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Research Article

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Urban sprawl change detection analysis of Vijayawada city using multi temporal remote sensing data

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ABSTRACT

Remote sensing and GIS techniques are widely used for modeling the climate change and managing the water resources with greater accuracy. In the present study, a change detection analysis was carried out for Vijayawada urban city, Andhra Pradesh using landsat images generated from thematic mapper and enhanced thematic mapper plus sensors. Land use and land cover classes considered in the study were habitat, open scrubs, agricultural land, water bodies and siltation respectively. Accuracy assessment was performed using kappa statistics. Normalized difference vegetation index (NDVI) was also carried out to interpret the analysis. From the study, it is inferred that the habitats were increased from 4097.32 to 4591.08 ha during the years from 1990 to 2002. On the other hand, dense forest was decreased from 4039.32 to 3006.84 ha, which infers a solid impact of climate change on the water bodies and habitats of Vijayawada urban city in future.

Key words: Accuracy assessment, Land use land cover changes, NDVI, Remote sensing

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INTRODUCTION

The land use and cover changes, in which the human activities play a dominant role, interact with the environment and have significant effects on the ecosystems at the local, regional, and global scales and consequently directly or indirectly exert great influence on the global climate changes [2, 3, 6, 7]. Variations in these processes due to land use and land cover changes affect the local, regional and global climate pattern in general and water resources availability in particular. Key processes that include are uptake and release of greenhouse gases through photosynthesis, respiration, evapo-transpiration and release of aerosols and particulates from surface land cover perturbations. Added to this, land cover changes such as deforestation and forest fires, alter the ecosystems by releasing carbon dioxide, carbon monoxide and aerosols to the atmosphere by changing the reflectivity of the land [8].

Land-use and land-cover change studies also provide critical inputs to large-scale vegetation biomass and forest cover assessments that are key components of the carbon cycle. Future land-use and land cover change goals include very accurate biomass estimates to refine knowledge of carbon storage in vegetation, understanding regional land use changes that affect biomass and quantifying linkages and feedbacks between land use and land cover change, climate change and other related human and environmental components [1].

The study area is located in the state of Andhra Pradesh, India covering the parts of Krishna district with a total geographical area of 23348.16 ha, confines to Vijayawada city and Krishna River (Figure 1). The average annual rainfall of the study area is 1200 to 1400 mm mostly through south west monsoon during July to September. During summer, maximum temperature rises to 40- 45^{o}C, whereas in winter, it is 8^{o}C. In the study area, deciduous forest species like Sal, Gamhar, Mahua, Palash and Bamboo were found and shrubs and grass are being the main vegetation. Due to industrialization and mine quarrying deforestation has taken place.

The major focus of this study is to evaluate the changes in land-use land-cover (LULC) and vegetation pattern, owing to migration of large inhabitants and industries in to the study area for seeking and employment and business in Vijayawada city. For this purpose, satellite imageries of 1992 to 2002 were collected and analyzed using remote sensing techniques. The study reveals that, large changes in the water bodies have occurred along with reduction of dense forest. This paper essentially enumerates the change detection analysis of the study area using land use and land cover changes over a period of time.

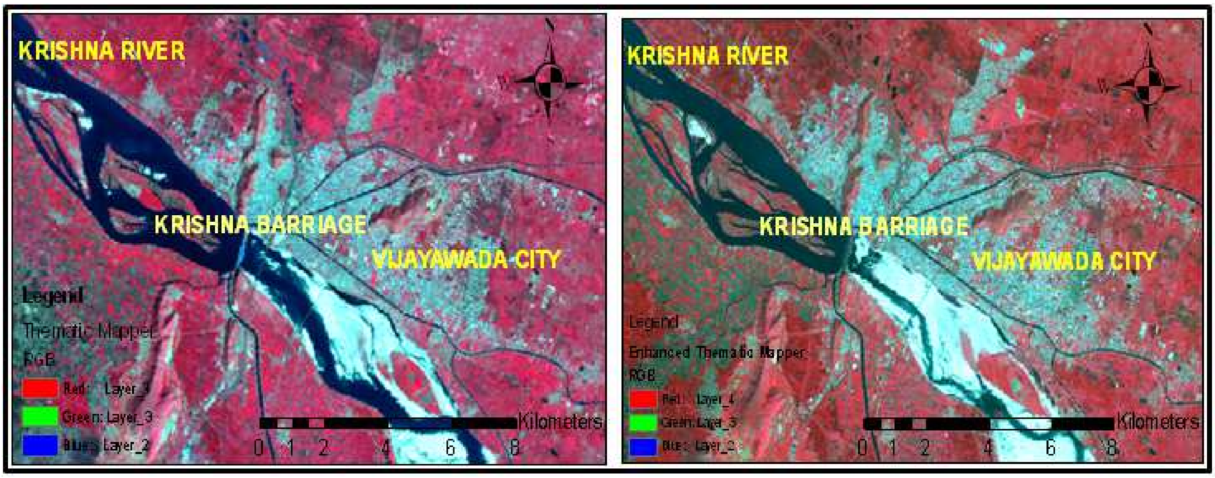

Figure1: Landsat with thematic mapper sensor (1992) and Enhanced thematic mapper plus (2002)

EXPERIMENTAL SECTION

2.1. Remote Sensing Techniques

Remote sensing images provide most reliable surface information. The satellite images of an area keep the records of its changing hydro-geomorphology with time. Remote sensing system includes airborne as well as satellite based system, scanned imagery, photographic products that are capable of providing data on repetitive basis with resolution varying from 10 m and 20 m in SPOT [9]. In the present study, satellite images of LANDSAT-4 and LANDSAT-7 with resolutions of 14.5m and 28.5m, respectively have been downloaded from GLCF website. The present work was carried out with intensive ground truth verification using GPS. Information on bands and spatial resolution present in LANDSAT-4 and LANDSAT-7 at different levels are listed below (Table 1).

Table 1: Details of satellite data

Satellite	Sensor	Bands	Spectral Range	Scene Size	Pixel Resolution
L 1-4	MSS multi-spectral	1,2,3,4	0.5 - 1.1 µm	185 X 185 km	60 meter
L 4-5	TM multi-spectral	1,2,3,4,5,7	0.45 - 2.35 µm		30 meter
L 4-5	TM thermal	6	10.40 - 12.50 µm		120 meter
L 7	ETM+ multi-spectral	1,2,3,4,5,7	0.450 - 2.35 µm		30 meter
L 7	ETM+ thermal	6.1, 6.2	10.40 - 12.50 µm		60 meter
Panchromatic	ETM+ thermal	8	0.52 - 0.90 µm		15 meter

Note: L-1-4-5 (landsat-4), L-7 (landsat-7)

2.2. Image Processing Platforms and Database Creation

Using ERDAS VECTOR 8.5 carried out the image processing work. The unprocessed satellite imageries were first processed so as to transform them into image platform, readable by ERDAS IMAGINE software. Images were restored and geo-referenced using GPS locations collected from the field. The Geographic (lat/lon) projection with WGS-84 datum was applied for deriving geo-referencing satellite imageries. Digital image processing involves manipulation and interpretation of digital images. The central idea behind digital image processing is "The digital image is fed in to a computer one pixel at a time". The computer is programmed to insert the data into an equation and then store the results of the computations for each pixel [4]. This results form a new digital image that may be recorded in the pictorial format. The image classification procedure is shown in Figure 2.

3. Land use land cover classification

The method of land use and land cover change detection involves two major steps like classifying the multi date images independently and comparing the LULC class memberships of the corresponding pixels in the multi date images. The accuracy of LULC classification depends on several inter related factors like number and types of image features, desired level of classification, and the level of sophistication of the classification algorithm. The higher levels of LULC classification depends on more bands of images and the requirement of sophisticated classification algorithm. However, limited by the number of available spectral bands of satellite images, the classification accuracy generally decreases with the increase of the desired level of LULC classes. For better classification changes, all the pixel sizes should be same in size. For this purpose, the cell size is considered as 20 m for both the images. In this study, only five major LULC classes VIZ., vegetation, water body, dense forest, siltation and habitats are specified in order to achieve high classification accuracy for each of the multi-date images. The classification procedures are to be supervised or unsupervised. In supervised classification, each measurement vector is assigned to a class according to a specified decision rule. Classes have been defined on the basis of representative samples of known identity. In the unsupervised scheme, no human interaction is involved, except providing some basic parameters.

In this study, supervised classification was used to classify satellite images of two years (i.e., 1992 and 2002) by set of pixels. The efficiency and accuracy of the supervised classification have been verified by random selection.

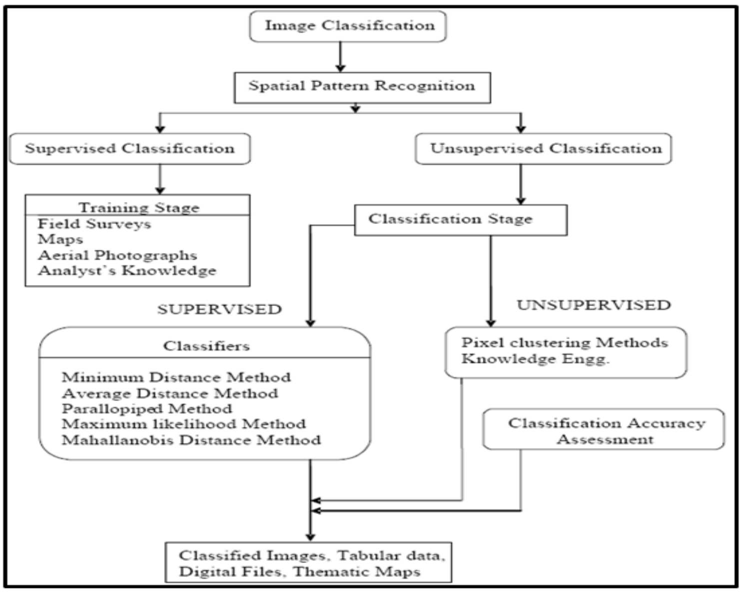

Figure 2: Image Classification Procedure

The classified images were checked visually by displaying both classified and satellite images in the color monitor. Limited field checks were also carried out to validate the classified images. The accuracy assessment was also carried out using kappa statistics by selecting 256 random samples from the study area. The supervised classification has clearly separated features such as water bodies, siltation, open scrubs, agriculture land and habitats as shown in Figure 3 in all the cases.

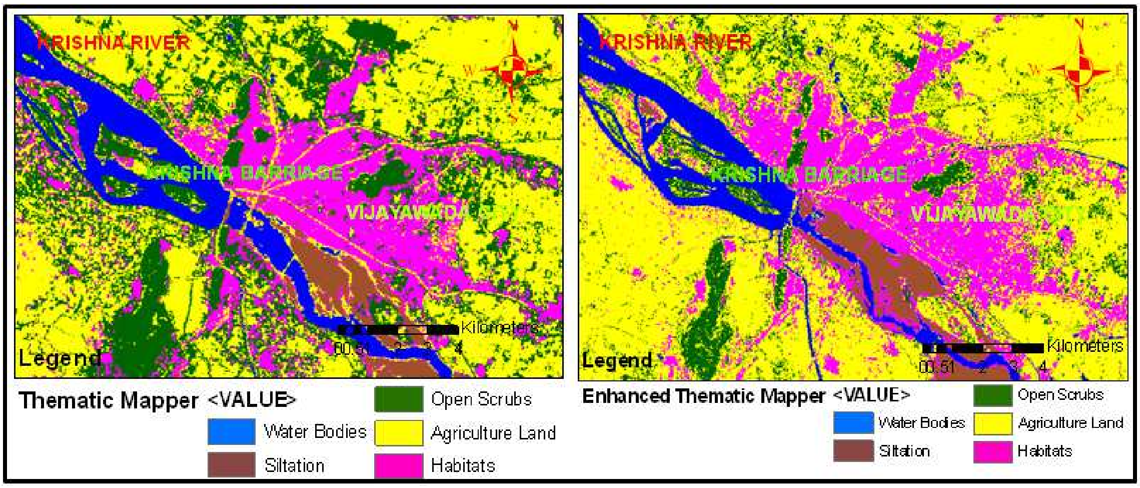

Figure 3: Supervised land use land cover classification of TM- 1992 and ETM+- 2002

Table 2: Land use land cover changes in hectares

Classes	Thematic Mapper (TM) area in ha	Enhanced thematic Mapper (ETM+) area in ha
Water Bodies	1931.28	1792.28
Siltation	835.08	904.48
Open Scrubs	6033.52	2527.84
Agriculture Land	10402.72	13455.04
Habitats	4097.32	4591.08
Unclassified	48.24	77.44

3.1. Change Detection Analysis

For change detection analysis, landsat-4 with TM sensor and Landsat-7 with ETM+ sensor were used. To perform this analysis, the pixel size is fixed as 20 m. The details with regard to land use land cover changes are explained in Table 2. From Table 2, it is observed that, the water bodies and open scrubs decreased from 1931.28 ha to 1792.28 ha and 6033.52 ha to 2527.84 ha, respectively. The siltation, agriculture land and habitats are increased from 835.08 ha to 2527.84 ha, 10402.72 ha to 13455.04 ha and 4097.32 to 4591.08 ha respectively. Figure 4 shows the change detection analysis for the years 1992 and 2002.

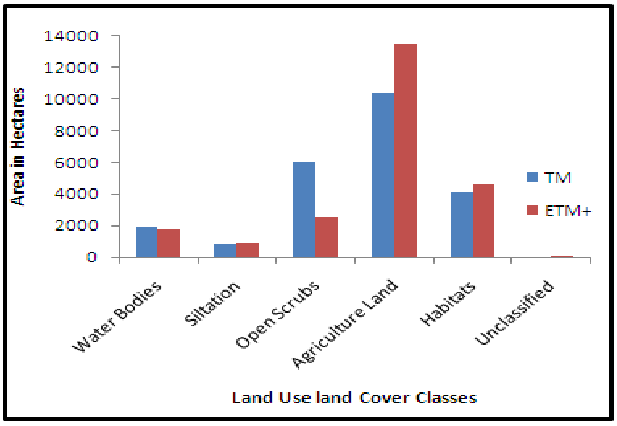

Figure 5: Change detection analysis

3.2. Accuracy Assessment

The Accuracy Assessment has been carried out by taking 256 random points in the entire study area. Water bodies, siltation in the river, open scrubs, habitats as three times, and agricultural lands as seven times have been considered for classification purpose. The overall classification accuracy is achieved as 67.19% and the overall kappa statistics as 0.6405. The details of all the information is shown in Table 3.

Table 3: Overall classification accuracy

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Unclassified	1	1	1	---	---
Water Bodies	2	2	0	0.00%	0.00%
Water Bodies	10	10	6	60.00%	60.00%
Water Bodies2	11	8	5	45.45%	62.50%
Siltation	5	3	2	40.00%	66.67%
Siltation	9	6	6	66.67%	100.00%
Siltation	6	5	3	50.00%	60.00%
Open Scrubs	13	8	7	53.85%	87.50%
Open Scrubs	18	16	12	66.67%	75.00%
Open Scrubs	9	9	6	66.67%	66.67%
Agriculture land	15	15	11	73.33%	73.33%
Agricultural land	54	44	32	59.26%	72.73%
Agricultural land		0	0	--	---
Agricultural land	17	22	15	88.24%	68.18%
Agricultural land	28	41	25	89.29%	60.98%
Agricultural land	20	17	16	80.00%	94.12%
Agricultural land	2	3	0	0.00%	0.00%
Water bodies	2	1	1	50.00%	100.00%
Habitats	6	14	6	100.00%	42.86%
Habitats	13	17	9	69.23%	52.94%
Habitats	13	14	9	69.23%	64.29%
Totals	256	256	172		

4. Normalized Difference in Vegetation Index [NDVI]

NDVI is related to healthy vegetation that reflects well in the near infrared part of the spectrum. It helps to compensate changing illumination conditions, surface slope, aspect and other extraneous factors [4]. The value is normalized to the range of -1<=NDVI<=1 to partially account for differences in illumination and surface slope. NDVI provides an accurate estimation of vegetation health and a means of monitoring changes in vegetation over time. The possible range of values is between -1 to 1, but the typical range is between about -0.1 (not very green area) to 0.6 (for a very green area).

The NDVI phenomenon, ranged from measurement of vegetative seasonal dynamics to tropical forest clearance, leaf area index, biomass estimation, percentage of ground cover determination and photosynthatically active radiation, and various vegetation models are used to study photosynthesis, carbon budgets, water balance and related processes [4]. The details of reflectance of vegetation at different bands are shown in Figure 5.The formula for normalized difference vegetation index is

$$NDVI = \frac{NIR-RED}{NIR+RED} \quad (1)$$

Figure 5 shows reflectance of healthy vegetation, stressed vegetation and highly stressed vegetation in visible and NIR bands. In this study, NDVI is divided into four groups. These are class I, class II, class III, and class IV. The details of these classes are shown in Table 4. It is noticed that vegetation and agricultural land has been increased from 8574.08 ha to 10916.48 ha, and simultaneously dense forest has been decreased from 4039.32 ha to 3006.84 due to rapid urbanization and industries. The Normalized Difference Vegetation Index (NDVI) for the thematic mapper and enhanced thematic mapper plus are shown in Figure 6. Graphically Figure 7 shows the NDVI changes over the period of 1992 to 2002.

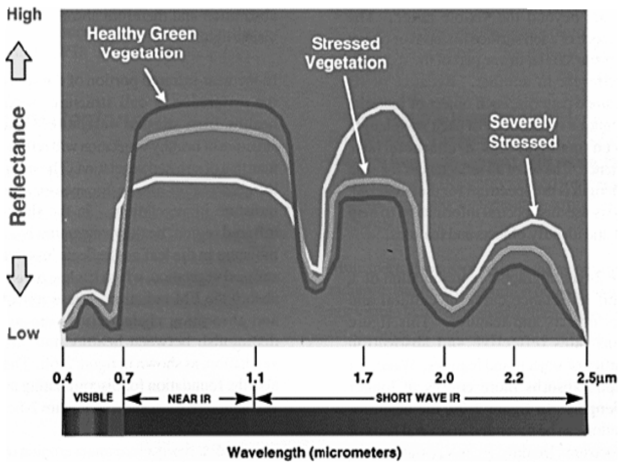

Figure 5: Relfectance of vegetation at different bands

Table 4: Normalized difference in vegetation index classification

Class Type	NDVI Range	Remarks
I	Less than -0.05	Water bodies, settlement with reflecting roofs, pakka roads and others
II	Between -0.05 to 0	Settlements, barren land or rock surface, kaccha roads
III	Between 0 to 0.2	Low vegetations, agricultural lands and others
IV	More than 0.2	High vegetation, dense forest and others

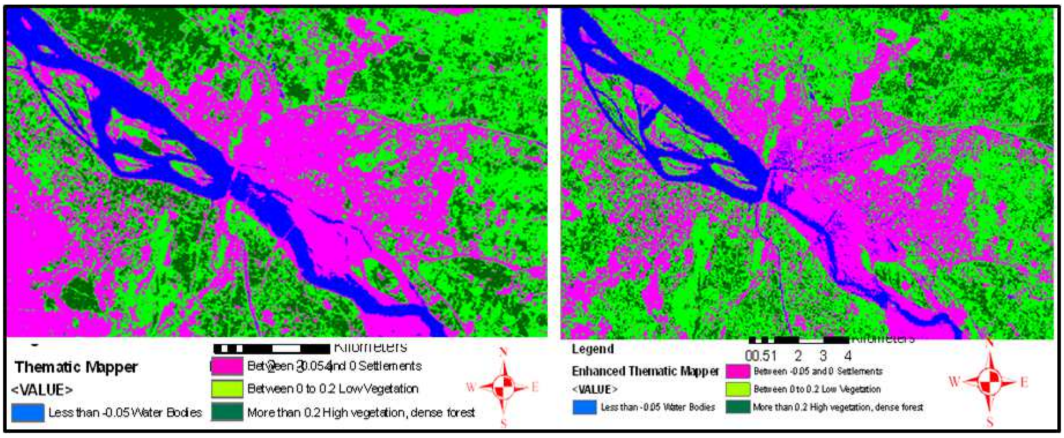

Figure 6: Normalized Difference Vegetation Index for TM 1992 and ETM+-2002

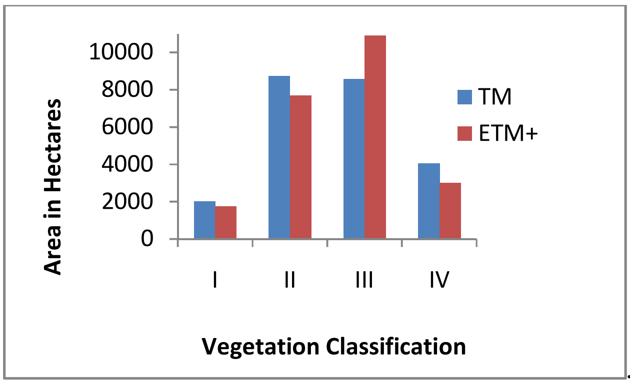

Figure 7: Vegetation changes during the period of 1992 to 2002

CONCLUSION

The present study was taken up to detect the changes around Vijayawada urban city, Andhra Pradesh using remote sensing and digital image classification techniques. Different categories of land use land cover and normalized difference in vegetation index were delineated using ERDAS IMAGINE 8.5 software. Accordingly, the study area is classified in to five land use land cover categories VIZ., water bodies, open scrubs, agricultural land, siltation and habitats respectively. Significant changes in the water bodies, vegetation and dense forest occurred have been noticed over a period of time. The results inferred that, vegetation and agricultural land increased from 8574.08 ha to 10916.48 ha, and dense forests decreased from 4039.32 ha to 3006.84. On the other hand, water bodies were decreased from 1931.28 ha to 1792.28 ha and habitats have increased from 4097.32 ha to 4591.08 ha over a period of time. It is inferred that, the study area has undergone extensive changes during in the last decade and hence, the results of the study is of extensive use in the decision making for policy makers in general and scientists in particular.

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