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Research Paper

Delineation of Groundwater Potential Zone and Flood Risk Zone in Cachar District area, India

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ABSTRACT

Cachar district is one of the most populated districts of Assam, India. The region has been exposed to frequent catastrophic flood during monsoon which is responsible for sufferings of the community. The uncertain or shifting pattern of rain in recent times apart from usual monsoon has further escalated the woes of this area. The LOOK EAST POLICY and quest for the development of this part is causing rapid industrialisation and urbanisation, which demands an additional source of freshwater opposed to traditional demand in irrigation and other domestic needs in this region. This demand for freshwater is vertical in the graph and continuously rising. Consequently, the source of freshwater in the area is depleting and further mismanagement will be devastative for resources of water in the entire district. To satisfy the demand and to ensure sustainable development in the region, there is an urgent need for its conservation and management aimed to ameliorate water resources. With this idea behind the present investigation is to pinpoint flood risk zones as well as to demonstrate the variability in groundwater prospects in Cachar District, using geospatial technology. The study is based on thematic maps of Land Use/Land Cover (LULC), elevation, soil type, rainfall, lineament density, drainage density, slope, and aspect in a Geographical Information System (GIS) environment. The groundwater potential zone (hereinafter, GWPZ) areas have been classified into five zones, viz; Very low, Poor, Moderate, Good, and Very Good. About 74.37% of the total area comes under Moderate GWPZ. To identify Flood Risk areas, the whole district has been categorised into Very Low, Low, Moderate, High, and Very High, risk flood zones. About 50.47% of the total area of Cachar District has been found under Moderate flood risk zone. The study at hand may help decision-makers in identifying the GWPZ and earmarking High-Risk Flood Zones for the planning of integrated water resources management.

Keywords: Cachar District; Groundwater Potential Zone; Remote sensing; Flood Risk Zone; GIS.

INTRODUCTION

Groundwater is the leading accessible source of fresh water lying beneath the soil. One of the foremost needed resources for human existence is freshwater, drinkable and which is also being utilised/exhausted in agriculture and industries. This reservoir provides 80% of potable water to the total population and 50% of the water required for irrigation in rural areas (Maheshwari, 2006; Saraf and Choudhury, 1998). However, there is a crisis of groundwater in present times, and it's rising faster in both rural and urban areas due to the overexploitation of available groundwater to fulfil the current demand of water in agricultural and industrial activities as well as highest ever domestic demand of human activities. In water resource management and planning, depleting underground water is drawing our ever-increased attention due to depletion of surface water resources. Over 90% of the rural and 30% of the urban population in India rely on groundwater for their drinking water and other domestic necessities (Reddy et al., 1996). Groundwater investigation has become decisive to identify GWPZ to maintain demand and supply and also for monitoring and preserving this dynamic source. On the other hand, such a tactic for groundwater utilising pragmatic studies through field observation is quite costly, time-taking, and needs well-trained manpower (Sander et al., 1996). Recent scientific studies embrace geophysical techniques along with other methods like geological, hydrogeological, and photo-geological techniques that are employed for the delineation of GWPZ (Lillesand and Kiefer, 1994; Teeuw, 1995; Edet and Okereke, 1997; Sander et al., 1996; Taylor and Howard, 2000; Srivastava and Bhattacharya, 2006). The integration of various conventional methods with Remote sensing (RS) technique and GIS helps in increasing the accuracy of results as well as the ability to explore GWPZ. However, as pointed out by (Jha et al., 2007), it has been observed that the studies on groundwater using RS and GIS techniques in developing countries are very limited whereas groundwater resources are significant for the developing countries especially in view of rapid industrialisation and increasing pressure on agriculture; still, the only a few regional and river basin studies have been carried out in the last few decades. In the Cachar District region, no study was ever carried out to find out the GWPZ using RS and GIS techniques. Hence, there is an urgent need to evaluate the sustain ability of groundwater resources in this region. For the sustainable development of the surface and subsurface resources, it is also necessary to identify flood-prone areas to protect the declining/decaying rate of groundwater recharge. Hence, it is also essential to identify flood-prone areas of the district. The increasing trends in precipitation, deforestation, along with the growing population are affecting this flood-prone area as well as the groundwater resource. Cachar district is situated in the Barak River Basin. The basin possesses a dendrite drainage pattern in this district. A significant amount of run-off from the Barak River allows less infiltration resulting in less groundwater recharge in this region. Hence, the present study aims to prepare the maps of groundwater potential zone and flood risk zone for better planning and management of the water resources using a combined approach of RS and GIS.

MATERIALS AND METHODS

Study Area

Cachar district is located between 92°20′ E to 93°15′ E longitude and 24°20′ N to 25°10′ N latitude (Fig. 1). It is spread over an area of 3786.86 km^2. The topography of the study area varies from small hill ranges to plain areas. Cachar is occupying the northern region of the Barak river basin. The region receives annual rainfall about 2,000−2,700 mm having temperature and relative humidity in the range of 12−34 °C and 52%−92%, respectively (Dattagupta et al., 2014). In the monsoon season from April to September months, the whole district is down poured by a massive amount of water in the Barak basin. Mostly tropical evergreen type of vegetation is found here. Rainforests are observed in the northern and southern parts of the district. The district has several hydrogeological features. The geology of the area is comprised of clay, silt, sand, and gravel. Most of the aquifer strata are moderately homogeneous (Kanungo, 2016). During the monsoon period, higher amounts of rain and floodwater contribute to the rise of the groundwater level whereas in the winter seasonal discharge of groundwater into streams and rivers causes a decline of groundwater level. Every year large areas come under the grip of floods which is causing extensive damage to the properties and agriculture and disrupt the communication system, particularly in the rural areas (Das and Dey, 2011). In the wake of these, it is necessary to understand the vulnerability of natural hazards such as floods.

Data

Landsat data of the year 2019 in 30 m resolution is used in current research work to prepare various thematic maps. This data has downloaded from USGS Earth Explorer which belongs to land sat 8 OLI. The data is presented in Table 1. Landsat data is used for the preparation of LULC map. ASTER Global DEM V3 data (Fig. 2) in 30 m resolution is downloaded from https://earthdata.nasa.gov/. It is used to prepare drainage density, slope, lineament density, and aspect map. A soil map is obtained from FAO Digital Soil Map of the world. The lithology of the area is prepared from the soil map. Gridded data of rainfall in 0.5 x 0.5 degree for the year 2019 is downloaded from the website http://www.cru.uea.ac.uk/. In the present study, two software, namely; ArcGIS 10.6.1 and ERDAS Imagine, have been used.

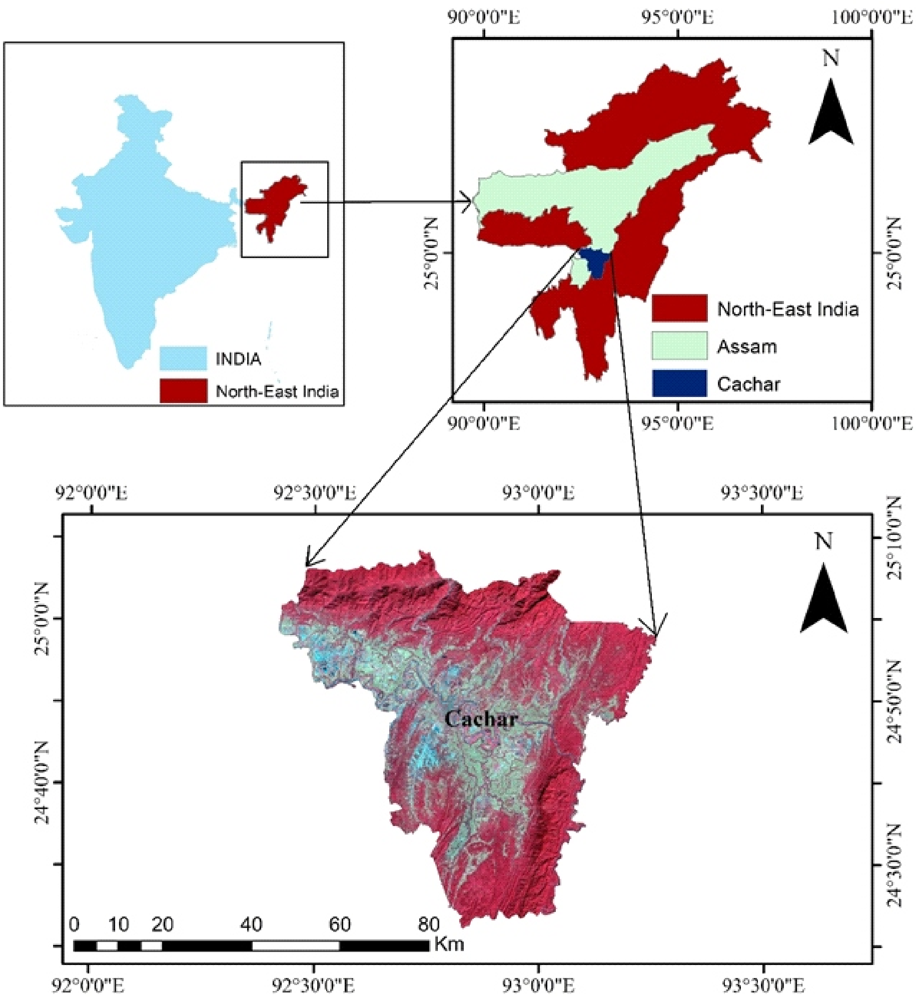

Fig. 1. Location map of Cachar District in Assam, India

Table 1: Acquired data and source

Sl.	Data Type	Spatial Resolution	Source
1	Landsat 8 OLI	30 m	USGS Earth Explorer
2	ASTER Global DEM V3 data	30 m	https://earthdata.nasa.gov/
3	Soil Map	1 km	FAO Digital Soil Map
4	Rainfall Gridded Data	(0.5 x 0.5) degree	http://www.cru.uea.ac.uk/

Groundwater Potential Zone (GWPZ)

The influencing factors such as DEM, drainage density, aspect, soil condition, lineament density, slope, and LULC are used to delineate GWPZ with the help of RS and GIS technique (Waikar and Nilawar, 2014; Fenta et al., 2015; Sisay, 2007; Dev, 2015; Rose and Krishnan, 2009). Aspect is the directional measure of slope faces. Hydrogeological environments and topographic settings control the groundwater occurrences (Gintamo, 2014). Weighted overlay analysis is adopted for this study in which influencing parameters are calculated with the help of a multi influencing factor technique. It simplifies the analysis to understand the combination of factors influencing groundwater potential. The process considers the relative importance and grade of parameters. The criteria of the study should be well defined, and each parameter should be assigned a value (Saraf and Choudhury, 1998). According to Preeja et al. (2011), weightage of individual factor is prioritised and assigned to the different parameters based on their impact on groundwater prospects (Table 2). The methodology consists of identification of parameters influencing the groundwater potential.

Table 2 **Effect of influencing factors, relative rates and scores for each potential recharge factor**

Factors	Major Effect (A)	Minor Effect (B)	Total, Y=(A+B)	Weightage (%) = (Y/ΣY) ×100
DEM	1	0.5	1.5	10
Slope	1+1	0.5	2.5	15
Drainage Density	1+1	0.5	2.5	17
LULC	1+1	0.5+0.5	3	20
Lineament Density	1+1	0	2	15
Aspect Ratio	1+1+1	0	3	13
Lithology	1+1+1	0.5	3.5	10
		Total	18	100

The GWPZ of an area depends upon some factors that affect the recharge of aquifers such as LULC, slope, drainage density, soil condition, aspect, and lineament density (Shahid et al., 2000; Chandra et al., 2006; Yeh et al., 2009; Saravanan, 2012; Ndatuwong and Yadav, 2014; Moghaddam et al., 2016). The influencing parameters are analysed, and scores are assigned to the subclasses of parameter maps. The subclasses with a major effect on groundwater recharge, *A* has been assigned a value of *2*, and classes with minor effects, *B* are given a value of *1*. The subclasses with no impact on groundwater recharge have given a value of zero. The cumulative value *A+B* for both major and minor effects are considered for computing the relative impact as shown in Table 2. This relative effect is further used to calculate the weightage of all the influencing parameters (Shaban et al., 2006; Adham et al., 2006). The weightage of each influencing factor is computed by using the formula

$$\text{Weightage (\%)} = [(A + B)/\sum(A + B)] \times 100 \quad (1)$$

After this step, reclassification of all the thematic maps with computed scores of subclasses is to be done in Arc Map. The resultant map is expressed in numerical values of different classes with the effects of subclasses of influencing factors on groundwater recharge potential. The final step is the integration of all layers of influencing factors and classifies the output layer into different zones. The flowchart of the adopted methodology is shown in Fig. 2.

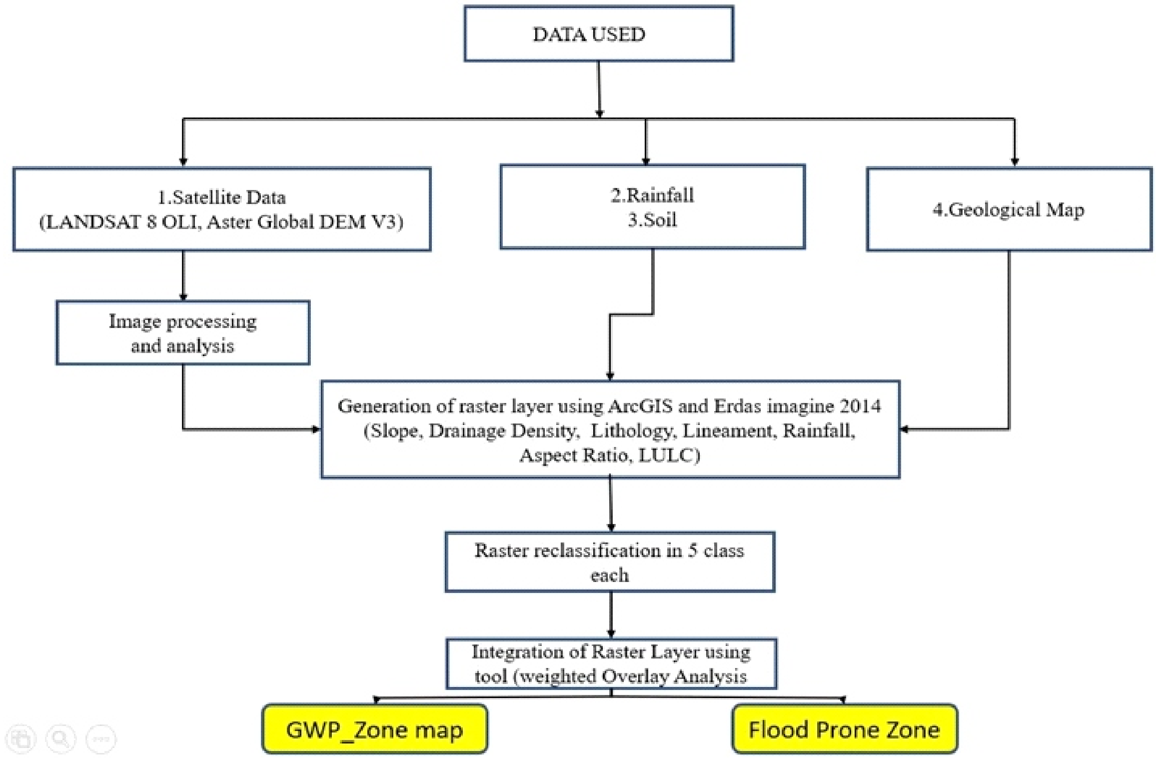

Fig. 2. Flowchart of methodology

Flood Risk analysis

The flood risk (or hazard analysis) is computed using a weighted overlay analysis. The factors causing floods such as LULC, soil condition, lineament density, slope, drainage density, and rainfall are selected and weighted for this analysis. The weighted overlay method is applied here to generate a flood risk map using suitable class weighted values in Arc GIS. Details of the flow chart for flood hazard analysis are shown in Fig. 2. To identify the flood risk areas, the whole study area is classified into five categories based on different degrees of flood risks, i.e. very high, high, moderate, low, and very low. The weight for each influencing factor for the preparation of flood risk map is calculated by using the Equation (1). The cumulative score considered for calculating the relative impact in the flood risk map for both major and minor effects is shown in Table 3.

Table 3: Effect of influencing factors, relative rates and scores for each flood risk factor

Factors	Major Effect (A)	Minor Effect (B)	Total, Y=(A+B)	Weightage (%) = (Y/ΣY) ×100
Drainage Density	1	0.5	1.5	10
Slope	1+1	0.5	2.5	12
DEM	1+1	0.5	2.5	12
LULC	1+1	0.5	2.5	12
Lineament Density	1+1	0	2	9
Aspect Ratio	1+1+1	0	3	15
Lithology	1+1+1	0.5	3	10
Rainfall	1+1	0.5	2.5	20
		Total	19.5	100

Influential factors

Land use land cover (LULC) is one of the key parameters that influence the occurrence and development of groundwater and flood risk. The run-off and infiltration capacities depend upon the land use pattern. The forest cover and fallow land are generally favourable for groundwater recharge as it increases the infiltration rate, whereas built-up areas increase the run-off. An unsupervised image classification technique is used to obtain major LULC features. Agricultural activity depends mainly on the rainfall, and it is adversely affected by the floods. The slope is one of the essential terrain parameters which can be described as the horizontal spacing of the contours. Here, the lower slope value indicates the flatter terrain, and a higher slope value corresponds to the steeper slope of the ground. The slope values are calculated either in percentages or degrees in both vector and raster forms. The slope values in degree are classified in 5 classes where 0-7 degree is considered as flatter terrain, whereas 33-72 degree is regarded as steeper slope (Argaz et al., 2019).

The surface run-off is slower in the areas having a smaller value of the slope, which facilitate more amount of percolation. Such areas are considered as a good groundwater potential zone. On the other hand, a higher degree of slope enables higher run-off rate allowing less amount of percolation of rainwater and consequently, reduced groundwater potential (Magesh et al., 2012). The slope is being used as an essential feature to delineate the GWPZ. It is also a necessary aspect of the flood having control over the infiltration into the subsurface. Slope and flood risk are inversely related to each other. A higher slope implies flood risk and vice versa. Lithology is an essential factor influencing the quantity of groundwater recharge in a region (Bhuvaneswaran et al., 2015). The infiltration capacity of the fine-grained soil is lower than that of coarse-grained soil, which results in low groundwater recharge. The flood prone area is characterised with fine-grained soil which provides flood risk of enormous scale. Heavy rainfall is the major flood causing factor. When a higher amount of rain occurs, the flash flood or flood occurs in the lower parts of the river basin and low-lying areas. Thus, the higher rainfall increases the possibility of increased flood hazard.

The drainage network helps in the delineation of GWPZ and zone affected by flood hazards. Drainage density (km/km^2) gives the information related to run-off, infiltration, and permeability of an area. Drainage density indicates the closeness of spacing of channel as well as the nature of surface material. High drainage density is the result of weak or impermeable subsurface material, light vegetations, etc. Lower drainage density occurs due to fewer numbers of stream networks, whereas higher drainage density is due to the presence of large numbers of stream networks. The drainage density is closely related to the run-off in an area. Lower drainage density indicates the higher possibility of groundwater recharge. High drainage density in an area causes more run-off, which results in flood hazards. Lineaments are geological structures which play a vital role in the development of groundwater resources and contaminant transport in aquifers. Remote sensing data is useful for mapping lineaments. Lineament density map can show the linkage between lineament and groundwater reservoirs. Mapping of lineament density can be done after digitizing lineaments using a line density tool in ArcGIS. Lineament density can be calculated by the sum of all mapped lineaments length on the map area (Pirasteh et al., 2010). Higher lineament density will reflect more significant groundwater potential zone, whereas lower lineament will show lesser groundwater prospect. Aspect is the directional measure of slope faces; it can help us to define and analysing physical landform characteristics. The aspect map is prepared with the help of the DEM map. Slope and aspect are important parameters for measuring GWPZ and flood risk zone.

RESULTS AND DISCUSSION

Evaluation of influencing factors

A LULC map of Cachar district for the year 2019 is prepared using the Maximum Likelihood Classification (MLC) technique of supervised classification in ERDAS Imagine. The prepared LULC map is shown in Fig. 3. Prominent features in this region have been identified. Six different LULC classes are observed during the image analysis. These are: (a) water bodies, (b) light vegetations, (c) dense vegetation, (d) agricultural land (e) built-up areas, and (f) others. The LULC map shows that dense vegetation (36.15%) is covering a significant part of the district followed by agricultural land (26.66%), and light vegetations (21.45%) as shown in Table 4. During weight assignment for groundwater potential analysis, agricultural land, and others are assigned as the highest weightage (Table 5). On the other hand, in the case of flood hazard analysis, built-up areas and others are assigned the highest weightage value of 5 (Table 6).

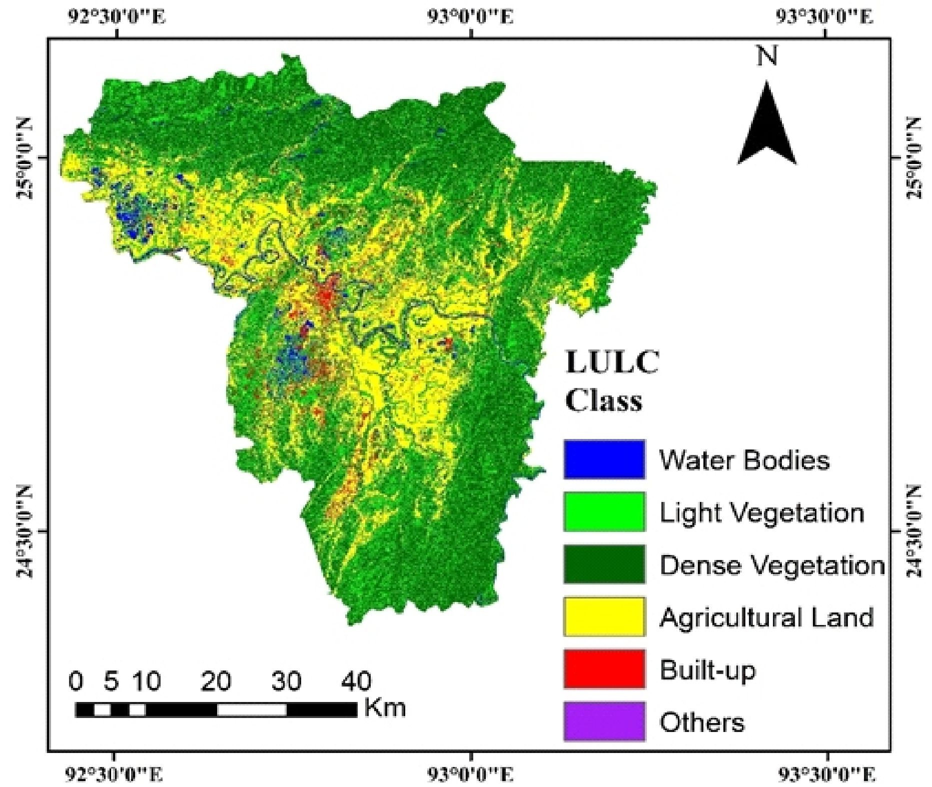

Fig. 3. Land Use/ Land cover map of Cachar district for the year 2019

Table 4: Land Use/ Land Cover distribution for Cachar district for the year 2019.

Class	Area (km^2)	Area (%)
Water	179.9325	4.75
Light Vegetation	812.4329	21.45
Dense Vegetation	1368.768	36.15
Agricultural Land	1009.53	26.66
Built-Up	386.3207	10.20
Others	29.8665	0.79

Table 5: Weights assigned to sub-factors of each Influencing Factor based on their influence on groundwater recharge

S.No.	Factors	Classes	Assigned Weightage
1	Drainage Density	Very Low (0-1.26 km/km^2)	1
		Low (1.26-2.53 km/km^2)	2
		Moderate (2.53-3.80 km/km^2)	3
		High (3.80-5.06 km/km^2)	4
		Very High (5.06-6.33 km/km^2)	5
2	Slope	Nearly Level (0-7^0)	5
		Very Gentle (7-14^0)	4
		Gentle (14-23^0)	3
		Moderate (23-33^0)	2
		Steep (33-72^0)	1
3	DEM	-58-63	5
		63-246	4
		246-500	3
		500-845	2
		845-1693	1
4	Land Use/ Land Cover	Water	1
		Light Vegetation	3
		Dense Vegetation	4
		Agricultural Land	5
		Built-Up	1
		Others	5
5	Lineament Density	>0.32-0.51 km/km^2	1
		>0.25-0.32 km/km^2	2
		0-0.05 km/km^2	3
		>0.14-0.25 km/km^2	4
		>0.05-0.14 km/km^2	5
6	Aspect Ratio	Flat (-1-0)	5
		North (0-22.5)	5
		Northeast (22.5-67.5)	4
		East (67.5-112.5)	4
		Southeast (112.5-157.5)	3
		South (157.5-202.5)	3
		Southwest (202.5-247.5)	2
		West (247.5-292.5)	2
		Northwest (292.5-337.5)	1
		North (337.5-360)	1
7	Soil type	Ferric Acrisols	1
		Dystric Cambisols	3
		Dystric Gleysols	4
		Eutric Gleysols	5
		Orthic Acrisols	2

Table 6 : Weights assigned to sub-factors of each Influencing Factor based on their influence on flood risk

S.No.	Features	Classes	Assigned Weightage
1	DEM	-58-63	5
		63-246	4
		246-500	3
		500-845	2
		845-1693	1
2	Drainage Density	Very Low (0-1.26 km/km^2)	1
		Low (1.26-2.53 km/km^2)	2
		Moderate (2.53-3.80 km/km^2)	3
		High (3.80-5.06 km/km^2)	4
		Very High (5.06-6.33 km/km^2)	5
3	Slope	Nearly Level (0-7^0)	5
		Very Gentle (7-14^0)	4
		Gentle (14-23^0)	3
		Moderate (23-33^0)	2
		Steep (33-72^0)	1
4	Rainfall	Very Low (738-1061 mm)	1
		Low (1062 - 1332 mm)	2
		Moderate (1333-1623 mm)	3
		High (1624 - 1938 mm)	4
		Very High (1939 - 2315 mm)	5
5	Land Use/ Land Cover	Water	3
		Light Vegetation	2
		Dense Vegetation	2
		Agricultural Land	3
		Built-Up	5
		Others	4
6	Lineament Density	>0.32-0.51 km/km^2	1
		>0.25-0.32 km/km^2	2
		0-0.05 km/km^2	3
		>0.14-0.25 km/km^2	4
		>0.05-0.14 km/km^2	5
7	Aspect Ratio	Flat (-1-0)	5
		North (0-22.5)	5
		Northeast (22.5-67.5)	4
		East (67.5-112.5)	4
		Southeast (112.5-157.5)	3
		South (157.5-202.5)	3
		Southwest (202.5-247.5)	3
		West (247.5-292.5)	2
		Northwest (292.5-337.5)	1
		North (337.5-360)	1
8	Soil type	Ferric Acrisols	1
		Dystric Cambisols	2
		Dystric Gleysols	3
		Eutric Gleysols	5
		Orthic Acrisols	3

In flood hazard, the built-up area is profoundly affected by the other resources such as water, soil condition and land cover, whereas the forest cover areas are least affected. The DEM map extracted for the Cachar district is shown in Fig. 4. The northern parts of the study area represent the highest elevation (1693 m) because this area is the steep hill mountain region. The middle part of the district serves the lowest elevation (-58 m). During monsoon, run-off water moves from higher altitude to lower altitude. This causes flood hazards in low-lying areas. The highest elevation values are assigned the lowest weightage for groundwater potentiality (Table 4). The soil map for the region is prepared from the FAO digital soil map of the world (Fig. 5). There are five different FAO soil types found in the study area. About 45.32% of the total area is mainly composed of Eutric Gleysols soil type and the rest followed by Dystric Gleysols (35.26%) and Dystric Cambisols (10.73%) (Table 7). Gleysols are the soil types where groundwater comes closer to the ground surface. These are found in the central part of the study area. Cambisols are also favourable for groundwater recharge. These are located in the southern part of the district.

Table 7: Distribution of soil type in Cachar district

FAO Soil Type	Area (km^2)	Area (%)
Ferric Acrisols	168.1056	4.44
Dystric Cambisols	406.4535	10.73
Dystric Gleysols	1335.346	35.26
Eutric Gleysols	1716.167	45.32
Orthic Acrisols	160.7877	4.25

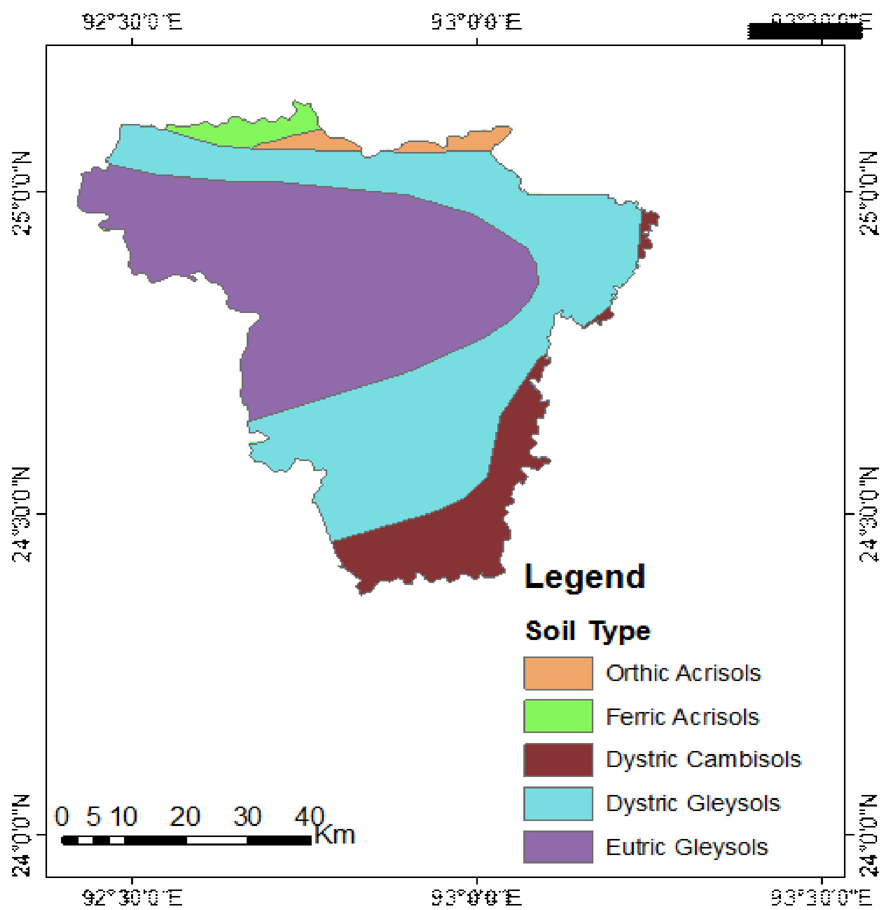

Fig. 5. Soil map of Cachar District

Here, for groundwater potential zoning, the weightage of different types of soil is listed in Table 5. In the case of flood risk analysis, Eutric Gleysols is assigned highest weightage as tabulated in Table 6. An annual rainfall map of the whole region is prepared for the year 2019 using IDW interpolation. Mean annual rainfall amount for 2019 ranges from 738 to 2315 mm distributed over the entire study area. The rainfall map is classified into five different classes. These are very low, low, moderate, high, and very high, as mentioned in Table 6. The detailed classified rainfall map is shown in Fig. 6. Generally, a higher amount of annual rainfall specifies the probability of a higher flood risk zone. Hence, the area with higher amounts of rain is given more weightage as compared to an area with lower annual rainfall in flood risk analysis, as shown in Table 6.

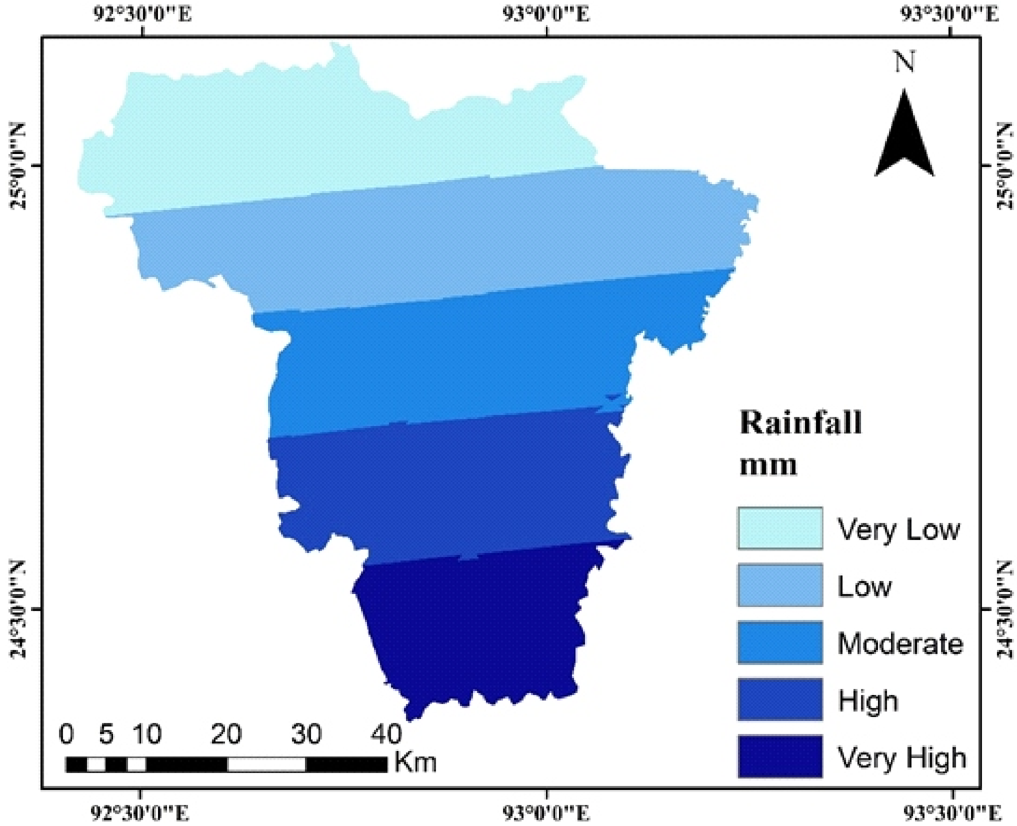

Fig. 6. Rainfall distribution map of Cachar District

The slope map is prepared from ASTER Global DEM data in Arc GIS and is presented in Fig. 7. The slope in the study area can support us to describe the several types of a slope, i.e. nearly level, very gentle sloping, gentle sloping, moderate sloping, and steep sloping. A classified prepared slope map shows 26% nearly level (0-5.22^0), 24% very gentle slope (5.22-12.28^0), 19% gentle slope (12.28-20.39^0), 17% moderate slope (20.39-29.54^0), and14% steep slope (29.54-66.67^0). Weightages for each class in case of groundwater potential zone and flood risk analysis are assigned, which is presented in Table 5 and Table 6, respectively. The drainage map is prepared from the DEM map in the Arc GIS environment. Further, these drainage maps have been used to make the drainage density map which is presented in Fig. 8. The drainage density map is divided into five classes. These are very low (0-1.26 km/km^2), low (1.26-2.53 km/km^2) region, moderate (2.53-3.80 km/km^2), high (3.80-5.06 km/km^2), and very high (5.06-6.33 km/km^2). Low drainage density is observed in large part of the region. Here, for groundwater potential and flood risk analysis, the weighted values are assigned with the increase in values of drainage density values, as shown in Table 5 and Table 6, respectively. The lineament density map is created using the DEM map (Fig. 9). The lineament density map is categorised into mainly five classes. The classes (>0.32-0.51 km/km^2) and (>0.25-0.32 km/km^2) are occupying the majority parts of the study area. The weightage of lineament density for groundwater potential and flood risk mapping is assigned, as shown in Table 5 and Table 6, respectively. The aspect map is extracted from the DEM map, as shown in Fig. 10. The map is classified into ten number of classes such as Flat (-1-0), North (0-22.5), Northeast (22.5-67.5), East (67.5-112.5), Southeast (112.5-157.5), South (157.5-202.5), Southwest (202.5-247.5), West (247.5-292.5), Northwest (292.5-337.5), and North (337.5-360). For groundwater potential and flood risk analysis, the weighted values are assigned as listed in Tables 5 and 6, respectively.

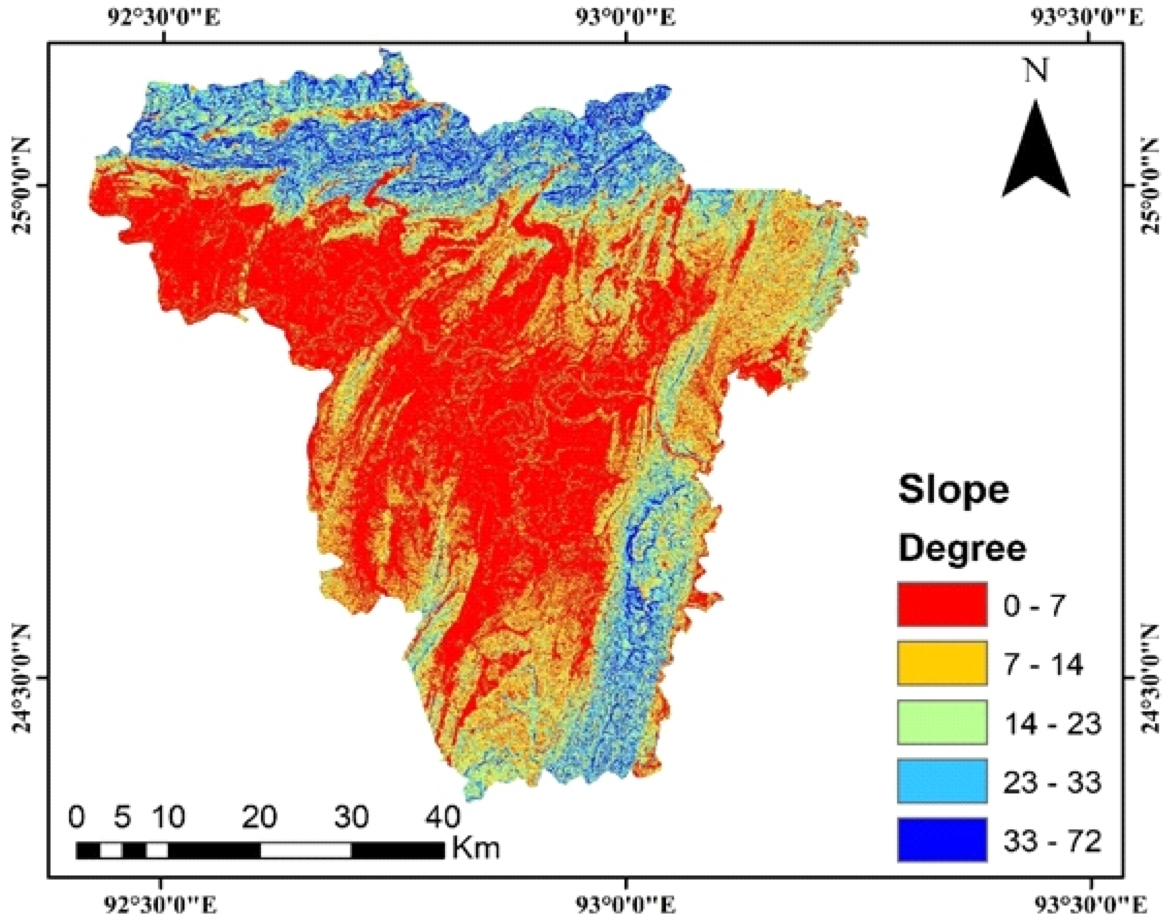

Fig. 7. Slope map of Cachar District

Table 7: Distribution of soil type in Cachar district

FAO Soil Type	Area (km^2)	Area (%)
Ferric Acrisols	168.1056	4.44
Dystric Cambisols	406.4535	10.73
Dystric Gleysols	1335.346	35.26
Eutric Gleysols	1716.167	45.32
Orthic Acrisols	160.7877	4.25

Table 8: Distribution of Groundwater Potential Zone in Cachar district

Sl. No.	Class	Area (km^2)	Area (%)
1	Very Poor	2.538	0.07
2	Poor	591.651	15.62
3	Moderate	2816.309	74.37
4	Good	368.0847	9.72
5	Very Good	8.2674	0.22

Table 9: Distribution of Flood Risk Zone in Cachar district

Sl. No.	Class	Area (km^2)	Area (%)
1	Very Low	42.1092	1.11
2	Low	928.4931	24.52
3	Moderate	1911.237	50.47
4	High	891.0702	23.53
5	Very High	13.9401	0.37

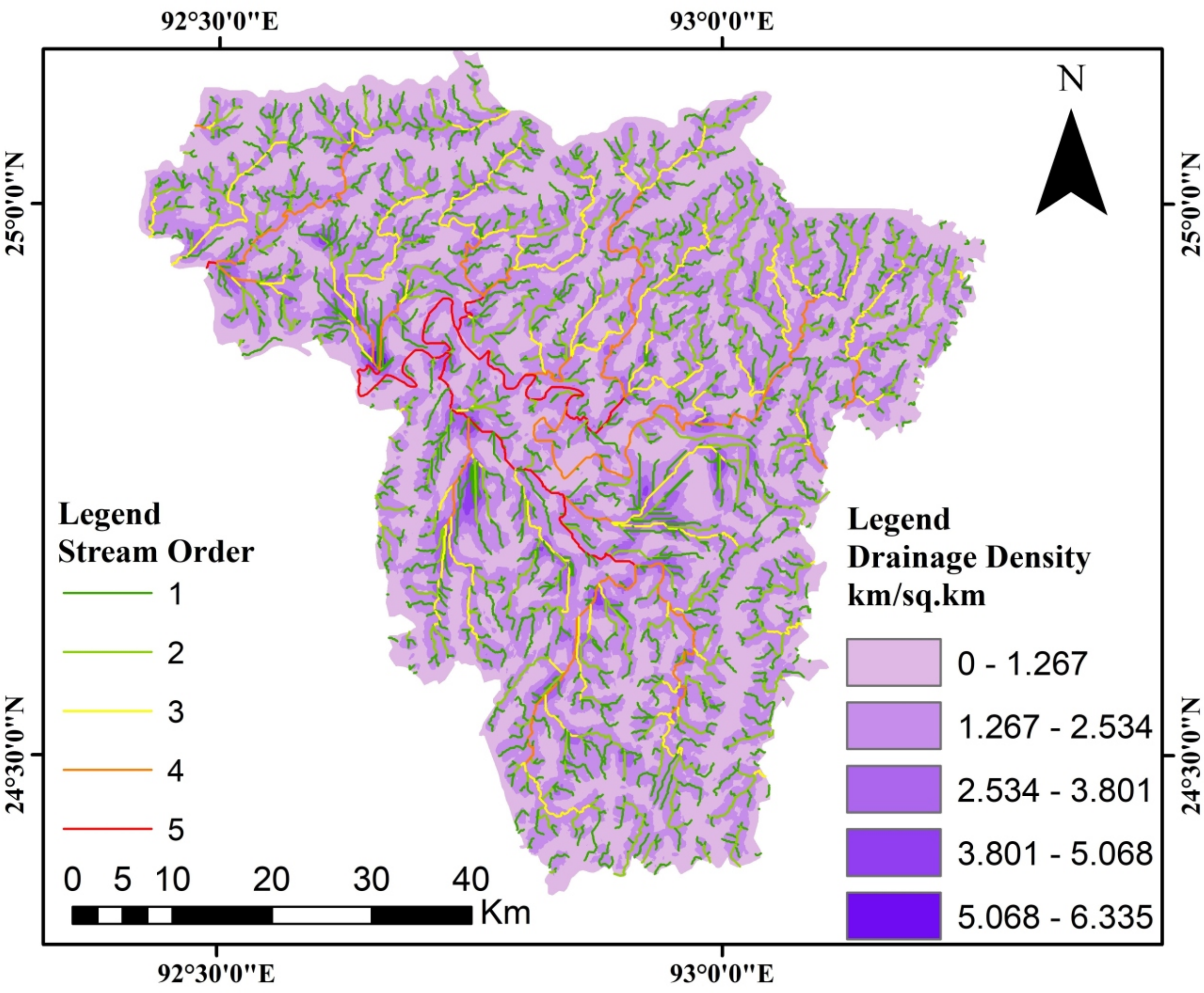

Fig. 8. Drainage Density map of Cachar District showing the stream networks

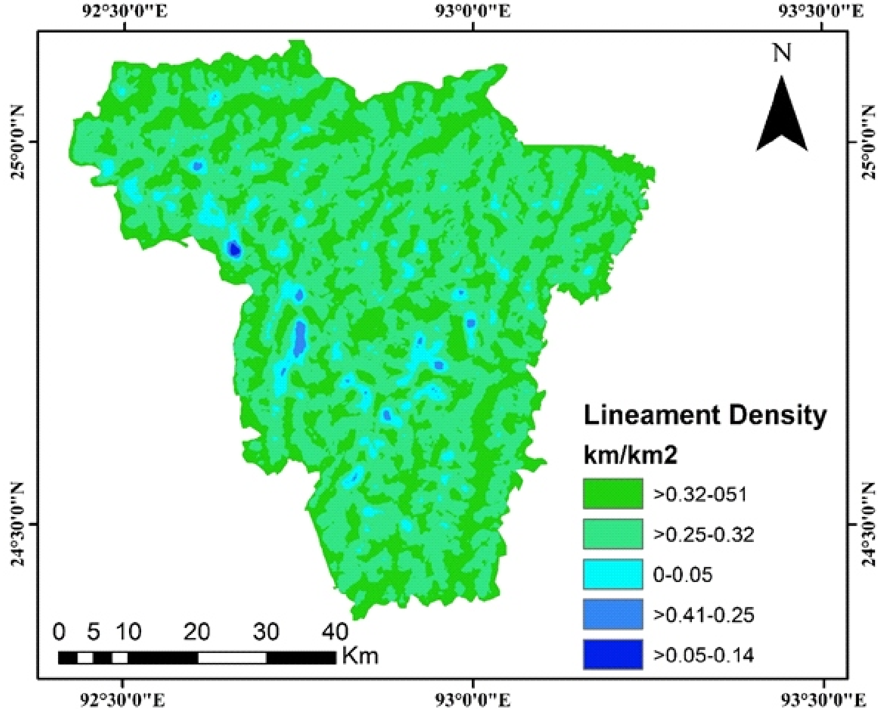

Fig. 9. Lineament Density of Cachar District

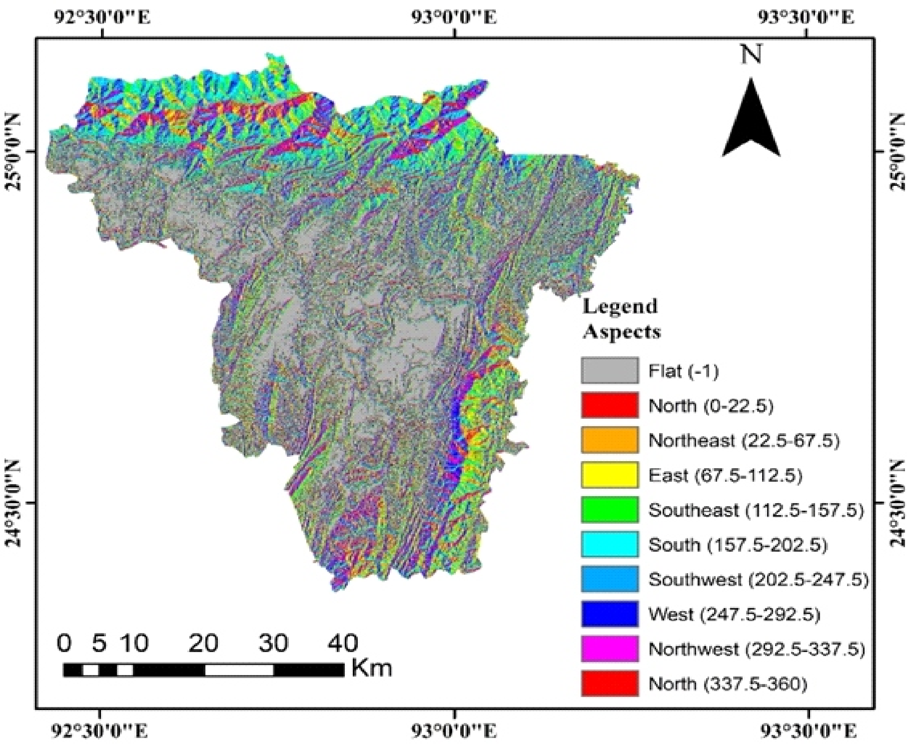

Fig. 10. Aspect map of Cachar District

Delineation of Groundwater Potential Zone (GWPZ)

The zoning of groundwater potential (GWP) has accomplished according to the weighted overlay technique of multi influencing factor (MIF) which can affect the GWP. The weightage is taken off from mainly seven influencing factors. These are DEM map, LULC, soil condition, drainage density, lineament density, slope, and aspect using Arc GIS (Fig. 11). The drainage and lineament maps are used to prepare drainage density and lineament density maps. The weightage has been decided based on the inter-relationship between the MIF with major and minor effects (Table2). The GWPZ for Cachar district has been divided into five categories. These are very poor, poor, moderate, good, and very good, as presented in Table 8. During the analysis, it has been observed that about 2816.309 km^2 (74.37%) of the total area comes under a moderate GWPZ having almost plain areas characterised with good drainage density and land use. These areas have alluvial plains with high lineament density. Very good and good GWP zones have been occupied by about 0.22% and 9.72% of the total area of the region situated in the southern parts of the district.

Flood Risk Zone (FRZ) Mapping

In the present study, the weighted overlay technique is applied to prepare flood risk map for the Cachar district using different weighted values in Arc GIS (Fig. 12). The flood hazard map is created with the help of all primary and secondary data in the Arc GIS model builder tool. The flood risk map is classified into five zones, such as very low, low, moderate, high, and very high, as shown in Table 9. The northern and southern parts of the Cachar district fall in the category of very low (1.11%) and low (24.52%) flood risk zones whereas the central parts of the study area are falling under moderate (50.47%) and high (23.53%) flood risk zones. Moderate and high flood risk zones are observed in the plain agricultural lands with higher drainage density. These areas are being flooded during the monsoon season every year due to a high rate of precipitation.

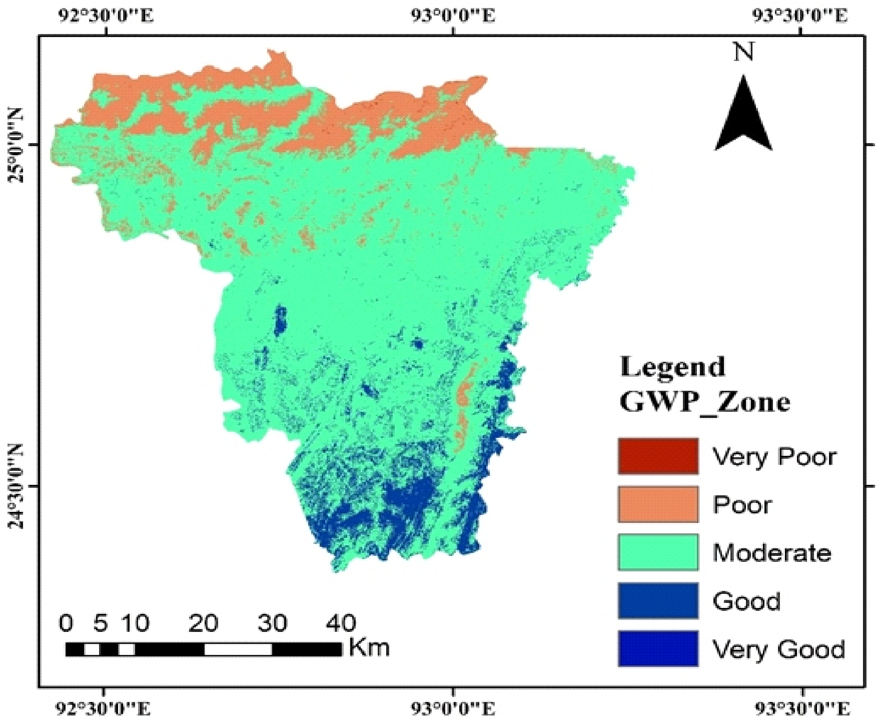

Fig. 11. Groundwater Potential Zone map of Cachar District

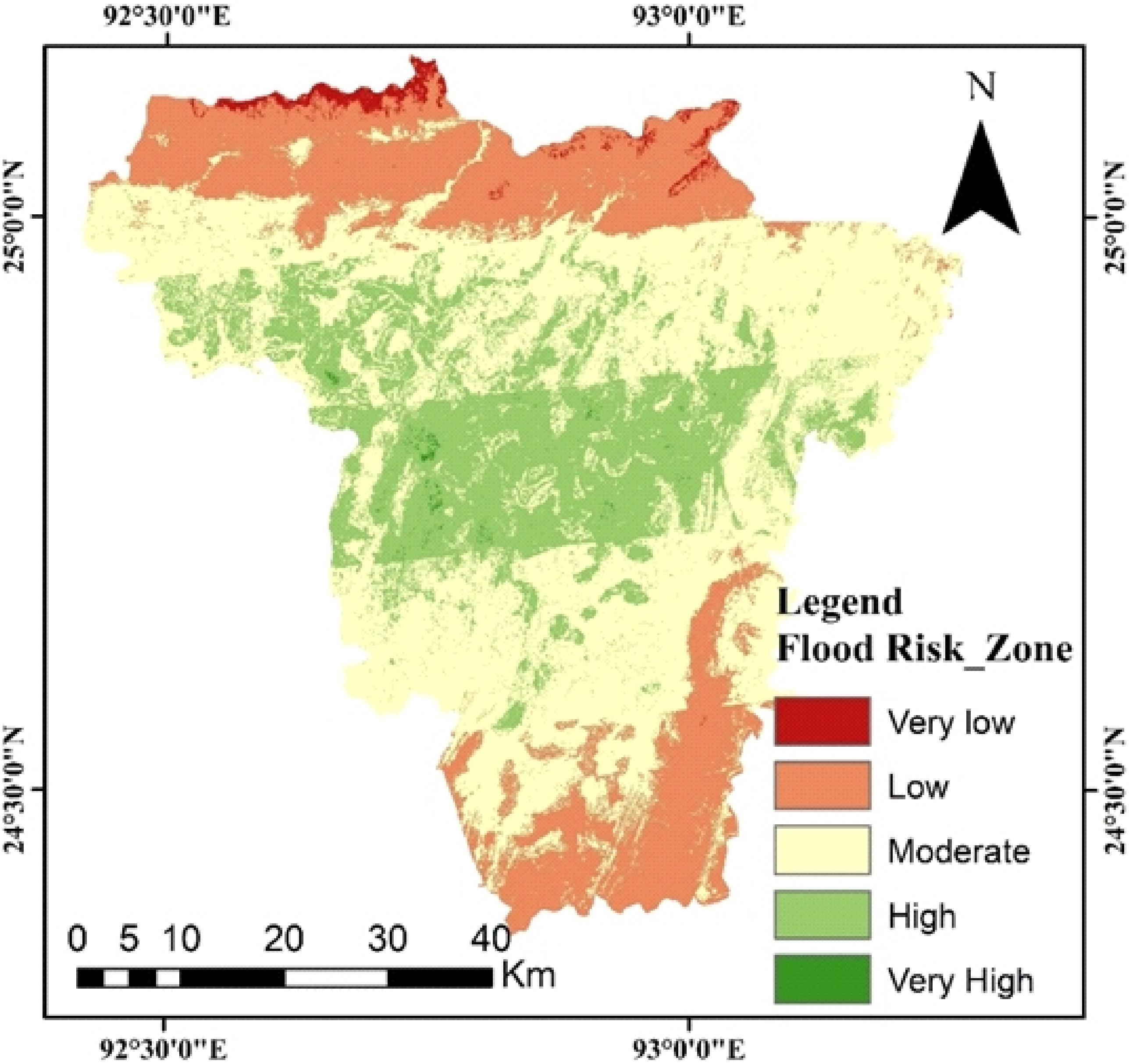

Fig. 12. Flood Risk Zone map of Cachar District

CONCLUSION

In the present research work, potential groundwater zones and flood risk zones in Cachar district, India, are delineated using different Remote Sensing data and GIS approaches. Seven influencing parameters that affect the groundwater potentiality are considered, and their thematic maps have been prepared. After that, these thematic maps are integrated by the weighted overlay analysis technique. In case of flood risk mapping, eight influencing factors are considered to develop the map using the weighted overlay technique. This study shows that agriculture lands, built-up areas, vegetations, and the

Barak basin ecosystem are more affected due to floods. GIS has a significant role to play in natural hazard management. Though, weighted overlay analysis is not free from a few limitations, it is still simple to use for the regions where all the necessary data are not always available. Although, results of the present work have not been validated with field data, the results would provide the required information in planning future groundwater recharge projects and thus would be beneficial in further groundwater survey analysis and flood risk management.

ABBREVIATIONS

ASTER: Advanced Space Borne Thermal Emission and Reflection Radiometer; DEM: Digital Elevation Model; ERDAS: Earth Recourses Data Analysis System; FRZ: Flood Risk Zone; GIS: Geographical Information System; GWP: Groundwater Potential; GWPZ: Ground Water Potential Zone; IDW: Inverse Distance Weighted; LULC: Land Use Land Cover; MIF: Multi Influencing Factor; MLC: Maximum Likelihood Classification; RS: Remote Sensing.

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