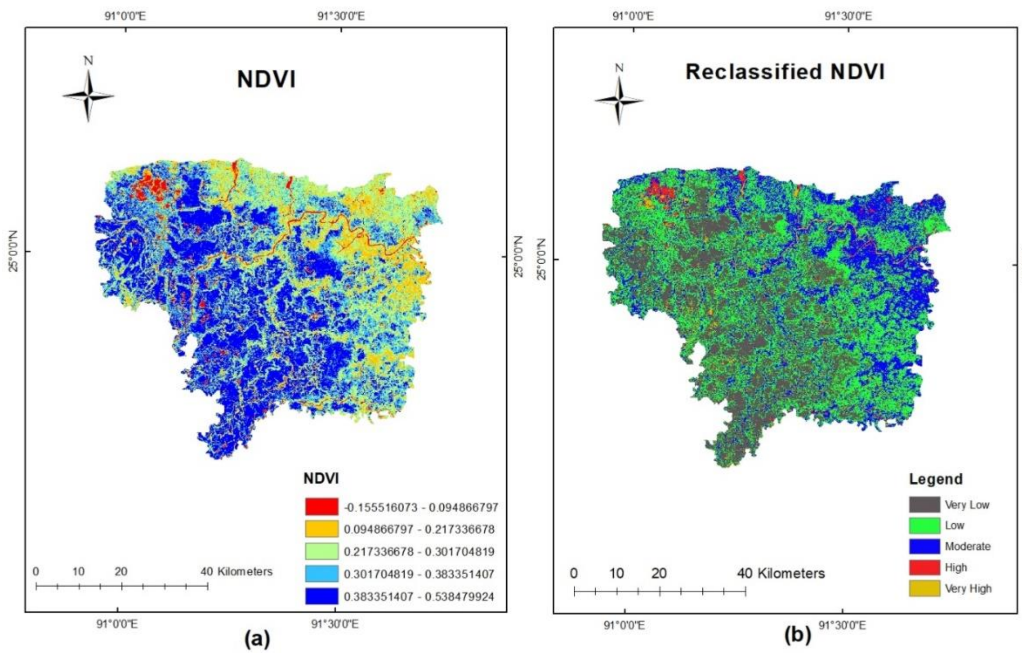

Figure 06: (a) Normalized Difference Vegetation Index of Sunamganj. (b) Reclassified Normalized Difference Vegetation Index.

Source: The Normalized Difference Vegetation Index (NDVI) was prepared with landsat 8 imageries using the equation 7 and equation 8. The reclassified map was created on a scale of 1-5 ranking from very low to very high.

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5.5 Distances from River

A significant component that contributes to the accuracy of flood mapping is distance from the river. The slope and elevation both raise to a greater degree as the distance traveled rises. Another interesting fact is that a stream is almost always located at the lowest point in the surrounding area. As a direct consequence of this, areas that are remote from the canal have a significantly reduced risk of being flooded. Therefore, the probability of being flooded is reduced by increasing the distance from a river. The study area's distance from the river (Figure 07a) was calculated using ArcGIS' buffer tool. The distance covered ranged from 0.5 km all the way up to 7 km. On a scale from 1 to 5, the region that was the farthest apart received the rating of 1, while the regions that were closer together received the score of 5, which referred to the zone with the highest potential for flooding in the reclassified map (Figure 07b)

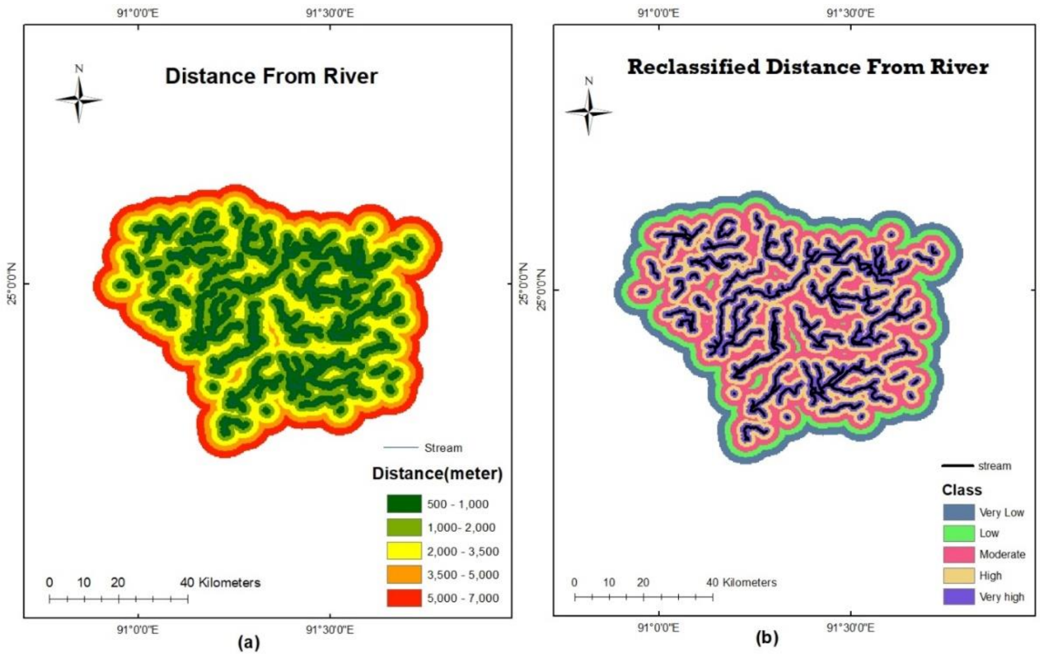

Figure 07: (a) Distance from river in kilometer. (b) Reclassified map.

Source: The distance from river was prepared using DEM and ring buffer tool on Arc Map. The reclassified map was created on a scale of 1-5 ranking from very low to very high.

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5.6 Drainage Density

The drainage density is determined by dividing the length of the stream channel by the surface area of the drainage basin. Mathematically it is expressed as:

Drainage density = river length / basin area...................(9)

Drainage density, a basic length scale in the landscape, is recognized to be the transition point between scales where unstable channel-forming processes yield to stable diffusive processes. This notion is examined in terms of equations for the evolution of landscapes that include the minimum necessary mathematical complexity (Tarboton et al., 1992). The drainage density map of the study area (Figure 08a) was prepared using SRTM

DEM. The risk of flooding increases with the density. The reclassified density map (Figure 8b) is done according to it.

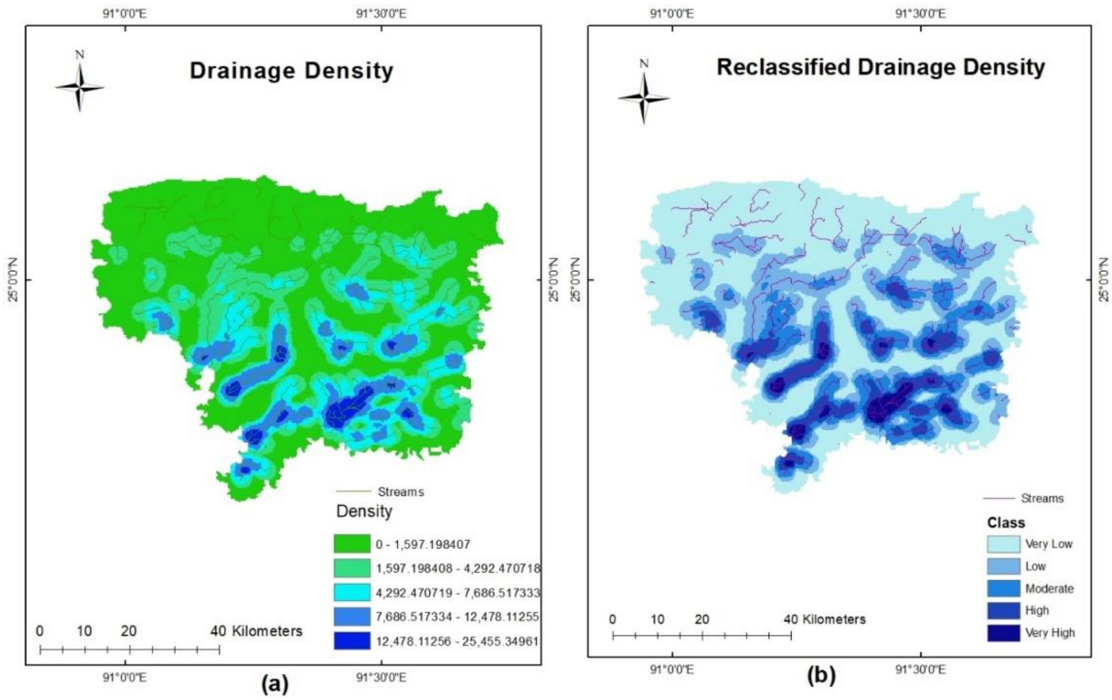

Figure 08: (a) represents the drainage density map of Sunamganj District. (b) Reclassified drainage density on the scale of 1-5.

Source: The drainage density map was prepared with SRTM DEM using equation 9. The reclassified map was created on a scale of 1-5 ranking from very low to very high.

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5.7. Lithology

The lithological features of sediments control the heterogeneity in permeability (Jin et al., 2021).Flood intensity can be influenced by such factors/properties of a rock. Geology of a region has great impact on flooding. Marsh clay leads the geological features of Sunamganj district. The area is also influenced by dupi tila (Lower hills composed of yellowish to light brownish to very fine moderately hard to loose mudstone, shale, siltstone, and clay, with occasional conglomerates containing petrified wood clasts.) and Pleistocene uplands followed by sands, limestone, and other bedrocks. The Lithological map of study area (Figure 09a) was made from world geologic shape file which was collected from USGS Certmapper website. The reclassified map (Figure 09b) was made according to the porosity and height.

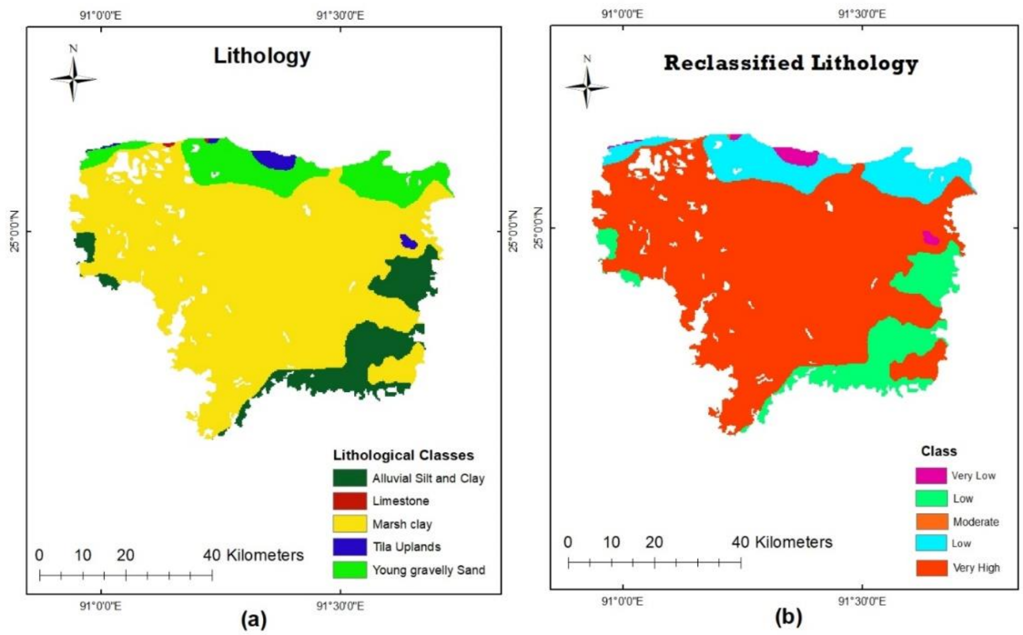

Figure 09: (a) represents the lithological map of Sunamganj district. (b) the reclassified lithological map for flood risk assessment on the scale of 1-5.

Source: The Lithological map of Sunamganj was derived from world geological map from USGS Certmapper. The reclassified map was created on a scale of 1-5 ranking from very low to very high based on the infiltration.

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5.8 Digital Elevation Model (DEM)

The Digital elevation model represents the elevation data of a region. Digital elevation model (DEM) data have been used to derive hydrological features which serve as inputs to various models. Currently, elevation data are available from several major sources and at different spatial resolutions: the National Elevation Dataset (NED), Shuttle Radar Topography Mission (SRTM) data, and the Light Detection and Ranging (LIDAR) data (Li et al., 2010). SRTM DEM is used for the study area (Figure 10a). Elevation of an area has great impact on flooding. The higher the elevation, the less vulnerable a place is to flooding. In reclassified map (Figure 10b), reversed reclassification was used.

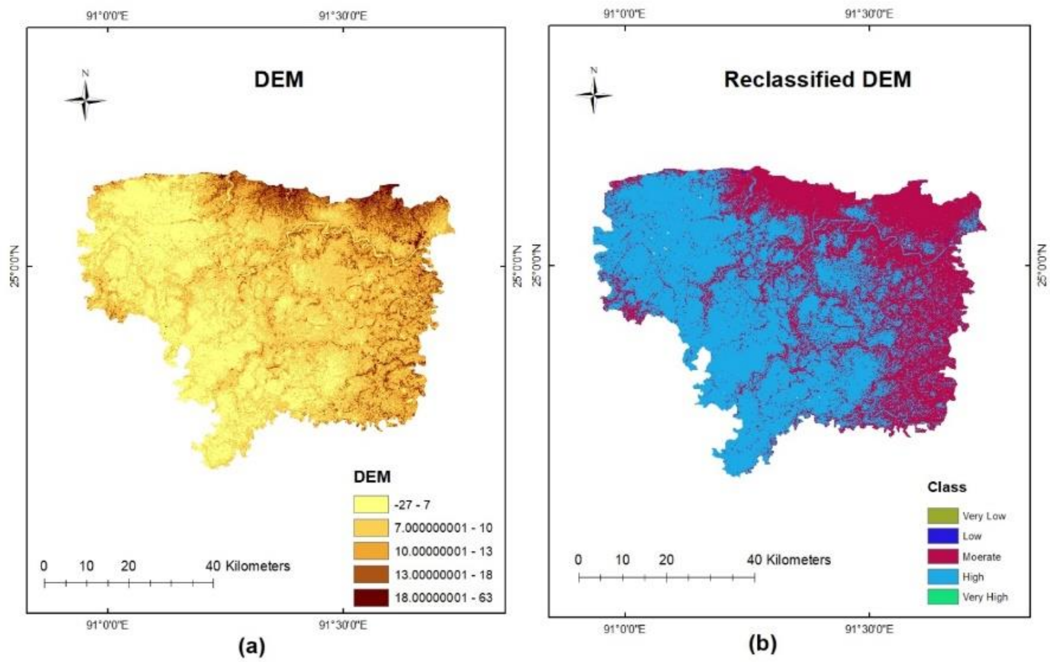

Figure 10: (a) represents the topographic surface elevation. (b) Reclassified map for flood risk assessment on the scale of 1-5.

Source: The Digital Elevation Model represents the elevation of the study area. It was derived directly from the SRTM DEM. The reclassified map was created on a scale of 1-5 ranking from very low to very high.

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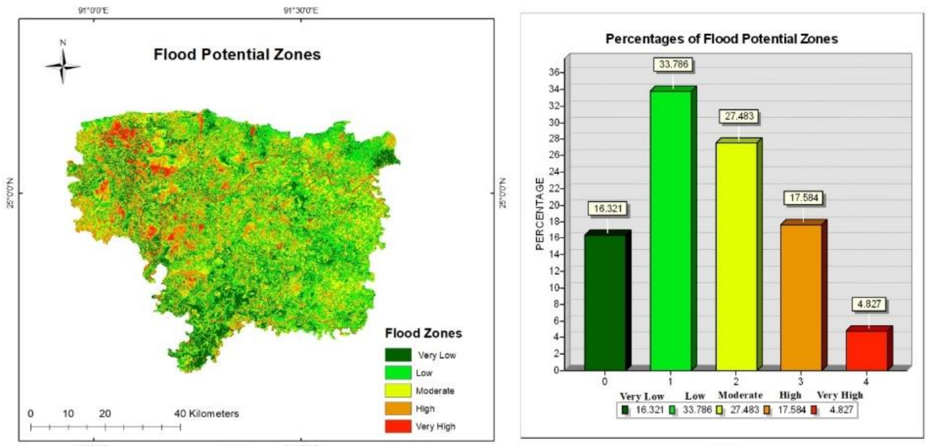
6. Result and Discussion

According to the resultant map (Figure 11a), very low potential zone covers a small portion of the Sunamganj District. It hardly covers 4.827% of the total area. Following that, 17.584% of the region is in a high flood zone. A moderate flood potential zone covers around 27.483% of the area. The low potential zone encompasses 33.786% of the land area. Only 16.321% of the region is extremely low vulnerable to flooding. The graph (Figure 11b) is the visual representation of proportions.



(a) (b)

Figure 11: (a) Potential flood risk zones of Sunamganj District. (b) The Graph represents the percentage of potentiality.

Source: The potential flood zone was prepared with weighted overlay tool from ARC Map with all the flood potential variables and their weights derived from the AHP model. The graph was created with the flood potentiality percentage from the flood potential zone map.

Compiled by Author, 2022

According to the analysis 5 categories are found as flood potential zones. (1) Very low. This category suggests that these areas are almost not flooded. These areas are structured with high hills. (2) Low. There might be a small flood in those places. This category mostly includes urban regions. (3) Moderate. The category represents the moderately flooded zones. These are largely interfluve areas with moderate elevation and urban areas. (4) High. Most of the highly flooded zones are either low lying or river catchments. (5) Very High. Areas within water bodies and wetlands are most commonly extremely high flooded zone.

In this study, eight topographical factors were used to quantify the flood zones. Furthermore, geospatial mapping can increase susceptibility by using high-resolution spatial datasets (Ghosh et al., 2011). The outcome can vary depending on the number and the type of assessment parameters.

Conclusion

Flood-prone zones in Sunamganj District were delineated using a cumulative analytical hierarchy process (AHP) and GIS techniques. This process is not very much complex and not time-consuming. The suggested method can help the policy-makers to quickly examine and evaluate the occurrence of flooding in metropolitan communities. The outcomes of this study demonstrate that about 23% in total of the study area is prone to exescssive flood and more than 33% is moderately flood vulnerable. This can be beneficial for the policymakers and related authorities to take perfect steps to mitigate the risks. In establishing flood risk zones and also for potential future projections, the use of multi-criteria evaluation has been found to be advantageous in a number of areas. This process can be applied in different regions in the world too by using related spatial and climatic criterias.

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