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Analysing the Spatial and Temporal Dynamics of Land Use and Land Cover Change in the Jia dhal River Basin Using Geospatial Techniques

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Abstract

Rapid and unplanned urbanization, coupled with changing climatic conditions, has intensified the frequency and severity of flooding across the floodplains of India. The Jia dhal River basin in Assam is a typical example of such environmental stress, where anthropogenic interventions such as channel modification, embankment construction, and settlement expansion have significantly altered the natural hydrological regime. This study examines the spatio-temporal dynamics of Land Use and Land Cover (LULC) change in the Jia dhal River basin and assesses its environmental implications using geospatial techniques. Satellite imagery and GIS-based analysis were employed to detect changes in land cover patterns over time and to relate them with hydrological and ecological transformations.

The findings reveal a notable decline in forest and agricultural land, accompanied by a marked increase in built-up areas and barren surfaces, indicating rapid land transformation driven by population pressure and developmental activities. These LULC changes have disrupted the basin's natural drainage, intensified soil erosion, and heightened flood vulnerability, thereby threatening local livelihoods and ecosystem sustainability. The study underscores that land cover modification, coupled with climatic variability, has significantly altered the basin's water balance and geomorphic stability.

The research highlights the urgent need for sustainable watershed management and policy interventions focusing on eco-friendly infrastructure development, land use regulation, and community-based adaptation strategies. By integrating spatial data and environmental analysis, the study contributes to a better understanding of human–environment interactions in flood-prone regions and provides a scientific basis for future land and water resource planning in the Jia dhal River basin.

Keywords: *Land use/land cover, Change Matrix, Human Intervention, Jiadhal River Basin*

Introduction

Urban centres located in coastal regions and floodplains across India have increasingly become vulnerable to flooding due to the rising frequency of high-intensity rainfall events over short durations (Gosain et al., 2006). Such vulnerability is further worsened by unplanned urbanization, infrastructural encroachments, and anthropogenic interventions in natural drainage systems. The Jia dhal River basin, the focus of the present study, exemplifies this problem. The river's hydrological and geomorphological stability has been severely disturbed by infrastructural developments and channel modifications. These human-induced alterations, such as embankment construction, sand mining, and settlement expansion have intensified the area's exposure to flooding and erosion, thereby heightening environmental risk and livelihood insecurity.

"Land cover" refers to the biophysical characteristics of the Earth's surface, including vegetation, water bodies, and built-up areas, whereas "land use" represents the ways in which humans utilize these surface features for economic, social, and cultural purposes (Wilkie & Finn, 1996). Although natural processes shape the Earth's surface, human activities have significantly transformed these landscapes, especially in densely populated and resource-dependent regions. Land Use and Land Cover (LULC) change has thus emerged as a crucial dimension in the study of environmental management and natural resource conservation. It serves as a vital indicator of human-environment interactions and a key driver of ecological and hydrological transformations (Shafiq et al., 2017).

At regional scales, widespread LULC changes have profound environmental implications, including loss of biodiversity, soil degradation, altered surface runoff, and increased flood susceptibility (Das, 1981; Majumder, 2005). These transformations are influenced by both natural factors—such as climatic variability—and socio-economic dynamics like agricultural expansion, population growth, and urban development. With increasing demographic pressure and intensification of land-based activities, land has become an increasingly scarce and contested resource, particularly in developing countries (Majumder, 2005).

The impacts of climate variability and LULC changes are particularly severe in developing nations, where adaptive capacity is often limited (Gosain et al., 2006). Many Indian River basins have undergone extensive land cover transformations during the past century, resulting in recurrent hydro-meteorological extremes such as floods and droughts (Singh et al., 2010). The interplay between climatic factors and human-induced LULC change has significantly altered hydrological regimes, sediment loads, and groundwater recharge patterns. These transformations not only disrupt ecosystem stability but also pose long-term challenges to water resource sustainability and regional development.

Recognizing these emerging challenges, the Indian Space Research Organisation (ISRO), under its Geosphere-Biosphere Programme (ISRO-GBP), initiated a comprehensive national-scale assessment of LULC dynamics to understand the spatial patterns, driving forces, and environmental implications of land use changes across India (Aggarwal et al., 2012). Such studies are critical in formulating adaptive strategies for managing land and water resources in the context of climatic and anthropogenic pressures.

In the Jia dhal River basin, where a majority of the population depends on natural resources for their livelihoods, LULC changes have had direct implications on agricultural productivity, flood vulnerability, and overall ecosystem services. The increasing encroachments into floodplains, conversion of agricultural lands into settlements, and deforestation in upper catchments have amplified both the frequency and intensity of flood events. These processes threaten not only the ecological balance but also the socio-economic well-being of local communities.

Hence, the **primary objective** of this study is to analyse the patterns and processes of land use and land cover change within the Jia dhal River basin and to identify the environmental problems resulting from these transformations. By understanding the linkages between human activities, land dynamics, and hydrological responses, the study aims to contribute to sustainable watershed management and inform policy interventions for environmental resilience in the region.

Study Area

The study is confined to the Jiadhal river basin of Assam which comprises of three districts, Dhemaji and Lakhimpur in Assam and west Siang district of Arunachal Pradesh in the upstream. The basin covers an area of 118995.6 hectare having latitudinal and longitudinal extensions of 27°08’ N to 27°45’ N and 94°15’ E to 94°38’ E respectively (Figure 1). Out of its total area, Arunachal Pradesh claims 397.94 km^2 i.e. 35.47 percent and rest 724.06 km^2 i.e. 64.53 percent belongs to Assam (Hazarika, 2006, p.19). Jiadhal river systems originate from the hills of Arunachal Pradesh joining three tributaries named Siri, Sika and Sido, and flows to Assam through narrow valley ending at the river Subansiri. The slope of the basin drops from northern and eastern corners towards south and western sides. After the confluence the mighty rivers i.e. Kumotia or Jiadhal, Gai, Kanibil, Sisi, Simen, Dikari and Royang from their hilly course to the valley exert tremendous impact of peak runoff at the eastern most corner of Dhemaji district, making the district susceptible to annual flooding.

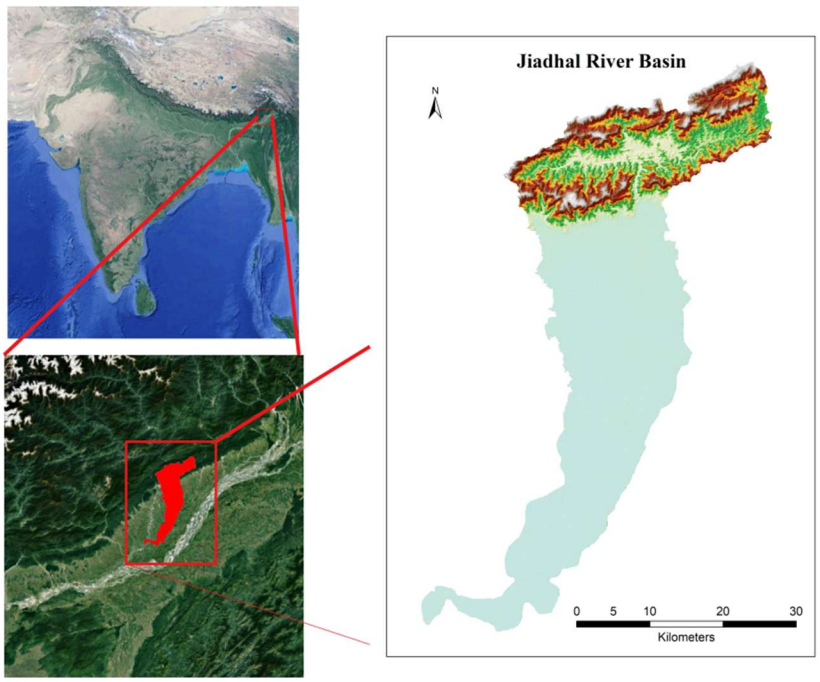

Figure.1 Location of the Jia dhal River Basin

It exhibits difference in temperature, rainfall, fog, wind etc. The sub- tropical monsoon climate as the general climate for the whole catchment, with the upper catchment moist in all seasons, with a harsh winter and shorter summers at higher elevations. Average annual rainfall within the catchment ranges from 2,965 to 4,386 mm, with a mean annual rainfall of about 3,150 mm. The rainfall generally increases from southeast to northeast. July is that the rainiest month within the area. On a mean there are about 200 days with 3.5 mm or more rain during a year. The temperature varies between 39.9ºC in summer and 5.9ºC in winter. The maximum rainfall occurred during the month of July (91.9 mm) and December is that the dry month.

Methods:

The survey of India (SOI) topographical sheets (83I/6; 83I/7; 83I/8; 83I/9 83I/10; 83I/11, 83I/12) of 1:50,000 scale and DEM have been used for the demarcation of the Jia dhal River basin to UTM WGS 1984 datum with zone 46 Northern Hemisphere projection through GIS Software. Global Digital Elevation (GDEM) are used to delineated the boundary of the study area and ASTER GDEM tiles were used with the standard GIS techniques to delimit Jia dhal River basin. Landsat Thematic Mapper image of 2000 and Landsat operational land imager (landsat-8) image of 2022 were used to examine the changes in land use and land cover and their effects on agriculture. Using supervised image classification, maps of the study area's land use and land cover for the years 2000 and 2022 were produced. For both supervised classifications of the 2000 and 2022 were used to create an overlay analysis and land use/land cover change map. Cross-tabulation in the GIS module was used to create a transition matrix that analysed the spatial distribution of various land use classes and changes. Using decision, training pixel sites were categorised to assess classification accuracy. The identified training pixels and training pixel sites were then compared. For both 2000 and 2022, the overall categorization accuracy was determined to be 78.5 percent and 91.0 percent, respectively.

Result and discussion

The rapid pace of urbanization in recent decades has led to extensive deforestation in the upper reaches of the Jia dhal River basin. This large-scale loss of vegetation cover has accelerated soil erosion and sediment deposition within the river channel, making the basin increasingly prone to severe flooding each year. The intensification of sedimentation processes has caused significant alterations in Land Use and Land Cover (LU/LC) patterns, leading to the gradual shrinkage of land suitable for urban and agricultural purposes.

The present study analyses the relationship between LU/LC changes and the geomorphic dynamics of the Jia dhal River, highlighting their implications for the surrounding township areas. Between 2000 and 2022, five major LU/LC categories were identified within the basin: (i) sand and built-up areas, (ii) mountain vegetation, (iii) agricultural land, (iv) other vegetation, and (v) water bodies (Figure 2). Spatial analysis indicates that the foothill regions of Arunachal Pradesh, particularly in the West Siang district, where the

river originates, have undergone notable land cover transformations. These upstream changes have triggered a series of environmental consequences in the downstream plains of Assam.

The Jia dhal River flows from the hilly terrains of Arunachal Pradesh into the alluvial plains of Assam in a braided pattern, transporting a substantial sediment load. During the monsoon season, the river experiences high discharge and frequent overbank flooding, resulting in geomorphological instability and environmental degradation in the downstream areas. Human interventions in the upstream catchment, including deforestation, road construction, and unregulated land use, have intensified the downstream impacts, contributing to significant geo-environmental changes in the basin.

The downstream portion of the Jia dhal River is densely populated, with agriculture being the primary source of livelihood for most inhabitants. As agricultural expansion continues alongside settlement growth, the landscape has witnessed widespread conversion of natural land cover into built-up areas, riverine sand deposits, and cultivated fields (Figure 3). Analysis of the LU/LC data reveals that a substantial portion of the natural and vegetative cover has been replaced by human-dominated land uses. Table 1 clearly shows that physical and ecological features have been increasingly transformed into anthropogenic land types such as agricultural fields, built-up zones, and exposed river sands.

These findings suggest that the combined effects of deforestation, sedimentation, and human-induced land use changes have significantly altered the hydrological behaviour and environmental stability of the Jia dhal River basin. The cumulative impact of these transformations not only exacerbates flood risks but also poses a serious challenge to sustainable land and water resource management in the region.

	Mountain Vegetation	**Other Vegetation**	**Agriculture**	**Water body**	**Sand and Built-up**	**2022**
Mountain Vegetation	39160.4	3675.33	722.7	298.44	1902.51	45759.38
Other Vegetation	2546.64	5080.86	1933.83	348.03	2715.2	12624.56
Agriculture	1111.32	4930.47	21702.5	2236.41	17177.8	47159
Water body	187.56	305.01	499.73	815.04	1096.74	2904.08
Sand and Built-up	98.19	520.2	3404.79	802.17	5723.73	10549.08
2000	43104.11	14511.87	28263.55	4500.09	28615.98	118995.6

Table 1: Change matrix of the study area during 2000 to 2022 in hectares

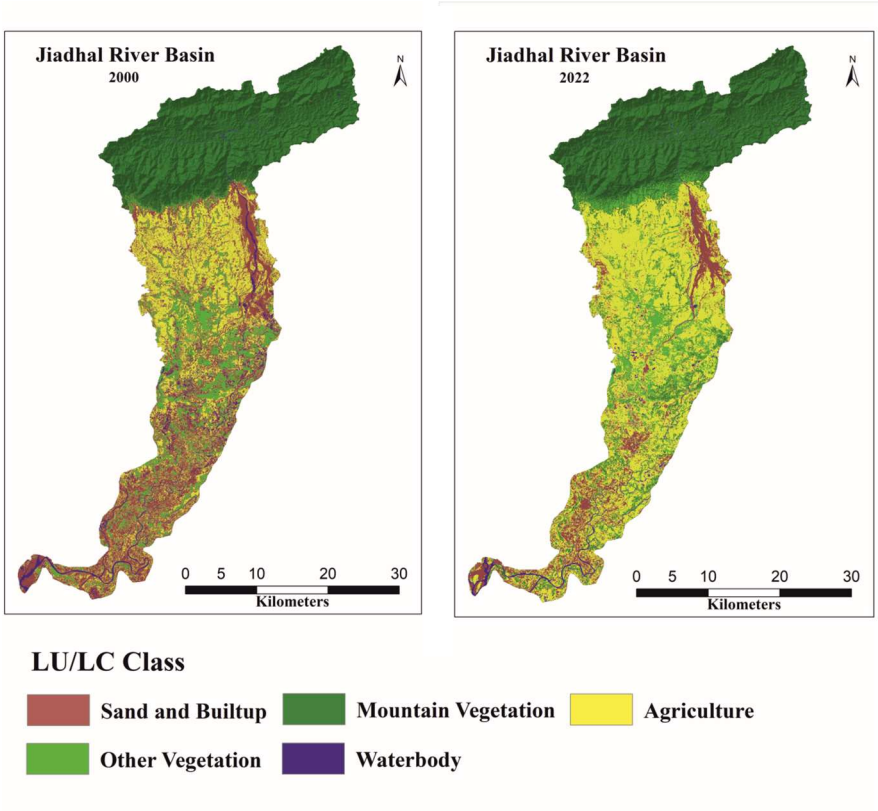

Figure 2: Classes of land use/ land cover during 2000 to 2022

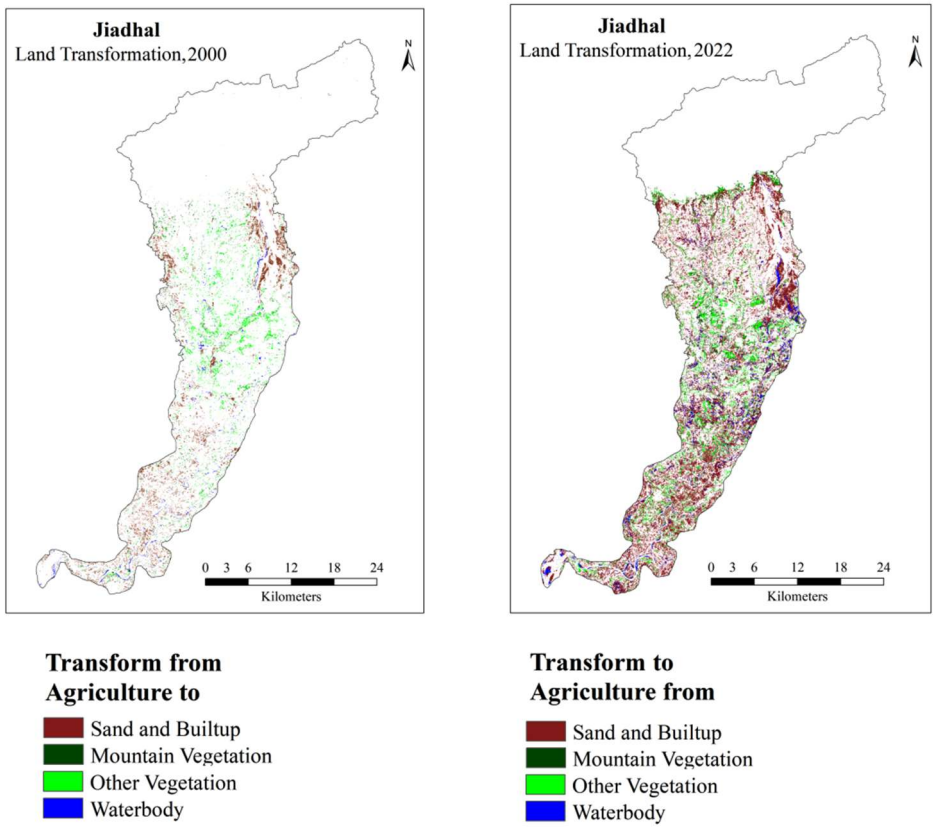

Figure 3: Land transformation during 2000 to 2022

From Table 1 it is seen the percentage of changes in the water bodies, river sand, agricultural land, built-up area, forest cover area for the year 2000 to 2022 respectively. In 2000, water bodies cover an area of 4500

hectare of the total area and in 2022 it cover an area of 2904 hectare, since 2236.41 hectare transformed to agriculture land. Agricultural land has increased from 28263 hectare to 47159 hectare in 2022. The increase of agricultural land mostly came from river sand i.e. 17177.8 hectare. The other vegetative class mostly dominate in the plains has showed declining trend of 14511.87 hectare to 12624.56 hectare in 2022. Most of this land declining is the result of land transformation to agriculture i.e. 5080.86 hectare. Like agriculture, mountain vegetation was also showed positive change in the study. It has an area of 43104 hectare in 2000 and increases to 45759 hectare in 2022. Thus massive deforestation and encroachment of forest land for settlement purpose has further aggravated the process of siltation in the river bed. The new expansion of area under flood plain due to heavy sedimentation on both sides of river beds are being transformed into agricultural lands as revealed in Table no. 2. As a result the area under agriculture has increased from 28263.55 km^2 in 2000 to 47159 km^2 in 2022 and the rate change is 66.85%.

The variability of rainfall and preventive measures in the upstream created this result. The sand and built-up has showed negative trend which is due to the transformation of flood plain into agricultural land. The declining trend of land in this mixed class only attributed to river sand deposited during flood. The river forms many small tributaries and all the marshy area was under water. From the matrix it is very clear that all the increased parameters are enclave from vegetation, sand cover area of the basin.

LU/LC Class	2000	2022	Rate of Change (%)
Mountain Vegetation	43104.11	45759.38	6.15
Other Vegetation	14511.87	12624.56	-13.01
Agriculture	28263.55	47159	66.85
Water body	4500.09	2904.08	-35.46
Sand and Built-up	28615.98	10549.08	-63.13
Total	118995.6	118995.6	-

Table 2: Rate of change in land use/ land cover during 2000 to 2022

The rate of change in the study showed some positive and negative changes in the study area (Table 2). Out of the five land use and land cover classes only two classes showed positive changes i.e. agriculture and mountain vegetation. These classes attributed 66.85% and 6.15% respectively. The changes in mountain vegetation are due to climate variability like increase of rainfall. However, agriculture has the extensive increase in the basin due to transformation of land from river deposits and other vegetation in the plain. Other three classes revealed declining trend of growth as they are transformed into agricultural land primarily. Sand and other vegetation have showed large extent of change during the study period such as 63% and 35% respectively. In the cross section in figure 4 clearly evident that the changes were occurred in the plain as compared to mountain regions. At the same time, due to fast socio-economic changes and urbanization in the region there is a need for extension of build-up area which has forced to expand the

build-up area towards land under forest cover as most of the fringing area under township is affected annually by flood due to changing nature of channel shifting of the Jiadhal River. LULC changes in the study area were attributed to urbanization, population growth, encroachment, social-economic growth and climate change.

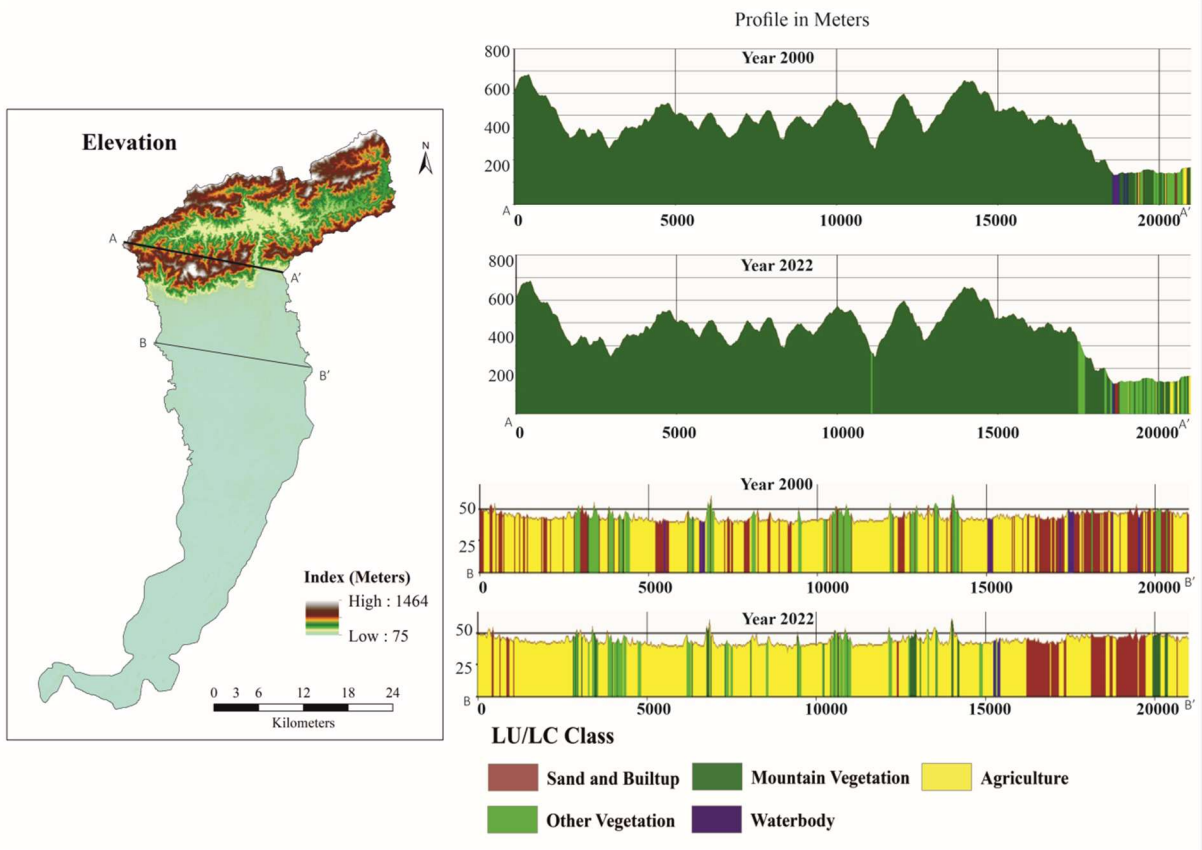

Figure 4: Cross section in the study region over mountain and plain

Conclusion:

The current study has revealed that several factors have been contributing towards the change in LULC in the study area, including population increase, rapid urbanization, social-economic growth, climate change, poor planning, and poor plan implementation. Population increase is directly responsible for the increase and the decrease of built-up land and forest land, respectively. Rapid population growth rate has necessitated the demand for settlement areas which has forced the people to expand their habitation to forest lands. The foregoing discussion also reveals that, due to land use/ land cover change in the study area the other vegetation cover and sand areas of river flood plain are mainly declining. The intensity of the flood waves are increasing annually. The rate of sedimentation is ever-increasing creates the possibility of crop field in the basin. The meteorological and hydrological regime of the river basin is changing. River flood plain sand and other vegetation area had declined to a large extend and increased in agricultural land, and river sand are becoming an acute problem in the area resulting to environmental changes of the river basin. Therefore land use/ land cover changes have brought a negative impact on the natural environment.

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Figure Captions

Figure 1: Location of the Jiadhal River Basin

Figure 2: Classes of land use/ land cover during 2000 to 2022

Figure 3: Land transformation during 2000 to 2022

Figure 4: Cross section in the study region over mountain and plain

we, hereby declare that the subject matter of the present research paper entitled "**Impact of Land Use/ Land Cover Change on Agricultural land of Jiadhal River Basin, Assam**" is the record of original work done by us, that the contents of this research paper did not form basis of the award of any previous paper to us or to the best of our knowledge to anybody else, and that the research paper has been submitted for publication. This research paper exclusively focuses on how rapid urbanisation and fast developed economy has accelerated the rate of land use and land cover changes in the recent times.

Cite this Article

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