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Land use and land cover classification and geomorphological characterization of Achanakmar region using geospatial technology

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Abstract

The rapidly developing geospatial technology not only offers an efficient and timely approach for mapping the land use/land cover classification but also provides the information regarding different parameters of soil characterization. The land use/land cover map, soil type map, geomorphology map and geomorphology map of Achanakmar region has been characterized and evaluated using geospatial technology. The different land use/land cover classes identified are: forest land, agricultural land, grassland, wasteland, settlements, water reservoirs/ponds and rivers. The different soil types identified are: red gravelly soil, red sandy soil, medium black soil, shallow black soil and laterite soil. The identified geomorphologic units include denudation hills on Deccan traps, region of high level plateau, pediment/pediplain, structural plain on Gondwana rocks, flood plain and water body. The identified units of geology in the study area include laterite/bauxitic laterite, unclassified metamorphics, unclassified shale and limestone, unclassified granites and gneiss, limestone/arkosic sand stone and clay, sand stone and conglomerate, basalt flow, boulder/sandstone, shale and water body. The land use/land cover classification map, soil map, geomorphology and geology map are an important aspect to know the soil characterization and hence helps in the management of soils with regard to different land use land cover classes.

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Introduction

Information on Land use/land cover in the form of maps and statistical data is very vital for spatial planning, management and utilization of land for forestry, agriculture, pasture, wasteland development, urban-industrial, environmental studies, economic production. Today with the growing population pressure, low man land ratio and increasing land degradation and conversion, the need for optimum utilization of land assumes greater relevance. Understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for proper land management and decision improvement (Prakasam *et al.,* 2010). Land use means those areas which are used by humans for their need. Land cover is nothing but the physical material on the earth surface which is covered by different parts of the nature or also the man made parts on the earth surface i.e. soil, rocks, water bodies, vegetation, built-up areas, trees, etc.

The use of geospatial technology to support decision making in detecting land use and cover is essential and recent. For local, regional and macro level planning and management land use/land cover plays an important role by using RS and GIS (Meliadis *et al*., 2011). It is possible to make planning and decision process more realistic and effective (Tripathi *et al*., 2012). Extracting land use land cover information is crucial exercise for agricultural and forestry lands which is most useful for decision support system, planning and development (Sandeep, 2011). Due to the population and urbanization land use and land cover rapidly change, to acquire the exact land pattern remote sensing and GIS technique is most essential (Ujoh *et al.,* 2011; Lakshumanan *et al.,* 2012). Land use land cover classification is very essential for better understanding of landscape dynamics during a known period of time having sustainable management. Land use and land cover studies has been recognized as an important driver of environmental change on all spatial and temporal scales (Tansey *et al.,* 2006) as well as emerging as a key environmental issue & on a regional scale is one of the major research endeavors in global change studies.

Remote Sensing technology for capturing the spatial data, Geographic Information System for undertaking integrated analysis, presentation of spatial and associated attribute data are found to be much more effective to known the change detection of land use land cover (Lillesand *et al.,* 2001). Remote sensing via satellite imagery is an excellent tool to study LULC mapping and classification because images can cover large geographic extents and have a high temporal coverage.

In India, a number of research papers have been published relating to land use and land cover analysis. Alaguraja and Durairaju (2010) have analyzed land use/ land cover categories i.e. crop land, dense forest, fallow land, barren rocky land, and land with or without scrub, plantations and water bodies of Madurai district in Tamil Nadu using satellite data. Chaurasia *et al.,* (1995) studied the agricultural land use change in Bathinda, Punjab through Remote Sensing Techniques. Minakshi and Sharma (2004) have studied systematically Land use/Land cover categories i.e. built up land, agricultural land, forest, waste land, water bodies and mining and brick kilns of Fatehgarh Sahib District Punjab. Ravi Singh (2000) studied land use levels of agricultural development in Arunachal Pradesh. Shah and Roy (2006) have analyzed techniques of supervised classification in land cover/land use mapping in Rishikesh, Uttarakhand. Land use land and cover classes of Pilibhit District in Uttar Pradesh were studied by Nayak and Behera (2008). Veena and Vikas (2010) has systematically analyzed Land use land cover classes in Paravara River Basin. Harikrishna *et al*. (2011) has systematically analyzed Land use land cover classes in Greater Visakha Municipal Corporation. Harikrishna *et al.,* (2013) studied systematically land use land cover categories i.e. built up land, agricultural land, aquaculture, forest, waste land and water bodies around Kolleru Lake. It is evident that a lot of research work has been carried out on lulc mapping and classification based on geospatial technology in India, but little work has been carried out related to the significance of these technologies to the geomorphologic characterization of soils.

In our present study, an attempt has been made to highlight the significance of geospatial technology in the geomorphologic characterization of soils in Achanakmar region. The major objectives of the study are: a) to prepare a land use/land cover map and determine the different land use/land cover classes of Achanakmar region. b) Characterization and preparation of the soil type map, geomorphology, and geology map of Achanakmar region.

Materials and methods

Study Area and climate

Achanakmar lies between 22°15' to 22°58' N and long. 81°25' to 82°5' E on the northwestern part of the Chhattisgarh state falling in the Survey of India topo sheets: 64J01, 64J02, 64J03, 64F06, 64F07, 64F10, 64F11, 64F13, 64F14, and 64F15. The location map of the study area is shown in Fig. 1.

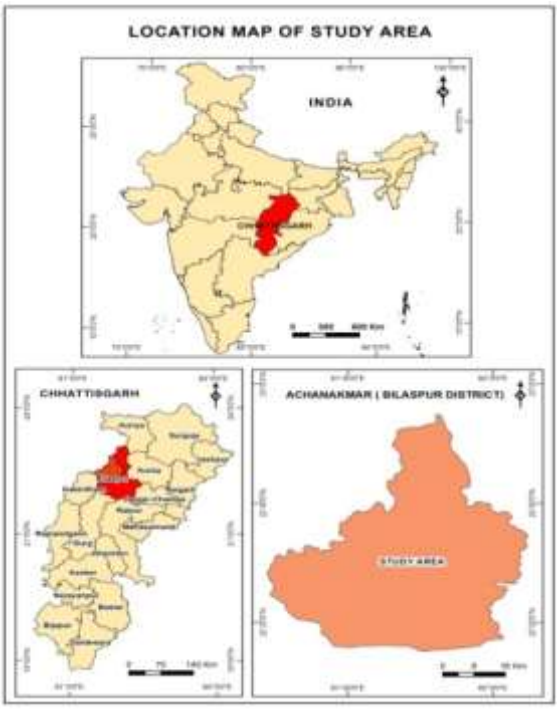

Fig. 1. Location map of study area**.**

The study area covers an area of about 2476.78 sq. km. The Achanakmar receives rainfall mainly from the southwest monsoon. It sets in 3rd/4th week of June and continues till mid August- September with heaviest showers in the months of July and August. The average annual rainfall for the district is around 1100-1700 mm.

The months of July and August are the heaviest rainfall months and nearly 95% of the annual rainfall is received during June to September months. The rainfall is unevenly distributed in different tehsils and also the amount of rainfall varies from year to year and experiences a hot and semi-humid climate.

The annual temperature varies from 9.2°C to 42.1°C. The hottest months are May and June and the minimum temperature is observed in the months of December and January. The maximum temperature in May 46°C and mean minimum temperature is 10° in December.

May is the hottest month and December is the coldest. The average rainfall in the district is 130 cm. In May, the thermometer rises to nearly 116°C but its usual range is in between 82°C to 107° C. The relative humidity is higher during the South West monsoon season, being generally over 75%. After Monsoon Season, humidity decreases and during the winter season, air is fairly dry.

LULC classification and data analysis

Analysis was carried out by image processing of Landsat TM data of year 2013 using Arc-Gis and ERDAS software's. The study has made use of various primary and secondary data sources.

These include Survey of India (SOI) topographic sheets (64J01, 64J02, 64J03, 64F06, 64F07, 64F10, 64F11, 64F13, 64F14, 64F15) of 1:50,000 scale. These (Landsat) data were visually and digitally interpreted by using the ERDAS imagine (for classifying the image) and Arc-GIS software (for processing, analysis and integration of spatial data) to reach the objectives of the study. Adequate field checks were made before finalization of the thematic maps.

The Survey of India topographical map no's were scanned, geo-referenced and all the maps were subset and mosaic using the ERDAS and Arc GIS software's. After applying necessary enhancement techniques, digital data have been converted to vector formats for further GIS analysis.

The Geometric corrections of Land sat TM data 2013 were done using survey of India (SOI) Top sheet of 1:50,000 scales. Based on the information obtained from the satellite imagery and corresponding ground truth verification in the field.

The land use land cover map, soil map, and geomorphology and geology map of Achanakmar have been prepared and their land use land cover statistics were characterized and evaluated using Remote Sensing and Geographic Information System.

The maps are shown in Fig.s: 2, 3, 4 and 5. The following steps were involved in mapping and classification procedure:

i. Data acquisition, loading and merging.
ii. Georeferencing of remote data.
iii. Field survey and ground truthing.
iv. Study area subsetting.
v. Image processing and visual interpretation.
vi. Training area definition, signature generation and classification.
vii. Preparation of land use land cover map.
viii. Generation of lulc statistics.
ix. Final map generation.

The process of georeferencing of remote sensing data has been done using georeferenced Survey of India (SOI) topographical map of 1:50,000 scale by identifying the ground control points (GCP's) from the map and the corresponding points on the satellite images and finally applying the map-image transformation model.

On screen digitization of different land use features from the SOI maps and satellite data was done to transfer the same on the georeferenced image using Arc-GIS software. Analysis and interpretation of satellite was done by digital image processing.

The processes generally include Image Pre-processing, Image enhancement and Image classification. During the study of classification, the accuracy assessment was done by automatic random point to be selected by software, which shows about more than 90% accuracy of map.

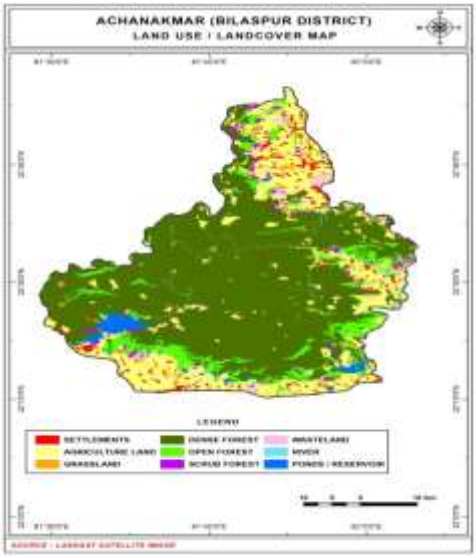

Fig. 2. Lulc classification map.

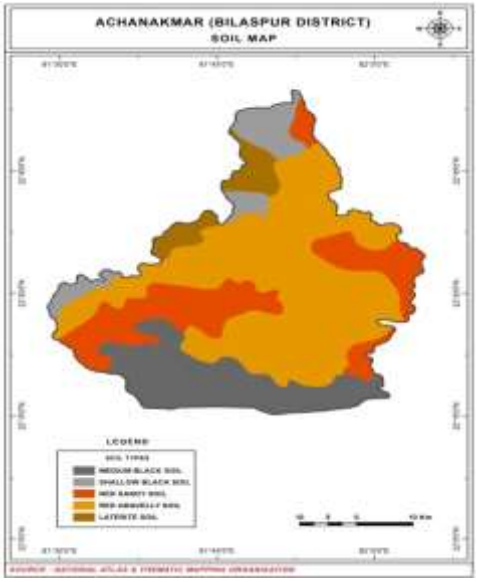

Fig. 4. Soil map.

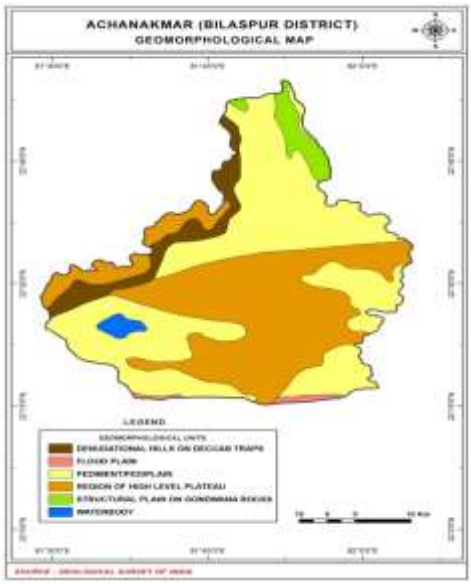

Fig. 3. Geomorphological map.

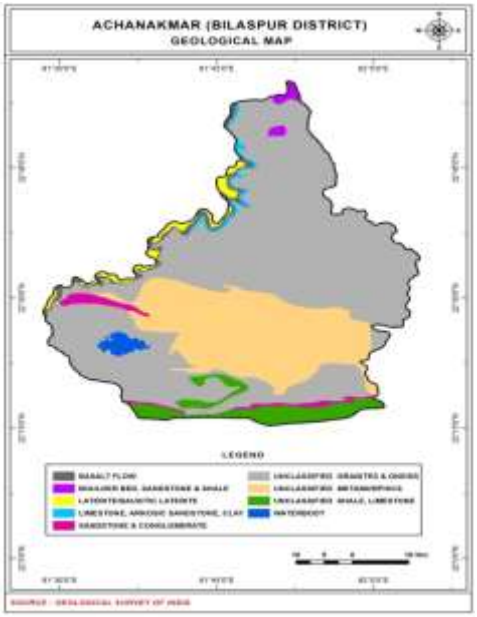

Fig. 5. Geological map

Results and discussions

The land use/land cover mapping and classification of the study area was done by using Land sat TM data of year 2013 of 1:50,000 scale. The satellite data was visually interpreted and after making thorough field check, the map was finalized. The various land use/land cover classes interpreted in the study area include, forest (dense, open and scrub forest), agricultural land (crop land) built-up land (Habitation), waste lands (open degraded lands), rivers and water bodies (ponds and reservoirs). From the present study it was recorded that the total area of Achanakmar region is about 2476.78sq. kms of which 70% of the total area is covered by forests and rest of it is covered under other land uses.

The area under different land use include: dense forest (1511.09sq.km), open forest (211.98sq.km), scrub forest (38.85sq.km), agricultural land (514.85 sq. km), wasteland (36.43sq.km), grassland (19.77sq.km,) settlements (72.60sq.km), water reservoirs/ponds (56.05sq.km) and river (15.16sq.km). Thus, percentage wise area under dense forest is (61.02%), agricultural land (20.79%), open forest (8.56%), settlements (2.94%), water reservoirs/ponds (2.26%), scrub forest (1.56%), wasteland (1.06%), grassland (0.80%) and river (0.61%) (Table 1).

Table 1. Land use Land cover statistics of Achanakmar region.

Land use /land cover category	Area in Sq. Km.	Area in Hectare	% of Area
Dense Forest	1511.09	151109	61.02
Open Forest	211.98	21198	8.56
Scrub Forest	38.85	3885	1.56
Agricultural land	514.85	51485	20.79
Wasteland	36.43	3643	1.06
Grassland	19.77	1977	0.80
Settlements	72.60	7260	2.94
Water reservoirs/Ponds	56.05	5605	2.26
River	15.16	1516	0.61
Total	2476.78	247678	100.00

The mapping of soil classification reveals that the major soil types found in study area include: red gravelly soil (1209.47 sq. km), red sandy soil (517.74sq.km), medium black soil (444.21sq.km), shallow black soil (178.85sq.km) and laterite soil (126.51sq.km) and their percentage cover in study area are: 48.84%, 20.90%, 17.94%, 7.22% and laterite soil 5.10% respectively (Table 2).

Table 2. Area statistics of major soil types of Achanakmar region.

Soil type	Area in Sq. Km.	Area in Hectare	% of Area
Red Gravelly soil	1209.47	120947	48.84
Red Sandy soil	517.74	51774	20.90
Medium Black soil	444.21	44421	17.94
Shallow Black Soil	178.85	17885	7.22
Laterite Soil	126.51	12651	5.10
Total	2476.78	247678	100.00

The different geomorphologic units include: denudation hills on Deccan traps (159.25 sq. km), region of high level plateau (982.87 sq. km), Pediment/Pedi plain (1203.74 sq. km), structural plain on Gondwana rocks (83.28sq.km), flood plain (20.28sq.km) and water body (27.36sq.km).

The percentage wise cover under different geomorphologic units are: pediment/pedi plain (48.60%), region of high level plateau (39.69%), denudation hills on Deccan traps (6.43%), structural plain on Gondwana rocks (3.36%), water body (1.10%) and flood plain (0.82%) (Table 3).

Table 3. Area statistics of geomorphological units of Achanakmar region.

Geomorphological units	Area in Sq. Km.	Area in Hectare	% of Area
Denudation Hills on Deccan Traps	159.25	15925	6.43
Region of High level Plateau	982.87	98287	39.69
Pediment/Pediplain	1203.74	120374	48.60
Structural plain on Gondwana Rocks	83.28	8328	3.36
Flood plain	20.28	2028	0.82
Water body	27.36	2736	1.10
Total	2476.78	247678	100.00

Based on the classification of remote sensed data the area wise different geological units found in the study area include: laterite/bauxitic laterite (40.46692 sq.km), unclassified metamorphics (593.4036 sq. km), unclassified shale and limestone (129.4575 sq. km), unclassified granites and gneiss (1564.197 sq. km), limestone/arkosic sand stone and clay (20.36852sq.km), sand stone and conglomerate (41.84699sq.km), basalt flow (45.66272sq.km), boulder/sandstone and shale (16.25854sq.km), water body (24.83331sq.km) and the percent wise area of these geological units in the study area is: laterite/bauxitic laterite (1.64%), unclassified metamorphics (23.96%), unclassified shale and limestone (5.23%), unclassified granites and gneiss (63.16%), limestone/arkosic sand stone and clay (0.82%), sand stone and conglomerate (1.69%), basalt flow (1.84%), boulder/sandstone and shale (0.66%) and water body (1.00%) (Table 4).

Table 4. Area statistics of geological units of Achanakmar region.

Geological units	Area in Sq. Km.	Area in Hectare	% of Area
Laterite/Bauxitic Laterite	40.46692	4046.692	1.64
Unclassified Metamorphics	593.4036	59340.36	23.96
Unclassified Shale and Limestone	129.4575	12945.75	5.23
Unclassified Granites and Gneiss	1564.197	156419.7	63.16
Limestone, Arkosic sand stone and Clay	20.36852	2036.852	0.82
Sand stone and Conglomerate	41.84699	4184.699	1.69
Basalt Flow	45.66272	4566.272	1.84
Boulder, Sandstone and Shale	16.25854	1625.854	0.66
Water body	24.83331	2483.331	1.00
Total	2476.4951	247649.51	100.00

Conclusion

Land use/land cover classification is very essential for better understanding of landscape dynamics during a known period of time. Geospatial technology plays a vital role in planning, management and utilization of land for forestry, agriculture, pasture and wasteland development. Land use land cover classification maps, soil maps, geomorphology and geology maps are important aspects to know the soil characterization and management of soils with regard to different land use land covers.

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