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Landcover Change Detection Analysis Using Remote Sensing and GIS Techniques: A Study on part of West Godavari Delta Region, Andhra Pradesh, India

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Abstract

Landscape changes were measured in the delta region of West Godavari district, Andhra Pradesh state over a period of six years using satellite images. Digital image processing techniques such as supervised and unsupervised along with GPS were used to identify various land cover classes in the research area. Rapid land cover changes were occurred mainly due to exponential increase of aqua farming. In the year 2008, the agricultural land category occupied about 45.4% of total geographical area and was decreased to 36.4% in 2014. The agriculture was found to have been altered which could be attributed to the increasing populations that living in this region for their financial growth. The increase in area of water bodies was 41% of total for the period of six years which may be due to newly upcoming aquaculture dugout ponds. The study reveals that the integration of remote sensing and GIS was an effective approach for analyzing land cover changes. The overall accuracy of the classification found to be more than 90%.

Keywords: *Land Cover Classification, Aquaculture, Godavari Delta, Andhra Pradesh, Remote Sensing and GIS*

Introduction

In the light of growing human needs and the vast changes in land cover, awareness of various activities which are affecting the landscape changes in a particular area. The decision-makers need to be better access of scientific knowledge in order to make well-informed decision making systems. Satellite remote sensing technologies are able to provide accurate, real time and reliable information regarding the spatial variables of the land surface to maintain the sustainable management of natural resources (Roy and Giriraj 2008, Thenkabail et al. 2009). Landsat series of satellites are one of the best sources for land cover studies and are very useful for land cover mapping. Landsat images can be used at the local level with its 30 m spatial resolution (Jensen 2005). Digital image classification methods particularly supervised and unsupervised are helpful to categorize pixels in an image or raw remotely sensed satellite data to obtain a given set of labels or land cover themes (Babykalpana and Thanushkodi 2010, Miao et al. 2014). Several researches were used various methodologies and algorithms to derive land cover and change information from different sets of remotely sensed data (Chen and Stow 2003, Rodriguez and Chica

2012, Kun et al. 2014). The objective of this present study is to identify the land cover changes and to assess the accuracy of the land cover in the study area over the period by using the remote sensing and GIS technologies.

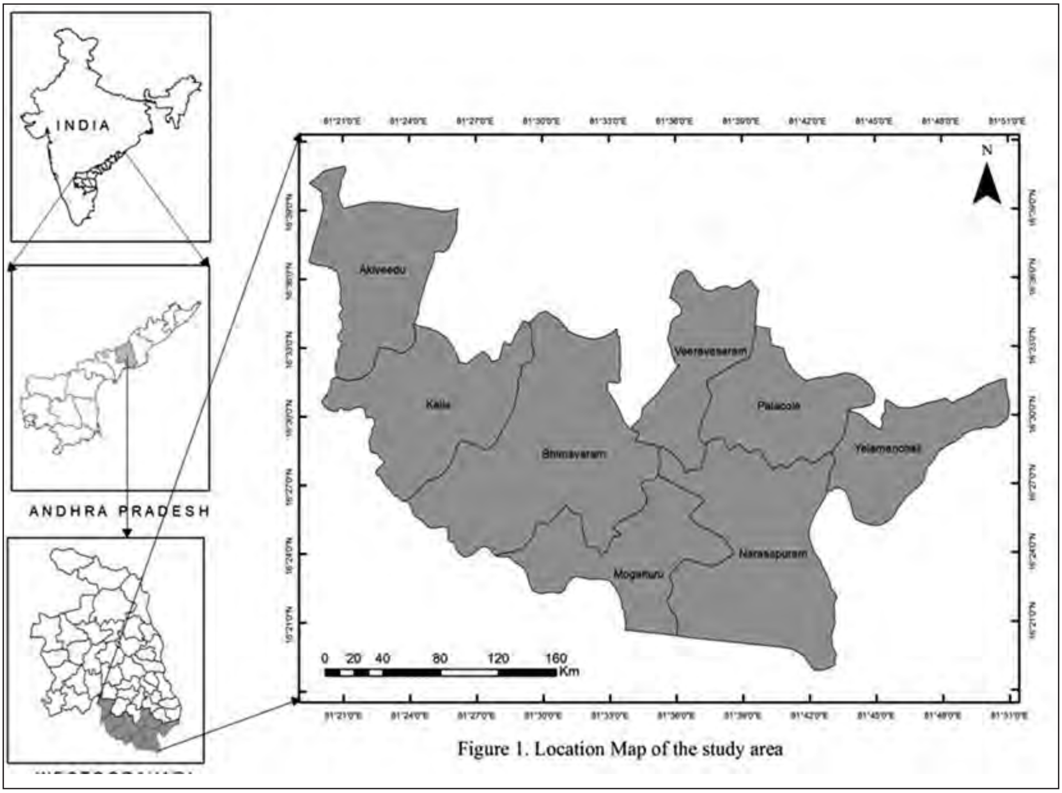

Figure 1. Location Map of the study area

Study Area

Geographically the area under study is a part of delta region of Godavari river covering eight mandals of West Godavari district in the State of Andhra Pradesh namely Akividu, Kalla, Bhimavaram, Mogalturu, Narsaspuram, Veeravasaram, Palacole, Yelamanchali, and lies in between latitudes 16^0 19’ N to 16^0 40’ N and longitudes 81^0 19’ E 81^0 51’ E. The area covering about 1,000 km^2 and is situated on the west banks of river Godavari (Fig. 1). The population of the study area comprises about six lakhs, distributed in 114 villages and their main activities are paddy and aquaculture cultivation. The area experiences tropical maritime climate with an average annual temperature of 20^o C in winter and of 38^o C in summer. The average annual rainfall is about 875 mm.

Data Used And Methods

Survey of India (SOI) toposheet Nos: 65 H6, H7, H10, H11, H14 and H15 on 1:50,000 scale were used as a base map in the present study. Landsat 8 Operational Land Imager (OLI) data for the year 2014 and Resorcesat-1 (IRS-P6) LISS-III data for the year 2008 were used. The Landsat data was downloaded from USGS Earth Explorer website http://earthexplorer.usgs.gov/. Landsat 8 consists of nine spectral bands with a spatial resolution of 30 meters (Bands 1 to 7 and 9). The resolution for Band 8 (panchromatic) is 15 meters. The imagery in Geotiff (level-1) format was downloaded and georeferenced with UTM-Zone 44N, WGS-84 datum. The precision geocoded data consisting four spectral bands of LISS-III of Resourcesat-1 with 23.5 m spatial resolution was procured in digital format from the National Remote Sensing Centre (NRSC), Hyderabad. ERDAS Imagine 9.2 and ArcGIS 10 software were used for digital image processing and statistical spatial analysis studies. False Colour Composite (FCC) was generated by layer stack option in ERDAS Imagine software by using seven bands for Landsat 8 and four bands for LISS-III data.

Image Classification

A land cover layer was generated for this study. Land cover classification was performed adopting digital image classification techniques such as supervised and unsupervised. Supervised technique works on each pixel of the image classified into different type of land cover categories as training sites. A total of five classes were selected as training sites based on the supervised classification. For each class, seven training areas were selected and giving a total number of 35 training areas for the whole study area. The training sites delineation technique is a traditional approach, and the training site polygons were created visually by onscreen digitizing all features, on the display system. *Signature Editor* tool in ERDAS IMAGINE software automatically produces a signature group file with the same name as the training site file. It helps to modify the signatures, before performing a supervised classification, with the maximum likelihood decision rule in order to achieve the desired classes. Unsupervised algorithm along with GPS data were used for confirming the land cover classes. The main purpose of this approach on land cover features identifying by combining unsupervised algorithm and training data is to improve the accuracy of land cover classification made by supervised algorithm. The clustering technique Iterative Self-Organizing Data Analysis (ISODATA) was used to perform the classification from multispectral image.

Classification Accuracy Assessment

There are two data sets a) classified map which derived from the satellite data b) reference test information utilized to perform the accuracy assessment of the classified map. The relationship between these two sets of information is commonly summarized in an error matrix. The test reference pixels had been collected from the randomly located sites. In the stratified random sampling, a minimum number of samples will be selected from each category. The test sites were identified by using GPS instrument. After the test reference information has been collected from test sites, it is compared on a pixel by pixel basis with the information present in the classification map. Agreement and disagreement are summarized in the cells of the error matrix. An error matrix with columns of reference classes and rows of classified classes was created. By using simple descriptive statistical technique, overall accuracy is computed by dividing the total correct (sum of the major diagonal) by the total number of pixels in the matrix. An accuracy of 85% or more overall accuracy is considered acceptable (Jensen 2005).

Results And Discussion

The classification was performed on the generated FCC images. Spatial distribution of land cover classes for IRS-P6 LISS-III (2008) and Landsat 8 (2014) are presented in Figs. 2 and 3 (see page 247) respectively. The statistical results were presented in Table 1. Five land cover classes namely built-up, agriculture, scrub forest, bare soil/ fallow and water bodies were identified in the study area. Overall accuracy of the classification was found to be 92%.

Table 1. Statistical results of land cover classes of the study area

Land Cover Class	**2008**		**2014**		**Growth in Percentage**
	sq km	%	sq km	%	
Built-up	96.0	9.6	121.2	12.1	26.3
Agriculture	453.9	45.4	364.0	36.4	-19.8
Bare soil/ Fallow	32.5	3.3	67.1	6.7	106.5
Scrub forest	237.3	23.7	193.3	19.3	-18.5
Water bodies	180.4	18.0	254.4	25.4	41.0

Table 2. Error matrix of land cover classification

Classification	**Built-up**	**Agriculture**	**Bare soil/ fallow**	**Scrub forest**	**Water**	**Row Total**
Built-up	477	15	18	23	0	**533**
Agriculture	10	321	0	8	1	**340**
Scrub forest	0	8	0	493	0	**501**
Bare soil/fallow	65	2	369	0	14	**450**
Water bodies	1	3	10	2	398	**414**
Column Total	**553**	**349**	**397**	**526**	**413**	**2238**
Producer’s Accuracy (%)	86.26	91.98	92.95	93.73	96.37	
User’s Accuracy (%)	89.49	94.41	82.00	98.40	96.14	
Overall Accuracy (%)	91.96					

- **Built-up**

  Built-up land is demarcated by considering of buildings and transport lines in association with water bodies, vegetation and vacant lands. The built-up area increased from 96 km^2 to 121 km^2 between 2008 and 2014. The major urban agglomeration is concentrated at Bhimavaram, Narasapuram, Palacole regions which indicate the positive growth. It was found that the phenomenal increase of built-up and is due to the conversion of small towns into municipal corporations where rural populations being migrated for employment, education and services etc.

- **Agriculture**

  Agricultural land is primarily used for farming and for the production of food, as well as commercial and horticultural crops. It includes crop land, fallow land and plantation. Agriculture is the main occupation of the people living in the study area. The majority of farmers have small and marginal holdings (70% $\leq$ 1 ha). The main crops identified in the study are paddy, sugarcane, cereals and pulses which are mainly under canal irrigation. In 2008, the agricultural land occupied by about 45.4% of total geographical area (TGA) and was decreased to 36.4% in 2014. It was observed that most of the crop land area was converted into aqua ponds for commercial development. Ponds are classified under water bodies category.

- **Bare Soil/Fallow**

  Wastelands include bare soil/fallow, degraded lands, sand are categorized and are currently under utilized lands, which are deteriorating due to lack of appropriate water and soil management or on account of natural causes. This category is continuously growing from 3.3% in 2008 to 6.7% of total area in 2014 which shows positive growth accounts about 106.5%.

- **Scrub Forest**

  Vegetation density under forest cover is 40% or above called as dense or closed forest. The dense and scrub forest area category was occupied about 193.3 sq km in 2014. As per digital classification of the image it was found to be decreased to 19.3% from 23.7% in 2008. Under scrub forest category, all natural vegetation was demarcated lies at present. This activity takes place due to overgrazing and clearance of land for agricultural and built-up purpose.

- **Water bodies**

  Most of the water bodies in the study area are in the form of water tanks, streams, canal and ponds. The streams of the area are mainly seasonal and comprises with water in rainy season only. The total land area under water bodies was 180.4 sq km in 2008 and it was drastically increased to 254.4 sq km. The increase in area of water bodies was 41% of total for the period of six years which may due to newly upcoming aquaculture dugout ponds.

Conclusions

Land cover change analysis using OLI and LISS-III multispectral data for the years 2008 and 2014 in delta region of West Godavari, Andhra Pradesh was performed by adopting digital image processing techniques. Land cover types were identified based on multi image analysis. A maximum likelihood of supervised classification was performed to identify various classes i.e. built-up, agriculture, scrub forest, bare soil/fallow and water bodies and overall accuracy of the classification was found 92%. Agriculture (36.4%) and water (25.4%) in 2014 are occupies major part of the study area. Major portion of the water bodies identified were under aquaculture activity. Forest cover represents negative growth of about 18.5%. This temporal change of land cover information obtained through classification is useful for various organizations to carryout preparation of crop inventories, farming activities, optimum use of water and to assess the changes in environmental conditions etc.

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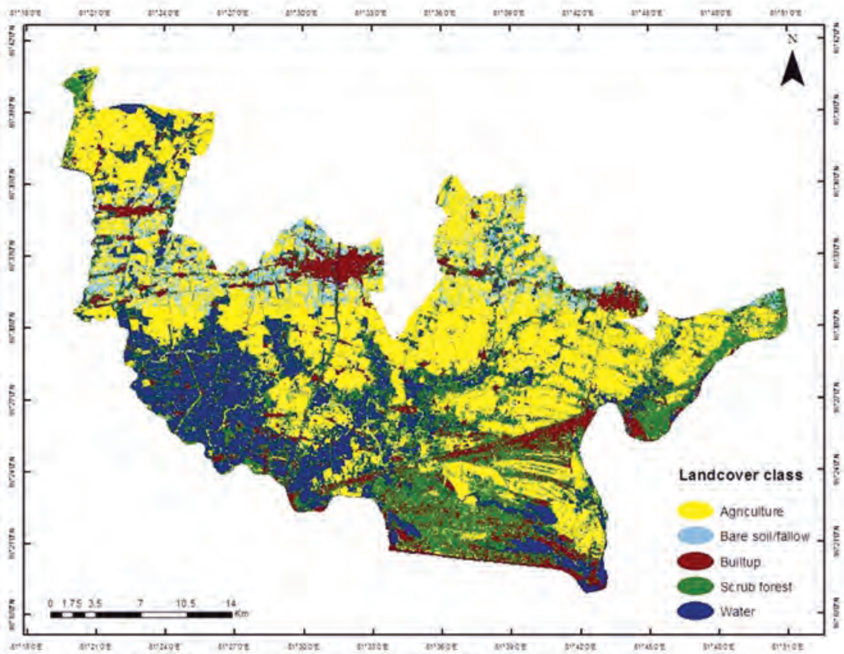


Figure 2. Classified land cover map using using Reserocesat-1 (LISS-III, 2008) in the study area

Fig. 2 (see page 244 for the text)

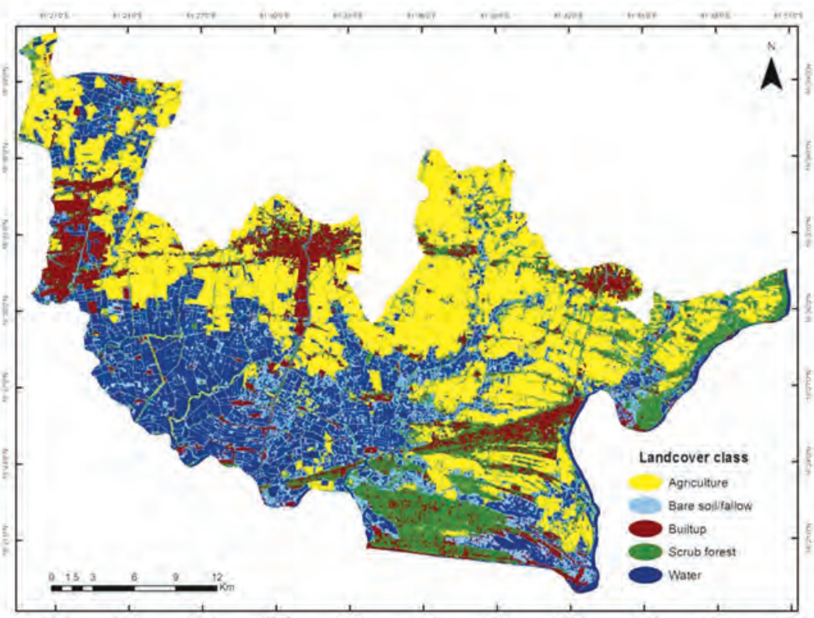
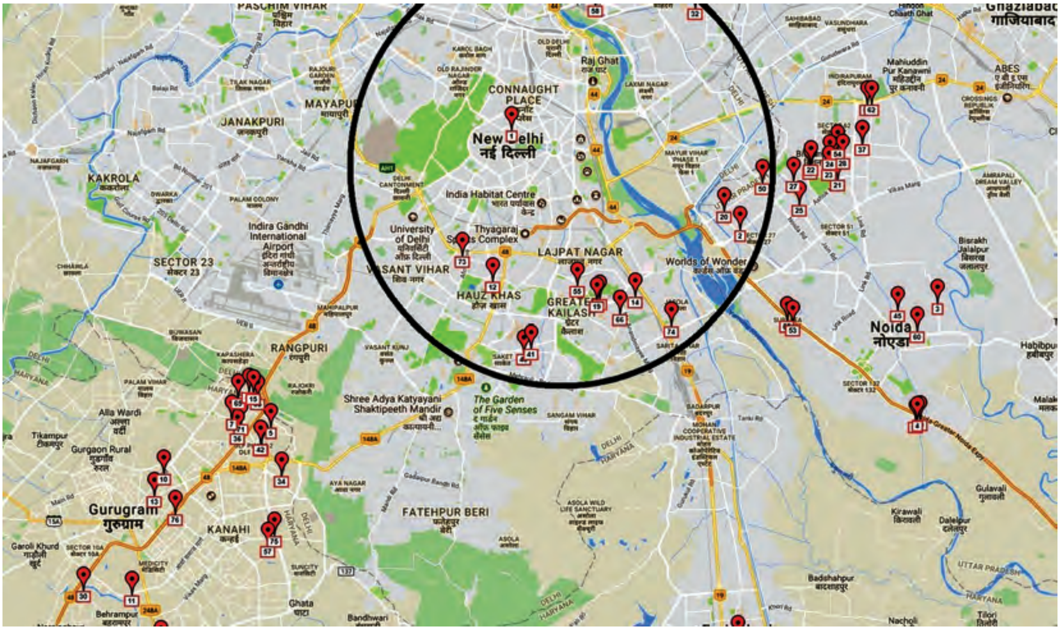
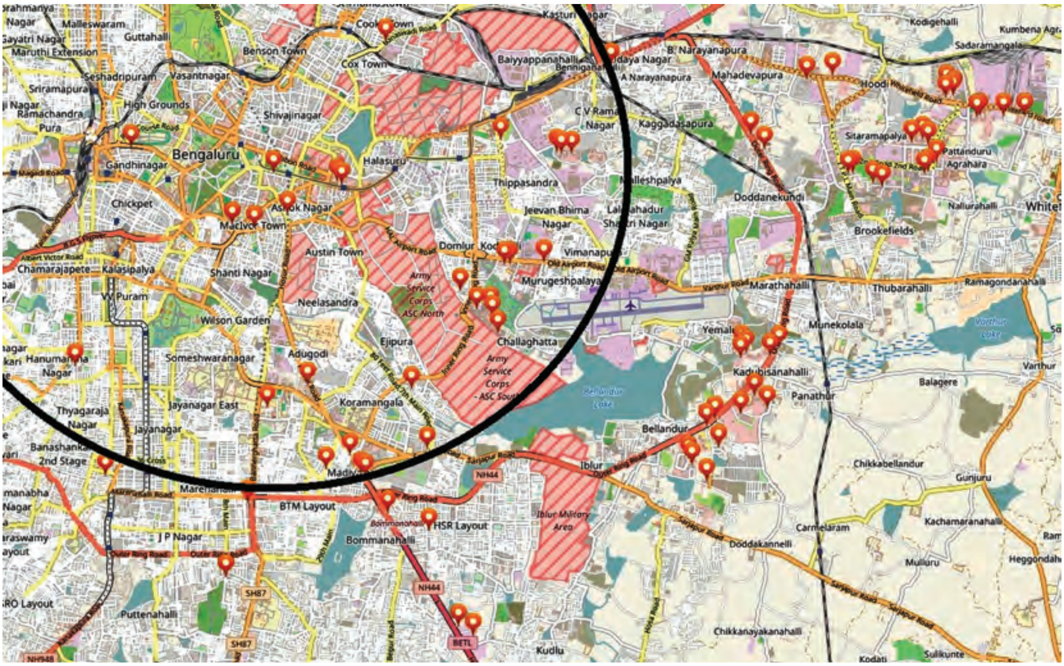


Figure 3. Classified land cover map using Landsa-8 (OLI, 2014) in the study area

Fig. 3 (see page 244 for the text)



(a) Delhi (see page 252 for the text)



(b) Bangalore (see page 252 for the text)

Fig. 3: Map of cities showing distribution of offices inside and outside of imaginary 15 km fringe boundary line.