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A GIS BASED LAND USE/LAND COVER CHANGE ANALYSIS AND FLOOD VULNERABILITY STUDY USING HIGH RESOLUTION SATELLITE DATA IN THE DAKHIN BHOLA GAON PANCHAYAT, RANI BLOCK, KAMRUP, ASSAM

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ABSTRACT

Dakhin- Bhola Gaon Panchayat (DBGP), Rani Block in Kamrup district of Assam is located in the peri-urban area around Guwahati city which is undergoing haphazard urbanisation and rapid population growth thus putting lot of pressure in the DBGP area impacting its ecology, environment and land use pattern. A GIS based study was carried out in the DBGP area to analyse the impact of urban densification in the Guwahati metro city on the peri-urban DBGP area. The DBGP area comprises 43 villages with a population of over 20,000. Land use land cover change analysis through geo-spatial application reveals that there is 6.2% increase in the built-up area from the year 2001 to 2018 following gradual decrease in forest and agriculture land by 5.7% and 0.89% respectively. The DBGP area is also affected by floods and flash floods primarily affecting the agricultural lands, built-up areas, educational facilities and road network. In this paper an attempt has been made to analyse the spatio-temporal dynamics of the peri-urban land use, percentage of land use change due to various development. The study also focused on the need to restrict further unplanned urbanisation, adequate regulation on encroachment of forest area, appropriate mitigation for the blockage of natural drainage/stream, wetland conservation and mitigation strategy for recurrent floods.

***Keywords**: High resolution satellite data, GIS, Land Use Land Cover, Flood vulnerability, Flood Hazard Resilience.*

INTRODUCTION

Urbanization is a gift to the human society if it is controlled, coordinated and planned. However, unplanned urbanization is a curse [1]. The process of urbanization is faster in the developing countries which are more often unplanned and disorganized, resulting in various hazards. The land in the peri-urban-urban inter face is of vital importance as there is a lack of clarity in the planning and policies in this region whether they should be governed under the authority of rural administration. In general, these areas are frequently ignored as a specific area in the study of urbanization being neither pure urban nor pure rural [25]. Role of urban planning, development and management of Guwahati, the capital city of Assam is becoming more and more crucial due to dramatic increase in urban population and allied urban problems. Although urbanization contributes many advantages in terms of economics, but if uncontrolled, would produce negative consequences to the physical, social and natural environment. Urbanization has many negative impacts that include loss of agricultural lands, biodiversity and human induced degradation and urban flooding which are mainly linked to the Land use pattern. Geospatial application offers excellent opportunities not only for mapping, measuring, managing and monitoring the changes or developments caused by urbanisation but also helps planners to enforce regulatory control measures. This requires the present and past land use land cover information of the area and pattern with respect to settlements and other local resources. This is possible only through Geo-spatial application that can help planners and policy makers to initiate appropriate action.

The main objective of this study is to estimate the concomitant impacts of urban densification in the Guwahati city area and its impact on the peri-urban region in Dakhin Bholagaon Panchayat under Rani CD Block of Kamrup district which is located in the fringe of Guwahati city, the largest metro in the Northeast India. Since flash Floods and inundation are one of the major problem in the Dakhin Bholagaon Panchayat due to unplanned haphazard growth, we also analysed the vulnerability of various land use categories and the existing utilities to the floods in the study area.

The city of Guwahati is the gateway to Northeast India and located in an undulating plain with varying altitudes ranging from 49.5m to 55.5m above the mean sea level [2]. Southern and eastern parts are surrounded by hill areas, swamps and water bodies. The city under Municipal Corporation is situated within 26°5' N to 26°12' N latitudes and 91°34' E to 91°51'E longitudes [3]. Over the years, the city is experiencing tremendous growth in population, rapid urbanization and migration from different districts and neighbouring small and medium towns that has created huge deficits in urban amenities and infrastructure. Guwahati is growing in population and has seen a decadal growth of 18.29% from about 8, 18,809 in 2001 to 968, 549 in 2011 and the population density is recorded as 4455 person per sq.km [4]. Simultaneously the physical expansion of the city also grew from 43.28 sq.km in 1971 to 262 sq.km in 2001 and presently it is 328 sq.km [5]. The

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city also experiences rapid migration and floating population from its nearby areas and towns for various purposes because the city is served in terms of labour force, agriculture products, goods and services, education, health etc. Thus, Guwahati act as a hub for generation of secondary and tertiary services and centre for economic growth. Such expansion and growth demands increase infrastructure, land use development, proper housing, various services and open areas. However, unplanned urbanization and growth has created several hazards like water logging, landslides, clogging of drainage network, severe traffic congestion and shrinkage of open space, encroachment, water scarcity and urban flooding. Analysis of land use imageries of Guwahati city indicates increase in the built-up area and decrease in forest cover. The reduction in green cover increases the vulnerability of the city towards hazards like flooding and landslides, and also impacts the ambient micro-climate [6].

Since the city does not have enough space for expansion and is congested, the inhabitants are exploring nearby peri-urban plain and hills areas for their settlements which resulted to land use changes. Further, the development near neighbouring Meghalaya state border not only causes topographical changes but at the same time contribute to flash floods near border areas which disrupt road connectivity. Number of industries, schools, colleges and other institutions which has come up along the border threatens the environment of Guwahati city due to cutting of hills for settlement, encroachment and causes landslides, floods, siltation, air pollution and devastation of the road network. These activities put severe pressure on the infrastructure and other services of the city because of its dependence on Guwahati city for its requirement.

The study area, Dakhin Bholagaon Panchayat is spread over a total geographical area of about 113 sq.km of which 37 sq.km area is under reserve forest like Jaral, Kawasing and Mathaikar. The people in the area are mainly engaged in agriculture, livestock farming and sericulture activities for their livelihood. The population in the area is growing steadily from 12823 in 2001 to 19893 in 2011. The area also faces heavy rainfall every year especially during June and July causing landslide and soil erosion. This ultimately leads to siltation, thus reducing the drainage discharge and causes accumulation of rain water in areas having no outlet and result in flooding and water logging.

Considering the importance of this peri urban area located close to the city of Guwahati, an attempt is made to monitor and analyse the Land use and Land cover changes using temporal satellite data of the year 2001 and 2018 from open source high resolution satellite archive of Google earth to create spatial database using Quantum GIS 2.18. Further attempt was also made to identify the vulnerable areas that are susceptible to flood inundation, by overlaying land use land cover; educational facilities and road network of the area so that appropriate initiative can be taken by authorities for flood mitigation in the area. Remote sensing and GIS technology is an indispensable tool for studying various aspects of urban flooding because of its capability to integrate spatial data with non-spatial attributes and data layers of various flood zones. This helps in modelling for proper management, land utilization practices and proper designing of storm water discharge system based on topography of the city [7]. The applications of this technology are also widely used for LULC change detection at various levels right from village to regional levels. LULC classifications of temporal satellite images represent the overall decrease and increase of LULC areas of the several years [8]. GIS & RS application along with interpretation can also be used for better understanding and analysis of urban expansion which is considered to be one of the major cause for Land use land cover change in Guwahati City [9].

An efficient and effective flood management program depends on scientific data on the vulnerability of population, land use and crucial infrastructures to be translated into effective evidence based and place based policy [10]. Remote sensing and GIS is a powerful tool for vulnerability study for effective flood management in prevention, preparedness and relief management of flood disaster. GIS also facilitates integration of spatial and non-spatial data like historical flood maps, infrastructures, land use, and socio-economic data. Such data set are critical for the in-depth analysis and management of floods [13].

STUDY AREA

The area selected for this study is located approximately 15 km from Lokpriya Gopinath Bordoloi International Airport (Guwahati) where development is very less and settlements are unplanned. The study area Dakhin Bhola Gaon Panchayat under Rani CD Block in the Kamrup district of Assam covers an area of 113 sq.km situated between Latitude 25°51‘23.536"N - 26°2’26.42"N and Longitude 91°28‘0.577" E. - 91°34‘18.89" E and comprising of 43 villages with a population of over 20,000. The area is situated at a distance of about 5 to 6 km from Rani Community development block HQ and connected with Guwahati city through state high way (Fig.1). People of the area suffer due to non-availability of all-weather roads. Drainage conditions are poor and the existing road conditions are pitiable. The situation becomes critical during rainy season when most of the roads, agricultural fields and other infrastructures submerge under flood water. Guwahati and its peri-urban areas face heavy rainfall during monsoon season. According to TERI report [6], extreme rainfall events for 29 years period indicated that 12 out of 29 years have experienced heavy rainfall (HR) events of which 3 years i.e., 1985, 1991, and 2011 have experienced very heavy rainfall (VHR) events.

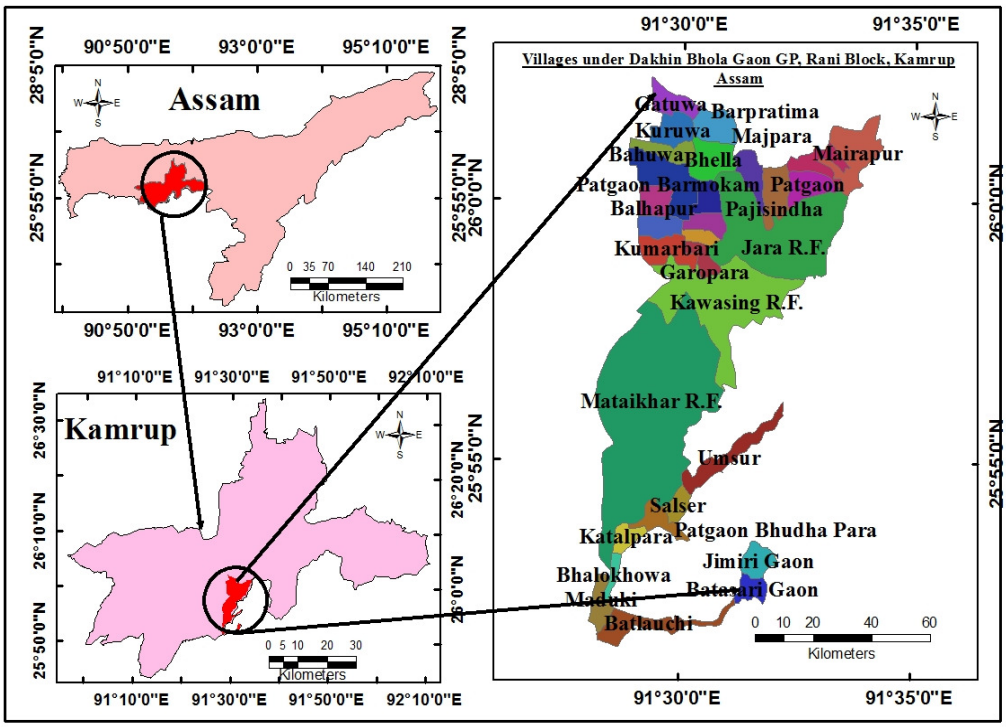


Fig.1: Location map of Study area (Dakhin bhola gaon Panchayat)

DATA AND METHODOLOGY

In this study we analysed time series datasets on 1:80K scales corresponding to the original resolution of the satellite datasets. The Land use/ Land cover (LULC) of the study area for the year 2001 and 2018 were digitised from google earth images and compared (Fig 2) to evaluate the changes in Land use land cover and shown in table 1. The survey of India toposheet of 1:50K scales were obtained from NIRD-NERC and were georeferenced and projected to UTM zone in GIS environment. The natural streams of the area were also extracted and digitized from Survey of India Toposheets, 78-N- 12, 78-N-8, 78-O-5, 78-O-9 [12] (Fig 4). The Road network was also digitized from Google earth images and updated through field visits. Flood Hazard zonation map (categorized into High, Moderate,

Very high, Low and very Low hazard zones) of the study area has been taken from Bhuvan web portal of National Remote Sensing Application Centre and digitized in the GIS environment in order to analyse the flood zones of study area. The Flood Hazard Zonation map of the study area was overlaid on Land Use land cover layer of the year 2018 in GIS environment to identify land classes that falls into the different flood hazard zone categories (Fig 3). In order to determine the exposure of educational facilities falling in the flood prone zones in the area, information on educational institutions were also collected through field visit using GPS to prepare spatial layer (Fig 6, 7 and 8) and the road network was also mapped and integrated in Quantum GIS 2.18 to ascertain the vulnerability of the educational facilities and the road network.

RESULT AND ANALYSIS

The land use pattern, Land use change analysis, vulnerability of educational institution and roads to floods have been illustrated in the following sub-heads.

Land use Land cover

The map (Fig.2) shows the various classes of land use land cover of the year 2001 and 2018 of the study area. The area statistics of different land use / land cover classes of the area are shown in the following table 1.

From the above result & analysis it is found that the Built up area has increased from 5.72 sq. km in 2001 to 12.65 sq. km in 2018. On the other hand the agricultural lands have decreased from 40.38 sq. km in 2001 to 39.37 sq. km in 2018. The forest cover of the area also decreased from 66.44 sq. km in 2001 to 60.00 sq. km in 2018. The areas consisting water bodies of about 0.43 sq. km shows no change in the year 2018. The area has a waste land of about 0.29 sq. km which was not present in 2001. This reflects that as the built up area increases of about 6.2 % in the process of urbanization, the forest and agricultural lands were decreased to 5.7% and 0.89% in the study area. This gradual increase in built up area at the cost of forest and agricultural land in the study area is expected to continue as the city of Guwahati expands towards this Dakhin Bhola gaon Panchayat peri urban area. This will result in more

Table 1: Area statistics of the land use land cover of the study area for the year 2001 and 2018

Land Use/ Land cover Classes	Area of 2001 (Sq. Km)	% of Area of 2001	Area of 2018 (Sq. Km)	Area Change (in Sq. km)	% of Area of 2018	% of Area Change in seventeen years (increase/decrease)
Agriculture	40.38	36	39.37	1.01	34.8	0.89 % decrease
Built-Up	5.72	5.06	12.65	6.93	11.2	6.2% increase
Forest	66.44	58.79	60.00	6.44	53.1	5.7% decrease
Water bodies	0.43	0.38	0.43	No change	0.38	No change
Waste land	-		0.297	0.297	0.26	0.26% increase
Total Geographical Area (TGA)	113	100	113	14.6	100	-

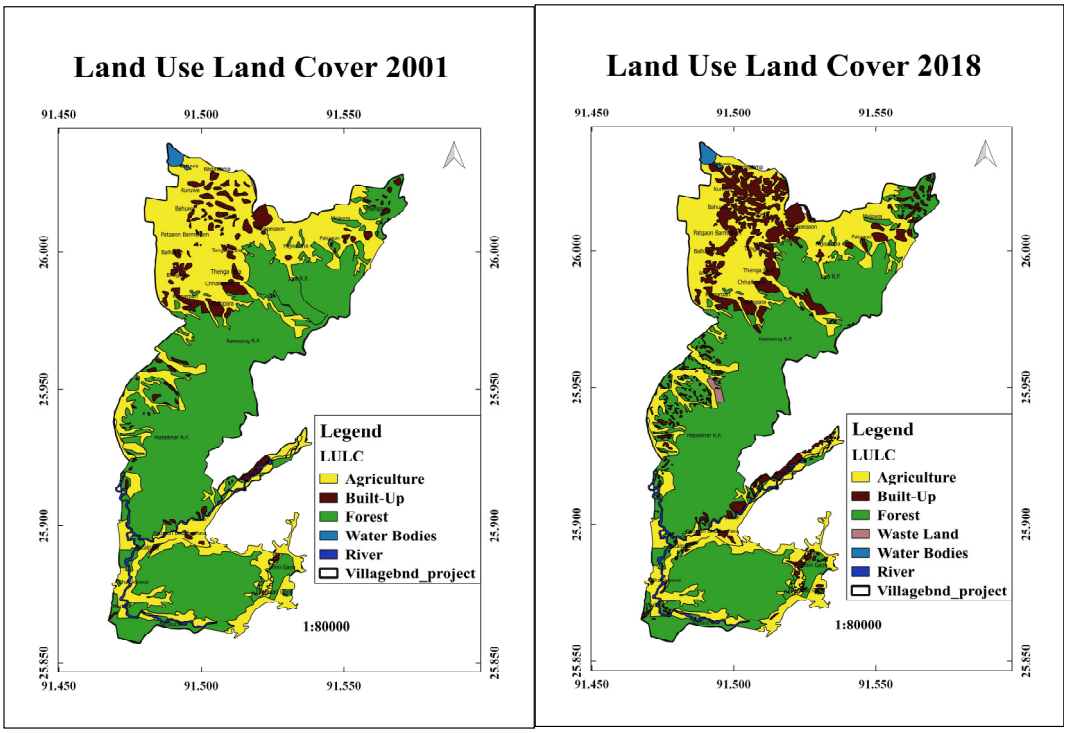


Fig.2: Map showing Land Use Land cover changes in the Study area (2001 to 2018)

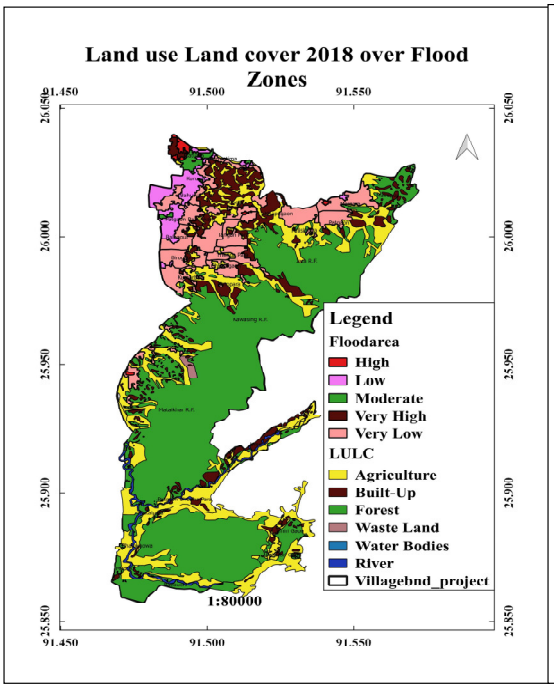
loss of habitats in the region in near future that are relatively undisturbed by urban development for so long and will threaten biodiversity through loss of habitat, biomass, and carbon storage.

Flood Hazard Zones

The Flood Hazard Classification by NRSC is based on number of times / years an area is subjected to flood inundation during the period 1998-2007. Flood hazard zonation map of Assam including the study area is categorized into High, Moderate, Very high, Low and very Low Hazard zones. Very Low Flood Hazard zones means 1-2 times/ year the area was inundated during the period 1998-2007, similarly Low Flood Hazard zones 3-4 times, Moderate Flood Hazard zones 5-6 times, High Flood Hazard zones 7-8 times and Very High Flood Hazard zones 9-10 times i.e., almost every year [11].

Flood Zones

In order to identify areas that fall into the different flood zones categories (Fig 3), Land Use Land Cover 2018 has been overlaid on the flood hazard zones. From the result & analysis, it has been found that 0.026 sq. km built-up area and 0.194 sq. km agricultural land falls under the High zone and 0.135 sq. km and 0.53 sq. km of built-up area and agriculture land falls in Moderate flood hazard zones. Agricultural land of 2.90 sq. km and built-up land of 0.117



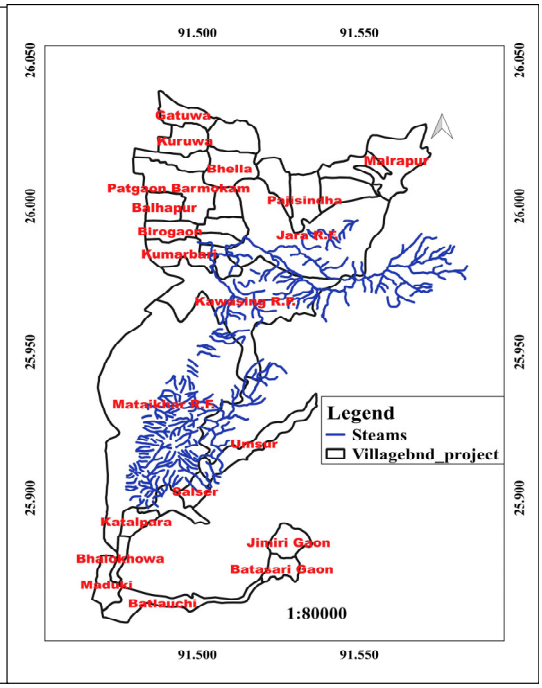
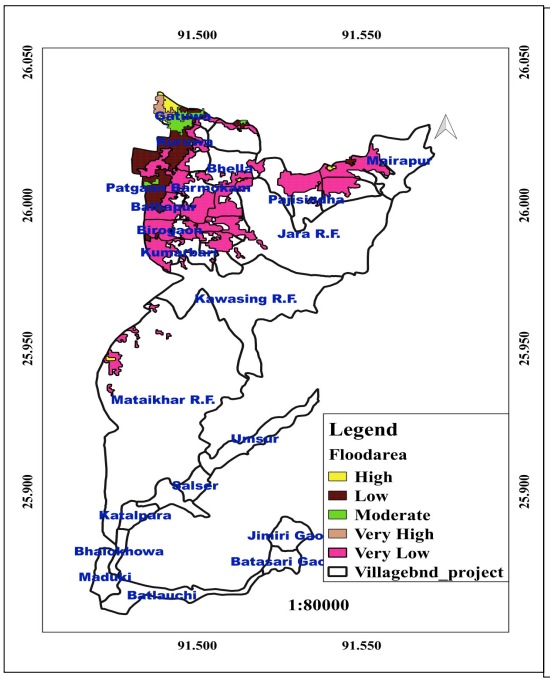


Fig.3: Land Use Land Cover 2018 overlaid on

Fig.4: Natural Streams of the study area



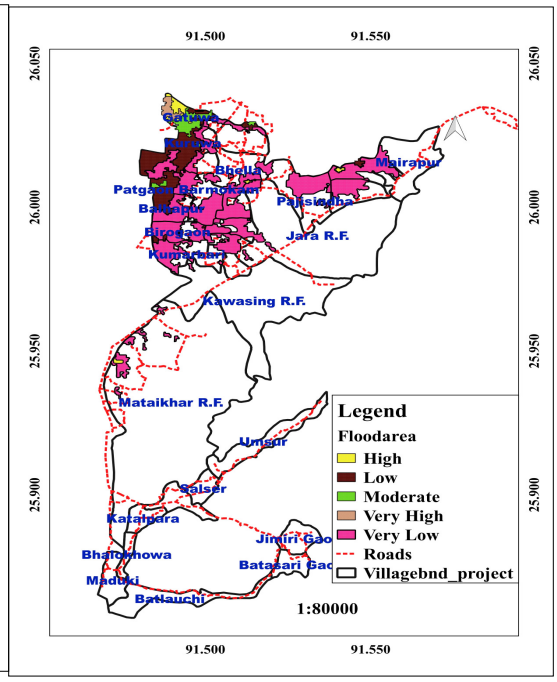


Fig.5: Flood Hazard Zonation map of the area

Fig.6: Roads overlaid on Flood Hazard zones

sq. km falls into Low zones and agricultural land of 9.27 sq. km and built-up land of 2.65 sq. km falls under Very Low Flood Hazard Zones. Rest of the area (97.17 sq. km), dominantly forest land falls in safe zone that are free from Flood hazards. The area being rural, the drainage system has not been developed. Even the existing road does not have proper drainage network and mostly depends on natural streams as shown above in the map. This causes waterlogging and flash flood during heavy rains. The study area has a wetland of about 0.43 sq.km.

A total of 133 km of roads have been digitized of which 57.62 km are black topped, 16.640 km are gravelled, 54.35 km are earthen and remaining 5.147 km are paved roads. It has been observed that the following 14 villages of the area come under flood affected zones with a total population of over 7803. These are Barpratima, Kuruwa, Bhella, Bahuwa, Patagaon, Barmokam, Tangan para, Birogaon, Thenga para, Balahpur, Challigaon, Kumarbari,Garopara and Gatuwa. Although the intensity of flood is low in some areas as reflected but during rainy season as the intensity of water

increases, it causes inundation of agricultural land, habitations and other infrastructures resulting heavy economic loss. But the most affected are the roads, as the panchayat has mostly gravel roads which get submerged under flood water causing disruption of communication that makes marketing of agriculture products, educational facilities and health services difficult and make life miserable. Under the assistance of Pradhan Mantri Gram Sadak Yojana (PMGSY), the panchayat has been provided with one all-weather road connectivity. The roads that submerge under flood water are black topped and gravel roads which mainly connect one village with another and state highway and mostly falls under low, very low and moderate flood hazard zones.

Educational facilities and other amenities

Apart from roads and settlements, other infrastructures that get affected during flood are the educational institutions as shown in the map below. A total of 39 educational facilities are available in the area out of which 32 area Lower primary, 3 middle schools and 4 secondary schools (Fig 7). 10 educational facilities falling under the flood zones as identified include 4 secondary schools and 6 Lower primary schools (Fig 8). During monsoon months of June and July, the schools remain closed as per the school's curriculum. But once the schools re-open, due to water logging and damage of road network it becomes difficult for the students to attend their respective schools especially for female students, as they travel mostly on foot.

CONCLUSION

Spatial distribution of land use and land cover information and its changes is desirable for any planning, management and monitoring programmes at local, regional and national levels. This information not only provides a better understanding of land utilization aspects but also provides a vital role in the formulation of policies and programmes required for developmental planning. For ensuring sustainable development, it is necessary to monitor the ongoing changes in land use land cover pattern over a period of time.

In the present study, an attempt has been made to show the changes through geo-spatial application on land use land cover for the year 2001 and 2018 and identified vulnerable areas that are susceptible to flood inundation, like educational facilities and road network. This case study also shows the impact of settlements pattern resulting changes in the pattern of Land use Land cover with application of Geo-informatics.

The study also reveals an increase in the built-up area from 5.72 sq. km in 2001 to 12.65 sq. km in 2018. Simultaneous increase in the built-up area has an impact on the agricultural and forest land, as the agricultural land decreased from 40.38 sq. km in 2001 to 39.37 sq. km in 2018 and forest cover also decreased from 66.44 sq. km in 2001 to 60.00 sq. km in 2018. This process of urbanization and expansion of the area as observed is primarily due to its proximity to Guwahati city and rise in population and economic growth. Over the years due to increasing demand for infrastructure and settlements there is 6.2% increase in built-up areas through decrease of 5.7% forest cover and 0.89% in agriculture land which has resulted to land-use changes and other hazards. This gradual increase in built up area at the cost of forest and agricultural land in the area is expected to continue as the city of Guwahati expands towards this peri urban area. This may in due course of time

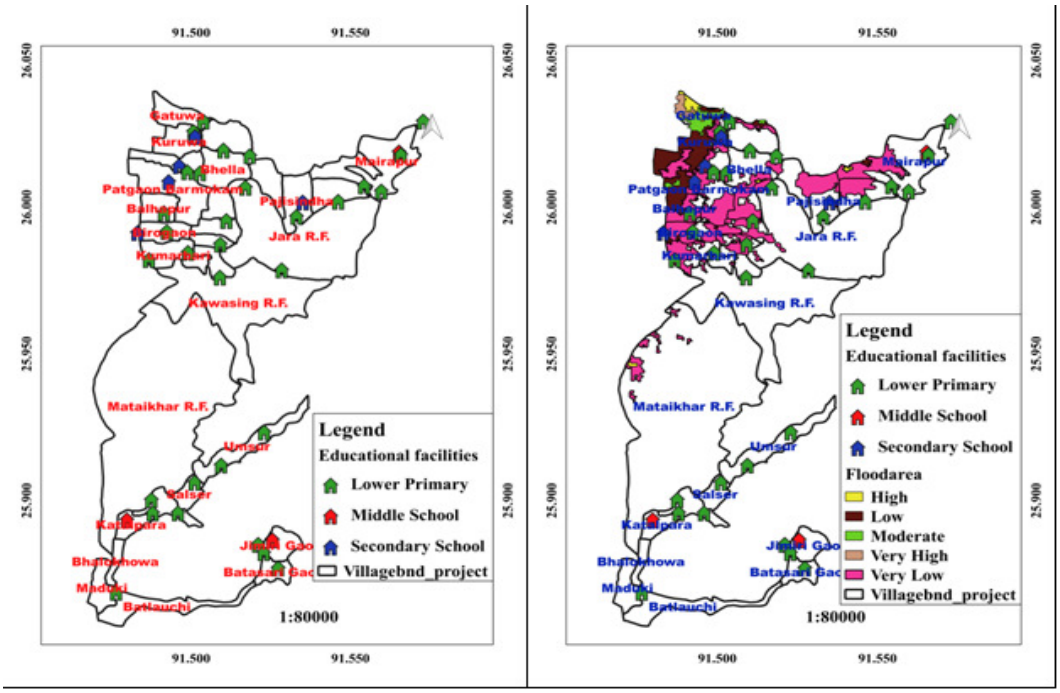


Fig.7: Educational Facilities 2018 **Fig.8: Educational Facilities overlaid on Flood zones**

will result in more loss of habitats in the region and threaten biodiversity through loss of habitat, biomass, and carbon storage.

Further analysis shows that a total of 2.928 sq. km of built-up area falls under flood hazards zones. Various categorisations suggests that out of the total built up area, 2.65 sq. km area is under very low zones, 0.117 sq. km into low zones and 0.026 sq. km. and 0.135 sq. km. falls under high and moderate flood hazard zones. Apart from built-up area, a total of 12.894 sq. km. area of agricultural land falls under flood hazard zones. Out of which, 9.24 sq. km comes under very low flood zone category, 2.90 sq. km under low category and 0.153 sq. km and 0.194 sq. km falls into moderate and high flood zones category.

Survey of the study area further reveals extremely poor condition of existing roads and non-availability of proper all-weather road connectivity which causes difficulty in transportation and emergency evacuation of patients to nearest medical facilities. Inadequate health care facilities or hospitals in the area compels the villagers to either depend on Anganwadi centres or travel to Guwahati city in emergency situation which is again difficult in absence of ambulance service or transport facilities. Apart from health care facilities, other educational, banking and postal facilities are also not adequately available in the area.

The study further identifies road network and villages in the area falling under different categories of the Flood Hazard zones that are either affected or vulnerable. The result indicates that 14 villages with a population of over 7803 are affected and falls under the moderate, low and very low categories. The area does not have proper open and closed drains and mostly depends on natural streams. As a result during rainy season there is water logging and flash flood in the area. Therefore, based on the above study, following suggestions are made to mitigate flood inundation and flash floods in the study area to attain Flood hazard resilience:

1. There is a need to restrict further unplanned urbanisation and blockage of natural drainage/stream system in the study area.
2. Wetland conservation is also important in the study area as wetlands function as natural sponges that trap and slowly release surface water, rain water, flood waters and groundwater.
3. Appropriate regulation on encroachment of forest areas in the study area.
4. Awareness camps for the local villagers about Flood Hazard Zones.
5. Setting up of Community Based Flood Early Warning System (CBFLEWS) for the villagers to avoid loss of life, livestock's and damage to agricultural lands and infrastructure.

The study helped in understanding the role of rapid growth of Guwahati city and its impact in the peri-urban areas. There is a need for a perspective land use plan for the peri-urban areas as the population growth and developmental activities will put considerable pressure in these areas. The flood vulnerability analysis in the present study will help planners and decision makers to address the issues to initiate appropriate action for prevention and control of flood hazards of the area for larger interest of people.

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