P-ISSN: 2659-1561
E-ISSN: 2635-3040

Research Article

Assessment of Land Use Land Cover Patterns and Impacts: A Case Study from Cuddapah Basin, India

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Received: Jun 9, 2020 **Accepted:** Jun 21, 2020 **Published:** Jun 29, 2020

Abstract: The present study focuses on the digitization of LULC patterns of the Veerupanayini Palli Mandal, Kadapa district, Andhra Pradesh, India which is witnessing the rapid growth of urbanization, industrialization, and sustainable increase in population. This work is considered to be the first of its kind in the study area, which assists as baseline data to the policymakers and decision-makers, to utilize the natural resources viz., water, land, soil, cropping patterns, forest cover, etc., for sustainable development. Thematic maps like drainage maps, land use/land cover maps, lithological maps, etc., were generated by using satellite imageries coupled with adequate ground checks. This study falls under level IV of Anderson classification. The total area of the region is 293.64 sq.km. Results showed that the barren land/wasteland occupies a lion's share in area wise followed by agricultural lands. The water bodies in the study area exist at a very low percentage. So, to have a better understanding of controls of hydrological conditions, lithological and drainage maps were generated by using ASTER data spectral signatures. It is found that most of the area comprises of purple shale with volcanic flows that produce the dendritic drainage pattern (tree-like branching).
Keywords: Veerupanayini Palli, LULC map, Drainage Map, Lithological map, ASTER Data, Spectral signatures.

Introduction

The most significant challenges facing the earth over the next century will be the Land Use and Land Cover Changes (LULCC). According to some estimates (Vitousek *et al.,* 1997), about 50 % of the ice-free land surface has been manipulated by human activities. According to recent and reliable projections, the global population will increase by 50-75 percent to the current population which mounts the pressure of conversion of natural ecosystems according to the human needs (Rojstaczer *et al.,* 2001). As we all know that, the Earth becomes a scarce source of the exponential use of the ever-increasing human population. Therefore, it is significant to know the Land Use Land Cover pattern which further aids in understanding the interactions of human activities with the environment for better human living and sustainable development.

The anthropogenic course of action affects many parts of the earth systems viz., biodiversity, radiation emissions, hydrology, climate, and carbon dynamics, etc., Moreover understanding the LULC patterns, facilitates to know its impact and gives feedbacks between natural and human systems (Riebsame *et al.,* 1994). Thus it helps to know the socio-economic drivers of land cover and land use changes. Hence it is imperative to monitor and detect the changes in Land Use and Land Cover (LULC) to maintain a sustainable environment. The terms Land Use and Land Cover are different terminologies that are often used interchangeably. The words Landcover is associated with the physical characteristics of the earth's surface which includes the distribution of vegetation, water, and other physical properties of the soil, together with those produced by human activities. And the term Land Use refers to the way land is used by humans and their habitats viz., settlements, roads, mining, construction of dams and reservoirs, etc,. In nutshell, it focuses on the functional role of land for socio-economic activities. The form of land use/landcover is the mutual result of natural and socio-economic factors and their use by man in time and space. Changes in land cover for land use do not necessarily mean land degradation. Mapping of the LULC patterns at various periods of the time gives the picture of changes that occurred on the Earth Surface.

From the past several decades, sophisticated remote sensing technology aids to map spatio-temporal changes and also facilitates, understanding the nature of changes on the earth's surface as a whole. The modern field sensor technologies of photogrammetry and satellite systems collect the physical data repeatedly at a rapid rate over a given period. The collected physical data, when coupled with Geographic Information System (GIS) tools, helps us to display, store, integrate, manipulate and to analyze thus generated data which optimizes the planning and decision-making process in less time with greater accuracy (Brondízio *et al.,* 1994; Ruiz-Luna *et al.,* 2003, Turner and Ruscher, 2004; Yuan *et al.,* 2005; Sreenivasulu *et al.,* 2013;2014).

There is a dearth for superlative land use land cover classification system because, keeping with demands for natural resources, the LULC patterns are in dynamic nature. Anderson (1976), proposed four levels of LULC classification system. Level I and II LULC information is generally the interest of the users who works on the National, interstate, and intrastate wide basis. Level III and IV LULC information will be used by the users who deal at the regional and municipal level where many customizations were incorporated into the LULC classification system.

The present chapter deals with the digitization of LULC patterns of the Veerupanayinipalli Mandal, Kadapa district, Andhra Pradesh, India which is witnessing the rapid growth of urbanization, industrialization and sustainable increase in population that falls under category III and IV of Anderson’s classification (1976).

The objective of the present study is to know the current status of the natural resources viz., water, land, soil, cropping patterns, forest cover, etc., by using satellite data and sustained by field data which assists in further land use. Besides, the generation of the thematic maps like drainage map, land use/land cover map, lithological maps, etc., of the study area has been considered for the better juxtaposition of the investigation.

Description of the study area

The study area Veerupunayini Palli Mandal situated at the western part of the Kadapa district covers an area of 293.64 sq km^2 and lies between the 14^0 28' 40 " to 14^0 31' 36" N latitudes and 78^0 22 ' 58 " to 78^0 35 ' 8 " E longitudes (Fig 1). This forms as part of Toposheets 57J06, 57J07, 57J10, and 57J11. The annual rainfall of the study region is about 464.5mm and post-monsoon availability of water is abundant. The area consists of various geomorphological features such as denundational origin-low dissected hills and valleys, structural features with low dissected hills, pediment-pediplain complex with scattered irregular water bodies.

The accessible water is adequate amid the early piece of the winter season (till December). Later, the water table drops low quickly, and by March, a large number of the shallow wells tapping the upper unconfined aquifers either turned out to be dry or don't sufficiently meet the prerequisite. In this way, even though surface water is abundant, there is yet an intense deficiency of water in summer. Consequently, there is a need to distinguish areas where site-explicit artificial recharge techniques can be embraced to expand water supply during the scarce season as well.

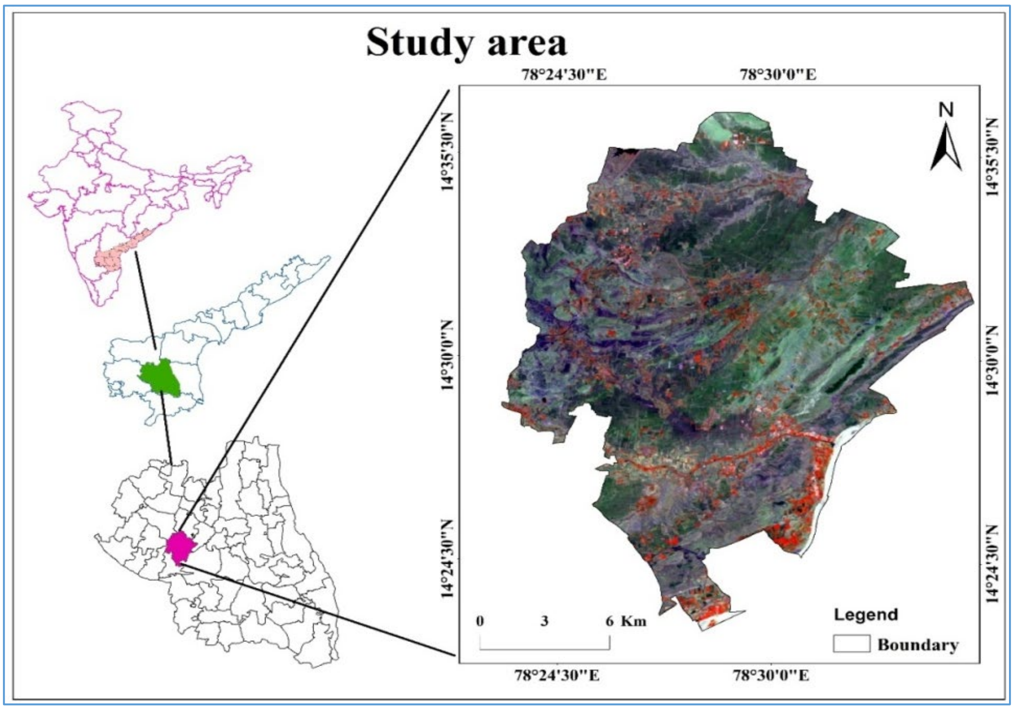

Figure 1. Location map of the study area

Methodology and Data Used

Geocoded false-color composite scene of IRS-P6 LISS (Linear Imaging Self Scanner Sensor) III satellite imagery data procured from National Remote Sensing Centre (NRSC), Government of India, Hyderabad and Survey of India (SOI) toposheets (57J06, 57J07, 57J10, 57J11) were used to generate baseline thematic maps. The spatial resolution of the satellite imagery of LISS III and PAN is 30m and 5.8m, with spectral resolutions of 4 and 1 meters, respectively.

The Toposheets are obtained from the Survey of India are georeferenced and mosaicked by using ArcGIS software 9.3 and later to demarcate the boundary of the study area spatial analyst tool was used.

The mosaicked toposheet was used as a base map. The downloaded satellite imagery was enhanced by using histogram equalization in ERADAS Imagine software to realize LULC classes by using the image interpretation elements (such as tone, texture, shape, pattern, association, etc.) in conjunction with existing map/literature and Arc GIS software (9.3) was used for processing, analysis, and integration of spatial data to reach the objectives of the study. Adequate ground truth checks were made before the finalization of the thematic maps (Srinivasulu *et al.,* 2013).

The detailed methodology followed in the present study is given (Figure 2).

 P-ISSN: 2659-1561
E-ISSN: 2635-3040

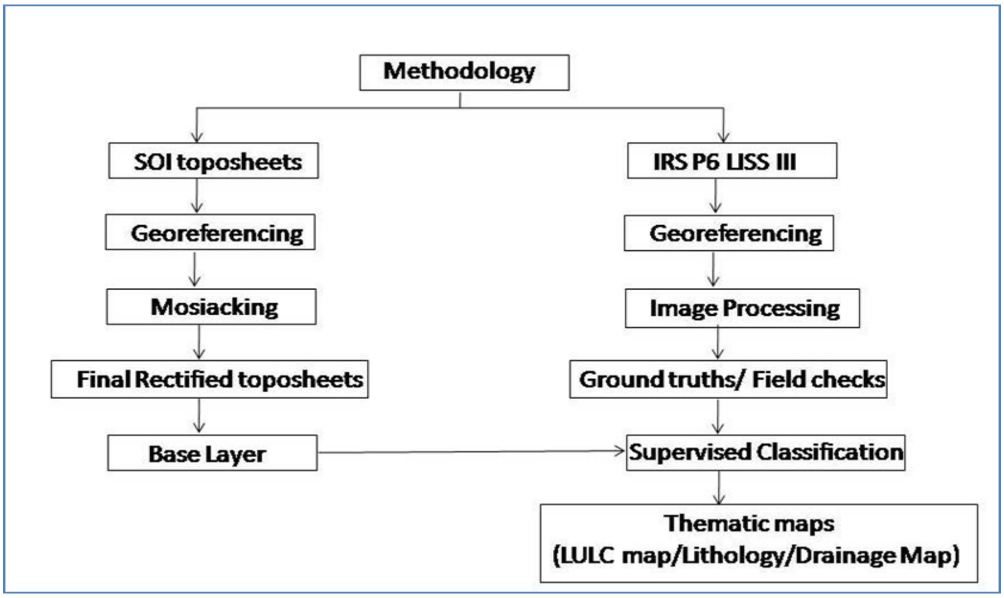

Figure 2. Methodology

Results and Discussion

To achieve the LULC classes in the study area, a supervised classification method with maximum likelihood algorithm which is based on the probability that a pixel belongs to a particular class was employed to classify the digital data. An extensive field survey was carried out throughout the study area by using the Global Positioning System (GPS) to attain precise locational point data before the classification of digital data. The maximum likelihood method needs a long time of computation, relies heavily on a normal distribution of the data in each input band, and tends to over-classify signatures. In supervised classification, knowledge of all cover types needs to be mapped is prerequisite (Lillesand and Keifer, 2000; Jonathan *et al.,* 2007; Yu *et al.,* 2007; Chaudhary *et al.,* 2008). Based on spectral signatures from the specified locations in the satellite imagery, a user-defined generic name was assigned to the specific locations. In general, a vector layer that consists of various polygons was drawn on the raster scene or image that helps further to develop the spectral signatures for the outlined areas. Based on the spectral signatures, five land use/Land cover types are identified in the study area viz., (i) Agricultural land (ii) Barren/Waste/ Uncultivated lands (iii) Forest (iv) Built-up land and (v) Waterbodies.

Agriculture Land

This part of the land covers crops orchards and plantations. The total agricultural land in the study area is 99.53 sq.kms (33.89%) with the croplands of both wet and dry cultivations. Wet cultivation includes food crops such as paddy, groundnut vegetables, and other mixed varieties like flower plants, etc. and dry cultivation includes Bengal gram, red gram groundnut, and other pulses, etc.

Barren/Waste/Uncultivable Land

This is defined as the Land which has thin soil, sand, or rocks. Barren rocky, salt-affected land, land with and without scrub, sandy area, sheet rocks, uncultivated lands, and stony regions are considered under this category. Such lands are formed due to the anomalous physical properties of soil, temperature, rainfall, and local environmental conditions, etc. This category occupies a lion's share with 141.40 sq/km (48.55%) in the study area (Table.1). Majority of the Barren/ Waste/Uncultivated land exits in the North, East, and South directions of the under consideration area (Figure 3).

 P-ISSN: 2659-1561
E-ISSN: 2635-3040

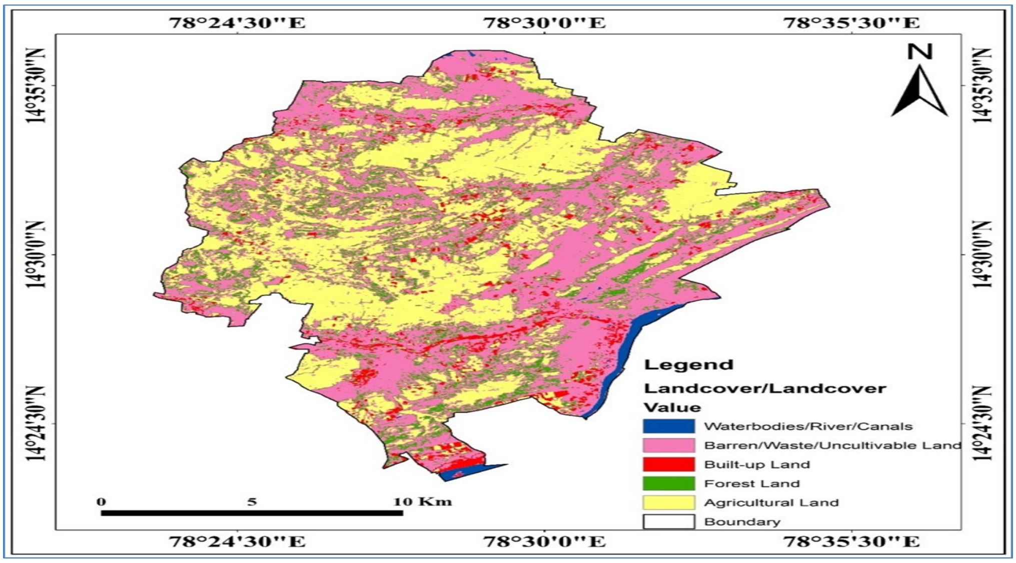

Figure 3. Landuse land cover map of the study area

Forest Land

Forest comprises of thick and dense scrub of trees. Forest is identified by their red to dark green tone and varying in size. They are irregular in shape with a smooth texture. The forests exist on the North West and North East parts with a total area of 37.55 sq.km (12.79%). The study area covers mostly the dense and scrubs forest. The relative concentration of scrubs, bushes, and smaller trees are predominant in this category. In the satellite image, such a scrub is identified by a green tone with a smooth texture. These lands are subject to degradation, erosion, and weathering processes, etc. such areas are identified from their yellowish tone and their association with uplands, and their irregular shapes. Land with scrub found in the north and eastern part of the study area.

Table 1. Land use land cover classification details of study area

Landuse/Landcover types	Area (km^2)	Percentage (%)
Agricultural Land	99.53	33.89
Barren/Waste/Uncultivable Land	141.40	48.15
Forest Land	37.55	12.79
Built-up land	11.87	4.04
Water bodies	3.30	1.12

Built-up Land

Built-up land is defined as areas of land covered by residential, commercial complexes, institutions, and industrial structures, with having a total area of 11.87 sq. km (4.04%) (Figure 3 and Table 1). The study area is connected mainly with road transportation network facilities.

Water bodies

This includes both natural and man-made water features, namely Streams, lakes, canals, tanks, and reservoirs. The shallow water and deep water features appear in light blue to dark blue. Tanks with plantation are identified by the square/rectangle shape and blue color tone. Small canals are noticed in the area covered by vegetation areas. Tanks are mostly concentrated in the middle part of the study area with few (dry tanks) scattered around in the eastern parts. The water bodies in the study area occupy 3.30 sq.kms (1.12%) of the total area (Table 1).

Though the Veerupunayini Palli area comprises geomorphological features like low dissected hills and valleys, pediment–pediplain complex with water bodies but water table dries out quickly by March. Moreover, the water bodies occupy a meager percentage (3.3 %) of the area (Figure 3 and Table.1). To have a proxy on better water management, it is imperative to generate a drainage system map which in turn controlled by lithology. The lithological and drainage maps serve as baseline data to the policy and decision-makers for the construction of watersheds, artificial recharge sites at the appropriate locations or points which helps for the recharge of the water table for the better monitoring, management, and utilization of water for domestic, agricultural and industrial use.

Lithological Map

To generate the drainage map and lithological map orthorectified Digital Elevation Model (DEM) of Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data with 30m resolution has been used in the present study. Numerous researchers (Madani and Emam, 2009; Pour *et al.,* 2011; Rajendra *et al.,* 2012; Liu *et al.,* 2014; Masoumi *et al.,* 2017) have used ASTER data in geological mapping and discerning rock units through indirect evidence that can be visible at the surface mainly due to distinctive spectral signatures bands of the ASTER data in the Visible/Near-InfraRed (VNIR), Short Wave Infrared (SWIR) and Thermal Infrared (TIR) parts of Electro-Magnetic (EM) spectrum. The lithological map of the study area is given (Figure 4). The study area i.e. Veerupanayini Palli forms as a part of the Cuddapah basin which comprises predominantly sedimentary formations. From ASTER spectral signatures it is found that most of the study area consists of purple shale with volcanic flows, emplaced quartzite rock with conglomerate in concordant form having North East–South West trend (Figure 4). The other rock types found in the study area are quaritize, shale tuff/ dolomite, and Vempalli dolomites.

Drainage System Map

To generate the drainage system map ASTER DEM data of 30m resolution has been used and the drainage pattern of the study area is extracted by using Arc GIS software (9.3). The drainage system is defined as the pattern formed by streams, rivers, and lakes in a particular area or region. The drainage pattern of an area depends on the geological structures or lithological controls of the underlying rocks. It is realized that the dendritic drainage pattern (tree-like branching) (Figure 5) is the dominant type that unravels the homogenous rock type i.e. purple shale which is confirmed by the lithological map (Figure 4).

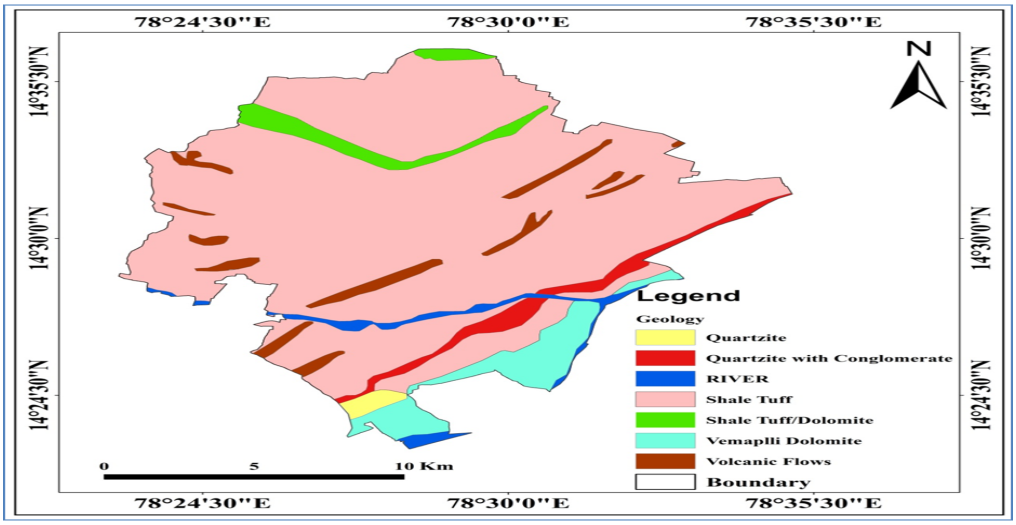

Figure 4. Lithology of the study area

Stream Order (U)

The first and foremost step in the drainage analysis is giving stream order (U) based on the hierarchical ranking of the stream. Strahler (1964) stream ordering procedure has been adopted in this study. The smallest unbranched stream is designated as the first-order stream. The confluence of two first-order streams gives a segment and named a second-order segment (Figure 5). The two-second order segments confluence gives a third-order segment or stream and so on. The confluence of two different order channels assigned the higher-order number. The mainstream through which most of the water discharges designated as the highest stream order number. The study area has five (V) order streams (Table 2).

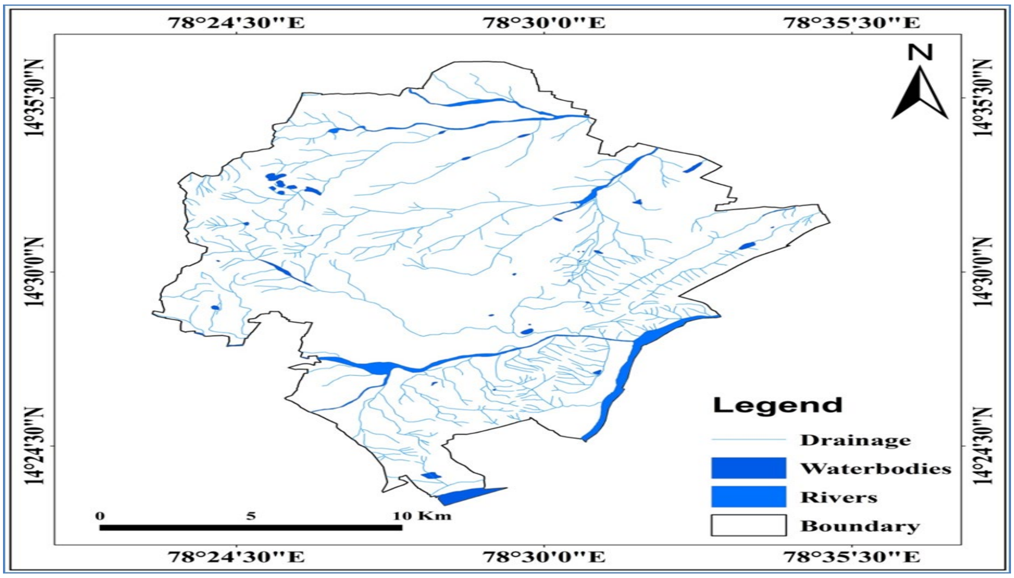

Figure 5. Drainage map of the Study area

Table 2. Details of Drainage Map Analysis

S. No	Stream order	No. of streams	Bifurcation ratio
1.	I	245 (63.3%)	-
2.	II	107 (27.6%)	2.29
3.	III	28(7.2%)	3.83
4.	IV	5(1.1%)	6.5
5.	V	2 (0.8%)	2.2

Stream Number (Nµ)

It has 387 number of streams irrespective of the order number of which 245 (63.6%), 107 (27.6%), 28 (7.2%), 5 (1.1%) and 2 (0.8%) number of streams belongs to 1st, 2nd, 3rd, 4th, and 5th order respectively. The consistent decrease in the number of streams in relation to the stream order indicates the more runoff and erosional landforms, (Wakode *et al.,* 2013; Haghipour and Burg, 2014) which again reiterates the existing lithological rock type i.e., purple shale (Figure 4) which have high porosity and low permeability nature.

Bifurcation Ratio (R_b)

Bifurcation ratio is an important drainage analysis parameter which refers to the water carrying capacity and flood potentiality of an area (Horton 1945; Joji *et al.,* 2013; Kim and Jung., 2015) which can be evaluated as the ratio of the number of streams in a given order (U) to its next higher-order (U+1) (Strahler, 1952; Strahler, 1964; Nautiyal, 1994). The bifurcation ratio for different orders in the study area is 2.29 to the first and second-order, 3.83, 6.5, and 2.2 to the second to third order, third to fourth-order, and fourth to fifth-order

 P-ISSN: 2659-1561
E-ISSN: 2635-3040

respectively with 3.705 mean bifurcation ratio (R_{bm}). The gradual increase of bifurcation ratio from first to fourth order indicates mature geomorphological adjustment further the mean bifurcation ratio i.e., 3.705 suggests the drainage pattern of the basin has not affected by the structural disturbances but controls by the lithological rock units that were existed (Prafull Singh *et al.,* 2013; Avijit Mahala, 2020).

Conclusion

The present chapter focuses on the digitization of LULC patterns of the Veerupanayini Palli Mandal, Kadapa district, Andhra Pradesh, India which is witnessing the rapid growth of urbanization, industrialization, and sustainable increase in population. The aim of the present study to know the current status of the natural resources viz., water, land, soil, cropping patterns, forest cover, etc., by using satellite and field data which assists as baseline data to the policymakers and decision-makers in further land use besides generating the thematic maps like drainage map, land use/land cover map, lithological maps, etc.

The total area of the region is 293.64 sq.km. From the LULC map, it is evident that the barren land/wasteland occupies a lion's share in area wise followed by agricultural lands. The water bodies in the study area exist at a very low percentage, hence it is imperative to have a better understanding of lithological units and drainage system which controls the hydrological conditions. The lithological and drainage maps were generated. From ASTER data spectral signatures it is found that most of the area consists of purple shale with volcanic flows and quartzite with conglomerate rocks. It is understood from the drainage map that the dendritic drainage pattern (tree-like branching) is the dominant type that unravels the homogenous rock type.

The highest stream order available in the study area is 5, with a total of 387 streams/segments. The consistent decrease in the number of streams concerning the stream order indicates the more runoff and erosional landforms and the mean bifurcation ratio i.e. 3.705 suggests the drainage pattern has not affected by the structural disturbances but controls by the lithological rock units i.e. purple shale.

Conflicts of interest: The authors declare no conflicts of interest.

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Citation: Pramod Kumar, M., Lakshmi Prasad, T., Jayaraju, N., Nagalakshmi, K., Lakshmanna, B., Srinivasa Gowd, S. and Ratnakar, P.J. 2020. Assessment of Land Use Land Cover Patterns and Impacts: A Case Study from Cuddapah Basin, India. International Journal of Recent Innovations in Academic Research, 4(6): 43-52.