Land use Land Cover change mapping using Remote Sensing and GIS: A case study of Gudur Mandal, SPSR Nellore District, Andhra Pradesh.

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Abstract - *Evaluation of watersheds and development of a management strategy require accurate measurement of the past and present land cover/land use parameters as changes observed in these parameters determine the hydrological and ecological processes taking place in a watershed. This study applied supervised classification-maximum likelihood algorithm in ArcGIS 10.1 to detect land cover/land use changes observed in Gudur mandal, Nellore districts, using multispectral satellite data obtained from Landsat 5,7 TM and ETM+ for the years 2000 and 2015 respectively. The watershed was classified into six major land cover/use classes viz. Uncultivated Crop Land, Cultivated Crop Land, Baren /Waste Lands, Residential (Rural), Forest and Water bodies (Ponds/Streams/River/Canals). Resultant land cover/land use indicated a significant negative shift in water bodies, cultivation crop land, forest and positive shift in residential area, Uncultivated crop Land as -92.70%, -35.88%, -77.59%, 30.76%, 151.68% respectively. These land cover/use transformations posed a serious threat to the mandal since it is depended on the agriculture. Hence, proper management of the available surface water and limited use of groundwater, implementation of innovative methods in farming is required or else these resources will soon be lost and no longer be able to play their role in socioeconomic development of the area.*

Key Words: Change detection;Land cover/use change;Supervised classification;Gudur mandal.

1.INTRODUCTION

Changes in land use can be categorized by the complex interaction of structural and behavioral factors associated with technological capacity, demand, and social relations that affect both environmental capacity and the demand, along with the nature of the environment of interest (Verburg et al., 2004). Ecologists pay considerable attention to the land use change impacts predominantly with respect to its effects on biodiversity and aquatic ecosystems (Turner et al., 2001). Changes in the land use in a watershed can affect water quality and supply. For instance, land use patterns change due to watershed development frequently resulting in increased surface runoff, reduced groundwater recharge and transfer of pollutants (Turner et al., 2001). Thus, the assessment of land use patterns and their changes at the watershed level is crucial to planning and management of water resources and land use of the particular watershed.

Analysis of detected change is the measure of the distinct data framework and thematic change information that can lead to more tangible discernment to underlying process involved in upbringing of land cover and land use changes (Ahmad, 2012). Change analysis of features of Earth's surface is essential for better understanding of interactions and relationships between human activities and natural phenomena. This understanding is necessary for improved resource management and improved decision making (Lu et al., 2004; Seif and Mokarram, 2012). Change detection involves applying multi-temporal Remote Sensing information to analyze the historical effects of an occurrence quantitatively and thus helps in determining the changes associated with land cover and land use properties with reference to the multi-temporal datasets (Ahmad, 2012; Seif and Mokarram, 2012; Zoran, 2006).

Various studies have been conducted all over the world regarding the change analysis of watersheds through different methods. They are important to develop effective management strategies for watersheds worldwide (Ashraf, 2013; Bazgeera et al., 2008; Caruso et al., 2005; Dietzel et al., 2005; Fortin et al., 2003; Gajbhiye and Sharma, 2012; Hu et al., 2012; Kearns et al., 2005; Parker and Meretsky, 2004; Stewart et al., 2004; Wang et al., 2004). Watershed management is necessary because a watershed is not merely a hydrological unit (Singh et al., 2014) but also socio-ecological being which plays a vital role in determining economical, food and social security and provision of life support services to local residents (Wani et al., 2008). Changes in land cover/land use in watershed area including urbanization and de(/re)forestation continuously affect the water availability as well as the nature and extent of surface and subsurface water interactions thus influencing watershed ecosystems and the services provided by them. With proper understanding of the spatial and temporal variations occurring in a watershed over time and the interaction of the hydrological components of a watershed with each other, better water conservation strategies can be formulated (Ashraf, 2013).

Remote Sensing (RS) has been used to classify and map land cover and land use changes with different techniques and data sets. Landsat images in particular have served a great deal in the classification of different landscape components at a larger scale (Ozesmi and Bauer, 2002). Recently several change detection techniques have been developed that make use of remotely sensed images. A variety of change detection techniques and algorithms have been developed and reviewed for their advantages and disadvantages. Among these Unsupervised classification or clustering, Supervised classification, PCA, Hybrid classification and Fuzzy classification are the most commonly applied techniques used in classification (Lu et al., 2004; Rundquist et al., 2001; Zhang et al., 2000).

A variety of supervised classification methods have been applied extensively for the land use change analysis throughout the world. This technique depends on a combination of background knowledge and personal experience with the study area to a greater extent than other areas. Thus per-pixel signatures are taken and stored in signature files by using this knowledge and the raw digital numbers (DN) of each pixel in the scene are therefore converted to radiance values (Jensen, 2005; SCGE, 2011).

Several other researchers have employed the same technique and achieved highly satisfactory results including Rawat and Kumar (2015), who applied the same technique to monitor land use/land cover change in Hawalbagh block, district Almora, Uttarakhand, India. Boori et al. (2015) analyzed the land use/land cover disturbance caused by tourism using a number of Remote Sensing and GIS based techniques including supervised classification. Rawat et al. (2013) also applied the same technique for Ramnagar town area, Uttarakhand, India to track the changes observed in the area between the time period of 1990 and 2010.

The study area was selected for change detection because of being subjected to urbanization, which required a forehand planned watershed management to avoid the future clusters. Therefore, the main objective of the present research was to utilize GIS and Remote Sensing applications to discern the extent of changes occurred in Gudur mandal over a span of 15 years' time period. However the specific objectives included (i) to identify and delineate different LULC categories and pattern of land use change in the mandal from 2000 to 2015 (ii) to examine the potential of integrating GIS with RS in studying the spatial distribution of different LULC changes (iii) to determine the shift in LULC categories through spatial comparison of the LULC maps produced.

2. MATERIALS AND METHODS

2.1. Study area

2.2. Data Collection

The data used in this research were divided into satellite data and ancillary data. Ancillary data included ground truth data for the land cover/use classes, aerial imagery of watershed and its surrounding area, topographic maps. Satellite data for 2 years on the other hand consisted of multi-spectral data acquired by Landsat satellite for the month of September provided by USGS Earth Explorer. Specifications of the satellite data acquired for change analysis are given in Table 1. FCC of the Study area for the two years are given in Fig 1 and Fig 2.

2.3Image pre-processing and classification

Satellite image re-processing prior to the detection of change is immensely needed and has a primary unique objective of establishing a more direct affiliation between the acquired data and biophysical phenomena (Coppin et al., 2004). The data acquired from the USGS was corrected for reflectance, unregistered pixels, and atmospheric corrections before training the samples in ArcGIS environment. Then using signature file creation tool, six classes of LULC was developed i.e., Water Bodies, Residential Area, Uncultivated Crop Land, Cultivated Crop Land, Forest, Barren Land (Table-2). After that maximum likelihood algorithm was used for supervised classification of the images. It is the type of image classification which is mainly controlled by the analyst as the analyst selects the pixels that are representative of the desired classes. To improve classification accuracy and reduction of misclassifications, post-classification refinement was therefore used for simplicity and effectiveness of the method (Harris and Ventura, 1995). Moreover, using data having mediumspatial resolution such as that of Landsat mixed pixels are a common problem (Lu and Weng, 2005); especially for the urban surfaces that are a heterogeneous mixture of features mainly including buildings, grass, roads, soil, trees, water(Jensen and Im, 2007). The problem of mixed pixels was addressed by visual interpretation. For the enhancement of classification accuracy and therefore the quality of the land cover/land use maps produced, visual interpretation was very important. Thus, visual analysis, reference data, as well as local knowledge, considerably improved the results obtained using the supervised algorithm.

Table-1: Satellite data specifications.

Data	Year of acquisition	Bands	Resolution (m)	Source
Landsat 5 TM	2000	Multi-Spectral	30	USGS Earth Explorer
Landsat 7 ETM+	2015	Multi-Spectral	30	USGS Earth Explorer

2.4. Land use/cover change detection

Post-classification change detection technique, performed in ArcGIS 10 was employed by the study. Post classification has been successfully used by various researchers in urban environment due to its efficiency in detecting the location, nature and rate of changes (Hardin et al., 2007).

Table-2: Classes delineated on the basis of supervised classification.

S.No.	Class Name	Description
1	Uncultivated Crop Land	Crop fields without cultivation
2	Residential Area	Residential, commercial, industrial, transportation, roads, mixed urban
3	Baren soil/rock	Land areas of exposed soil and barren area influenced by human influence
4	Water Bodies	Rivers/ Streams/ Canals/ Ponds.
5	Forest	Deciduous and Scrub forest
6	Cultivated Crop Land	Crop land under cultivation

3. RESULTS AND DISCUSSION

The classified LULC map of Gudur Mandal of years 2000 and 2015 is given in (Fig. 2, Fig 3). The classification results for 2000 and 2015 are summarized in (Table 3). Percentage of classes based on these results show the land cover/land use practices observed in watershed area during 2000 and 2015. On comparision of 2015 LULC map with 2000 LULC map, resultant land cover/land use indicated a significant negative shift in water bodies, cultivation crop land, forest and positive shift in residential area, Uncultivated crop Land as -92.70%, -35.88%, -77.59%, 30.76%, 151.68% respectively. The comparison of each class of 1992 and 2012 showed that there has been a marked land use and land cover change during the study period of 15 years.

During the 2000–2015 period the percentage area covered by Cultivation class in watershed decreased by 35.88%. This is due to shift of seasonal rainfall. During 2000 year the seasonal rainfall was in time with normal intensity, but on the other hand the conditions seasonal rainfall was significantly shifted to unseasonal rainfall recording the monsoon period as less rainfall. It has also been observed in watershed that the Settlements or Built up areas are mostly surrounded by Agricultural area, especially in the catchment area and by the main streams. It means the area near the population has been cleared for the production of crops in order to fulfill the basic necessities of life (Hagler Bailly, 2007). This study elucidates the significance of incorporating Remote Sensing and GIS for change detection study of land cover/land use of an area as it offers crucial information about the spatial distribution as well as nature of land cover changes. The land use/land cover maps indicates that the integration of supervised classification of satellite imagery with visual interpretation is an effective method for the documentation of changes in land use and cover of an area.

Table-3: classification results for 2000 and 2015

Parameter/Duration	2015	2000	Change (sq.km)	% Change
Cultivated Crop Plantation	21.654	33.772	-12.118	-35.883
Residential	7.722	5.905	1.817	30.768
Water bodies	1.057	14.504	-13.446	-92.709
Barren	84.468	85.061	-0.593	-0.697
Forest	16.959	75.708	-58.748	-77.598
Uncultivated Crop Land	108.961	43.293	65.667	151.679

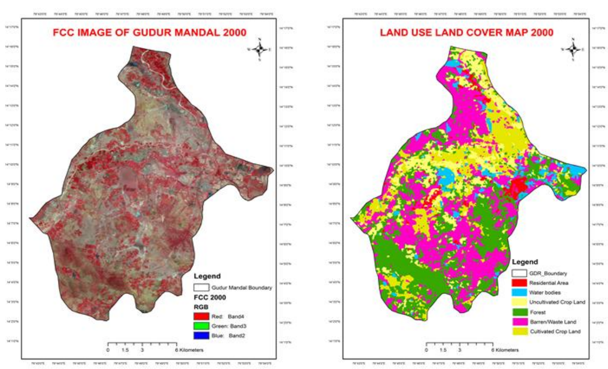

Fig-2: FCC and LULC of Study Area 2000

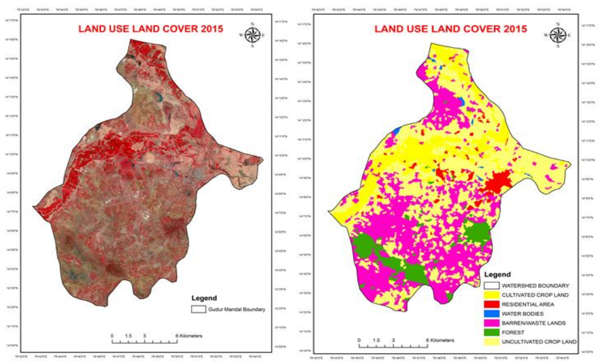

Fig-3: FCC and LULC of Study Area 2015

4. CONCLUSIONS

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 in 15 years. The LULC shift in the watershed area was evident by the decline in the area of Cultivated Crop Land, Water class, Forest (35.88%, 92.70% and 77.60% respectively) and augmentation of area covered by classes of Residential area (30.76%) and Uncultivated Crop Land (151.68%). Additionally, all these alterations in the land cover and land

use patterns if prolonged for future it will adversely affected water quality and accessibility. Land use change mapping and analysis using Remote Sensing and both rural growth and wrong agriculture

practice and may also be responsible for further loss of already shrinking Vegetation cover in the watershed areas. Hence, proper management of these water resources is required because without proper management, this valuable water resource will soon be lost or will no longer be able to play its required role in agriculture production and socio-economic development of the area.
Having said all that, there are several recommendations based upon the conclusion of the present study for the proper management and conservation of the forest, water and soil resources subjected to decline in the watershed.

- An effective water management practice could be breaking down major river basin into sub-watersheds and prioritizing the sub-watershed for conservation and management based on degradation level so as to conserve and minimize the human induced impacts faced by it.
- Government should take appropriate steps to restore the degraded lands specially degraded soil, water and forest lands and their further degradation must be prevented.

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