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Land Use & Land Cover System Using Remote Sensing and GIS

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Abstract:

This work explains the Land Use/ Land Cover classification, Land-cover refers to the physical characteristics of earth's surface, captured in the distribution of vegetation, water, soil and other physical features of the land, including those created solely by human activities e.g., settlements. Land-use refers to the way in which land has been used by humans and their habitat, usually with accent on the functional role of land for economic activities. Change detection is the measure of the distinct data framework and thematic change information that can guide to more tangible insights into underlying process involving land cover and land use changes than the information obtained from continuous change. Digital change detection is the process that helps in determining the changes associated with land use and land cover properties with reference to geo-registered multi-temporal remote sensing data.

It helps in identifying change between two (or more) dates that is un-characterized of normal variation. Change detection is useful in many applications such as land use changes, habitat fragmentation, rate of deforestation, coastal change, urban sprawl, and other cumulative changes through spatial and temporal analysis techniques such as GIS (Geographic Information System) and Remote Sensing along with digital image processing techniques. GIS is the systematic introduction of numerous different disciplinary spatial and statistical data that can be used in inventorying the environment, observation of change and constituent processes and prediction based on current practices and management plans.

Remote Sensing helps in acquiring multi spectral spatial and temporal data through space borne remote sensors. Image processing technique helps in analyzing the dynamic changes associated with the earth resources such as land and water using remote sensing data. Thus, spatial and temporal analysis technologies are very useful in generating scientifically based statistical spatial data for understanding the land ecosystem dynamics. Successful utilization of remotely sensed data for land cover and land use change detection requires careful selection of appropriate data set. This paper discusses the land use/land cover analysis and change detection techniques using GRDSS (Geographic Resources Decision Support System).

GRDSS is a freeware GIS Graphic user interface (GUI) developed in Tcl/Tk(Tool Command Language**)** is based on command line arguments of GRASS (Geographic Resources Analysis Support System). It has the capabilities to capture, store, process, display, organize, and prioritize spatial and temporal data. GRDSS serves as a decision support system for decision making and resource planning. It has functionality for raster analysis, vector analysis, site analysis, and image processing, modeling and graphics visualization. This help in adopting holistic approaches to regional planning which ensures sustainable development of the region.

Keywords:

Land use/Land cover Dynamics, Change detection, GIS, Remote Sensing, GRASS, GRDSS

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Introduction:

We perceive the surrounding world through our five senses. Some senses (touch and taste) require contact of our sensing organs with the objects. However, we acquire much information about our surrounding through the senses of sight and hearing which do not require close contact between the sensing organs and the external objects. In another word, we are performing Remote Sensing all the time.

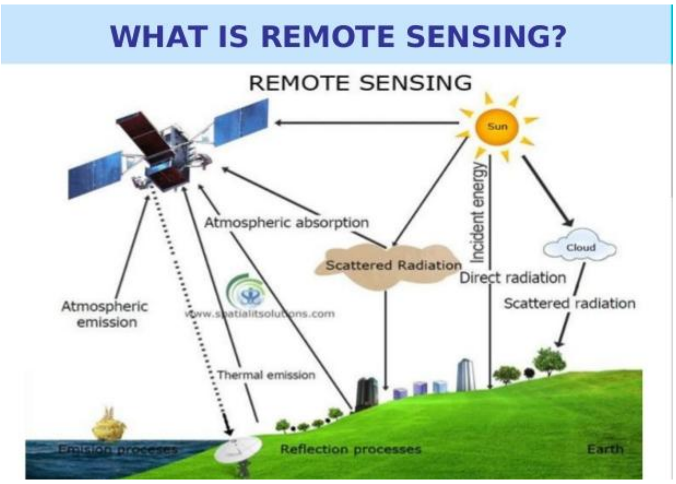

Figure 1 Remote sensing process

Generally, Remote Sensing refers to the activities of recording/observing/perceiving (sensing) objects or events at far away (remote) places. In remote sensing, the sensors are not in direct contact with the objects or events being observed. The information needs a physical carrier to travel from the objects/events to the sensors through an intervening medium. The electromagnetic radiation is normally used as an information carrier in remotesensing. The output of a remote sensing system is usually an image representing the scene being observed. A further step of image analysis and interpretation is required in order to extract useful information from the image. The human visual system is an example of a remote sensing system in this general sense. In a more restricted sense, remote sensing usually refers to the technology of acquiring information about the earth's surface (land and ocean) and atmosphere using sensors on board airborne(aircraft, balloons) or Space-borne (satellites, space shuttles) platforms.

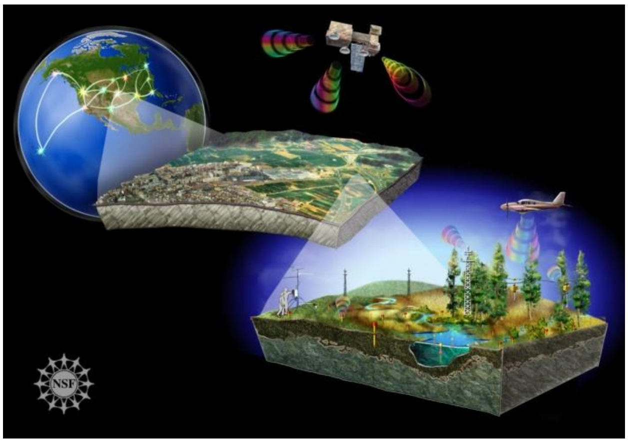

Figure.2.Remote sensing process

Overview of Remote Sensing:

Remote sensing (RS), also called earth observation, refers to obtaining information about objects or areas at the Earth’s surface without being in direct contact with the object or area. Humans accomplish this task with aid of eyes or by the sense of smell or hearing; so, remote sensing is day-today business for people. Reading the newspaper, watching cars driving in front of you are all remote sensing activities. Most sensing devices record information about an object by measuring an object’s transmission of electromagnetic energy from reflecting and radiating surfaces.

Figure 3 Satellite view

Remote sensing techniques allow taking images of the earth surface in various wavelength region of the electromagnetic spectrum (EMS). One of the major characteristics of a remotely sensed image is the wavelength region it represents in the EMS.

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Some of the images represent reflected solar radiation in the visible and the near infrared regions of the electromagnetic spectrum, others are the measurements of the energy emitted by the earth surface itself i.e. in the thermal infrared wavelength region. The energy measured in the microwave region is the measure of relative return from the earth's surface, where the energy is transmitted from the vehicle itself. This is known as active remote sensing, since the energy source is provided by the remote sensing platform. Whereas the systems where the remote sensing measurements depend upon the external energy source, such as sun are referred to as passive remote sensing systems.

Principles of Remote Sensing:

Detection and discrimination of objects or surface features means detecting and recording of radiant energy reflected or emitted by objects or surface material (Fig. 1). Different objects return different amount of energy in different bands of the electromagnetic spectrum, incident upon it. This depends on the property of material (structural, chemical, and physical), surface roughness, angle of incidence, intensity, and wavelength of radiant energy.
The Remote Sensing is basically a multi-disciplinary science which includes a combination of various disciplines such as optics, spectroscopy, photography, computer, electronics and telecommunication, satellite launching etc. All these technologies are integrated to act as one complete system in itself, known as Remote Sensing System. There are a number of stages in a Remote Sensing process, and each of them is important for successful operation.

Stages in Remote Sensing

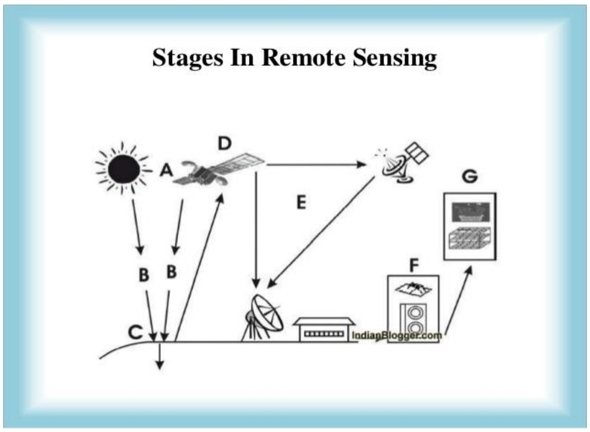

Figure 4 Stages in Remote Sensing

- Emission of electromagnetic radiation, or EMR (sun/self- emission)
- Transmission of energy from the source to the surface of the earth, as well as absorption and scattering
- Interaction of EMR with the earth's surface: reflection and emission
- Transmission of energy from the surface to the remote sensor
- Sensor data output
- Data transmission, processing and analysis

GEOGRAPHIC INFORMATION SYSTEM (GIS)

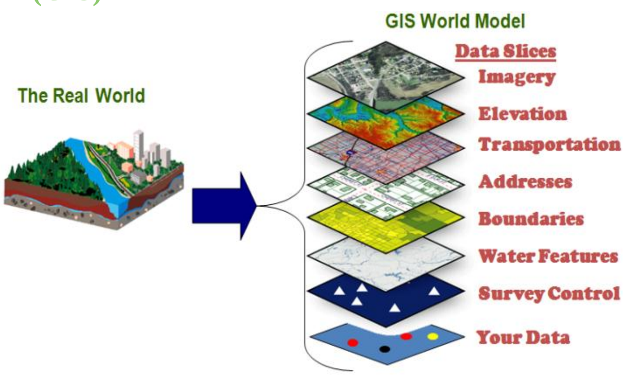

Figure 5 Geographic Information Systems

GIS are decision support computer based systems for collecting, storing, presenting and analysing geographical spatial information. These systems are spatially referenced databases giving users the potentiality to control queries over space, and usually

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through time. GIS is much more advanced than Computer Aided Design (CAD) or any other spatial data system. The basic output of GIS or spatial data analysis system is a map. The need to analyse maps to compare and contrast patterns of earth related phenomena, is confirmed by the long standing tradition of doing so with traditional maps. Many geographical phenomena are best described scientifically as fields. Good examples are topographic elevations, air temperatures, and soil moisture content. A 2-dimensional field may be defined as any single valued function of location in a 2-dimensional space and discrete fields, with nominal dependent variables. It appears that any geographical phenomenon can be represented either as a field or as a collection of digital objects. For example, a set of states or revenue or administrative units like mandals within a country would commonly be represented in a GIS as a set of areal objects, or as a set of linear objects that form their boundaries. Fields can be digitally represented by vector approaches, but are often represented by raster data structures.

Overview of Information System

GIS might provide the medium for studying one or more of the fundamental issues that arise in using digital information technology to examine the surface of the earth or any related systems. The Resource Information System (RIS) for agricultural management, for instance, has to be considered multidimensional with attribute dimension, spatial dimension and temporal dimension. Geographic Information System (GIS) offers capabilities of integrating multisector, multilevel and multiperiod database. GIS is a computerized database system for capture, storage, retrieval, analysis, and display of spatial data. It is a general-purpose technology for handling geographic data in digital form, and satisfying the following specific needs, 'among others

- The ability to pre-process data from large stores into a form suitable for analysis, including operations such as reformatting, change of projection, resampling, and generalisation.
- Direct support for ana1lysis and modelling, so that form of analysis, calibrations of models, forecasting, and prediction are all handled through instructions to the GIS.
- Post processing of results including such operations as reformatting, tabulation, report generation, and mapping.

Remotesensing Process For Landuse & Landcover Background

Remote sensing has become a powerful tool for the regional mapping of natural resources and geological features. Starting with the use of image during the early stages of development of remote sensing in the mid-seventies, enough progress has been achieved in data interpretation with the easy availability of digital data. Digital processing of remote sensing data have gained momentum in the last decade. In India, with the establishment of remote sensing centres all over the country in recent years, attention has been focused on the large scale data processing for natural resources evaluation. One important aspect in remote sensing is the characterisation and classification of spectral measurements taken from satellites into various features of the land surface. Pattern recognition can be carried out if appropriate procedures are adopted for classification.

Although several classification methods were developed in the field of statistics, their applicability to the processing of data was limited due to the spatial variation of natural features. In classification studies, it is often desirable to know how well the classes can be separated by observing the values of some feature vector for a set of samples (Toll 1984). In other words, one wants to know how much information the features provide for distinguishing the classes. To answer these questions a measure is needed to quantify the amount of information on the features. The objective of this study is to improve the classification accuracy of obtaining accurate and cost effective information about the features. This study utilises a multiband data set to determine the effectiveness in improving the classification.

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The study assesses the utility of the multi-band data for the study of the urban environments, the land covers which are often difficult to examine accurately with remotely sensed data. It also attempts to examine the classification accuracy of a number of land cover classes for different band combinations and the potential of the classification method. The emphasis is on the use of Maximum Likelihood Calcification and the derivation of meaningful confidence level to all land cover classes. (Anji Reddy and S. Srinivasulu, 1994)

Classification Methodology

During the testing of a maximum likelihood classifier for land use classification in the Hyderabad region, the need arises for an account of the application of statistical confidence level assessments in remote sensing. Such an account is necessary in evaluation of the classification which consists of the following components:

(i) The acquisition of data.
(ii) A decision to the level of class separability desired and attainable.
(iii) The selection of training areas which will suit a given computer-based classification software package.
(iv) The effective operation of the package.
(v) The selection of an appropriate threshold for each class to apply likelihood distribution of that class.
(vi) The creation of appropriate output production.

In the present study, Indian Remote Sensing Satellite is used as the data acquisition system and IDRISI software package for the analysis of data. This software uses a Maximum Likelihood Classifier. Each pixel is classified, using IDRISI, into the most likely class type.

The traditional method of storing, Analysing and presenting spatial data is the map. The accuracy of interpretation for the several categories should be about equal. For this paper 2003,2008 and 2009 data have been taken for classifying. The classification system should be applicable over extensive areas. The map is the features of the earth drawn to scale.

Categories should be divisible into more detailed sub categories that can be obtained from large-scale imagery or ground surveys. Aggregation of categories must be possible. Compression with future land use land over data should be possible.

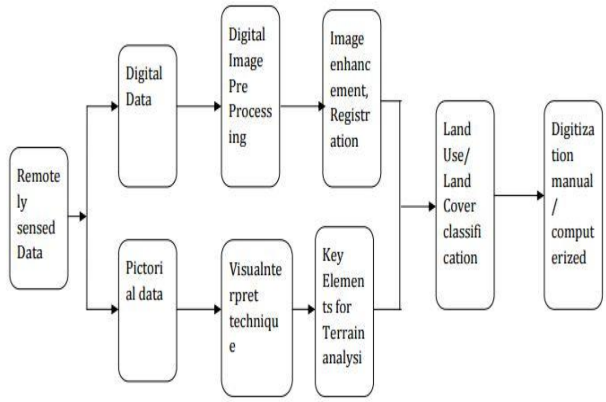

Figure 6 Remote sensing Process for Land use and Land cover

For efficient planning and management, the classified data in a timely manner, in order to get the classified data of the ground; satellites are the best resources to provide the data in a timely manner.Significance is that the data can be acquired by our eyes and the energy can be analyse, But satellites are capable of collecting data beyond the visible band also. This will help us to analyse the new things which are not possible in visible band.

Case Study

An Analysis On Land Use/Land Cover Using Remote Sensing And GIS – A Case Study In And Around Vempalli, Kadapa District, Andhra Pradesh, India

Study area

The study area lies between Kadapa and Pulivendula, Kadapa district, Andhra Pradesh, India, situated between parallels of 78°20’ to 78°35’E longitude and 14° 15’ to 14°30’N latitude with intended boundary falling in Survey of India top sheet no.57J07 and 57J11. The total area covered is approximately 711 square kilometres.

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Location map of the study area

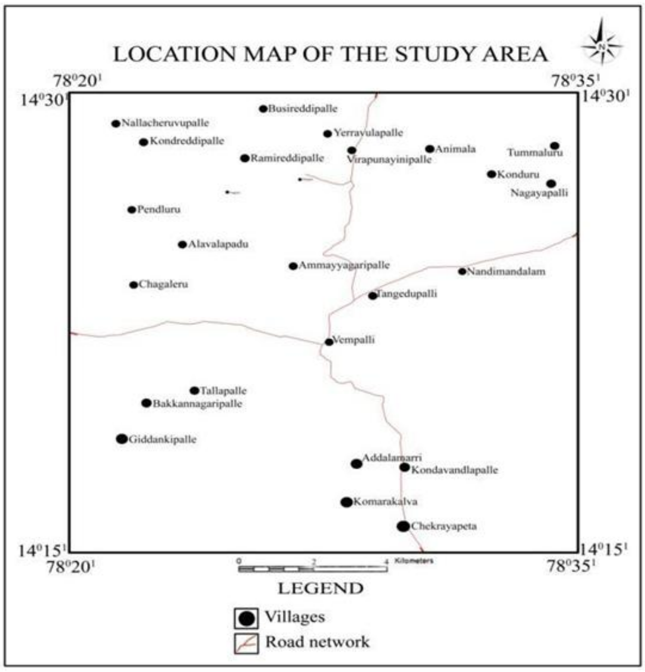

Figure 75 Location map of the study area

The climatic conditions of this area as its minimum temperature in November-January at about 28-30° C, The hottest temperature ranges between the 40-45°C ranges during April-May. There are extensive outcrops of limestone, Dolomites, Granite and Quartzite in major parts of the area, which could be utilised as building material. The major minerals in the study area are vein type barites, asbestos and the small deposits of white clay and iron ore. Vempalli, Chakrayapeta, Virapunayunipalli are the mandal headquarters and Nandimandalam, Komarakalva, Kondavandlapalli, Addalamarri, Tallapalli, Bakkannagaripalli, Giddankipalli, Ammayyagaripalli, Chagaleru and Tummuluru are the important villages in the study area.

Objectives

- To study the present status of water resources, natural resources, land resources, soil productivities, cropping patterns, forest cover etc. using satellites data, collateral data and field data.
- To prepare the thematic maps namely location, land use-land cover, and drainage.
- To prepare action plan for land resources and water resources.

Materials and methods

The study has made use of various primary and secondary data. These include Survey of India (SOI) topographic sheets of 57J07 and 57J11 of 1:50,000 scale and satellite image IRS P6 geocoded data of 1:50,000 scale. The Indian Remote Sensing Satellite (IRS) data was visually and digitally interpreted by using the image interpretation elements (such as tone, texture, shape, pattern, association etc.) and ArcGIS software was used 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 main goal of this study is to extract the land use/land cover changes and categories of the study area.

Preparation of thematic map

These maps are the true representation of earth's phenomena such as spatial distribution of natural resources existing at the time of survey (Ravi Gupta, 2003). In the present study satellite image (IRS P6) which is a true record of the various environmental resources information on the base map. These map showing spatial distribution of forest, agriculture, soil, water resources etc., and prepared by visual interpretation of the satellite imagery. Visual interpretation is carried out based on the image characteristics like tone, size, shape, pattern, texture etc. in conjunction with existing map/literature. These pre-field thematic maps are modified substantiated and confirm after limited field checks.

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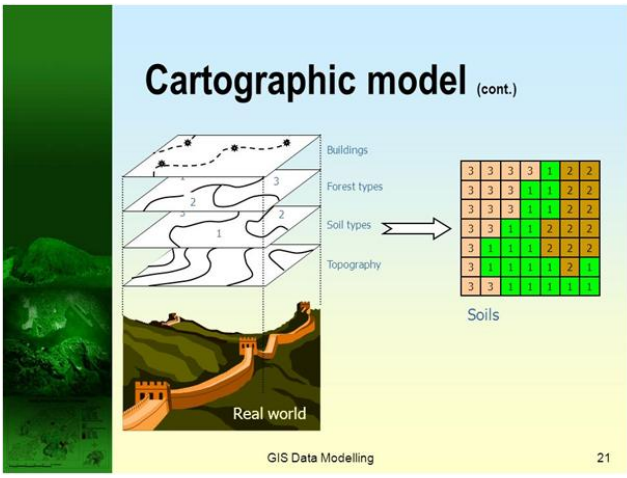

Figure 8 Cartographic Model

Results and Discussions

Analysis of Land use /Land covers by using Remote Sensing Data:

The land use/land cover categories of the study area were mapped using IRS P6 data 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 and land cover classes interpreted in the study area include, built-up land, cultivated land, forest land, uncultivated lands and water bodies.

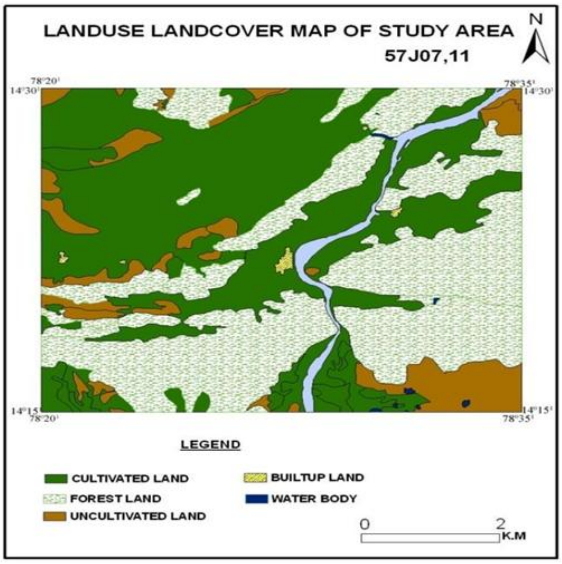

Figure 9 Land use/ Land cover map of the Study area

Table 1 Land use land covers classification system

LEVEL 1	Area in Sq. Km	Percentage of the area %
1.Built-up land	8.2	1.15
2. Cultivated land	335.13	47.13
3.Forest land	296.55	41.71
4.Water bodies	1.42	0.2
5.Uncultivated land	69.60	9.79

Detailed accounts of these land use /land cover classes of the study area are described in the following section.

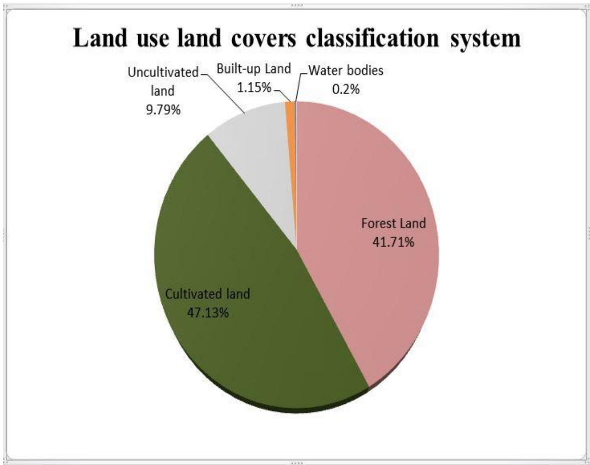

Figure 10 Land use land cover classification system

Built-up Land

Figure 11 Built -up land

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Built up land is composed of areas of intensive with much of the land covered by structures. Included in this category are cities, towns, villages, industrial and commercial complexes and institutions. In the study area major towns or villages are vempalli, Nandimandalam, Chagaleru, Tallapalle, etc. The transportation facilities in the study area are roads. The highway roads are present in the area are routes between, Pulivenduala- Kadapa, Vempalli- Rayachoti, Vempalli-Jammalamadugu. The industrial mining of asbestos, serpentine and uranium minerals is carried out at some places in the study area.

Cultivated land

Figure 12 Cultivation land

All the cultivated land with or without crops orchards and plantations are considered in this class. This land use class is further subdivided into two sub-classes they are wet land (crop land) and dry land (fallow land). Crop lands are the agricultural lands under crop. In the study area the crop lands have wet cultivation and dry cultivation. Wet cultivation includes food crops such as paddy, wheat, etc. Were present on either side of the Papagni River and its tributaries noticed in Vempalli Tummuluru, Konduru, Alavallapadu, Kondavandlapalli, Ramireddipalli and Addalamarri. Dry cultivation includes trees orchards, groundnut, etc. and the areas which have this type of cultivation is noticed at Ammayyagaripalli, Virapunayanipalli, Chagaleru, Chakrayapeta etc.

Fallow lands refer to all land which was taken up for cultivation but is temporarily out of cultivation for a particular period. The study area have more fallow lands and are surrounded by the villages of Tangedupalli, Giddankipalli, Alavallapadu, Busireddipalli, Nandimandalam, Etc.

Forest Land

Figure 13 Forest Land

Forest, comprises of thick and dense canopy of trees. These lands are identified by their red to dark red tone and varying in size. They are irregular in shape with smooth texture. The forests are found on the south eastern part of the study area. The study area covers mostly the dense and scrub forest. The relative concentration of scrubs, bushes and smaller trees are predominant in this category. In the satellite image such forest are identified by yellow tone with smooth texture. The forest areas are Giddankipalli, Kondavandlapalli, Nagayapalli, Animala, Busireddipalli, etc.

Water Resources

The water bodies include both natural and man-made water features namely rivers / streams / lakes / tanks and reservoirs. The water features appear black in tone in the satellite image. The shallow water and deep water features appear in light blue to dark blue in colour. Tanks with plantation are identified by the square/rectangle shape and red colour tone. Tanks without plantation are recognized by the shape and light blue to dark blue tone. Embankments are noticed

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in Kondavandlapalli, Alavallapadu, Bakkannagaripalli, Chakrayapeta, Busireddipalli etc. A major river Papagni flows in the study area. Small canals are noticed in the vegetation area. Tanks are mostly concentrated in the south east and North West parts of the study area with few dry tanks scattered around in the northern parts.

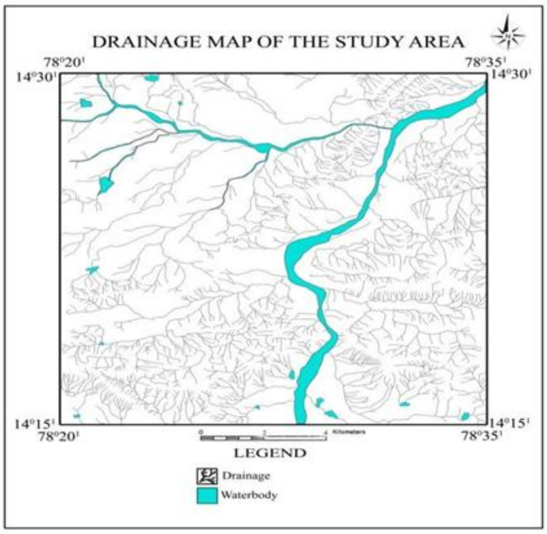

Figure 14 Drainage map of the study area

Uncultivated Land

Figure 15 Uncultivated Land

Land, which does not support any vegetation are known as uncultivated lands or waste lands. Barren rocky, salt affected land, land with and without scrub, sandy area, sheet rocks and stony regions include in this category. Such lands are formed due to the chemical and physical properties of soil, temperature, rainfall and local environmental conditions. In the study area uncultivated lands are present in the south east part.

i) Land with scrub: These lands are subject to degradation, erosion or thorny bushes. Such areas are identified from their yellowish tone and their association with uplands, and their irregular shapes. Land with scrub found in the western part of the study area.

CONCLUSION:

Based on the results obtained by employment of GIS and RS applications to achieve the specific research objectives, it is concluded that the land cover/land use practices in the study area have altered significantly classified as per the major land use/land cover types. The Indian Remote Sensing Satellite (IRS) data, image processing and Geographical Information System techniques were used to identify the land use categories such as built-up lands, cultivated lands, forest lands, water bodies and uncultivated lands. Satellite images in combination with predated topographic sheet of Survey of India were used for analysing land use and land cover change detection.

It is helpful for further macro and micro level planning. With the help of Geographic Information System the various land use and land cover zones are mapped, which in turn helps for decision maker for planning purpose. The cultivated lands are well distributed throughout the study area and it covers 335.13 sq. km (47.13 per cent). Forest occupies 296.55 sq. km and sharing about 41.71 per cent of the total land use land cover of the study area. The built-up land occupies 8.2 sq. km (1.15 per cent) and there was a rapid expansion of built-up lands. Uncultivated land occupies 69.60 sq. km (9.79 per cent). A water bodies occupy 1.42 sq. km (0.2 per cent) but well developed dendritic drainage pattern is there in the study area.

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