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GEOSPATIAL TECHNOLOGIES FOR DEVELOPING RESOURCE MAPS AT CADASTRAL LEVEL-A CASE STUDY FROM CENTRAL INDIA

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ABSTRACT

Identification and delineation of Land use/ Land cover, location, extent, and their spatial distribution patterns are possible through Remote Sensing (RS) because of its synoptic view and its ability to resolve both macro and micro details on a single imagery. The aim of this paper is to depict the quick and practical approach in mapping and analysis of Land use and Land cover patterns using high-resolution satellite images. The case study was carried out in Wihora watershed of Akola district, Maharashtra as part of project work in the training program at National Bureau of on Soil Survey and Land Use Planning (NBSS&LUP), Nagpur. In the study Geomatica, 10.2 software used to develop a land use classification using IRS 1-C, LISS III, image. Supervised and unsupervised classification methods were used to classify the image and visual image interpretation approach used to delineate the land use classes. The present study is focuses on demarcating boundaries of different land use/land cover units from an analysis, with the help of SOI toposheet, and Satellite images. Further, in the present study developed different thematic maps like contours, Digital Elevation Model (DEM), drainage, soil and slope, landforms etc., in a GIS environment. The extracted watershed parameters will be useful in watershed hydrology and irrigation water management effectively.

***KEYWORDS**: Land Use/Land Cover, Remote Sensing, Thematic Maps, Supervised Classification, DEM & GIS*

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Original Article

INTRODUCTION

Land is a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology, the near-surface sedimentary layers and associated groundwater reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (FAO, 1995). Information on the nature, extent, and spatial distribution of land resources is a pre-requisite to develop rational land use plans for agriculture, forestry, irrigation, drainage *etc*, Land use refers to the type of utilization to which man has put the land. It also refers to the evaluation of the land with respect to various natural characteristics. But land cover describes the vegetal attributes of land. Land use and land cover data are essential for planners, decision makers and those concerned with land resources management (Ndukwe, 1997). Land use map is a valuable tool for agricultural and natural resources studies, updation of these maps are essential due to the strength of natural resources monitoring and analysis of up-to-date Land use/ Land cover (LULC) information, for proficient and sustainable management of Agriculture (Alphan, 2003). Unfortunately, on the other hand, there is a general lack of accurate and current LULC maps (Ezeomedo, 2006).

However, the advent of air-and space-borne remote sensing has made it possible to acquire land use and land cover data inconsistent manner. In addition, the advent of geographic information system (GIS) has made it possible to integrate multisource and multidate data for the generation of land use and land cover maps (Adeniyi *et al*., 1999). This leads to the quick and truthful representation of the real world in the best possible way. Remote sensing provides land resource data in the digital form and different bands of the electromagnetic spectrum. Availability of such type data in different bands makes it very useful and easy way for delineation of land use/land cover classes. Over the years, remote sensing has been used for land use/land cover mapping in different parts of India (Gautam and Narayanan, 1983: Sharma *et al*.,1984).

The classification system facilitates the planners and researchers to study the spatial difference and distinction between various lands types, from satellite data. GIS involves mapping data and interpreting the relationships among that data and making inferences. It is also very useful for the production of land use and land cover statistics which can be useful to determine the distribution of land uses in the watershed. Land use land classification can be made using remote sensing image classification techniques. Remote Sensing research focusing on image classification has attracted the attention of many researchers (Lu and Weng, 2007) and a number of researches have been conducted using different classification algorithms. Classification is a process to assemble groups of identical pixels found in remotely sensed data into classes that match the required categories of the user by comparing pixels to one another and those of known identity (Palaniswami *et al*., 2006, Perumal and Bhaskaran, 2010). The classification of remotely sensed imagery relies on the assumption that the study area is composed of a number of unique, internally homogeneous classes and that classification analysis based on reflectance data and ancillary data can be used to identify these unique classes with the aid of ground data.(Lillesand and Kiefer, 1994, Townshend, 1981). The present study demonstrates the usefulness of geospatial technology in generation of thematic maps of contour, slope, drainage, flow direction, landform, land use land cover (LULC), DEM and soil-related maps in conjunction with available ancillary data at cadastrial level in wihora watershed, Akola, Maharashtra.

MATERIALS AND METHODS

Materials

In the present study an attempt has been made to analyze terrain characteristics and generate various thematic maps and land use/land cover and soil using SOI toposheet remotely sensed satellite imagery and ASTER DEM for the selected wihora watershed. To accomplish this task different data sources and software's were used. The study area and dataset used is described below.

Study Area

The study area is located in Akola district of Maharashtra, India, and lies between 77°.45′ E longitude and 20°.30′ N latitudes. The study area comprises Wihora Watershed and is included in the Survey of India topographical sheet No. 55H/2 on 1:50,000 scale.

Data Used

To develop various thematic maps, various field, topographic and satellite data have been used. The data used in this study include satellite data, Survey of India (SOI) topo-maps (55H/2) and ancillary information collected from Departments of, Agriculture and Institutes of Indian Council of Agricultural Research (ICAR).

Field Data/Ground Truth Data Collection

Ground truth information, which involves gathering information on land cover types, their spatial extent, condition and geographical coordinates of the location was collected to determine the signature The latitude, longitude, and altitude were recorded with the help of global positioning system (GPS), and water bodies, barren lands etc., were observed.

Satellite Data Used

The Indian Remote Sensing (IRS) satellite data is mainly used in this study. From the available orbital calendar of the satellite and the reference scheme supplied by the National Remote Sensing Agency, the scenes covering the study area are selected. The SOI topographical reference maps provide information on topo coverage of any region in India on different scales. Using such a reference map the required SOI maps covering the study area on 1:50,000 scales were identified and used in the present study. IRS - 1D digital data from LISS–III was used in the study. The LISS-III provides reflectance data in green, red, and near-infrared bands at 23.5 m spatial resolution and at 24 days revisit, covering a swath of about 141 km.

Methodology

To create thematic maps initially created a base map of the study area was prepared from the Topographic maps (1:50,000 scale), which were collected from the Survey of India. The SOI Toposheets were first rectified and then geo referenced to the Geographical Coordinate System. Then the geo referenced SOI Toposheets was used to delineate the watershed area. The geo referenced totposheet was considered for digitization of contours and the study area has been delineated correspondingly.

Land use/land cover of the study area was mapped using remote sensing classification methods. The classification is a complex process and requires a combination of many factors. The first step in image classification is the preprocessing of satellite images. Preprocessing of satellite images include geometric correction, atmospheric correction, radiometric calibration and radiometric rectification procedures (Jensen, 1996). After preprocessing, images have been geo referenced. Georeference -means to define the existence of an image in a physical space. That is establishing its location in terms of map projection or coordinate system. After georeferencing the remaining steps for classification are training sample collection, feature extraction, post classification processing and accuracy assessment. There are two fundamental approaches for classification of images. One is supervised and another one is unsupervised classification. In image classification, we used both supervised and unsupervised classification methods. Various steps used in the present study are described to generate various thematic maps in the following flow chart (**Figure 1**).

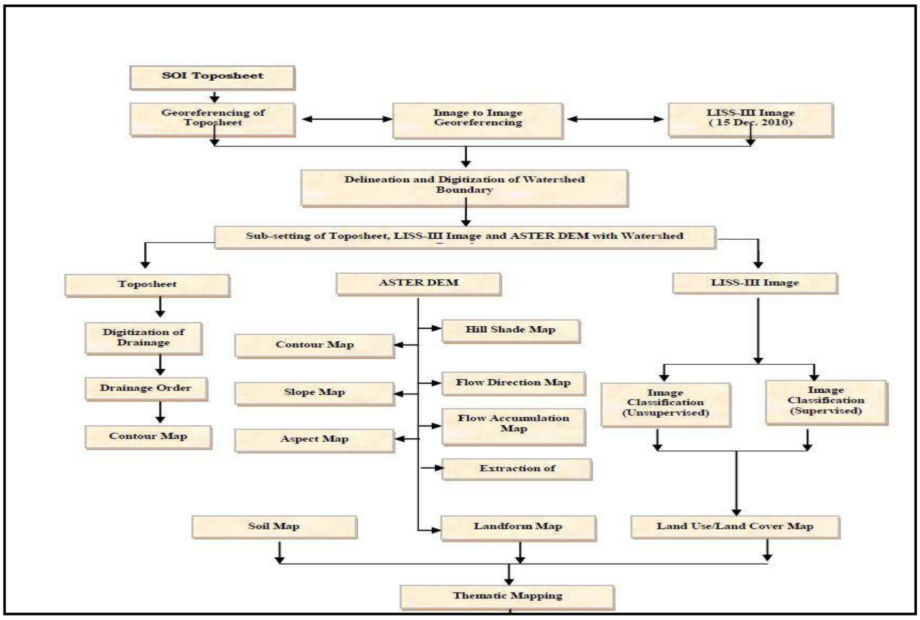


Figure 1: Steps used in the Present Study to Create Thematic Maps

RESULTS AND DISCUSSIONS

In the present study for selected wihora watershed various thematic maps are generated and the results are discussed.

Preparation of Topobasec Map for Watershed

Topobase is prepared based on Toposheet (55H/2). Firstly, scan copy of toposheet is geo-referenced based on the four ground control points and projected in UTM projection system with datum WGS84. The boundary of the watershed was digitized and delineated manually based on the drainage in ArcGIS platform (**Figure 2**). Further, this boundary is used to extract the information of the topobase from the geo-referenced toposheet.

Toposheet-based Drainage Map of Wihora Watershed

The geo-referenced toposheet in ArcGIS 9.3.1 was used to extract the drainage network of Wihora watershed. A new shape file (in *.shape format) was generated in a GIS environment. In this process, the drainage lines visible on the toposheet were digitized using editor tools/operation in ArcGIS. The generated drainage map of the Wihora watershed is given below in **Figure 3**.

Figure 2: Toposheet-Based Map of Wihora Watershed

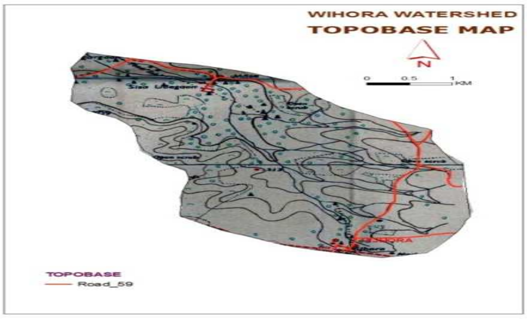


Figure 3: Toposheet-based Drainage Map of Wihora Watershed

Toposheet-based Drainage Map with Stream Orders of Wihora Watershed

The geo-referenced toposheet in ArcGIS was used to extract the drainage network of the Wihora watershed along with stream orders. The generated drainage map was further processed to assign the stream orders to each stream as per Strahler's stream ordering scheme. The 1st order streams were numbered by selecting those streams by holding SHIFT key ofthe keyboard and entering/typing stream order in the 'Attribute Table' of the shapefile (viz. *.shp). Selected the 'polyline' option while creating the drainage layer in ArcGIS. This procedure was repeated to enter other higher order streams. The option 'Label Features' was clicked after right-clicking on the layer to view the stream orders on the map The generated streams were ordered in the drainage map of the Wihora watershed as shown in **Figure. 4.**

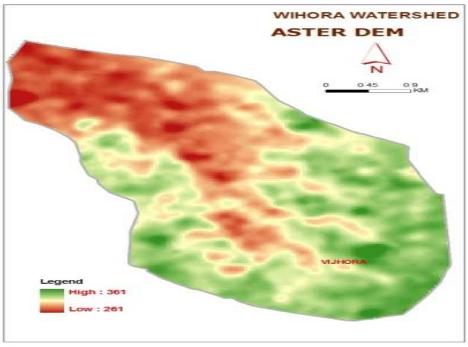


Figure 4: Drainage Map with Stream Orders

Creation of ASTER-based DEM of Wihora Watershed

The digital elevation model (DEM) of the Wihora watershed was prepared by using ASTER data having a spatial resolution of 30 m. The area of interest is extracted using the watershed boundary. The elevation details in the DEM are varying from 261m to 361m. DEM is prepared with elevation interval of 20m and various classes represented by various colors as shown on the map. The generated DEM with DEM-based drainage network of Wihora watershed is shown in **Figure. 5**. The DEM-based drainage network was created by using 'Hydrology' module of ArcGIS.

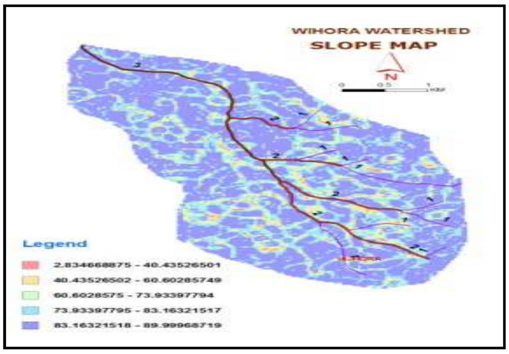


Figure 5: ASTER-DEM Generated for Wihora Watershed

Creation of ASTER-based Contour Map of Wihora Watershed:

A 10 m contour interval map was generated using the ASTER elevation data. This was accomplished by using the 3D analyst tool available in the ARCGIS-ARCMAP. The 3D analyst tool has the facility to generate a different type of maps and one of them was a generation of the contour map. The user has the option to choose the contour interval. The lowest value was 261 m and the highest value was 361m above mean sea level (**Figure. 6**).

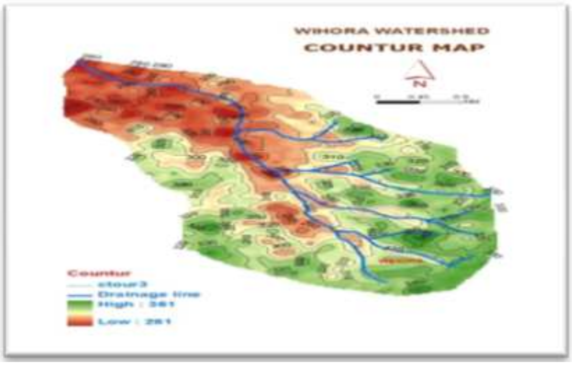


Figure 6: Contour Derived from ASTER DEM

Creation of Slope Map of Wihora Watershed

Slope map of the wihora watershed was developed using the 3D analyst tool available in ARCMAP software. ASTER data was used to generate this map **Figure 7**.

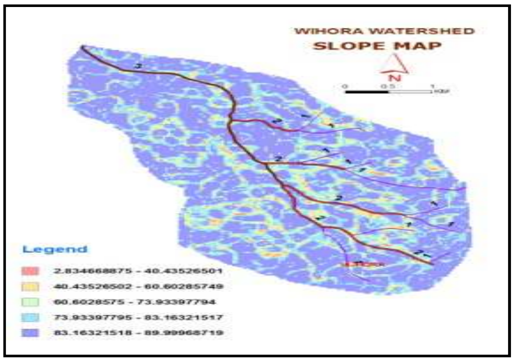


Figure 7: Slope Map of Watershed

LULC Classification of LISS III Imagery of Wihora Watershed

For land use land cover analysis, IRS P-6 Linear Imaging and Self Scanner (LISS-III) with 23.5 m spatial resolution having standard False Color Composite (FCC) was used. LISS-III imagery is geo-referenced with rectified toposheet (SOI) and projected in UTM projection with datum WGS84. A boundary of the watershed is used to extract the image information of LISS-III in the study area. False color composites are prepared based on assign the NIR band to red color, red to green and green to blue color. Visual interpretation techniques of satellite data were used to interpret and delineate the land use classes. For classification of land cover, ground data collection was considered an essential exercise, whereby relationships between different ground features and their corresponding spectral signature was established. A handheld GPS receiver was used for determining the location of different land cover classes in the field and relating these with pixel clusters in the image to identify their spectral characteristics. In addition to relating spectral signatures with land use type, ground data collected through field surveys provided the basics for determination of the accuracy of manual classification and identification of empirical relationships between surface properties and satellite observations. Hence, the collection of an unbiased data set for ground information was imperative for successful image classification and interpretation. The methods used for classification are supervised, unsupervised are discussed below.

Supervised Classification

In supervised classification methods are based on user-defined classes and corresponding representative sample sets. These sample sets are specified by raster data sets must be created prior to enter into the automatic classification process. The image interpreters must have a priori knowledge of the area covered by the image in terms of types and location of features. Supervised classification techniques require training area to be defined by the analyst in order to determine the characteristics of each category. Each pixel in the image is assigned to one of the categories using the extracted **in**formation. The maximum likelihood algorithm with equal probability of occurrence was used in the classification because it is powerful and produces the best results, if defined training sites are very good in uniformity (Congalton *et al*., 1998). They are attempting to classify it by using a signature file (assigning AOIs to different locations of features on the imagery). These signature files were used as input files to supervised classification.

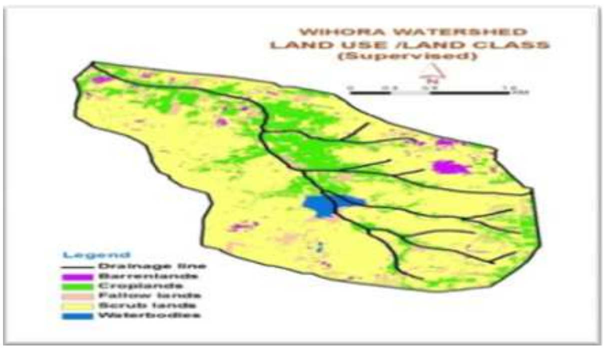


Figure 8: Supervised Classification of LISS III Image

These AOIs created using ground truth data coordinates like water bodies, crop, barren lands, etc. The results of supervised classification shown in the **Figure.8**, **Table 1**.

Table 1: Supervised Classification of LISS III Image of Wihora Watershed

Sl. No.	Land Use/Land Cover	Area (Sq.meters)	% of Total
1	Crop	2707852	2%
2	Fallow	912519	7%
3	Scrubs	10842407	86%
4	Barren	338990	3%
5	Water	212403	2%
	Total	**12576971**	

Unsupervised Classification

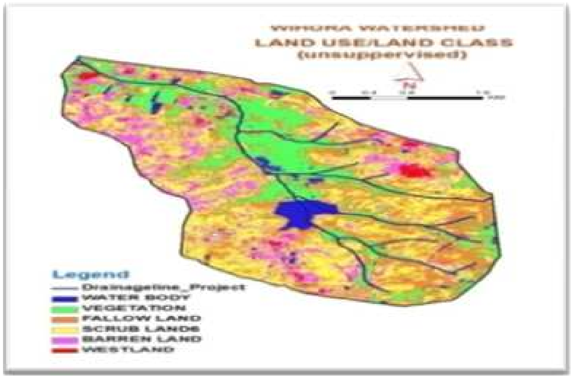


Figure 9: UnSupervised Classification of LISS III Image

Unsupervised classification distinguishes a pattern in the reflectance data and groups them into a pre-defined number of classes without any prior knowledge of the image. In this type of classification spectral classes are grouped first, based on the numerical information of the data, and are then matched. It involves algorithms called clustering algorithms, that examine the unknown pixels in an image and aggregate them into a number of classes based on the natural groupings or clusters present in the image values, and specifies the desired number of classes. ISODATA clustering method uses to perform unsupervised classification, using the ISODATA algorithm. The ISODATA clustering method use the minimum spectral distance formula to form clusters. The ISODATA utility repeats the clustering of the image until either a maximum number of iterations has been performed (**Figure. 9**). After this system generated classification, classes are assigned to the individual category as waterbody, dense forest, open forest, cropland, fallow land and open land based on the visual interpretation.

Landforms in Wihora Watershed:

Landforms represent the landscape of this watershed. Landform is prepared based on the toposheet and satellite imagery, slope map and ASTER DEM. The different landforms delineated are Lower foot slopes, Narrow Valleys, Settlements, Subdued Plateau, Upper foot slopes, Upper interfluvial slopes, and Waterbodies.(**Figure 10,11**), **Table 2**.

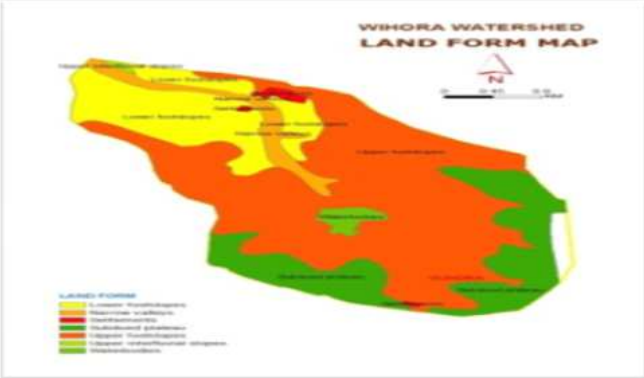


Figure 10: Landform Map

Table 2: Area under Various Landforms in Wihora Watershed

Geomorphic Unit	Area (ha)
Lower foot slopes	2.65394
Narrow Valleys	0.67382
Settlements	0.36529
Subdued Plateau	2.98786
Upper foot slopes	8.3164
Upper interfluvial slopes	0.03425
Waterbodies	0.36529

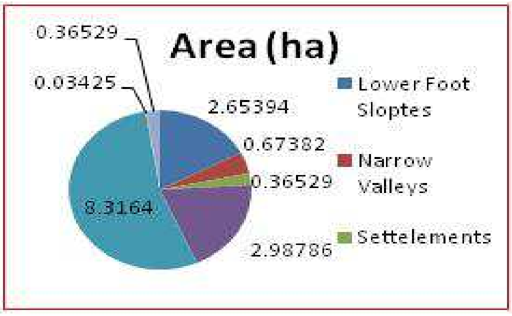
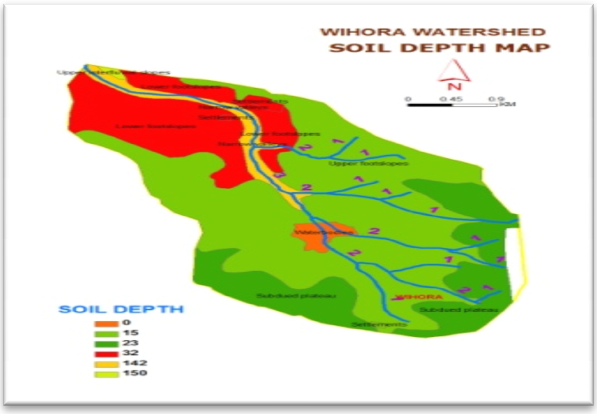


Figure 11: Land Form Details of Wihora Watershead Area

Cadastral, Soil Maps

Cadastral Map was prepared from Land Use Suitability database by placing the database layer on Watershed boundary (**Figure 12**). Soil Type map is generated from Cadastral Map of the Watershed area by selecting the class depth. The map shows different types of soils available in the Wihora Watershed (**Figure 13**). Soil depth in the study area shows that very shallow soils occurring on Upper footsteps and Subdued Plateau and occupies 11.30 ha (74%). The shallow soils have been notices on Lower foot slopes, which occupies 2.65 ha (17.38%). The deep soils have been noticed on Upper interfluvial slopes and on Narrow Valleys which occupy 4.66 ha. (**Figure 14**)



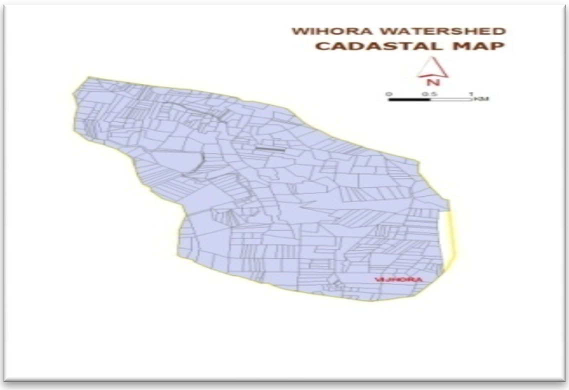


Figure 12: Cadastral Map **Figure 13: Soil Type Map**

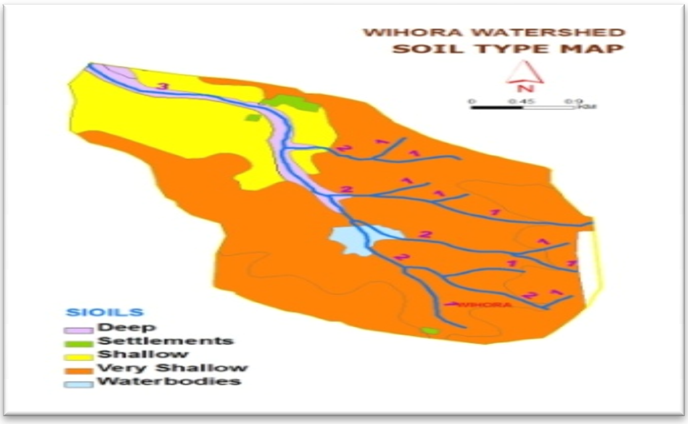


Figure 14: Soil Depth Map

CONCLUSIONS

The present study shows that how to classify land use and land cover from satellite imagery and calculation of land use/land cover area using supervised, unsupervised classification. The present study also demonstrates the usefulness of satellite data for the preparation of various thematic maps and up-to-date land-use/land-cover maps depicting existing land classes. Furthermore, the developed spatial map can serve as useful for formulating meaningful plans and policies so as to achieve a balanced and sustainable development in the region.

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