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Research Article

LAND UTILIZATION ASSESSMENT THROUGH SEASONAL REMOTE SENSING DATA AND GIS IN MIRZAPUR TAHSIL OF MIRZAPUR DISTRICT, UTTAR PRADESH, INDIA

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ABSTRACT
There exists an intricate and inseparable link between the land use and geomorphological settings of the area. These aspects are also essentially associated with resource management, inventories, and their utilization. The systematic and organized use of remote sensing and Geographic Information System (GIS) has proved to be a valuable tool in comprehending our spatial environment in various research platforms. This research paper deals with the land-use dynamics and patterns in Mirzapur tahsil of Mirzapur district as a case study through seasonal remote sensing data. The aim of using seasonal data is to assess the spatial distribution and utilization patterns throughout the year and exploring the possible causes of variations and suggesting possible measures for further development of its natural resources. A composite map by the combination of *kharif* (October, 2016) and *rabi* (February, 2017) season is generated. This map is analyzed with reference to the region's hydrogeomorphological characteristics. The region consists of Ganga alluvial plain in the north and the Vindhyan plateau in the southernmost part. The result states that nearly 56% of the cultivated region of the northern plain of the area, only 30.8% of the land is exposed to double cropping. Nearly 14.4% of the land is subjected to single *kharif* crops and left as fallow land in another season, whereas nearly 10.8% of the total area is under single *rabi* crops and this percentage of land is again not in utilized for the rest seasons. The southern region, being plateau and forest-covered, only buried pediment zones suitable for utilization. A proper drainage system development is required to convert seasonally left fallow land into multiple croplands. Various development prospects are also suggested for water and forest resources and their utilization.

Keywords*: *Land use and land cover (LU/LC); Hydrogeomorphology; Remote sensing, GIS; Rabi and Kharif cropland

INTRODUCTION
The consistent interaction of human beings with their natural environment leads to some modifications or alterations to its present form with the time. It is now possible to estimate the changes from spatial to temporal scale through various parameters and processes using remote sensing and Geographic Information System (GIS) (Brooke *et al.*, 2020; Wylie *et al.*, 2019). These issues have got their inevitable importance in various research works regarding resources management and development (Ahmadi Sani, *et al.*, 2016; Dong, *et al.*, 2019; Fernandez-Carrillo, *et al.*, 2019; White, *et al.*, 2016). While the remote sensing acts as a data feeder to the GIS environment, the GIS in itself is quite efficient in handling and processing of those data. The full-fledged capacity of the information generated from a multitudinous range of data as well as the availability of multi-temporal, multi-resolution and multispectral data have boosted the capacities of researchers to explore the dynamics of the phenomenon as well as mapping, modeling, and its monitoring (Kandakji, *et al.*, 2020; Musa, *et al.*, 2017; Sciortino, *et al.*, 2020). These technologies have facilitated to look into the relations, patterns, identification, and conversion of the phenomenon under investigation and also provide a deep insight to develop prospect strategies and opportunities to forecast (Hussain, *et al.*, 2013; Kandakji, *et al.*, 2020).

Mapping has always been an essential base and tool for geographers to address the information about the spatial phenomenon. Remotely sensed data carries lots of information which is easily processed and extracted at GIS platforms. The simple method to explain the phenomenon under investigation is the land use and land cover (LU/LC) mapping and change detection (Boakye, *et al.*, 2020; Reba & Seto, 2020; Valjarević, *et al.*, 2018). This comprehensive technique used to assess changes either at the local level, regional level, or global level (Friedl, *et al.*, 2010; Gibbs & Salmon, 2015). The technique is quite competent enough to articulate the multipurpose objectives like what, where, how much, characteristics, and possible causes of variations (Ali, *et al.*, 2016; Beitl, *et al.*, 2019; Malambo & Heatwole, 2020). Mapping and analysis of spatial data is a prerequisite condition in the monitoring, inventories, planning, management, and evaluation of resources and environmental-related concerns (Hall & Hossain, 2020; Rudke, *et al.*, 2020; Worqlul, *et al.*, 2017).

In the paper of Doan & Guo, (2019) have effectively presented the suggestive measures with the help of geospatial technologies in the conservation and protection of biodiversity in the Northern Great plain in North America. There are various methods of image classification, analysis, and detect changes (Blaschke, *et al.*, 2014; He, *et al.*, 2020; Lillesand, *et al.*, 2004). Pre- and post-classification are the most common change detection methods and monitoring (Samal & Gedam, 2015; Butt, *et al.*, 2015). Image differencing, band rationing, vegetation index differencing, principle component analysis, etc. are the pre-classification approach of change detection (Dewan & Yamaguchi, 2009). In post-classification, classified land cover data is preferred for comparison and detection and is the most widely used in the analysis (Tehrany, *et al.*, 2014). Analysts in this technique can classify land cover classes of the study area according to their desired categories. Merely quantitative detection through multi-date imageries is not enough. The LU/LC mapping study also needs to understand its land morphology that highly influences the nature and spatial distribution of its resources.

Geomorphology studies the landscape change (Murray, *et al.*, 2009) in which topological relationships between the features of the landforms play a crucial role in understanding the spatial phenomenon (Abbaszadeh Shahri, *et al.*, 2019; Bishop, *et al.*, 2012). Therefore, it becomes very necessary to know the geomorphological settings of the area in landscape planning (Panizza, 1996; Parupalli, *et al.*, 2019). Hydrogeomorphology, a subdiscipline of geomorphology, keeps its own an important place in the field of geomorphology. In natural resource evaluations, landscape conservation, and environmental management, the versatility of geospatial technology to comprehend the phenomenon and their characteristics have got immense utility in the field of hydrogeomorphology. Hydrogeomorphic probes are quite efficient in explaining the work of surface and subsurface water. It also investigates the features like an alluvial aquifer, flood plains, and other features carved by water that act as an important tool for further geomorphic resource inventories (Díaz-Alcaide & Martínez-Santos, 2019; Poole, 2010; Trisasongko & Paull, 2020; Voll, *et al.*, 2020). These maps are essentially helpful in resources evaluation (Downs & Booth, 2011; Griffiths, *et al.*, 2011). There are lots of applications where hydrogeomorphological mapping becomes a fundamental need such as soil mapping, hydrological zonation, mapping, and investigation, land and forest resources, etc. (Hossain & Hashim, 2019; Marchetti, *et al.*, 2020).

The works regarding LU/LC change detection of post-classification methods are commonly focussed to estimate the temporal changes occurring in an area during specified periods. LU/LC mapping and change detection methods are highly considerable and used in many research projects (Matlhodi, *et al.*, 2019), Their studies are crucial for the land parcel for development (Halmy, *et al.*, 2015) but hydrogeomorphological aspects are too important to deal with the land-use dynamics and their influences on the spatial pattern.

Mirzapur’s rich forest cover and fragmentation of forest at spatial and at temporal scale are important to understand in the conservation forest (Laxmi, *et al.*, 2019). Flood plain features and soil properties are also important in the region like Mirzapur where alluvial plains offer major socio-economic and ecological values and significance (Kanhaiya, *et al.*, 2017; Seema, *et al.*, 2020). The region consists of interesting as well as contrasting features like alluvial plain in the north and plateau regions in the south, which offers settlement and wide scope for agricultural practices. Regarding the seasonal pattern of land use in cultivation practices is still not explored in the study region.

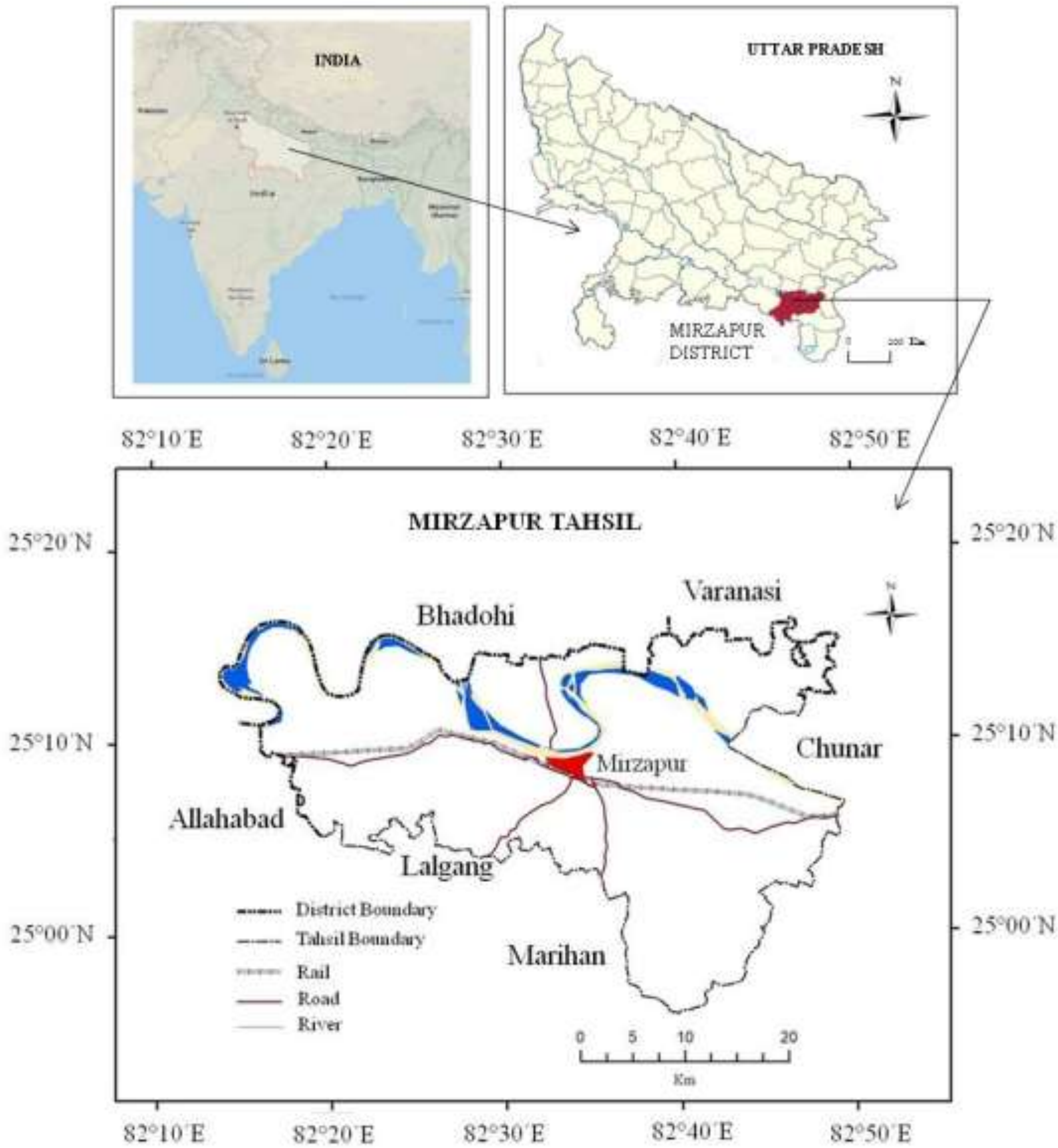

Figure 1: Mirzapur tahsil: Location

This paper primarily takes into account of LU/LC mapping and analysis through multi-seasonal remote sensing data in the study area Mirzapur tahsil (subdistrict) of Mirzapur district (Uttar Pradesh, India). It becomes necessary in the study area, where the climate is monsoon and variations exist in weather (http://mausam.imd.gov.in). Alterations in cropping patterns exist according to the seasons. The composite LU/LC map will provide the true picture of land use dynamics pertaining throughout the year in the region. To show the prevailing pattern in LU/LC, it is necessary to analyse each season's data separately and a combination of both (Ankana, 2016). Summer, winter, and rainy seasons are the characteristic features of the climate, and crop cultivation practices vary according to the seasons.

During *kharif* (June to October) or monsoon season nearly 42.5% of the total land is under crop cultivation and 15.4% of the land is left as fallow land. Forest cover constitutes nearly 30.0% of the region. But during *rabi* (November to March) or winter season cropland area enhances to 48.5% of the total area. Only 9.5% of the land is left unused. There are no appreciable changes seen in forest cover. It constitutes nearly 31.4% of the total land. The composite map of the LU/LC picture is different from its every season's land use tendencies. Nearly 56.0% of total land is exposed to cultivation. But of the total 56.0% of the total agricultural land, 30.8% is the land-only exposed to double cropping. Of this 56.0% of the land, 14.4% of such land exist, which are exposed only once during *kharif* season. Similarly, 10.8% of such lands are there which are used for only single *rabi* crops. Throughout the year only 6.0% of the total land is only found as permanent fallow land. Permanent forest covers constitute nearly 26.6% of total land.

Flooding, waterlogging, groundwater resource availability, etc. are the major challenges in the land utilization for the crop cultivation practices in the northern part. Whereas highly dissected southern plateau region, where low infiltration, high runoff, and rugged terrain limits to land resources utilization. In this research work, these aspects and variations are studied and suggestive measures are discussed accordingly.

GEOGRAPHICAL PROFILE

This section deals with the location and general characteristics of the region. These are physiography, slope, aspect, geology, climate, and drainage.

Location

Mirzapur tahsil is located between 24°55´ N to 25°10´ N latitudes and 82°15´ E to 82°50´ E longitudes. It is one of the four tahsils of Mirzapur district (Uttar Pradesh, India) and lies in the northwestern portion of the district (Fig.1).

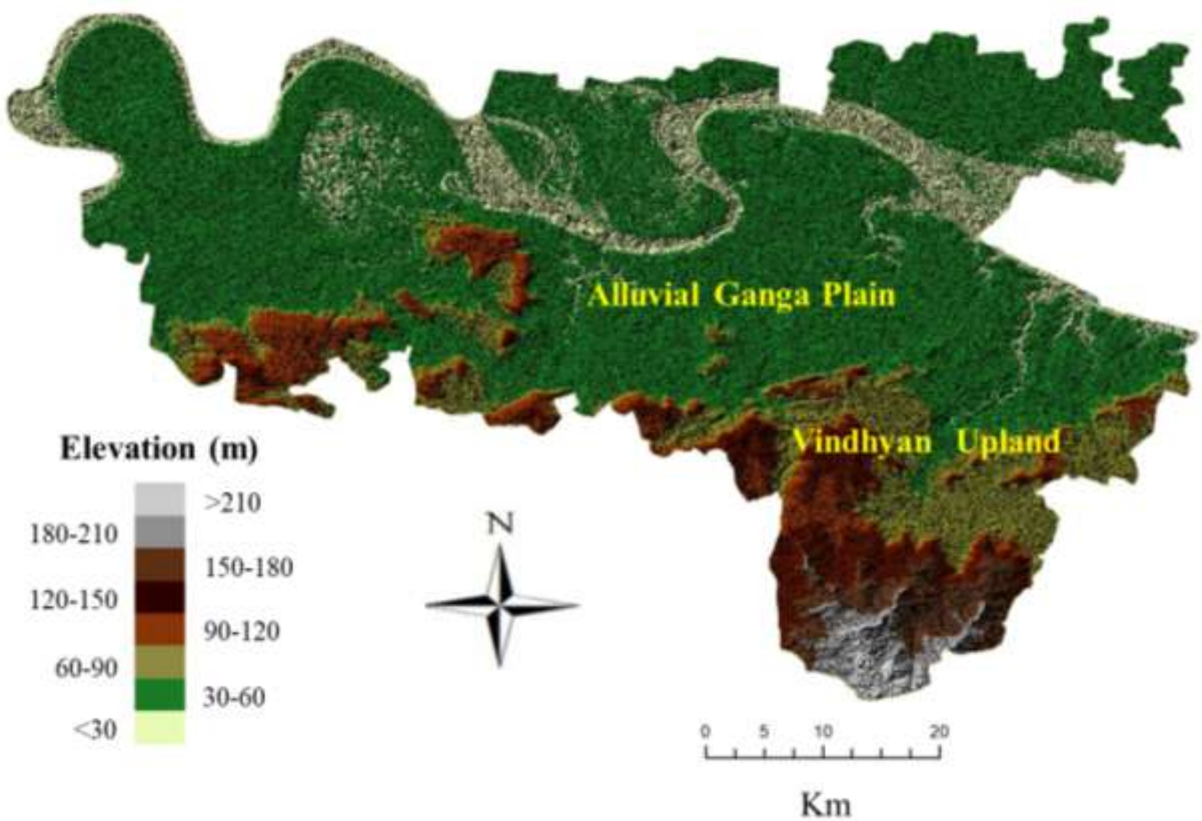

Figure 2: Mirzapur tahsil: TIN and physiographic units

Physiography

Almost the middle and the northern regions are located in Gangetic alluvial plain except some scattered residual hills. The plain nearly covers 71.9% (based on GIS computation) of the total area of tahsil. Elevation ranges even less than 50 m. Generally, the northern region can be described as a dead level plain and generally creates water logging problems in several parts of it. The southern upland is nothing but the extension of the Vindhyan plateau, which covers nearly 28.1% of the area. Lineaments, valleys, pediments, etc. are the characteristics features of the dissected plateau. The elevation of this southern plateau even goes beyond 300 m. Escarpment rises from the northern part of the plateau and faces towards the north (Fig. 2). Steep slopes are seen at the escarpment lying in the middle portion. The entire northern region reflects from level to the gentle slope (Fig. 3). Aspect is shown in Fig. 4.

Geology

From a geological perspective, Ganga alluvial plain in the north consists of sediments of Quaternary age, which is mainly composed of sand, silt, and clay. Vindhyan system in the southern part constitutes conglomerates, shale, sandstone, and carbonaceous beds.

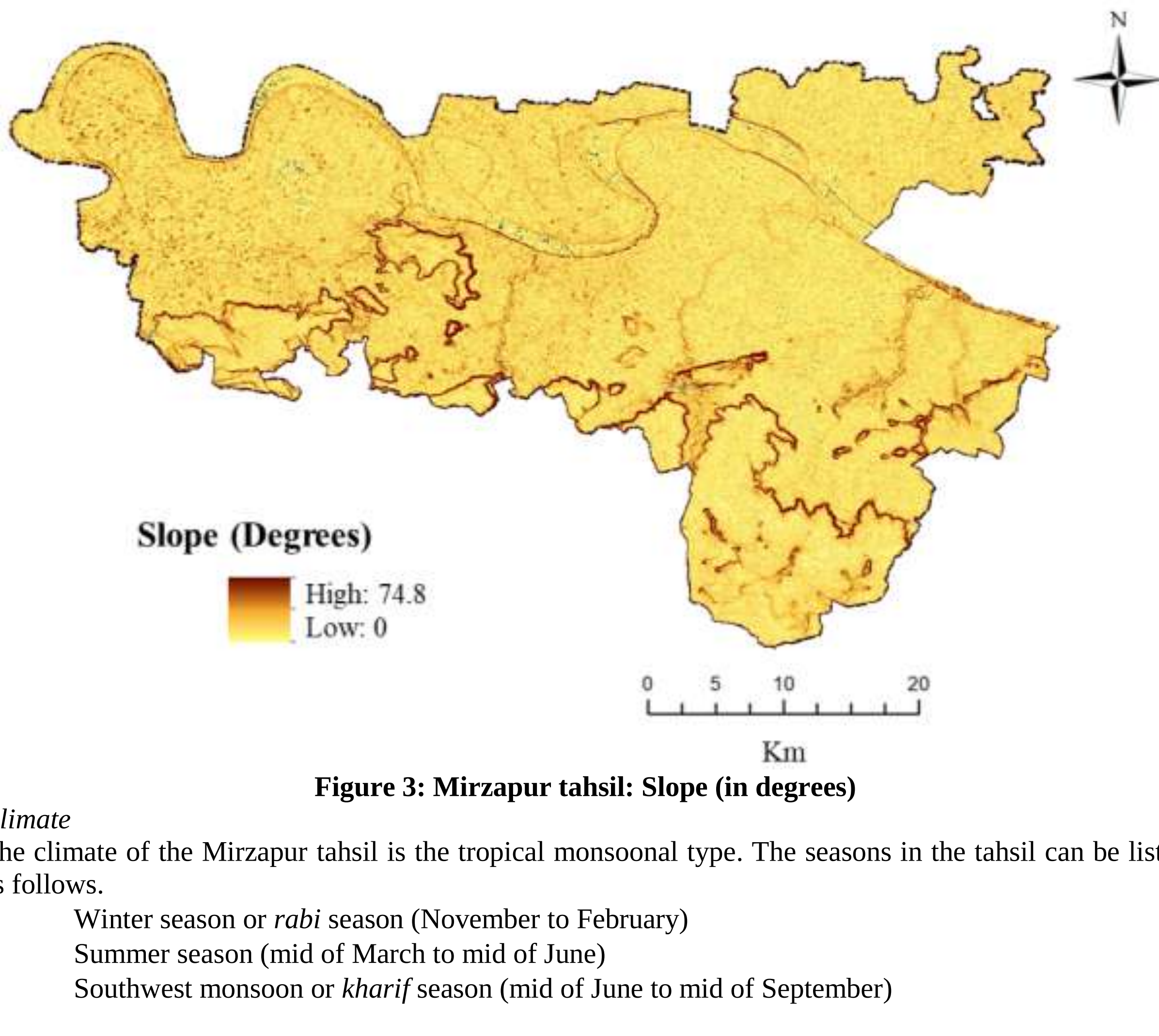

Figure 3: Mirzapur tahsil: Slope (in degrees)

Climate

The climate of the Mirzapur tahsil is the tropical monsoonal type. The seasons in the tahsil can be listed as follows.

- Winter season or *rabi* season (November to February)
- Summer season (mid of March to mid of June)
- Southwest monsoon or *kharif* season (mid of June to mid of September)

Drainage

The chief river of the tahsil is the river Ganga. Other important rivers include *Chatar Nadi*, *Madho, Ohjala, Karnauti*, etc. They also flow in the northern region and join the main river Ganga. The drainage density in the northern part is low and has a dendritic drainage pattern whereas the southern portion has high drainage density and they are showing almost trellised drainage pattern. Runoff is also very high in the southern portion (Fig. 5).

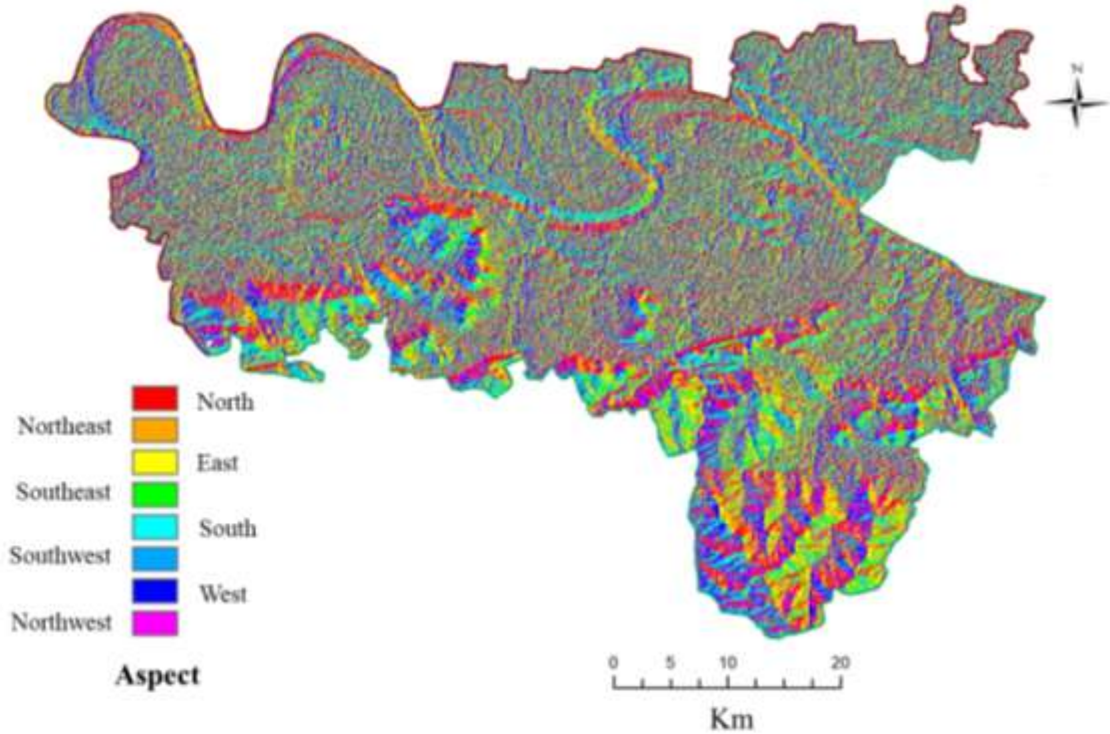

Figure 4: **Mirzapur tahsil: Aspect**

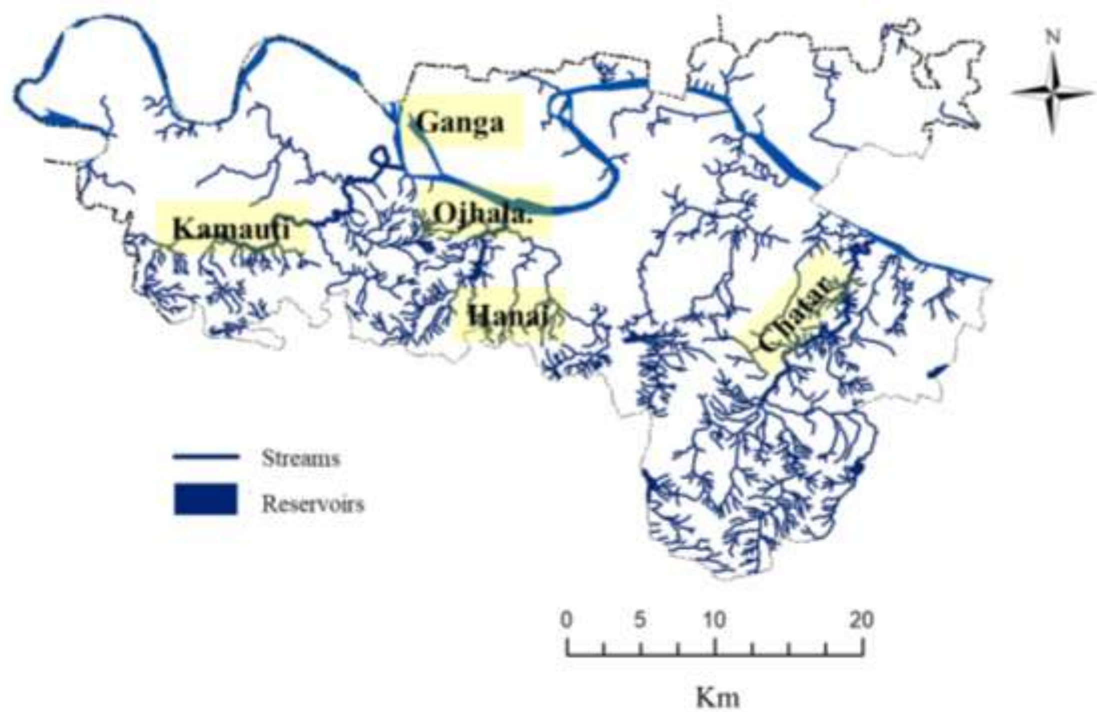

Figure 5: Mirzapur tahsil: Surface hydrology

DATA SOURCES AND METHODS

The data sources and procedure are described in the next sub-sections.

Data source

Survey of India (SOI) topographical sheet numbers 63K/4, 63K/7, 63K/8, 63K/11, 63K/12, 63K/13, 63K/15, 63K/16, 63L/1, 63L/2, 63L/5, and 63L/9 are collected from its official site *Nakshe* portal. Toposheets are used to produce a base map and hydrology map. Remotely sensed data are collected from BUVAN, ISRO's Geoportal. Various thematic maps are based on IRS P6, LISS-III of 23.5 m resolution at scale of 1:50 000. DEM is obtained from CARTOSAT 1 of 2.5 m resolution. The various steps are clearly depicted in Fig. 6.

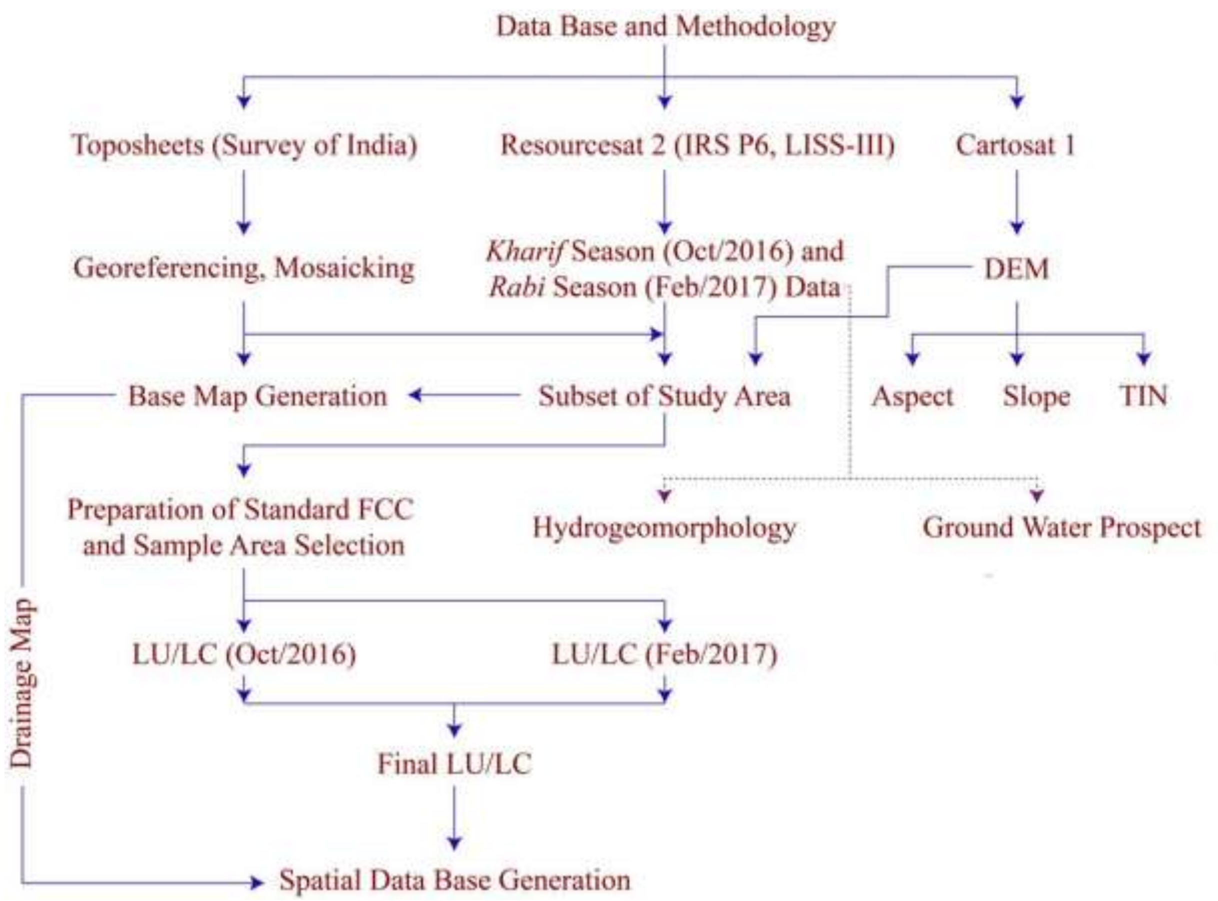

Figure 6: Database and methodology

Methodology

ArcGIS 10.1 is used to georeference all the toposheets. Mosaicking is completed in ERDAS Imagine software and then a subset of the study area is extracted. This georeferenced subset of the study area is taken further to georeference the satellite imageries and DEM data. DEM data has been used to extract slope, aspect, and TIN to understand the terrain conditions.

The downloaded images of the study area are projected to WGS-84 datum and mosaicked. The subset from the satellite images is extracted with the help of the subset image generated from toposheets. A false-color composite (FCC) is generated from the study area (Fig. 7).

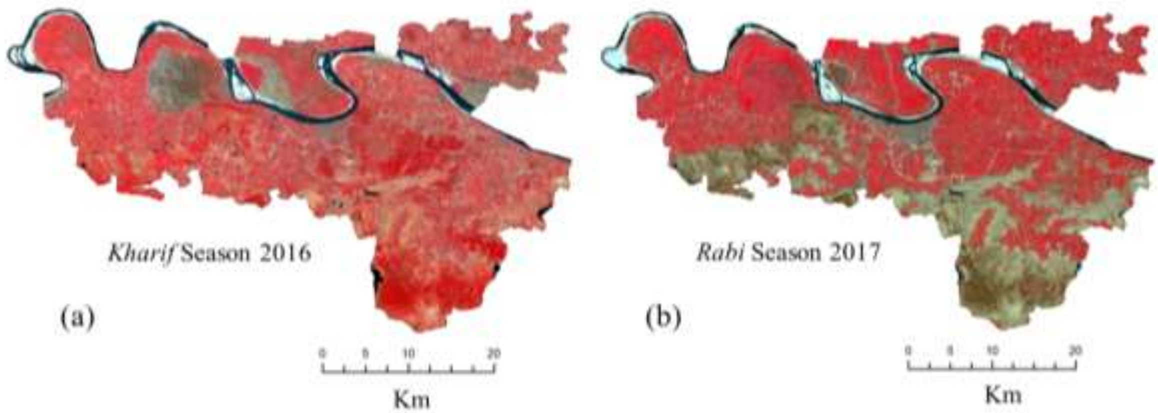

Figure 7: Standard FCC: Mirzapur tahsil. (a) *Kharif* season, October 2016, (b) *Rabi* season, February 2017)

The FCC images are quite helpful in improving the visual interpretability of the imagery and in the demarcation of feature classes. Visual image interpretation technique is applied in the identification and delineation of training samples. Based on prior information and selected field check, training samples for each class in each season's images are carefully marked. Supervised classification and maximum likelihood classifier is used in the LU/LC classification of October, 2016 and February, 2017 data.

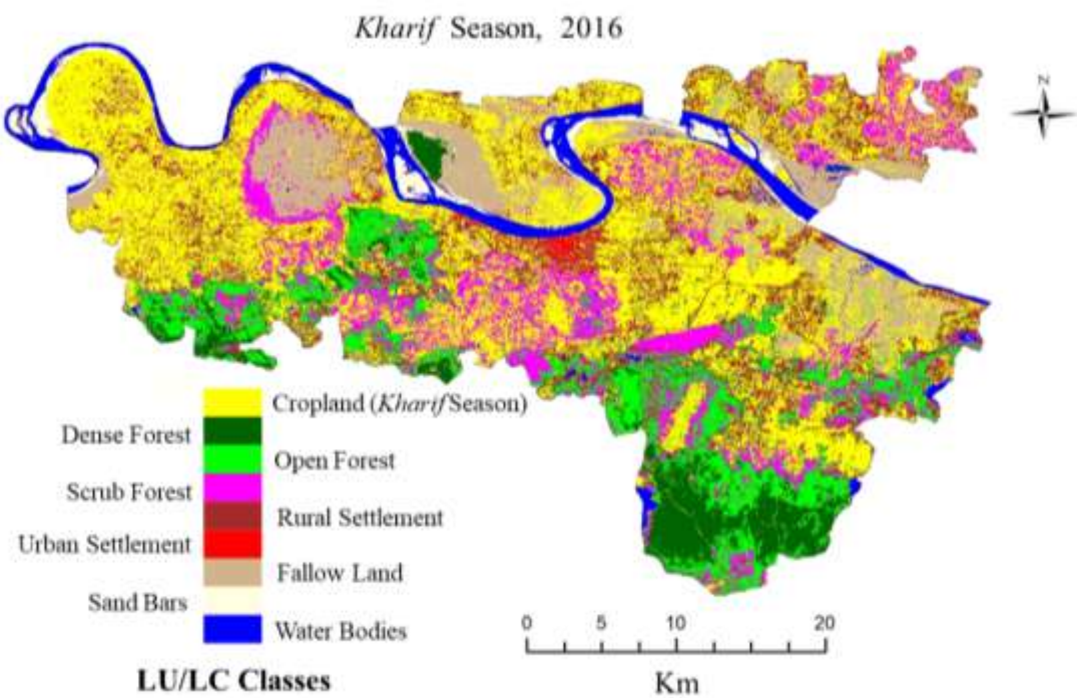

Figure 8: LU/LC of Mirzapur tahsil: *kharif* season, 2016

Cropland, dense forest, open forest, scrub forest, fallow land, rural settlement, urban settlement, water bodies, and sand bars are classified in the images which are shown in Fig. 8 and Fig. 9 (Lillesand, *et al.*, 2004). The resultant statistics and obtained thematic maps are analyzed separately. *Kharif* and *rabi* season outputs were again summed up using ERDAS imagine to generate the final composite LU/LC map of the area (Fig. 10). The resultant map and statistics of the final map is again used in the analysis of resources utilization pattern. Hydrogeomorphic features are categorized by taking February, 2017 image. The purpose of the study of hydrogeomorphology is to understand the relation and spatial distribution patterns of resources and their utilization. The features are categorized into alluvial plain (type1), alluvial plain (type 2), buried pediment (type 1), buried pediment (type 2), pediment, valley fill, sand bars, escarpment, lineaments, residual hills, and dissected plateau.

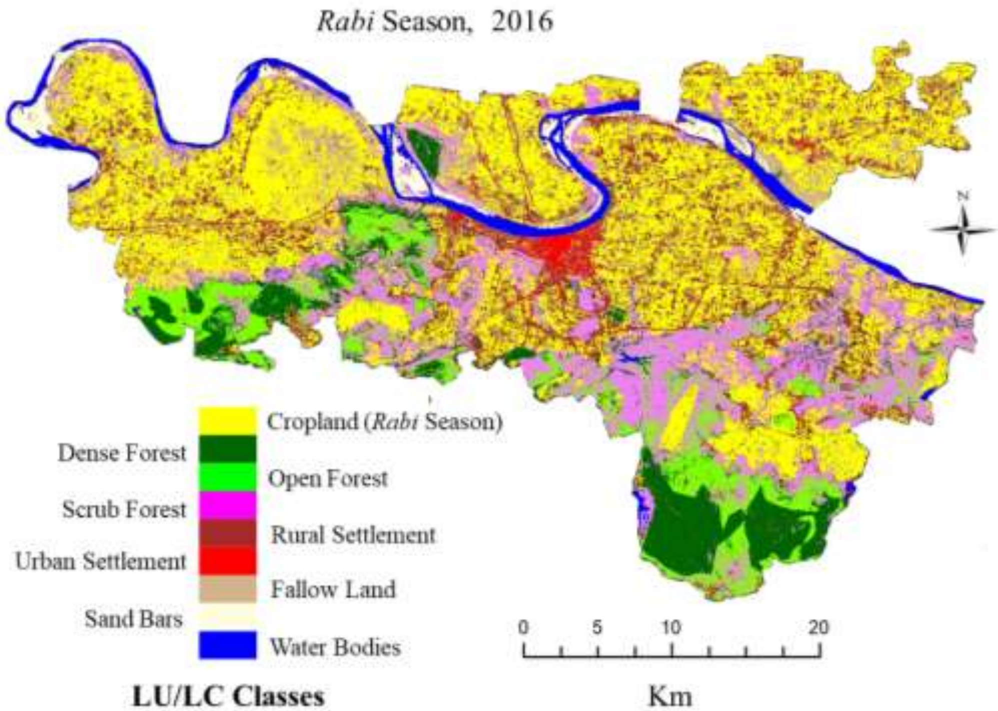

Figure 9: LU/LC of Mirzapur tahsil: *rabi* season, 2017

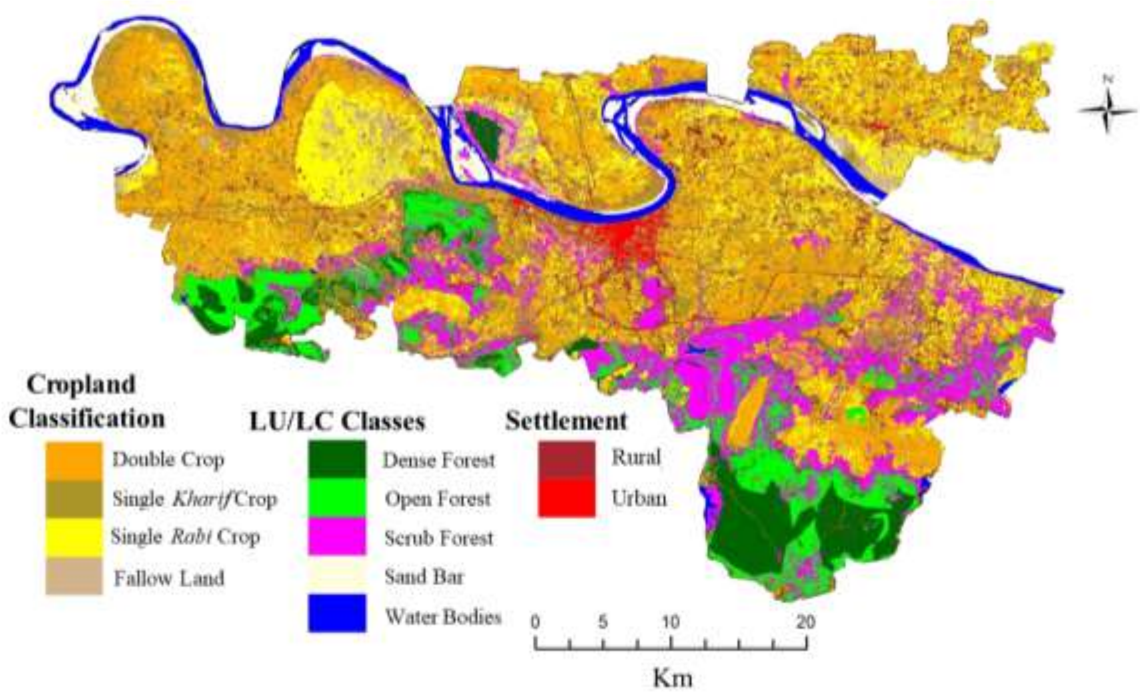

Figure 10: LU/LC of Mirzapur tahsil: Composite map

RESULTS AND DISCUSSION

This section analyses LU/LC patterns, utilization, problems, and possible prospects to the development and use of natural resources. Hydrogeomorphological aspects of the region are also dealt within this section. Based on information generated from LU/LC and hydrogeomorhological characteristics, groundwater prospect zones are also delineated.

LU/LC

The existing pattern of LU/LC in the Mirzapur tahsil is shown in Table 1. During the *kharif* season, nearly 42.5% area of land is under cultivation and 15.4% of the total land is left as fallow land. Nearly 30.0% of the area during this season is under forest cover. Rural and urban settlements constitute nearly 7.6% area of the total land. Most of the fellow land exists near the river channel in the north and north-eastern region. Dense, open, and scrub forest covers lie in the southern plateau region and constitutes only 26.6% of the total area. Water bodies in monsoon season nearly account for 4.5% in the region (Fig. 8).

During the *rabi* season, most of the fellow land during *kharif* season near the river channel is utilized. Cropland area nearly constitutes 48.5% of the total area. Nearly 9.5% of the land is left uncultivated. Forest cover nearly constitutes 31.4% of the land. Water bodies make nearly 3.0 % of the total region (Fig. 9).

The resultant composite map for the region (Fig. 10) reveals that nearly 56.0% of the total region is exposed to cropland cultivation including northern alluvial plain and southern buried pediment zones of the hilly tract. Out of 56.0%, only 30.8% of the land is exposed to double cropping. 14.4% of such land is there which are used only for single *kharif* cropping and left as a fallow land in another season. Similarly, nearly there are 10.8% of total land which is exposed to single-use during *rabi* season. Overall forest cover constitutes nearly 26.6% of the area almost occupying the southern plateau region.

In spite of being rich in agricultural land resources, the land is not properly utilized in all the seasons. In the north, most of the land near the river and an appreciable portion of the *Chhanwe* block is utilized only in the *rabi* season. During another season, it remains as fallow land. Low drainage density, waterlogging in some areas, and inundation in the northern part during monsoon season create obstacles in the cultivation. Whereas rugged topography in the southern plateau region is the major resistance in land utilization. The major possible prospects of the study are briefly discussed as follows.

Table 1: LU/LC: Mirzapur tahsil

LU/LC category	**Area (%)**			
	***Kharif* season**	***Rabi* season**	***Kharif* + *Rabi***	**Total**
Cropland				56.0
Kharif cropland	42.5		14.4	
Rabi cropland		48.5	10.8	
Double cropping			30.8	
Fallow land	15.4	9.5	6.0	6.0
Forest				26.6
Dense forest	7.3	5.9	6.8	
Open forest	14.0	12.0	7.7	
Scrub forest	8.7	13.5	12.1	
Built-up				7.6
Urban	1.3	1.3	1.3	
Rural	6.3	6.3	6.3	
Water Bodies	4.5	3.0	3.8	3.8
Total	100.0	100.0	100	100

Source: Based on IRS P 6, LISS-III, Image Interpretation and GIS based computation.

Since the areas which lie near the Ganga flood plain experience waterlogging problems. Dead level terrain and inundation lead to some parcels of land utilization only for single cropping. The development of a good drainage system and canal extension into the northern region can convert these land from moderate to well-cultivated zones. Depending on the moisture content, sandy waste near the river can be utilized for *rabi* pulses (gram, pea, etc.). Permanent fallow land and rocky wasteland which constitute nearly 6.0% of the total area can be utilized for fodder and fuel plantation. Southern upland, on the other hand, should be encouraged for rainfed cultivation like *jwar, bajra*, etc. Agroforestry is suggested into buried pediment zones of the southern plateau region.

Hydrogeomorphology

The alluvial plain is categorized in two broad divisions, namely Type 1 and Type 2 (Table 2 and Fig. 11). Alluvial plain Type1 is categorized on the basis that they exhibit good to excellent cultivated zones. On the imageries, they appear in dark red tones with medium to smooth textures. Groundwater conditions are also excellent in these regions. Light to medium-dark red tone with medium to coarse texture is categorized under alluvial plain Type 2. Groundwater prospect ranges from good to moderate.

Table 2: Hydrogeomorphic features.

Hydrogeomorphic features		**Area (%)**
Alluvial plain	Alluvial plain (Type 1)	37.4
	Alluvial plain (Type 2)	29.1
	Sand bar	3.0
Vindhyan upland	Buried pediment (Type 1)	1.3
	Buried pediment (Type 2)	1.0
	Pediment	1.7
	Valley fill	0.1
	Residual hills	2.0
	Dissected plateau	24.4
Total		**100**

Source: Based on IRS P 6, LISS-III , Image Interpretation and GIS based computation.

Alluvial plain Type1 and Type 2 collectively cover nearly 69.5% of the total area respectively including flood plain features like sand bars, meander, and young terraces. Buried pediments are flat and smooth surfaces covered with weathered material offers a good prospect for cultivated zones in the hilly uplands. The groundwater potential range is moderate. It covers nearly 2.3% of the total region. Buried pediment Type 1 has medium to smooth texture with medium to dark red tone with well-cultivated zones. Buried Pediment Type 2 provides moderate cultivation prospects. Buried pediments are marked in villages *Maholiya, Gaura Bisen, Bandhwa, Danti*, and *Dadri Khurd* in the southernmost region and *Dadar, Hatihar*, etc. in the southwestern region.

Pediments are appearing greenish-blue in the imagery identified in the southern part of the *tahsil* and share nearly 1.7% of the total area. These are marked near villages of *Ram badh, Sadlupura, Chatura, Shantikuti*, etc. Valley fills are the linear depression in between the hills filled with unconsolidated sediments. This is located near *Gajiyan* village in the northern part of the tahsil and constitutes nearly 0.03% of the total area. Residual hills as the end product resulting from the process of pediplanation (Oh, *et al.*, 2020) located in the southern part of the tahsil covering 2.0% of the total area. Dissected plateau shares nearly 24.4% of the total area and from the groundwater potential perspective, residual hills and the dissected plateau are very poor.

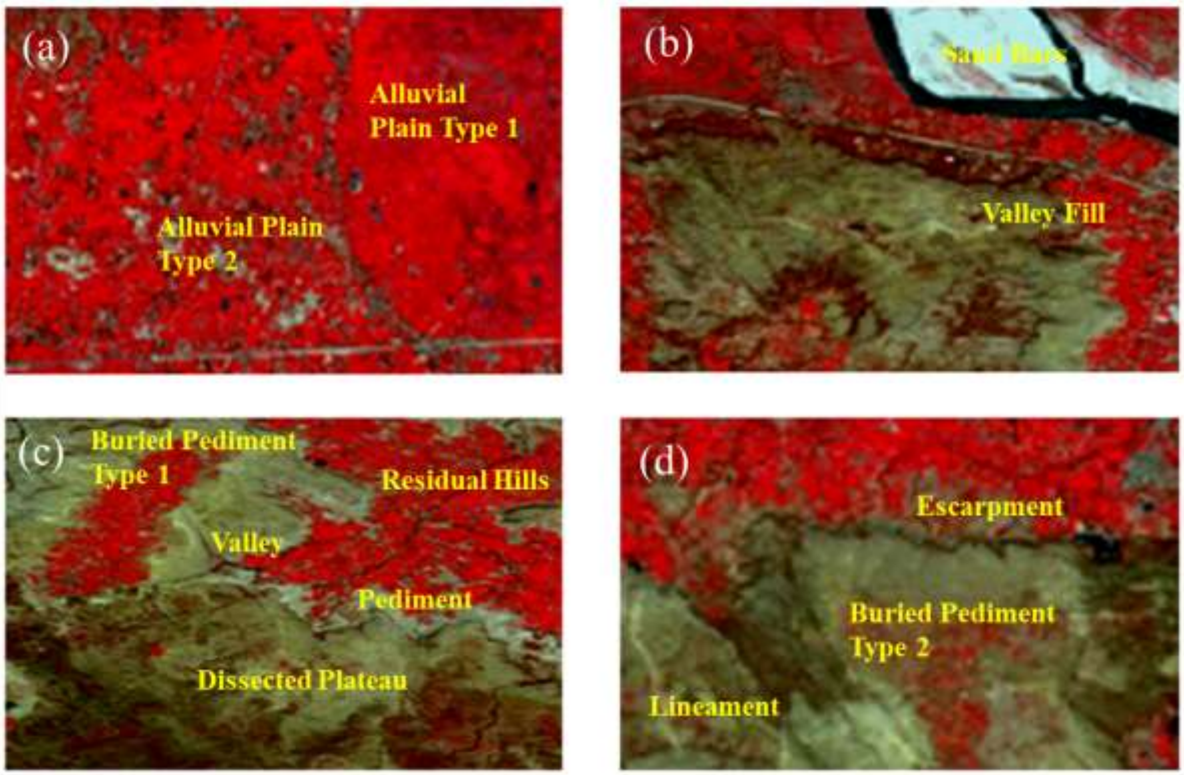

Figure 11: Hydrogeomorphic features demarcation through satellite image IRS P6, LISS-III, February, 2017. (a) Alluvial plain Type 1 and Type 2, (b) Sand bars and valley fills, (c) Buried pediment Type 1, valleys, residual hills, pediment, and dissected plateau, (d) Escarpment, lineaments, and buried pediment Type 2

Conclusion

In conclusion, the aim of the present work is to explore the spatial distribution of natural resources with the region's hydrogeomorphic characteristics and pattern of land utilization. It is oriented towards the uses of seasonal remote sensing data of *kharif* (October, 2016) and *rabi* (February, 2017) seasons acquired from the IRS P6, LISS-III in Mirzapur tahsil of Mirzapur district, Uttar Pradesh, India. The physical division consists of Gangetic alluvial plain (nearly 71.9% of the total area) in the north and Vindhyan upland (nearly 28.9% of the total area) in the south. The composite mapping through *kharif* and *rabi* season data facilitates to identify the land parcels under double cropping, single cropping, and permanently fallow land existing in the region. Northern plain offers excellent prospects for cultivation practices whereas buried pediment is the only prospects in the upland region. Season wise the results state that nearly 42.5% of the land is exposed in *kharif* season for cropland and 15.4% of the land is left as fallow land. These percentages share changes to 48.5% and 9.5% of the land for cropland and fallow land respectively during the *rabi* season.

However, it is concluded from the composite map that nearly 14.4% and 10.8% of the total area is used only for single *kharif* and single *rabi* crops, respectively throughout the year. Only 30.8% of the total exposed 56.0% for the cropland is available to all the seasons. At present, there is a challenge to convert the gap of nearly 25.2% of land to multiple cropping. Furthermore, a proper drainage system along with groundwater resources development is needed in the northern part to enhance the percentage share of land resources utilization. The southern region, which experiences high runoff and low infiltration due to the hilly rocky tract, lineaments can be a good prospect for the exploration of potential sites for groundwater storage. Agroforestry is suggested in the southern upland region. There is a strong need to understand the hydrogeomorphic aspects to develop the land, water, and forest resources of the region to achieve sustainable growth of the region.

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