Land Use/Land Cover Classification Using Normalized Difference Vegetation Index (NDVI) And PCA

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Abstract*—The Normalized Difference Vegetation Index(NDVI) is one of the most widely used vegetation index which uses red(RED) and near infrared (NIR)bands of electromagnetic spectrum, and is utilized for the analysis of remote sensing images to obtain the vegetation information of the target area. In this paper the land cover classification of Vijayawada region, Krishna district, Andhra Pradesh is analyzed using NDVI. Principal Component Analysis (PCA) is used to remove the redundant data in the images. Landsat8 images of the year 2020 were collected and derived NDVI values. Versatile bands of Landsat images are used to acquire the information of vegetation, water bodies, bare soil, and urban by applying NDVI and PCA, and compared results of NDVI and NDVI+PCA. Experimental results are compared where Overall Accuracy and Kappa coefficient are increased using NDVI+PCA.*

Key words: Remote sensing, Normalized Difference Vegetation Index (NDVI), Principal Component Analysis (PCA), Land Use Land cover, multi spectral images.

1. INTRODUCTION

Earth environment can be understood in a better way using Remote Sensing technology [1]. It is the Science and Art of getting information and extracting the attributes in form of Spectral, Spatial and Temporal about few physical objects, area development, such as vegetation, land cover classification, urban area, agriculture land and water resources without coming into physical contact of these objects [2]. Landsat is one of the most used remote sensing satellites .Features of Landsat 8 are as follows: It has two different operating sensors

i) Operational Land Imager (OLI)
ii) Thermal Infrared Sensor (TIRS) sensors,

Which have a total of 11 bands, consisting of 9 bands (band 1 - 9) situated at OLI and 2 bands (bands 10 and 11) at TIRS [3,4].

Change detection of Land cover is one of the most important techniques, widely utilized for planning and managing land [5]. In recent years, geographic information system and remote sensing have been employed for several applications admitting land use land cover change detection [5].

Land Cover provides information of physical assets on earth like forest,agriculture,barren land etc.[6],where information of land spatial distribution is also known as Land Use is a necessary input for numerous hydrological, climate and ecological models that aim to come through the natural resources and support in decision-making to face environmental issues[7].

Vegetation coverage for various time periods and for peculiar areas can be obtained using Normalized Difference Vegetation Index (NDVI).The NDVI aims to find land cover change caused by human action such as construction and development, and to analyze changes in vegetation because of environmental changes[10,11]. The NDVI is used as an index of measurement of balance among the energy accepted and gives out by earth objects. The NDVI can be computed by the combination of Red and NIR bands of Landsat8 images. This project

mainly aims to find out land cover changes of Vijayawada city by using the NDVI. The values of NDVI lies between -1 to +1and for soil and vegetation the values are positive [12,13]. NDVI is used to identify green vegetation indicators such as chlorophyll content, green vegetation content, and leaf area index

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Principal component analysis (PCA) is one of the oldest and most widely used method. It simply bring down the attributes of a dataset, while preserving as much changeability up to its maximum level. This means preserving as much variability as possible will translates into finding new variables that are linear functions of the original dataset, that successively maximize variance and that are uncorrelated with other. Finding these new variables, the principal components (PCs), reduces to solving an eigenvector problem[7,8].

PCA can be based on either the covariance matrix or the correlation matrix. The choice between these analyses will be discussed. In either case, the new variables depend on the dataset, alternatively being pre defined basis functions, and are adaptive in the broad sense.

2. LITERATURE SURVEY

Slim Mtibaa et al.[14] analyzed the cropland dominated area by vegetation phenology and seasonal Landsat 8 images of Tunisia, a country in North America. The surveys were taken in the months of March 2015 and January 2016. They firstly divide the area into type of trend of cereals and applied a supervised classification to every trend and multi date satellite images. The results they obtain result with high accuracy, the other obtained coefficients are overall accuracy of 86% and Kappa of 0.85.

G. Meera Gandhi et al.[15] analyzed the amount of vegetation change using remote sensing and GIS at Vellore District. The Satellite images are collected and applied enhanced change detection method. The ndvi method is applied accordingly to the vegetation type with different vegetation threshold values. They observe that forest land is decreased by 6% and Barren land types has decreased by 23%, on another side agricultural land, built up land and water areas are increased by 19%,4%,7%.

Meriame Mohajane et al.[16] applied NDVI transformation to obtain the discrimination between LULC by acquiring two thematic maps and one Landsat8 OLI image at Azrou Forest in the Middle Atlas, Morocco between years 1987 and 2017. In this study NDVI is classified into three types: low density vegetation, medium density vegetation, and high density vegetation. The results are summarized as: (i) the study area covered with more vegetation compared to previous (ii) the area of bare soil has diminished (iii) overall accuracy is increased in the entire study period .

Indrayani et al. obtained land use changes in a particular area with remote sensing technology and NDVI to minimize time and cost [17]. In this study based on multi spectral data NDVI is classified as high, moderate and low vegetation density with an overall accuracy of land use classification of 80%.

3. STUDY AREA

Vijayawada is a historic city located at the geographical centre of Andhra Pradesh state in India on the banks of Krishna River surrounded by the hills of Eastern Ghats with latitude $16^0$03'11" N and longitude 80^0 03'91" E at an altitude of 11 m (36 ft) above sea level. This city covers the area of 61.88 km2 with population of about 1.03 million. The city is also the third most densely populated urban built-up areas in the world. The people in this area per square km's are 31,200 approx. The climate is equatorial, with hot summers and moderate winters. The peak temperature reaches 47 °C in May-June, while the winter temperature is 20-27^0 C. The mean humidity is 78% and the mean annual rainfall is 103cm.

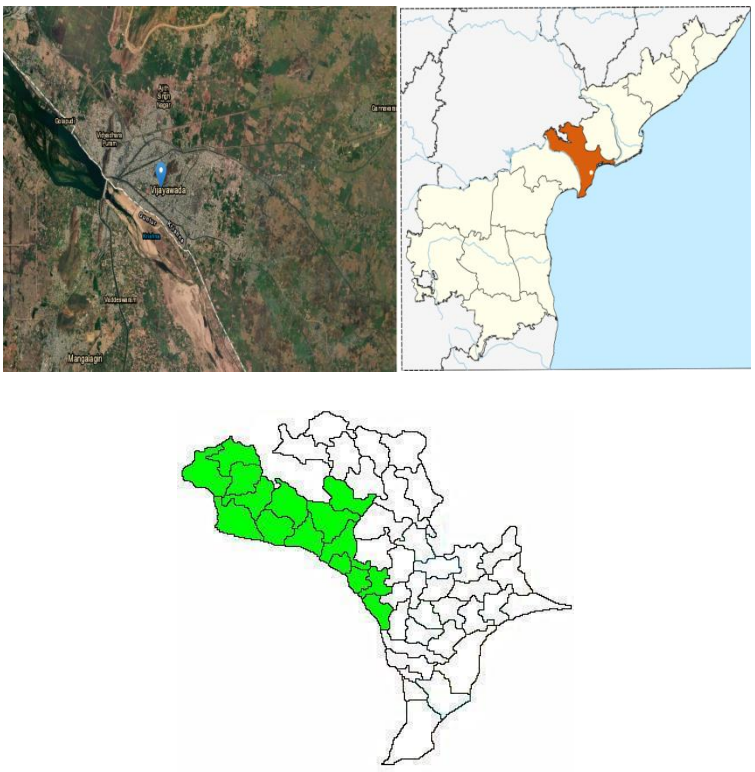


Fig. 1: Location of the study area (Vijayawada, Andhra Pradesh)

4. MATERIALS &METHODOLOGY

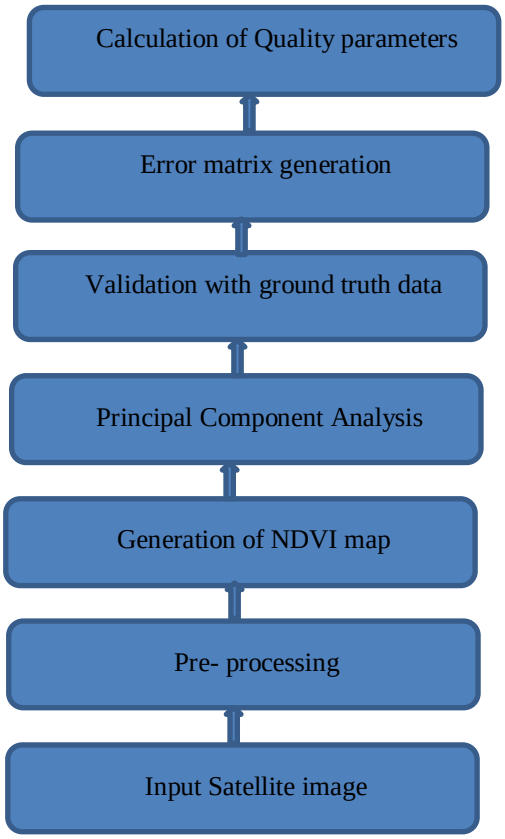


Fig 2: Flowchart of Proposed method

Input Satellite image: The satellite images were taken from the USGS website which is maintained by the US geological survey department. The images are Operational Land imagery(OLI) type. The images taken are the landsat 8 type images which is consist of 11 bands of images where every band of image has their own specifications. The table1 will gives the details of all 11 bands.

TABLE 1. Characteristics of OLI and TIRS sensors on image Landsat 8

Sensors	Band	Spectrum	Wavelength (μm)	Spatial Resolution
OLI	1	Coastal aerosol	0.433 – 0.453	30 m
	2	Blue	0.450 – 0.515	30 m
	3	Green	0.525 – 0.600	30 m
	4	Red	0.630 – 0.680	30 m
	5	NIR	0.845 – 0.885	30 m
	6	SWIR 1	1.560 – 1.660	30 m
	7	SWIR 2	2.100 – 2.300	30 m
	8	Panchromatic	0.500 – 0.680	15 m
	9	Cirrus	1.360 – 1.390	15 m
TIRS	10	TIRS 1	10.6 – 11.19	100 m
	11	TIRS 2	11.5 – 12.51	100 m

4.1 Pre-processing:

Pre-processing is the next step of the process. The obtained images will contain many types of noises and these noises are removed and boosted by nearest neighbour interpolation algorithm. From arithmetical point of view nearest neighbour interpolation is faster and simpler than that of other techniques like linear, bilinear and bicubic interpolation methods. In this method every pixel and intensity values are assigned to nearby point of the input image. This techniques is known as replication method.

4.2 NDVI:

In the obtained satellite images to know the level of greenness of various types of land was covered, here the vegetation index is used as the indicator to measure. Normalized difference vegetation index (NDVI) is the commonly and mostly used index type. The NDVI usually varies from -1 to +1. The amount of land covered by vegetation can be inspect the images from the band 4 and band 5 wavelengths. The formula for NDVI is as follows.

NDVI= (band 4 – band 5) / (band 4 – band 5)

The figure3 is the image of the NDVI processed image.

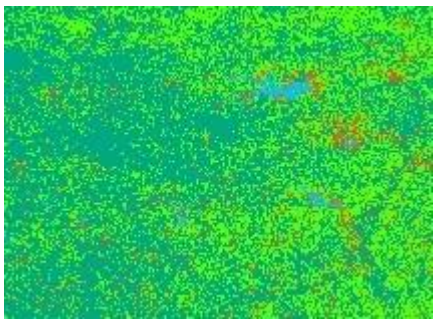


Fig.3. NDVI Image

4.3 Principal Component analysis:

Principal Component Analysis (PCA) is an essential scheme used to minify a lot of connected multivariate measure to a smaller set where the attributes are uncorrelated. The rise of satellite remote detecting in digital design with multispectral and hyper spectral images has presented a new measurement to the stock, mapping and following of the different resources. The multi spectral (multiband) images were taken from different places of the electromagnetic range, in this way keeping up band correlation.PCA technique have been incorporated in the advanced digital images of satellite images as a one of a kind change where various corresponded image data groups have been decreased to uncorrelated groups.

Multi-temporal and multiband images are expected to perform the PCA. The images input must have a similar size, pre-preparing level, measure of groups for each scene, geographic growth, format, and ideally the equivalent occurrence angle. The reason for utilizing PCA is to diminish the dimensionality of the information in order to the measure of data from the biggest groups into the most modest number of PCs, the quantity of unique groups for this situation. A lot of correlated factors are changed over into other uncorrelated factors containing the most elevated introductory information that requires being investigated. The figure 4 is the NDVI+PCA resultant image.

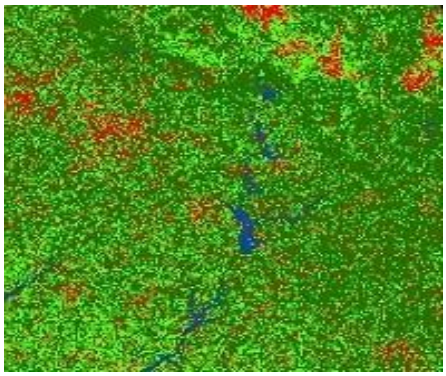


Fig.4 NDVI+PCA Image

4.4 Validation with ground truth data

In this, the reference data is compared with ground truth data to generate the error matrix. From the generated error matrix by applying the formulas Overall accuracy and kappa coefficient can be measured.

5. RESULT

In this study the classified image contains four different classes Dense Vegetation,Vegetation,Built-up and water and classified using NDVI+PCA and NDVI alone and the results are compared. The overall accuracy and kappa coefficient are increased for NDVI+PCA compared to NDVI. Total area of all four classes is compared and represented graphically.

Table 2: Error matrix of 2020 of supervised classification using NDVI and PCA

	Class ID	Reference data				
		Dense Vegetation	Vegetation	Built-up	Water	Total
Classified data	Dense Vegetation	23	1	0	1	25
	Vegetation	1	22	1	1	25
	Built-up	2	0	22	1	25
	Water	1	1	0	23	25
Total		27	24	23	26	100

The Overall Accuracy (OA) and kappa coefficient obtained are given as 91%, 0.88.

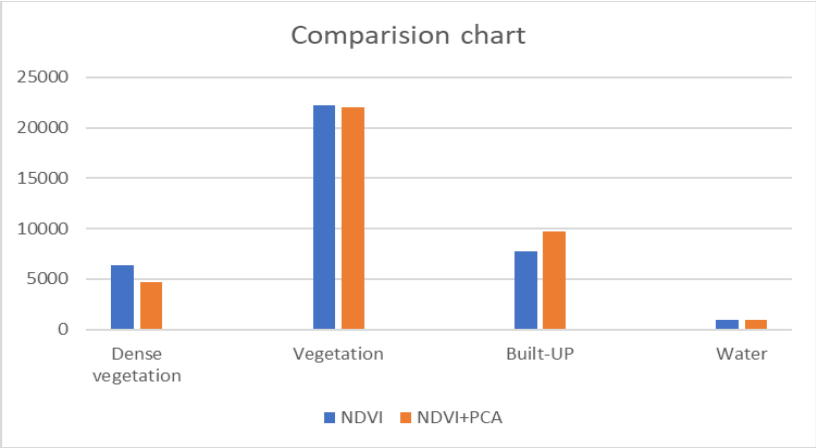
Table 3: Error matrix of supervised classification using NDVI

	Class ID	Reference data				
		Dense Vegetation	Vegetation	Built-up	Water	Total
Classified data	Dense Vegetation	16	2	0	1	19
	Vegetation	2	17	0	1	20
	Built-up	0	2	18	1	21
	Water	1	1	0	18	20
Total		19	22	18	21	80

From the above table the Overall Accuracy (OA) and kappa coefficient are obtained as 86%, 0.81when only NDVI used.

From the above analysis it is concluded that NDVI + PCA is more more efficient method compared to NDVI.

Fig 5: Graphical representation of area the area using NDVI and NDVI+PCA



6.CONCLUSION

The NDVI is a predominant indicator that is in use to ascertain land use and land cover changes because of urban and economic development. Changes in land cover can be ascertained through extracted values of the NDVI map. From the results it is observed that NDVI+PCA gives accurate classification measures of LULC compared to NDVI. Results obtained can be used as index for future trends to acquire land cover changes and for identifying effective cause on vegetation cover for the reinforced perceptive of planners and decision makers on the cognitive content.

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