Application of Remote Sensing and GIS in Land Use/Land Covers Mapping in Allahabad District

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Abstract-*The paper attempts to assess various categories of Land use/land covers in Allahabad district using remote sensing and GIS techniques. The result of the study shows that a wide range of spatial variations in geomorphic features has been caused by differential erosion and sedimentation works of various geomorphic processes, which were operating in the past. For example, flood plain features are dominated in the major northern portion of the district that is formed during the Quaternary period whereas the southern portion is governed by features of Vindhyan plateau that are supposed to be developed from Pre–Cambrian to Recent period. The spatial variations in geomorphic features have put forward their impact on socio-cultural features and trend of their development. Attempts have also been made in present investigation to analyses and map-out the Land use/ land covers based on the geomorphic analysis and field observations. The cultivated land is largely confined in the flood plain area and rocky wasteland is found in pediment zone. Forest is marked near the denudation hill.*

Key words: Remote sensing, GIS, Ganga flood plain features, Vindhyan upland, Land use/Land cover, geomorphic features.

I. Introduction

The spatial dimension of the land resources in view of its utilization/surface cover pattern and analysis forms the essential components of planning and management for all sorts of human activities. Land use/land cover mapping and analysis using modern techniques of data reception and medicine of explanation are now being well practiced for betterment of land resources management. The term "land use" and land cover (LULC) are often used simultaneously to describe maps that provide information about the types of features found on the earth's surface (land cover) and the human activity that is associated with them (land use) (Shetty et.al. 2005). In other words, Land use refers to man's activities on land, which are directly related to lands utilization, land cover denotes the vegetational and artificial construction covering the land (Joshi and Chouhan, 1996:125). The development of any land area depends on the physiographical factors like drainage, slope, soil condition, land capability, erosion, rainfall condition, and distribution of water bodies besides others. Since both land use/land cover are closely related and are not mutually exclusive, they are interchangeable as the former is inferred based on the later on the contextual evidence. Planners compile, classify, study and analyses land use data for many purposes, including the identification of trends, the forecasting of space and infrastructure requirement, the provision of adequate land area for necessary types of land use, and the development or revision of comprehensive plans and land use regulations (Elangovan, 2006:137). Land use is a dynamic phenomenon and both its value and pattern changes from one particular point of time to another and also from one geographical unit to another. As a matter of facts, reliable and comprehensive information on spatial distribution pattern and temporal changes in land use are perquisite aspect of land resources development and planning.

There are various organizations in India who provide information on land use/land cover

in terms of maps, reports, statistical data which are very important for spatial planning, management and utilization of land resources for various purposes. Mention may be made for some of such organizations as National Atlas and Thematic mapping Organization (NATMO), National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), All India Soil & Land Use Survey (ALS &LUS), National Sample Survey, Survey of India, Town and Country Planning Organization. Land use/land cover mapping using remote sensing data are largely being done by different scholars. Mention of a few works may be made as presented by Srivastva and Narayan (1974), Nageswara Rao and Vaidyanathan (1981), Raghavaswamy (1982), Gautam and Narayan (1983), Reddy *et al.* (1990), Krishna Murthy *et al.* (1992), Khan *et al.* (1994), Murthy and Rao (1997), Mishra and Chaubey (1999), Joshi *et al*. (2005), Raju and Kumar (2006), Mishra (2006).

The availability of information on land use/land cover in form of thematic maps, record and statistical figures are inadequate and are not upto date especially at district or micro-level observeties. However the technology of remote sensing by providing a synoptic view of large to small areas at regular intervals, successfully offers good sources of information to inventory, evaluate and monitor them at periodic intervals of time.The Indian experiences on use of satellite data for land use/land cover analysis have mainly been the out come of studies conducted at National Remote Sensing Agency (NRSA) in collaboration with different agencies (Nagaraja, Ravi Shankar and Saxena 2004:88). In fact, satellite remote sensing data are currently being used very effectively for mapping and monitoring the land use/land covers that have assumed a great significance by putting imprints not only on detection, recognition and identification of these features but also favoring spatial analysis at different scales. The type and level of information to be extracted from these data largely depends on the expertise of the analyst and what he is 'looking for' in the data (Joseph, 2005:349). In present investigation, the mapping of land use/ land cover of Allahabad district has been attempted by using IRS P6 LISS III imagery and selective field visits.

II. Study Area

Allahabad District ($24^0$45'N to $25^0$45'N) and ($81^0$30'E to $82^0$30'E) with an area of 5246.0 km^2 with a population of 59, 54,391 persons (2011), lies in the south east part of Uttar Pradesh (U.P.). The district is famous for its rich religio-cultural heritage and historically glorious past and present. It is a bounded by the 6 districts of Pratapgarh and Jaunpur (north), Sant Ravidas Nagar (east), Mirzapur (south-east), Rewa (south), Banda (south-west) and Kaushambi (west). Geologically it exhibits more complex nature and broadly be categorized in two (i) Recent alluviums in the north and (ii) Vindhyan system in the south. The district is drained by rivers Ganga, Yamuna, Tons and their tributaries. Soils of the district are largely composed of the eroded materials brought by the rivers from Himalayas and the Vindhyan upland. Most fertile alluvial soil is stretches both side of river Ganga and Yamuna. In Vindhyan upland, black soil and red gravelly soil are found (Fig.1).

Soil resources information plays a critical role in the management of natural resources and more specifically in the field of agriculture (Venkataratnam and Ravisankar, 2004:158). Soils of the district are largely composed of the eroded materials brought by the rivers (Ganga and Yamuna) from Himalayas and the Vindhyan upland. It is dynamic non-renewable natural resources whose proper husbandry is essential for both continued agriculture productivity and to prevent of its degradation. In area under study, recent alluvium (*Khadar*) soils are found in the low areas of valley bottom, which are flooded almost every year. These soils are easily replenished by the yearly river floods and

support uninterrupted crop growth. The northern portion of the district is very rich for fertile soil

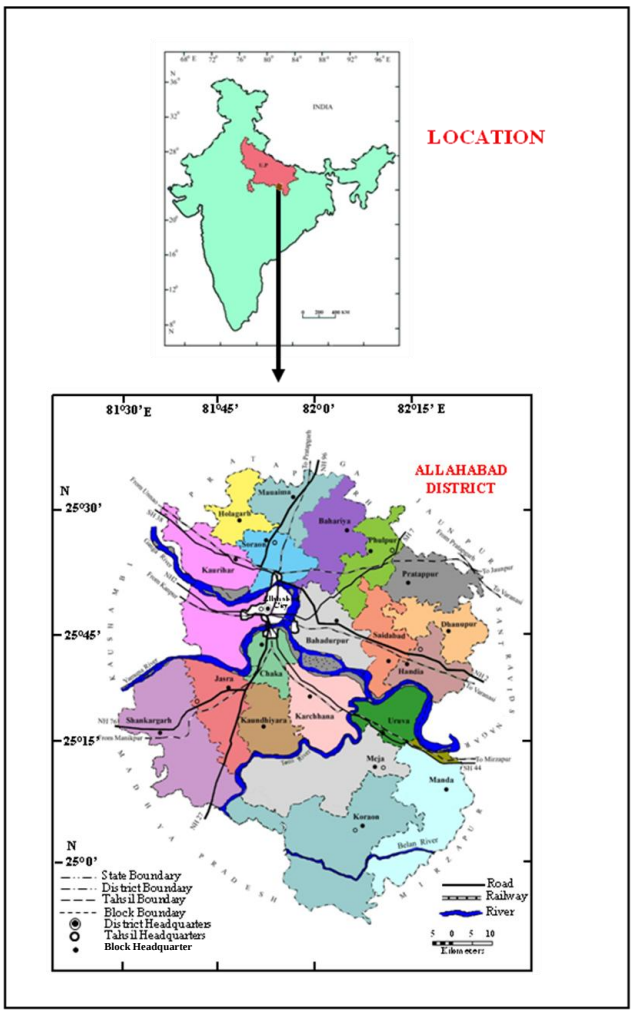

Fig.1

but some patches of the northern portion (Holagarh, Mauaima Phulpur, Bahariya and Saidabad blocks) soil is saline because the salt (mainly sodium chloride and sulphate) is derived from the evaporation of ground water lying just beneath the soil surface, it is pure white in colour and imperfectly drained. Southern portion of the district have found black soil, red gravelly and khaddar from other rivers (Belan and Tons). Red gravelly soil has marked in the foot of the plateau scarpment zone mainly Shankargarh, Koraon, Meja and Manda blocks. Black soils are also found in southern part of the district it is very retentive of moisture and it swells greatly then becomes sticky when wet in rainy season. These soils are generally dark grey to black in colour and rough in texture. They are well suited to the crops like *jower*, *bajara*, *gram*, *maize* etc. but where canal irrigation is available *paddy* is the prominent crop.

III. Methodology and Data Base

Remotely sensed data and GIS techniques have largely been used in the identification, demarcation and mapping of land use/land covers of Allahabad district. Homogeneity of tone, texture and pattern etc.and identification keys were taken into consideration to prepare the land use/land covers was delineated. The primary and secondary data used in the present investigation can be listed as: (i) Survey of India (SOI) Sheet No.63 G, 63 H, 63 K and 63 L (1:250,000). (ii) IRS P6, LISS-III with spatial resolution of 23.5 m. The study area is covered in path 101 and row 54 of IRS P6. Attempts made first to prepare the base map of area under study using Survey of India (SOI) toposheet, various process such as, import, georeferencing, mosaicing and subset creation etc. were applied. At the second step, the identification, demarcation and mapping of land use/land covers were attempted through pre-field visual image processing of satellite imagery using photo elements (tone, texture, shape, size, association, and pattern) and geotechnical elements. After completing the pre-field interpretation, the detailed information was transferred on base map by selecting numerous control points and using ERDAS software. Selective field checks were done to assess the validity of the pre-field image interpretation. In the last, incorporating the ground truth information using Arc View GIS software did finalization of image-based maps (PLATE I).

IV. Result and Discussion

The land use and land cover classification system adopted in this study is

oriented towards the traditional system of classification (revenue record based) but in new frame and style to accommodate the information received from satellite imagery. This may be facilitate for easy and logical comparison of facts from both type of data, i.e., data received from traditional secondary sources such as revenue records or District Statistical Magzine (Patrika) and remote sensing satellite can be related to system for classifying land capability, vulnerability to certain management practices, and potential for any particular activity or land value, either intrinsic or speculative. On the basis of remotely sensed data, Allahabad district divided into four major land use categories: (i) Land under forest (ii) Cultivable land (iii) Cultivated land (iv) Uncultivable land (Fig.2). Land use/land cover statistics generated using remote sensing techniques for the Allahabad district is shown in Table 1.

Land use/land cover is largely regulated by the geomorphic features and soil of the study area. Geomorphic features, the most fundamental of terrain attributes and diagnostic of geomorphic environment, provide basic sources of information for terrain analysis (Sharma 1991:21). The area under study is characterized with a complex nature of terrain having the recent alluvial deposits in the north (Ganga valley) and old Vindhyan plateau in the south. In the northern alluvial plain of the study area, river Ganga with its tributary, Yamuna, have been playing a dominant role in shaping the landforms with their frequent changes in courses. Rivers Tons and Belan are the major rivers flowing through Vindhyan plateau in the south, are the non-perennial ones. The Ganga flood plain includes new flood plain, old flood plain, paleo channels, channel bar, point bar and ox-bow lakes etc. while Vindhyan upland includes the features like buried pediment, pediment with vegetation, pediment with stony surface and denudational hill etc.

Table 1: Block wise Land Use/Land Cover Classification in Percent (2004)
GIS Analysis Based on IRS P-6 LISS III Satellite Imagery

Block	Forest	Cultivable Land	Uncultivated land	Cultivated Land
Kaurihar	-	15.23	15.21	68.40
Holagarh	-	13.00	10.65	77.34
Mauaima	-	12.89	12.03	75.23
Soraon	-	7.23	15.23	80.12
Bahariya	-	14.34	6.54	79.23
Phulpur	-	14.01	12.53	74.43
Bahadurpur	-	15.34	12.90	70.00
Pratappur	-	6.84	9.78	80.23
Saidabad	-	9.34	11.03	76.34
Dhanupur	-	9.46	11.21	80.12
Handia	-	12.14	16.05	76.45
Jasra	-	9.67	10.12	76.56
Shankargarh	9.23	22.34	6.89	54.78
Chaka	-	17.56	23.06	54.34
Karchhana	-	10.12	13.67	77.60
Kaundhiyara	-	6.56	9.34	80.23
Uruva	-	11.12	12.09	69.67
Meja	8.13	16.34	23.67	65.12
Koraon	8.01	6.05	3.23	80.67

Manda	11.22	15.76	8.67	61.56
Rural	2.39	14.74	11.15	71.72

Source: Computed by researcher from Satellite imagery

IV:a. Cultivated land

The land under cultivation constituted 71.72 per cent of total geographical area. Its further sub-categories are identified as very good (15.20 percent), good (28.15 percent), moderate (20.25 percent) and poor (8.12 percent). Agriculture in this region is mainly of intensive subsistence type wherein *paddy* in *Kharif* and *wheat* in *Rabi* are the prominent crops. Allahabad district as whole, except some southern Vindhyan upland blocks (Shankargarh, Koraon and Meja) is the prominent district for the cultivation. Some patches on the Vindhyan Upland are also marked cultivation but that are mostly dependent on the nature of terrain and availability of water for agriculture. Sub categories of land under cultivation like very good, good, moderate and poor at level II, are largely effected by geomorphic features and the other terrain characteristics. Very good cultivation can be marked in the new flood plain areas of the river Ganga, Yamuna and paleochannels. That is generally receive sediment deposition during each flood because of this fact the soils of this zone are extremely fertile. On the imagery, such land use is characterized by dark red tone, smooth texture, and irregular shape. During field investigation, it was noted that the major portion of Soraon, Bahadurpur, Kaurihar blocks and some parts of the Saidabad, Handia, Phulpur, Karachhana and Chaka blocks are reported to be very good in paddy and wheat cultivation. From Shankargarh to Nari Bari the roadside fields especially Kalyanpur and Shivrajpur villages were marked with very good cultivation of *paddy* crop. Near Bashera village, *potao*, *sarson*, *masoor*, *wheat* crops are found but cultivation is purely localized. Good agricultural lands are confined along the both side of very good agricultural lands. Soraon and Allahabad distributary of Sharda canal facilitate irrigation water in major areas of north and north-west district, which has resulted for good production of *paddy* and *wheat* crops. Here, well drained, fine loamy soils on nearly level to level plain with loamy surface are although deficient in calcium, organic matter and nitrogen but they favour to grow good *Rabi* crops when supplemented by fertilizers. While traveling from Koraon to Meja road it was reported that good to moderate cultivation of *rabi* crops is practiced depending on availability of canal water.

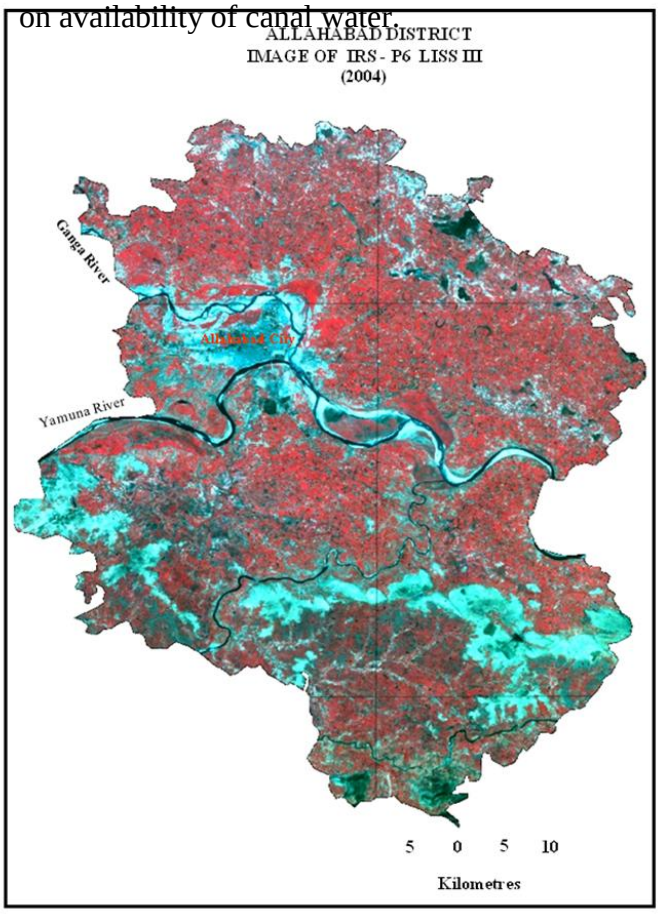

PLATE I

The spatial extent of moderate cultivation may be observed in northern old flood plain consisting of Holagarh, Mauaima, Bahariya and Saidabad blocks as well as in

major portion of Pratappur and Dhanupur blocks. It has been observed on satellite imagery by light red mixed with gray tones. The moderate cultivation on Vindhyan upland has been noted on shallow and deeply buried pediment zones, which also depends on availability of water for irrigation through canal. As regards the land under poor cultivation it may be observed in northern parts of the district especially in Holagarh and Mauaima blocks where soil is largely affected by water logging and salinity. In southern portion of the district, while traveling from Shankargarh to Nari Bari by road, one can see the vast pediment with stony surface showing extensive bare rocks and dissection in the upper parts causing poor cultivation in Shankargarh block. Rocky structure and soil mixed with stone bolder are found upto 10 feet depth, so such areas are not suitable for cultivation. The soils are generally dark grey to black in colour and rough in texture which are well suited for the crops like *jower, bajara, gram, maize* etc. Garden and groves are also found in the area under study although their spatial delineation and location are restricted by the scale and spatial resolution of satellite data. However attempt has been made to mark then through selective field observations. It was found that mango and guava gardens are more prominent in the district.

IV:b. Uncultivable land

This category of land use include land not available for cultivation or the area under non-agricultural uses, i.e., settlement, roads, railway, canals, ponds, etc. In other words, it includes land which cannot be brought under cultivation unless at a very heavy cost. The total uncultivable land accounted for 11.15 percent of total geographical area of the district. The identification and mapping of settlement from small-scale imagery is very tedious work. The small size villages cannot be easily marked on satellite imagery because their reflectance is mixed with the reflectance of surrounding features. The big urban settlement such as Allahabad city is self-identical and their built up area have been clearly marked on satellite imagery. The larger rural/urban settlement in Allahabad district such as Jhusi, Naini, Sirsa, Lalgopalganj, Phulpur, Handia, Meja, Koraon,

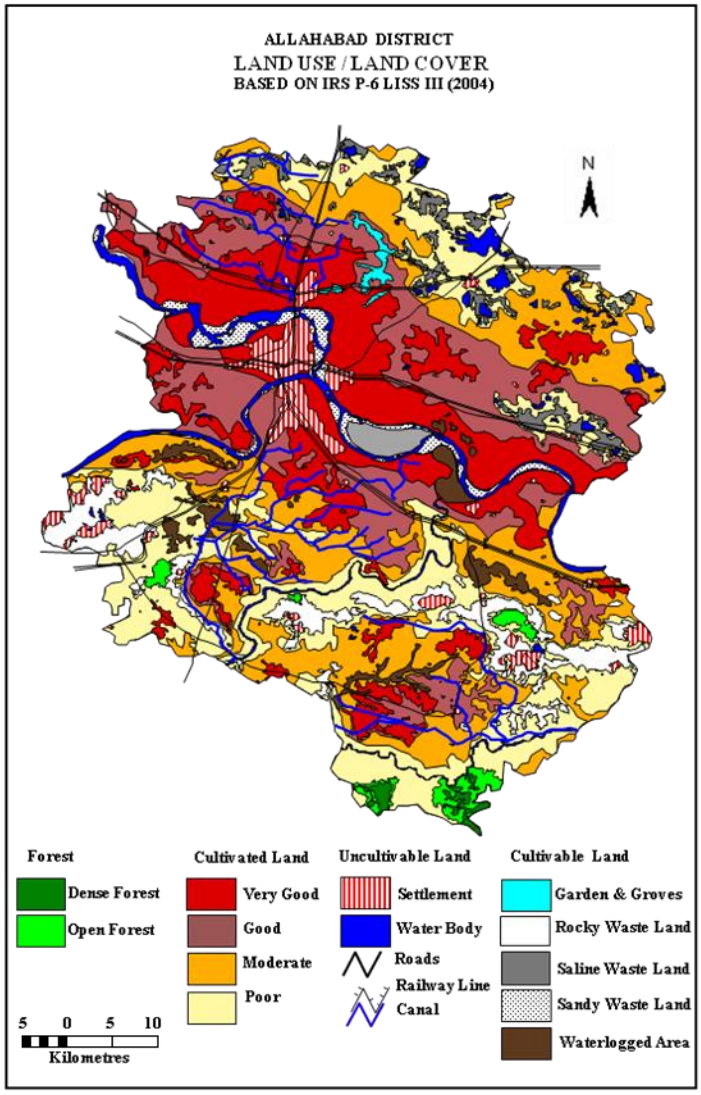

Fig. 5. 2

Soraon, Mauaima etc are also marked on satellite imagery.

These linear features can be marked on satellite imagery due to their shape and dark black tone. The identification of these two aspects on satellite imagery could not be easy where road and railway are overlapped. For example, the road–railways from Kanpur to Varanasi and from Kanpur to Mirzapur could not be mapped easily.

The lands under canal, reservoir/bandhis, tals river have been considered under this category. Allahabad city at the confluence of holy rivers Ganga, Yamuna and invisible Sarswati, popularly known as *Triveni Sangam*. Ganga, Yamuna, Tons and Belan river easily marked in satellite imagery. Depth of river Yamuna is high comparison to river Ganga, so the reflectance of Yamuna water in satellite imagery is dark black tone and light black tone in Ganga river. The distinguished bandhis Golahia and Baghala are easily detected on satellite imagery by their dark black. Bandhis are mainly found in southern part (Vindhyan Upland) of the district. Some important Tals such as, Mailhan, Kharon, Rarwal and Sahnua in northern portion of the district, which could be mapped through image interpretation at scale 1:250,000. Very few linear features canal could be mapped on satellite imagery by dark tone. The important canal observed on Ganga flood plain is the Soraon, Raipur disty and Mariahu branch of Sharda canal and Meja branch of Belan canal and Belan canal on Vindhyan Upland.

IV:c. Cultivable Land

About 14.74 percent of total geographical areas have been estimated as cultivable land in this study, in which land consists rocky waste 5.35 percent, saline 4.87 percent, sandy 2.73, waterlogged 0.38 and garden & groves 1.61 percent of total geographical area. Improper land management, excessive irrigation without proper drainage, uncontrolled use of chemicals etc. has resulted in vast stretches of wasteland that are salt affected, waterlogged, and gullied (Joseph, 2005:359). Rocky waste lands located in the form of patches on Vindhyan Upland, where no vegetation cover on it. Geomorphologically this area is confined in pediment type I observed especially in Shankargarh, Koraon, Meja and Manda blocks of the district. Such type of land cover visualized by light to very light tone (whitish) because of their higher reflectance as there is no vegetation cover on it. In open rock cut surfaces, without any deposited materials cultivation is not possible. Surfaces irrigation system is very difficult to develop here, hence this area is not suitable for cultivation. Many patches of saline waste lands can be observed in north and north-east part of alluvial plain. This patch is mainly found in Holagarh, Mauaima, Bahariya, Saidabad, Pratappur and Handia blocks of the district. It has been generally observed on satellite imagery characterized by red mixed with white tones (OFP type-III). Here soil is a highly salt content. The salt (mainly sodium chloride and sulphate) is derived from the evaporation of ground water lying just beneath the soil surface. In this area, imperfectly drained and calcareous soil on nearly level to level plain with loamy surface and highly saline with strongly sodic. Due to canal seepage, the land becomes a Usar, so cultivation of these lands is negligible. Numerous sand bars like point bars and channel bars can be marked in a narrow belt along the river Ganga and Yamuna. The soil of this land is purely sandy. The zaid crops like muskmelon, cucumber and watermelon are cultivated in sandy soils. Allahabad district is very rich for this type of crop production.

IV:d. Forest

In area under study, forested areas are marked 2.39 percent of total geographical area, on Vindhyan Upland being prominent on denudational hill. Open forest (1.94) and Dense forest (0.45 percent) can be marked on satellite imagery with dark tone. Land under forest can be observed in patches, mainly Shankargarh, Koraon, Meja and Manda block. In Koraon block, forest divided into two categories dense and open forest and dense forest surrounded by open forest.

V. Conclusion

The present study show remote sensing provides a very powerful database for identifies and delineating the geomorphic feature and land

use/ land cover while GIS provide a convenient tool for making a computerized mapping. The extraction of information from satellite imagery is largely based on the interpreter knowledge about image analysis and area under study. The remotely sensed data of IRS-P6-LISS III with 23 m resolution is proved to be very suitable for delineation of geomorphic features in the Allahabad district. As much as there are eleven major geomorphic features that have been delineated viz., new flood plain, old flood plain, oxbow lake, natural levee, channel bar, point bar, island, paleochannel, pediment, denudational hill, and lineament. As regards the areal extent, the old flood plain and buried pediment units have shown maximum coverage in the district. The above analysis also shows that a very close relationship exists between geomorphic features and land use/land cover. The geomorphic features of Ganga flood plain like new flood plain, paleochannels, etc. constitute the very good cultivation.

The scope of the present study is quite significant as geomorphic features present a platform for all shorts of human activities and socio-economic development in the area under study. During the field visits, it was noticed that the very good to good cultivation were being practiced on the dark grey-to-grey soils of the deeply buried pediment zones in Shankargarh, south Meja and Koraon blocks depending on the availability of water for irrigation by canals whereas poor cultivation was marked on shallow buried pediment. The pediment and dendunational hill zones on the other hand, are rocky waste lands where open forest and bushes are visualized in patches.

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