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# Physiographic Mapping of Vinayakpur Intermediate Catchment Using Remote Sensing and Geographical Information System

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**Abstract** The present study was carried out to map the land use/land cover, soil and geology of the Vinayakpur intermediate catchment using cloud free satellite data of Landsat TM with spatial resolution of 30 m for the year 2010. It indicated about 33.80% area of the catchment is covered by forest and 9.54% land used by agricultural crop production. The major portion of the basin is covered by fine, mixed, hyperthermitic, Typic haplusterts soil which is about 381.094 $km^2$ 37.39% of the total basin area. The upper part of the catchment is mostly prone to erosion while the south-west part is quite fertile with clay content. The geology of the basin is characterized into 12 rock groups . The purple calcareous shale covers an area of 359.92 $km^2$ followed by Banded haematite quartzite (0.270 $km^2$). This information has been generated in GIS environment which provides sound knowledge about the catchment for sustainable planning and management. Hence, integration of remote sensing with GIS technique is a good application for physiographic mapping of the catchment.

**Keywords** Catchment, Physiographic mapping, Landsat, Remote sensing, GIS.

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## Introduction

Mapping of the catchment area provides a vast knowledge about the land features and water resources. In this context, physiographic mapping is an important tool of the catchment using a lot of spatial and temporal data for generating the information. This information has been used to evaluate the characteristics of the area. For mapping there are a lot of conventional methods are available but they are more time consuming and laborious. To overcome these conventional methods a new sound technique RS and GIS plays an important role in mapping land resources, especially in mountainous areas where accessibility is limited. In the past, several researchers have used RS and GIS techniques for physiographic mapping, land use and land cover mapping of any area (Schaetzl et al. 2013, Kumar 2013, Shrikant et al. 2014, Reddy et al. 2016, Gangwar et al. 2017).

Land is a fundamental factor of production and contributes to economic growth of the nation. Often, improper land use is causing various forms of environmental degradation. For sustainable utilization of the land ecosystems, it is essential to know the natural characteristics, extent and location, its quality, productivity, suitability and limitations of various land uses. The land use and land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by the human in time and space. Land is becoming a scarce natural resource due to immense agricultural, industrial and demographic pressure. Therefore, information on land use/land cover and possibilities for their optimal use is essential for the selection, planning, management and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population. Land use is a product of interactions between a society's cultural background, state and its physical needs on the one hand and the natural potential of land on the other (Ram and Kolarkar 1993) . Land use constitutes soil characteristics, climate, topography and vegetation. It is an important resource for most human activities including agriculture, industry, forestry, energy production, settlement, recreation and water catchment and storage. On the other hand, land cover is defined by the attributes of the earth's land surface captured in the distribution of vegetation, water, desert and ice and the immediates sub-surface, including biota, soil topography, surface and ground water and it also includes those structures created solely by human activities such as mine exposures and settlement (Baulies and Szejwach 1997, Lambin et al. 2003). In order to improve the land resources of the catchment area without further deteriorating the environment, every bit of the available land has to be used in the most rational way. Satellite remote sensing provides a more practical way to map and monitor land use/land cover in the watershed as well as to develop land use classification mapping is a useful and detailed way to improve the selection of areas designed to agricultural,urban or industrial areas of a region. Improvements in satellite remote sensing, global positioning systems and geographic information systems techniques in the past decade have greatly assisted the collection of land use and land cover data and the integration of different data types (Star et al. 1997). The present study was carried out to evaluate the physiography in Vinayakpur intermediate catchment (Chhattisgarh) on a small scale by using Landsat 7 TM data and base information from toposheets and geology map of Chhattisgarh.

## Materials and Methods

The area under study i.e. Vinayakpur intermediate catchment was selected for hydrological analysis as shown in Figure 1. The study area falls in the Durg district of Chhattisgarh. The basin extends between the latitude of 20 35'10'' to 20 85'11'' North and longitude of 81 23'05''to 81 7' 30'' East. The total basin area is 1019.17 km$^2$. The Durg district is located at 317 m above MSL. The annual average rainfall is about 1052 mm. The average minimum and maximum temperature are 19.2$^o$C and 33$^o$C, respectively. Tandula river is the main river with total length of 51.01 km and stream order 5. Dem shows that the elevation of the basin from 244 m in the lower part of the basin to 480 m in the upper part of the basin. The

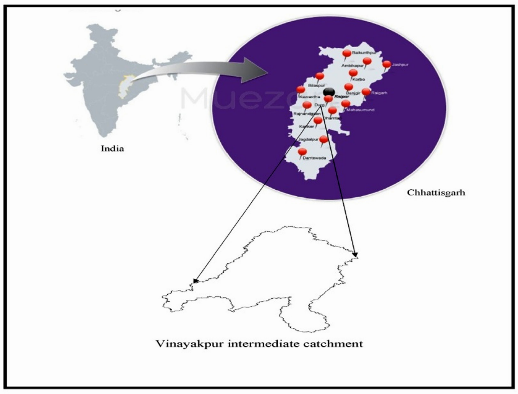


**Fig. 1.** Index map of Vinayakpur intermediate catchment.

**Table 1.** Specification of Landsat TM sensors.

| Satellite | Sensor | Band number | Wavelength range (µm) | Spectral location | Spatial resolution (m) | Swath (km) | Period (days) |
|---|---|---|---|---|---|---|---|
| Landsat | TM | 1 | 0.45–0.52 | Blue-green | 30 | 185 | 16 |
| | | 2 | 0.52–0.60 | Green | 30 | | |
| | | 3 | 0.63–0.69 | Red | 30 | | |
| | | 4 | 0.76–0.90 | Near IR | 30 | | |
| | | 5 | 1.55–1.75 | Mid IR | 30 | | |
| | | 6 | 10.4–12.5 | Thermal IR | 120 | | |
| | | 7 | 2.08–2.35 | Mid IR | 30 | | |

district is bounded by Bemetara district in the north, Rajnandgaon district in the west, Balod district in the south and Raipur district in the east. The climate of the basin is of tropical type. Summer is a little bit hotter. Rise of temperature begins from the month of March to May. May is the hottest month. July is the month of highest rainfall. Most of the rainfall occurs during the monsoon months. Most portions are covered by waste land. Paddy is the main crop grown in the catchment area.

## Methodology and data base

For declination of Vinayakpur intermediate catchment, 8 survey of India toposheet number : 64 G/4, 64 G/8, 64 D/13, 64 H/1, 64 H/5, 64 D/13, 64 H/2 and 64 H/6 in the scale of 1 : 50000 based on the ridge line and drainage network pattern. Cloud free satellite data of Landsat TM dated 26-11-2010 with spatial resolution of 30 m (path : 137, row : 42) for the year 2010 corresponding to the study area were downloaded from Aster Dem website to quantify the land use/ land cover type of the area. The specification of the sensors is given in Table 1.

## Land use/land cover mapping of the basin

The land use/land cover of the Vinayakpur intermediate catchment includes water body, agricultural land, built up/settlement , barren land and forest. Remote sensing based on satellite images being most reliable and offering synoptic views of large areas were the viable option to study and cover dynamics on a regional scale. Flow diagram of land use and land cover map preparation is illustrated in Figure 2.

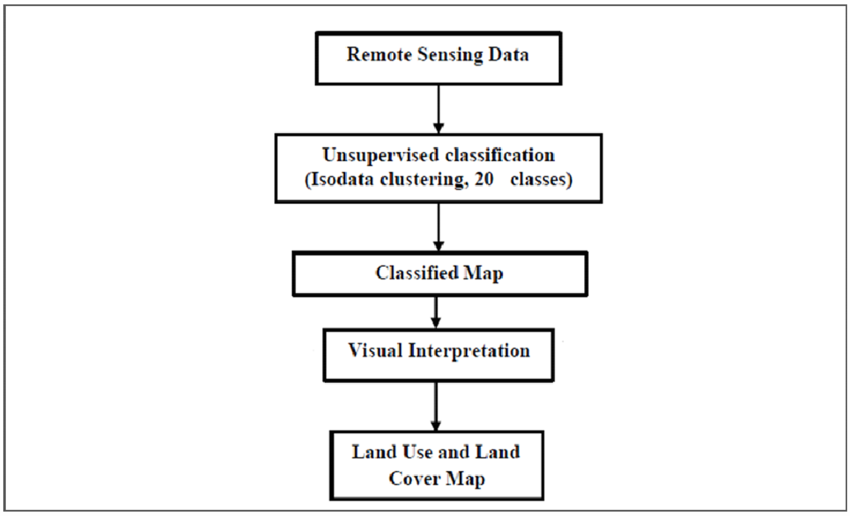


**Fig. 2.** Flow diagram of land use and land cover map preparation.

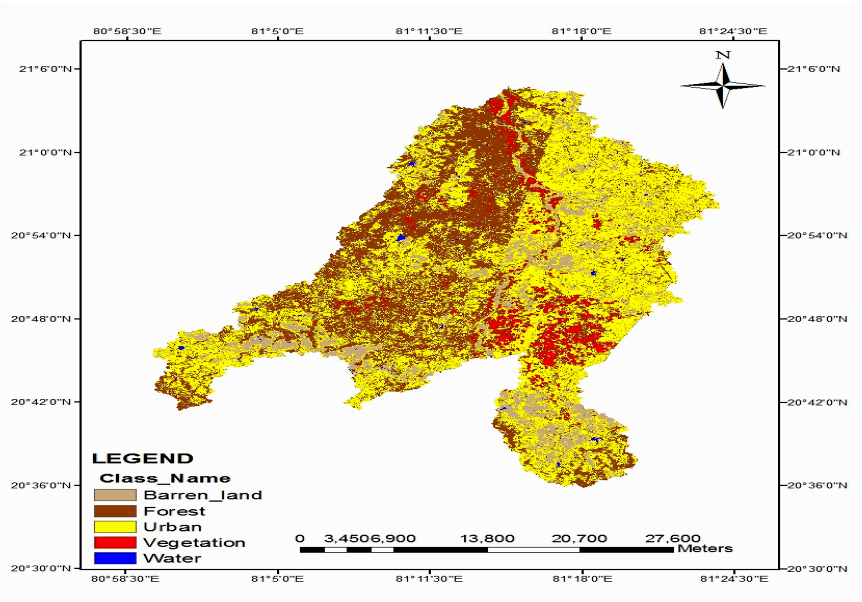


**Fig. 3.** Land use/ land cover map details of Vinayakpur intermediate catchment.

## Results and Discussion

Land use/land cover

The land use/land cover of a certain area depends on geomorphology, geology, climate and anthropogenic activities. It plays a significant role in various studies i.e. rainfall-runoff modelling, soil erosion modelling, groundwater modelling. Unsupervized classification technique was used to classify and to identify the type of LULC and five classes were identified followed by intense field verification. Those are namely Barren land, Forest Urban, Vegetation (agricultural land), Water bodies (Fig. 3) and distribution of these classes were presented in Table 2. Majority of land is under barren land which covers an area of 435.484 km$^2$ i.e. 42.72% of the total area followed by forest (33.8%). Forest area usually have higher organic matter than agricultural soils and favorable for groundwater recharge. The vegetation (agricultural land) holds an area about 97.3 km$^2$ (9.54%) of the catchment. Agricultural activities depend on the monsoon rainfall, most of the land remains vacant during the non-monsoon season. The water bodies cover a very small portion of the catchment, which is about 5.148 km$^2$ (0.50%) and it helps in irrigation and domestic supply over the catchment.

**Table 2.** Distribution of land use/land covers area under different classes.

| Land use type | Area (km$^2$) | Percent area (%) |
|---|---|---|
| Barren land | 435.48 | 42.72 |
| Forest | 344.51 | 33.80 |
| Urban | 136.73 | 13.41 |
| Vegetation (agricultural land) | 97.30 | 9.54 |
| Water bodies | 5.148 | 0.50 |

Soil

The soil map of the basin was prepared from the

**Table 3.** Details of soil in Vinayakpur intermediate catchment.

| Soil type | Area (km$^2$) | Area (%) |
|---|---|---|
| Fine, mixed, hyperthermic, Typic haplusterts | 381.09 | 37.39 |
| Fine, montmorillonitic, hyperthermic, typic haplus | 185.95 | 18.24 |

**Table 3.** Continued.

| Soil type | Area ($km^2$) | Area (%) |
|---|---|---|
| Fine, montmorillonitic, hyperthermic, verticustoc | 130.10 | 12.76 |
| Fine loamy, kaolinitic, isohyperthermic, typic haplus | 19.06 | 1.87 |
| Fine loamy, kaolinitic, isohyperthermic, typic hap | 79.50 | 7.80 |
| Fine, montmorillonitic, hyperthermic, typic haplus | 59.01 | 5.79 |
| Fine loamy, mixed , isohyperthermic, typic haplusta | 52.67 | 5.17 |
| Fine, mixed, hyperthermic, typicustochrepts | 45.28 | 4.44 |
| Loamy, kaolinitic, isohyperthermic, lithicustrope | 39.30 | 3.85 |
| Fine, mixed, isohyperthermic, lithic ustrope | 18.09 | 1.77 |
| Loamy, mixed, hyperthermic, lithic ustrope | 8.59 | 0.84 |
| Fine loamy, kaolinitic, isohyperthermic, typic ust | 0.46 | 0.05 |

national bureau of soil survey and land use planning using Arc GIS 9.3 for study purpose. The soil information generated of basin area are presented in Table 3 and shown in Figure 4. The basin has 12 different types of soil and accordingly the different sites were selected for collection of soil sample for testing and determination of various soil related parameters. The upper part of the catchment is most prone to erosion while the south -west part is quite fertile with clay content. The major portion of the basin is covered by fine, mixed , hyperthermic, Typic haplusterts soil which is about 381.09 $km^2$, (37.39%). It can be used for crop production as well as range land. The second most dominant soil in the basin is fine, montmorillonitic, hyperthermic, Typic haplus which covers an area of 185.59 $km^2$ (18.24%) followed by fine, montmorillonitic, hyperthermic, verticustoc 130.1 $km^2$ (12.76%) of the total basin area. The study indicated that the major part of the basin covered by vertisols (Typic haplusterts), which contain high amount of clay and it is good for rice crop production.

## Geology

The geology map of the basin was prepared using Arc GIS 9.3 with the support of Geological survey of India (GSI) and characterized into 12 rock groups namely laterite (ferricrete), ferruginous arenite with polymictic conglomerate, meta basalt, grey beded flaggy limestone quartz vein, alluvium sand/silt and clay alternating, quartz vein, granite gneiss and migmatite with enclaves of sch, banded haematite quartz, alluvium sand/silt dominant, grey beded

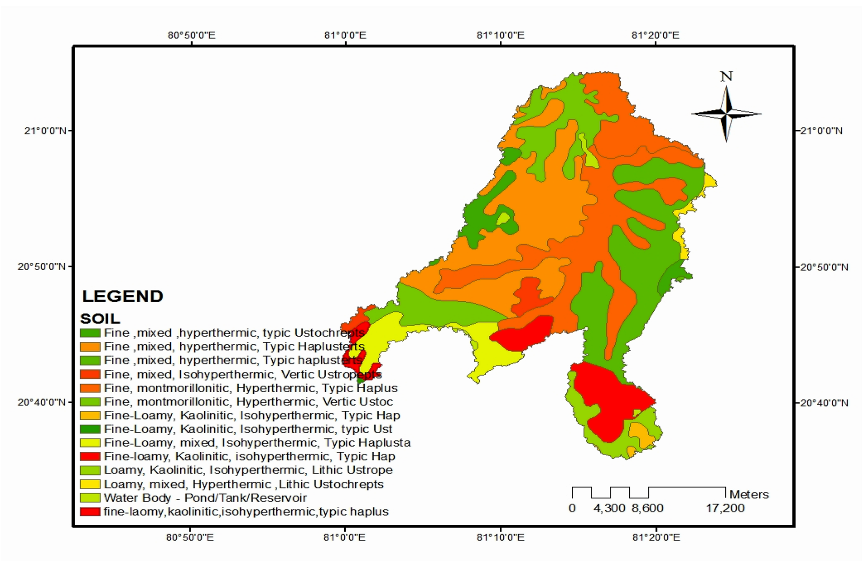


**Fig. 4.** Different types of soil in Vinayakpur intermediate catchment.

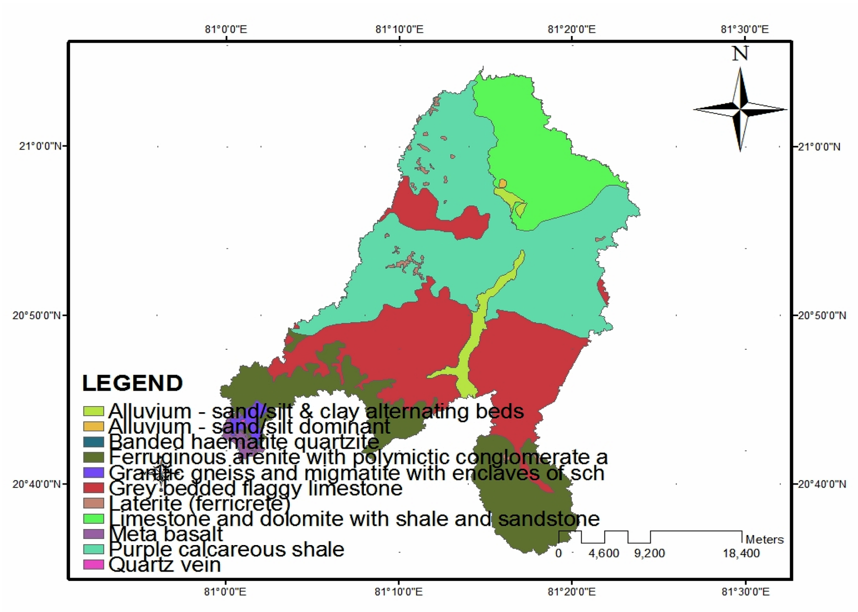


**Fig. 5.** Different rock types in Vinayakpur intermediate catchment.

flaggy limestone, purple calcareous shale limestone and dolomite with shale and sand stone as shown in Figure 5 and distribution of geological rocks over the catchment has been presented in Table 4. The purple calcareous shale of deccan trap occupiesan area of about 359.92 km$^2$ (35%) and occupies the major part of the basin whereas ferruginous arenite with polymictic conglomerate, spread over an area of 173.30 km$^2$ followed by grey beded flaggy limestone 168.74 km$^2$ area.

**Table 4.** Distribution of rock area in Vinayakpur intermediate catchment.

| Rock group | Area (km$^2$) | Percentage area (%) |
|---|---|---|
| Laterite (ferricrete) | 6.71 | 0.658 |
| Ferruginous arenite with polymictic conglomerate | 173.30 | 17.008 |
| Meta basalt | 8.038 | 0.788 |
| Grey beded flaggy limestone quartz vein | 110.30 | 10.82 |
| Alluvium sand/silt and clay alternating, quartz vein | 24.47 | 2.40 |
| Quartz vein | 0.293 | 0.028 |
| Granite gneiss and migmatite with enclaves of sch | 7.96 | 0.781 |
| Banded haematite quartzite | 0.270 | 0.026 |
| Alluvium sand/silt dominant | 0.560 | 0.054 |
| Grey beded flaggy limestone | 168.74 | 16.55 |
| Purple calcareous shale | 359.92 | 35.31 |
| Shale limestone and dolomite with shale and sand stone | 125.25 | 12.28 |

## Conclusion

This study presents the implementation of GIS application with the remote sensing data (satellite imagery) for mapping the physiography (i.e. land use/land covers soil map and geology) of Vinayakpur intermediate catchment. It will assist inlocating areas of high potential where more derailed soil/land information would facilitate efficient planning and management by introducing the new inexpensive technology for agricultural production and recommending measures to improve actual land capability to ensure a sustainable land resources development.

### References

Baulies X, Szejwach G (1997) LUCC Data Requirements Workshop Survey of Needs, Gaps and Priorities on Data for Land Use/Land Cover Change Research Organized by GBP/IHDP-LUCC and IGBP-DIS. Barcelona, Spain.

Gangwar A, Nayak TR, Singh RM, Singh BP, Kumar D (2017) Land use and land cover mapping of Bina command, Madhya Pradesh, Integrated natural resource management : The way forward, New Delhi Publishers, New Delhi, pp109-114.

Kumar S (2013) Physiographic mapping of Siwani area, Bhiwani District, (Haryana) using remote sensing and GIS techniques. Int J Res in Manag, Sci & Technol 1 (1) : 12—15.

Lambin EF, Geist HJ, Lepers E (2003) Dynamics of land use/ cover change in tropical regions. Ann Rev Environ and Resour 28 : 205—241.

Ram B, Kolarkar AS (1993) Remote Sensing application in monitoring land use changes in arid Rajasthan. Int-J Rem Sens 14 (17) : 3191—3200.

Reddy KY, Krishna KVSGM, Reddy IS (2016) Remote Sensing and GIS Based Topographical Mapping for environmental management study. Int J Appl Engg Res 11 (2) : 1325—1334.

Schaetzl RJ , Enander H, Luehmann MD, Lusch DP, Fish C, Bigsby M, Steigmeyer M, Guasco J, Forgacs C, Pollyea A (2013) Mapping the physiography of Michigan with GIS, http://dx.doi.org/10.1080/02723646.2013.778531.

Shrikant, Singh S, Nema AK, Meshram S, Chandola VK (2014) Physiographic mapping of Sonar sub-basin using remote sensing and GIS. Ind J Dryland Agric Res and Develop 29 (1) : 01—05.

Star JL, Estes JE, McGwire KC (1997) Integration of geographic information systems and remote sensing. New York, NY : Cambridge University Press.