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MACHINE LEARNING APPROACH FOR CLASSIFICATION OF LAND USE LAND COVER CHANGES OVER A REGION USING SATELLITE DATA

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ABSTRACT
In recent years, the data science and remote sensing communities have started to align due to user friendly programming tools, access to high-end consumer computing power, and the availability of free satellite data. In particular, publicly available data from the European Space Agency's Sentinel missions have been used in various remote sensing applications.
Land use and land cover (LULC) maps in many areas have been used by companies, government offices, municipalities, and ministries. Accurate classification for LULC using remotely sensed data requires State of Art classification methods. The SNAP free software and ArcGIS Desktop were used for analysis and report.
In this study, the optical Sentinel-2 images were used. In order to analyze the data, random forest (RF) algorithm was used. An accuracy assessment is also applied to the classified results based on the ground truth points or known reference pixels. The overall classification accuracy of 83,64% was achieved using RF. The study indicated that of RF algorithm achieved satisfactory results for LULC maps.

INTRODUCTION
Background to the Study:
This land use /land cover pattern of a region is an outcome of natural and socio- economic factors and their utilization by man in time and space. Hence, information on land use/ land cover is essential for the selection, planning and implementation of land use and used to meet the increasing demands for basic human needs and welfare. This information also as sists in monitoring the dynamics of land use resulting out of changing demands of increasing population
Why remote sensing
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 known as the Remote Sensing System are integrated to act as a complete system in itself. Remote Sensing is a way to obtain data about an object's characteristics without physical contact with it. It is a technology for examining electromagnetic radiation, acquiring and interpreting non-immediate geospatial data from which information on the characteristics of the objects on the earth's surface, oceans and atmosphere is extracted. Remote sensing offers

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useful information on resources, meteorology and climate in a short time, leading to better management of resources and thus speeding up domestic growth. As can be seen from the Figure 1.1, the sun's radiation falls on all objects on the Earth. The outgoing radiation from the object depends on its nature and properties.

This radiation is collected by a sensor in the satellite and analyzed further for identification of the object. Thus, basically remote sensing consists of three components viz., source of radiation, Object and sensor.

Earlier, when there was no remotely sensed data and the assistance of computers, land use / land cover change was detected with the help of tracing paper and topographic sheet. But then this method was tedious and studying large areas required lot of effort and time. Conventional ground methods of land use mapping are labor intensive, time consuming and are done less frequently.

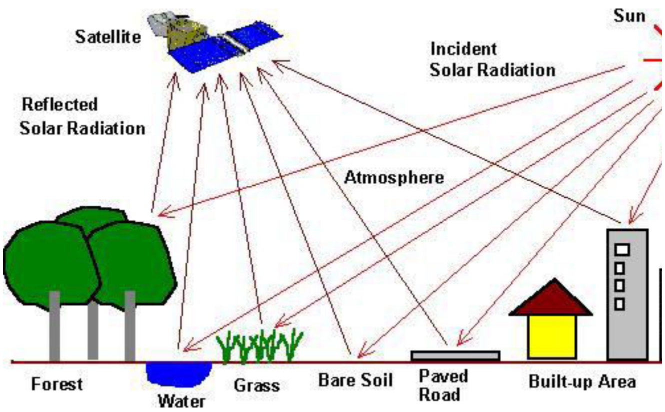

Fig 1: Remote Sensing

Earlier, when there was no remotely sensed data and the assistance of computers, land use / land cover change was detected with the help of tracing paper and topographic sheet. But then this method was tedious and studying large areas required lot of effort and time. Conventional ground methods of land use mapping are labor intensive, time consuming and are done less frequently. Thus, with the advent of satellite remote sensing techniques, preparing accurate land use and cover maps and moving monitoring changes at regular intervals of time is relatively simpler. In case of in accessible region, the only method of obtaining required data is by applying this technique.

Today remote sensing and GIS technology has enabled ecologists and natural resources managers to acquire timely data and observe periodical changes. With multi-temporal analyses, remote sensing gives unique perspective of how rural area evolves. The most important element for mapping land use changes due to mining is the ability to discriminate between rural users (farming, forests, and water body) and quarries. "Remote sensing methods can be employed to classify types of land use in a practical, economical and repetitive fashion, over large areas".

DEFINITION OF TERMS:

Remote Sensing:

It is defined as any process whereby information is gathered about an object, area or phenomenon without being in contact with it. Given this rather general definition, the term has come to be associated more specifically with the gauging of interactions between earth surface materials and electromagnetic energy. On the other hand it is the science of acquiring, processing and analyzing information.

Geographic Information:

A computer assisted system for the acquisition, storage, analysis and display of geographic data.

Land Use:

This is the manner in which human beings employ the land and its resources.

Land cover:

It implies the physical or natural state of the Earth's surface.

Ground Control points :

Ground Control Point can be defined as a point on the earth surface with know location (i.e. fixed within an established co-ordinate system) which is used to geo-reference image data sources, such as remotely sensed images or scanned maps.

Mosaicking :

Mosaicking is the process of joining two geo-referenced images into one.

Geo-referencing :

It is the place name or street address. (Wikipedia process of establishing the correct position of an aerial photograph within a map or finding the geographical coordinates of a)

2. LITERATURE REVIEW

With the advent of the first remote sensing satellite (Landsat 1) in 1972 many land cover land use study have been undertaken. These studies were conducted in various areas including urban areas, agricultural area, mining area. For example, Singh et al (1997) has done detail study on the impact of coal mining and thermal power industry on land use pattern in and around Singrauli coalfields using Remote Sensing data and GIS. Database for land use was prepared for multispectral, multi-temporal data of years 1975, 1986 and 1991 of LANDSAT MSS and TM using PAMAP GIS software. The study revealed that areas mining and build up land increased from 1975 to 1991. There was substantial loss in agricultural and forest land which was due to rapid industrialization of the area.

Sarmaet al (2005) have worked on coal mining impact on land use/land cover in Jaintia hills district of Meghalaya, India using remote sensing and GIS technique used LANDSAT data of 1975, 1987, 1999 and 2007 to conclude that there was four fold increase in mining area from1975 to 2007 accompanied by three fold decrease in forest area. Visual interpretation technique was used for land use/land cover mapping for the different data of four years.

Another study was carried out by Anil et al (2010) on the impact analysis of open cast coal mines of Chandrapur district on land use land cover using remote sensing and GIS technique. The study was carried out using multi-temporal satellite data(IRS-P5 data of 2009 and 2010 and LANDSAT-5 data of 1990) to create a land use/ land cover mapping of the area and reported a 67% increase in mine area.

Ololadeet al (2008) have worked on land-use/cover mapping and change detection in the Rustenburg Mining Region using Landsat images was carried out using remote sensed data Landsat MSS in 1973 (4 bands), TM 1989, 1997, 1998 (6 bands) and ETM 2002 (6 bands) and topographic maps of 1969 and 2005,used as reference base maps of the region. Standard image Enhancements and registration was performed on the images.

Supervised classification was performed by using maximum likelihood method. Land-use classes woodland, grassland ,cultivated land, bare soil, rivers, dams, water ponds, built-up area, tailing dams and open cast mines were identified from satellite data and field surveys. Results showed that in the last three decades open cast mines, tailing dams; mine dumps and return water ponds have increased extensively in the Rustenburg region; vegetation has undergone a general decrease; woodland and grassland have been changed to cultivated land. An expansion of the built-up area can be explained by the fact that there was increase in the development of transport networks settlements developed over the years due to the immigration of mine workers in the area. Consequently, the landscape became highly disturbed due to increased mining and agricultural activities.

A detailed study has been done on the work of Edward et al (2009) on open pit gold mining and land use changes in Bogosu-Prestea area, south west Ghana. Land use change due to mining employed over a twenty year period(1986–2006) was analyzed with in the Golden Star Resources Bogoso Prestea Limited (GSRBPL) concession. The study revealed that mining in the area increased by 12.1 % in land coverage from 1986 to 2006 with decrease in agricultural land use from 97.8% in 1986 to 82.7% in 2006. Settlements increased from 0.45 % in 1986 to 4.95% in 2006 due to a

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rural– urban migration.

Another interesting work was done by Byeong-Hyeoket al on forest reclamation monitoring in the abandoned mine of the Samtan coal mining area located in the southern part of Jeongseon-gun, Gangwon-do, Korea. Effects of vegetation health for abandoned and forest recovered period using multi-temporal satellite datasets was analyzed. Vegetation and forest health was analyzed using NDVI mapping on the three multi-temporal Landsat 5 and 7 satellite datasets. Results from NDVI map identified the new recovered forests and hence confirmed that the natural forests are restoring their vegetation health.

A work on land cover change study of the Oil Sands Mining Development in Athabasca, Alta ,Canada was carried out by Natural Resources Canada (2005). The primary impact was assessed using an information extraction method applied to two LANDSAT scenes .The study was done Using two LANDSAT images of 1990 and 2001.

3. PROPOSED SYSTEM

We use Remote sensing data to classify and estimate land use/land cover data.
In these we are using active remote sensing feature of the sentinel-2 satellite.

Methodology

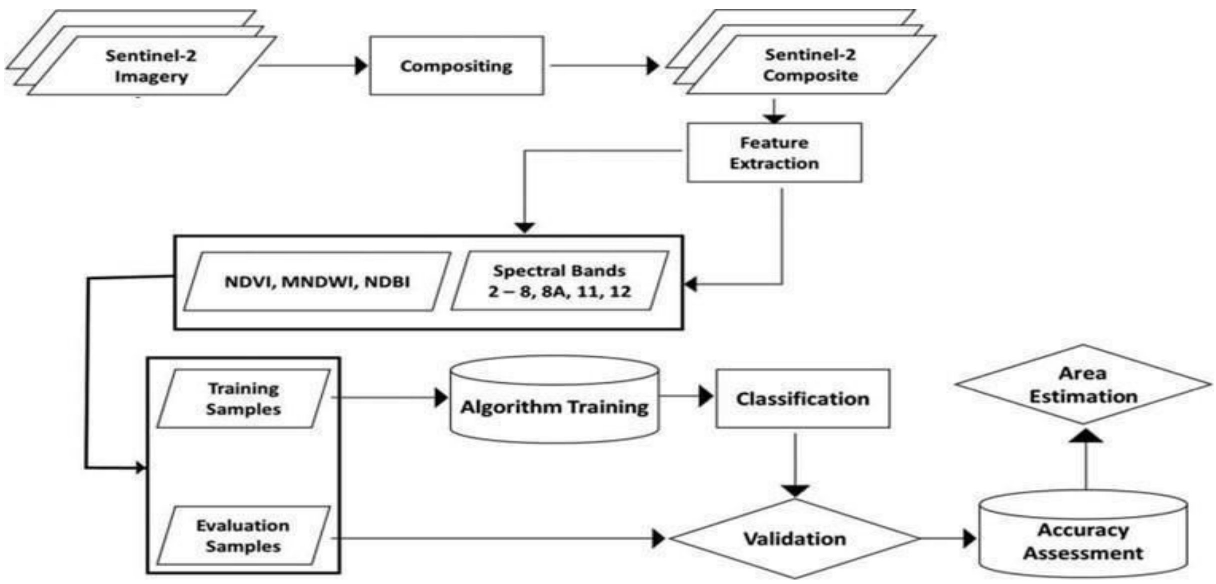

Fig 2: Methodology for Classification of data

Sentinel -2 imagery

The main objective of Sentinel 2 satellite are providing data for risk management, land use and land cover mapping, change detection, natural hazards, water management. Sentinel-2 gives global coverage every five days. It is equipped with a multispectral imager (MSI) with 13 bands.

Work Flow

A standard generic work flow to preprocess Copernicus Sentinel-2GRD data is presented here. The workflow was created in order to be used within the Sentinel application platform (SNAP), a common architecture for all Sentinel satellite toolboxes. The processing graph in 'xml' format allows the processing ofSentinel-2 GRD using the command line graph processing framework, which allows for batch processing of large datasets. The preprocessing work flowconsists of seven processing steps, designed to best reduce error propagation in subsequent processes, described here after in separate subsections. The code to perform the preprocessing work flow is available on the

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GitHub repository andin the Supplementary Materials as Computer Code.

Open and Display Sentinel-1Image

1. Initiate the SNAP tool
2. In the SNAP interface, go to File menu >> Open Product
3. Select the folder that contains the Sentinel-1data.
4. Open the image.
5. Double click the file name to view the directories within the file.
6. The World view window (in the lower, left-hand side) shows the coverage of the image opened.

ADVANTAGES

- The proposed solution for Land use land cover prediction model uses remote sensing data and provides result with better accuracy compared to other traditional approaches and it is very much practically implementable.
- It is only the practical way to obtain the data from inaccessible regions, e.g,Antartica,Amazonia
- At small scales, regional phenomena which are invisible from the ground are clearly visible

Examples: faults and other geological structures a classical example of seeing the forest instead of the trees.

- Cheap and rapid method of constructing base maps in the absence of detailed land surveys.
- Easy to manipulate with the computer, and combine with other geographic coverage's in the GIS.
- Usage of Latest processing tools for better and Precise Results.

METHODOLOGY

- Preprocessing was performed on the satellite data.
- Imported the vector data of various land types such as waterbodies, vegetation, barren lands, agricultural land, buildings etc.,
- Calculate NDVI for extraction of vegetation, NDWI for extraction of water bodies and NDBI for extraction of built up area.

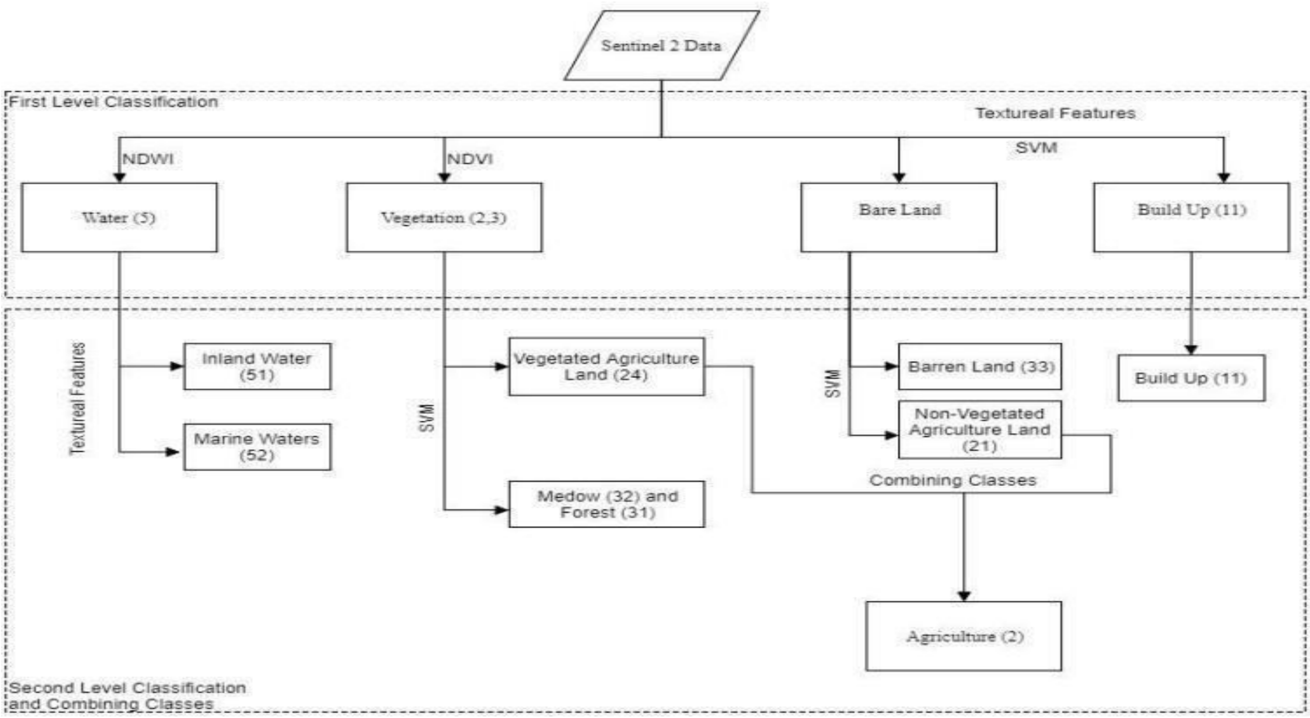

Fig 3: Representation of NDVI, NDBI, NDWI

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Normalized Difference Vegetation Index(NDVI)

Normalized Difference Vegetation Index (NDVI) uses the NIR and red channels in its formula.

Healthy vegetation (chlorophyll) reflects more near-infrared (NIR) and green light compared to other wavelengths. But it absorbs more red and blue light.

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Normalized Difference Water Index (NDWI)

The Normalized Difference Water Index (NDWI) is used to highlight open water features in a satellite image, allowing a water body to "stand out" against the soil and vegetation.
Since the NDWI index effectively measures moisture content, it is often compared with the NDMI index, also known as NDWI GAO.

In fact, there is a major difference in how the two are calculated and used. The NDMI makes use of the NIR-SWIR (near-infrared and short-wave infrared) combination to enhance the presence of water in leaves of plants. The NDWI, on the other hand, is calculated using the GREEN-NIR (visible green and near-infrared) combination, which allows it to detect subtle changes in water content of the water bodies.

NDWI = (Green – NIR)/(Green + NIR)

The Normalized Difference Water Index (NDWI) is derived from the Near-Infrared (NIR) and Green (G) channels. This formula highlights the amount of water in water bodies.

An alternate method of calculation uses the NIR and Short Wave Infrared (SWIR) channels [(NIR-SWIR)/(NIR+SWIR)]. The amount of water present in vegetation primarily affects the spectral reflectance in the SWIR channel. The information about vegetation contained in the SWIR channel is unique.

Normalized Difference bulitup Index (NDBI)

The Normalized Difference Built-up Index (NDBI) uses the NIR and SWIR bands to emphasize manufactured built-up areas. It is ratio based to mitigate the effects of terrain illumination differences as well as atmospheric effects.
NDBI = (SWIR – NIR) / (SWIR + NIR)

4. RESULT

This chapter describes results of landcover and land use analysis of multi- temporal satellite images.

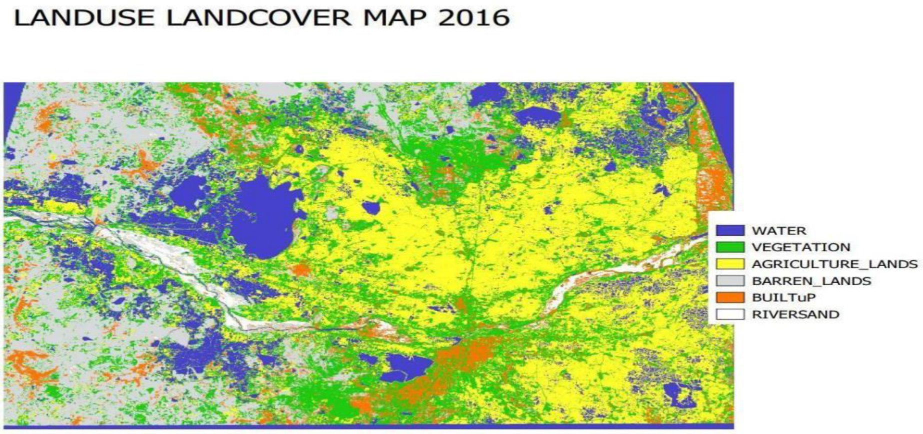

Figure 4.1: Landuse landcover map of Study area in 2016

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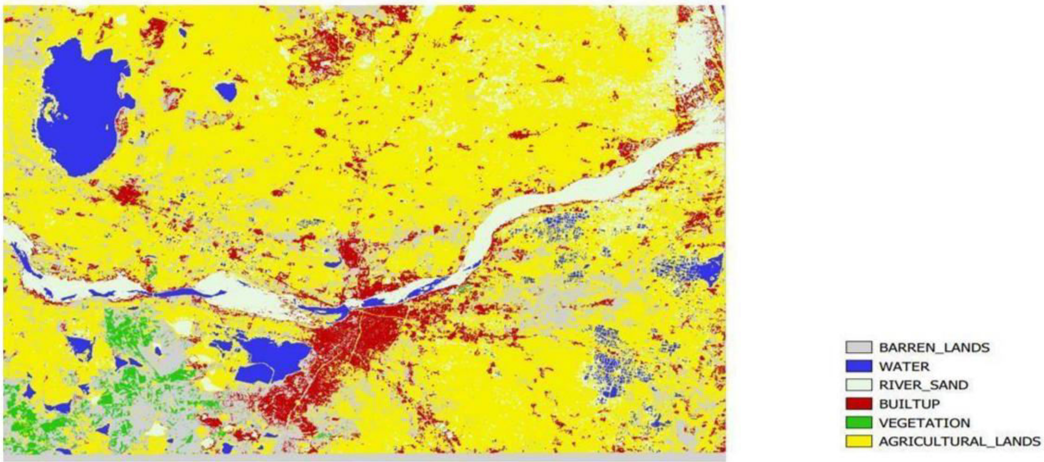
	WATER	VEGETATION	AGRICULTURAL LANDS	BARREN LANDS	BUILTUP	RIVER SAND
WATER	20	0	0	0	0	0
VEGETATION	0	17	3	0	0	0
AGRICULTURAL LANDS	0	5	13	1	1	0
BARREN LANDS	0	3	0	14	2	1
BUILTUP	0	0	0	3	14	3
RIVER SAND	0	0	0	1	3	16

Table 7.1: land use land cover category for the year 2016.

LANDUSE LANDCOVER MAP 2021



	WATER	VEGETATION	AGRICULTURAL LANDS	BARREN LANDS	BUILTUP	RIVER SAND
WATER	20	0	0	0	0	0
VEGETATION	0	15	4	1	0	0
AGRICULTURAL LANDS	0	4	14	1	1	0
BARREN LANDS	0	0	3	14	2	1
BUILTUP	0	0	0	4	14	2
RIVER SAND	0	0	0	1	5	14

Table 7.1: land use land cover category for the year 2022

There was an increase in built up area which may be attributed to an increase in settlement area, barren land and deforestation activities.

In 2021, land use land cover pattern has changed drastically with respect to 2016. Area under Waterbody witnessed a huge percentage increase of more than 12 percent.

Area occupied by increase in water body from 1 square kilometer to 1.6 square kilometer.

In 2021, area under agricultural land decreases more than 3 percent of the study area. This decrease can be attributed to the increase in built up area , water bodies like fisheries and prawn ponds..

5. CONCLUSION

In this study, LULC detection of Nellore region over the last five years had analyzed. The result of the study showed that significant change detection had observed during the study period. Agriculture and residential/urban areas showed an increasing trend of 12 and 9.1 %, respectively, while forest, bushland, and grassland showed a decreasing trend of 2.3, 9.8 and 10 %, respectively. This result revealed that the change of forest, bushland, and grassland to agricultural and residential areas which may problems including change in streamflow, soil degradation, and hydrological system in the basin. These changes could have implications for sustainable resource management and the livelihood of the local society. Therefore, improved land management practices (soil and water conservation), improved agricultural inputs, integrated watershed management (land use planning and management), and active participation of local community should be advance to prevent undesirable LULC dynamics in the basin. In this study, the change detection analysis using GIS and remote sensing could deliver useful information to understand the seasonal patterns of land use dynamics for planners and decision-makers consequently sustainable land management planning is possible.
At the outset, the result of the work showed that there was a rapid change of water bodies and built up area during the period from 2016 to 2021. Therefore, it can be concluded that increase in built up activities is damaging to vegetation. The present study can useful to identify the agricultural lands which are under risk due to fisheries, prawn ponds and built-up area.

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