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Land Use and Land Cover Changes Using Remote Sensing and GIS: A Case Study in Krishna River Basin

Samrat Gogineni, K S Kumar and Kiran Yerrakula
Department of Soil and Water Engineering, College of Agricultural Engineering, Bapatla 522101

ABSTRACT

Land use and land cover is an important component in understanding the interactions of the human activities with the environment and thus inevitable to assess properly for simulating any changes. In this paper an attempt is made to study the changes in land use and land cover in Krishna river basin over a period of 15 years (1992-2007). The study has been carried out through remote sensing approach using Land Sat imageries of 1992 and 2007. The land use land cover classification was performed based on Global Land Cover Facility (GLCF) an Earth Science Data Interface Satellite imageries. GIS software is used to prepare the thematic maps. Accuracy assessment was performed using standard procedures explained. The present study has brought that, major changes have been occurred in the agriculture land followed by forest land, habitants, open lands, water bodies and sand respectively in both the years of assessment. The increase in the agricultural land is from 217588 to 306769 ha and where as forest land decreased from 168066 to 63253 ha. Similarly, habitats increase is noticed from 46889 to 62605ha and then Open land has decreased from 46126 to 38928 ha. This study indicates that proper land use planning is essential for a sustainable development of Krishna river basin in future years to come.

Key words : Accracy Assessment, Enhanced thematic mapper, Land use, Land cover, Thematic Mapper .

Land is the most important natural resources on which all activities are based. The land use and land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use and land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet ever increasing demand for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population.

Krishna River is one of the longest rivers in India, about 1400 km in length and extends in an area of 258948 km² which is nearly 8% of total geographical area of the country. Geopolitically, the river basin lies in the states of Andhra Pradesh, Karnataka, and Maharashtra with areas of 113271 km², 76252 km² and 69425 km² respectively.

Tungabhadra, Koyna, Bhima, Mallaprabha, Ghataprabha and Dudhganga rivers are some of the important tributaries of Krishna River. There are about 30 major and medium dams and reservoirs constructed in the Krishna River. In Andhra Pradesh two major dams were constructed on the Krishna River, one is located at Srisailam and another is at Nagarjuna Hill. The mean annual rainfall in the catchment area ranges between 635mm to 1016mm, contributes mainly from South-West monsoon. The important soil types found in the basin are black, red soils, lateritic soils, mixed soils, saline and alkaline soils. Diversified cropping pattern persists in the Krishna River Basin. Principal cultivated crops are: paddy, sorghum, corn, sugarcane, millet, cotton, sunflower, groundnut, turmeric, banana and a variety of horticultural crops. The total cultivable area in the basin is about 203000 km^2, which is equivalent to 78 % of the total geographical area of the basin. The irrigation potential is about 47200 km^2 (23 % of cultivable area). Most of the crops grown in the basin are rain fed.

At Krishna barrage, floods have occurred thirteen times from 1903 to 2009. The peak flood inundation and loss to lives were more during the

year 2009, affected eighty seven mandals in Kurnool, Mahabubnagar, Krishna, Guntur and Nalgonda districts of Andhra Pradesh. For the first time in the history, all the three projects (Srisailam, Nagarjuna Sagar and Prakasam Barrage) in Krishna basin discharged the recorded maximum out flow. The impact of the flood affected 18.16 lakh population, destroying 2.14 lakh houses and inundation of 2.82 lakh hectares of crop. The total estimated damage is in Rs.12824.68 corers (APWRDC, 2009).

Remote sensing is considered (e.g., Geymen and Baz 2008; Treiz and Rogan 2003, Al Fugara *et al.* 2009) as a powerful tool in the change detection of the earth surface. The development of cities goes with an increasing deterioration of the natural environment. For Miller and Small (2003), the conjunction of rapid urban and environmental change could lead to significant urban environmental problems in the future. Policy makers, scientists, and environmental managers will need to use all the tools at their disposal to understand the causes and dynamics of environmental change in and around cities. Remote sensing data, combined with spatially referenced socioeconomic data may provide new ways of identifying, measuring, monitoring, and ultimately managing this change. Masser (2001) argued that a geographic information system (GIS) is an appropriate tool for applications in the field of urban planning and management because of integrating information from different sources.The objectives of this study are to determine the extent of land cover and land use change throughout the period under study (1992 to 2007), to highlight the driving forces behind these changes, and some environmental consequences, and to suggest some recommendations.

Study Area

The study area is Located at (Wadenapally) 104 Km away from Nagarjunasagar Dam. The four gauging stations over which the study is concentrated are Wadenapally, Keesara, PaleruBridge and Vijayawada. Wadenapally and Vijayawada gauging stations are located on the main Krishna River and Keesara and Palerubridge are placed on tributaries. The distance between the main gauging stations is 84 km. The study area of Krishna River is located between 15° 45^{1} N to 16^{0} 30^{1} N latitudes and 79^{0} 30^{1} E to 81^{0} 15´ E longitudes. The location of the study area is shown in Fig. 1

The present study is aimed at

- Preparation of various thematic data such as land use and land cover using Landsat data
- Create a land use land cover map from satellite imagery using supervised classification.
- Find out the areas from the classified data.

MATERIAL AND METHODS

For preparation of land use and land cover classification, thematic mapper images have been ortho-rectified before acquisition, and have the same path/row: 143/049, with a nominal spatial resolution of 28.5 by 28.5 m. The image is taken from Landsat- 4 satellite image using thematic mapper multi-spectral sensor. The Landsat TM is taken in a Universal Transverse Mercator (UTM)/ World Geodetic System 1984 (WGS 84) projection. Bands 5, 4, and 3 (RGB, Red, Green, Blue) have been combined to generate land use land cover change classes. The analysis of land cover implied the classification of main patterns. Land use patterns are classified in six main types in the Landsat satellite images for the period under study. The conventional supervised Maximum Likelihood method was used for the image classification. In addition, enhanced thematic mapper images have been ortho-rectified before acquisition, which have the same path/row: 142/049, with a nominal spatial resolution of 28.5 by 28.5 m. The image is captured from Landsat- 7 satellite image using enhanced thematic mapper plus multi-spectral sensor. The Landsat ETM^{+} is delivered in a Universal Transverse Mercator (UTM)/World Geodetic System 1984 (WGS 84) projection. Bands 5, 4, and 3 (RGB, Red, Green, Blue) have been combined to generate land use land cover change classes. The analysis of land cover implied the classification of main patterns. Land use patterns are classified in six main types in the Landsat satellite images for the period under study. The random sampling approach was used to assess the classification accuracy for each year. For validating these results, ground truth verification is also conducted using

Global Positioning System (GPS). The overall accuracy and overall Kappa statistics are also reported.

The study is based on secondary data; the satellite imagery was downloaded from GLCF (Global Land Cover Facility) web site, the downloaded imagery subset using Imagery software to clip the study area. The clipped satellite imagery was used to prepare the land use and land cover map using supervised classification.

Multi-temporal satellite data set observed by LANDSAT-1, Thematic Mapper (TM), and Enhanced Thematic Classification (ETM+), and Multi Spectral Scanner (MSS) and Survey of India toposheet map drawn on 1:50000 scale were used for the analysis (Table 1). TM and ETM+ are optical sensors which have 7 and 4 multispectral bands between visible and infrared radiations.

The resolution is 30 meters/pixel. Digital land use / land cover classification through supervised classification method, based on the field knowledge is employed to perform the classification. Arc GIS 9.3 and ERDAS Imagine 9.0 are powerful tools for extracting the land use, land cover layer, from toposheets map and satellite imageries. The land use land cover classes include agriculture land, habitats, forest land, open land, water bodies and sand cloud cover areas. This classification is performed based on the classification scheme of National Remote Sensing Center (NRSC), Department of Space, Govt of India.

Accuracy assessment

The Kappa coefficient generally ranges from 0 to 1. For the evaluation of accuracy assessment, it is desirable to calculate both the overall accuracy Kappa coefficient.

The Kappa coefficient is calculated as

$$\hat{k} = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}$$

Where

r = the number of rows in the error matrix,

X_{ii} = the number of observations in row i column i (along the major diagonal),

X_{i+} = is the marginal total of row i (right of the matrix),

X_{+i} = the marginal total of column i (bottom of the matrix),

N = the total number of observations included in the matrix.

RESULTS AND DISCUSSION

The findings of the present investigation are presented in table 2 and 3. From the tables, it is noticed that major changes have been occurred in the agriculture land followed by forest land, habitants, open lands, water bodies and sand respectively in both the years of assessment. Most of the forest lands which were reserved and dense, converted to agricultural land. The forest lands which occupied about 33 percent in 1992 (Land Sat TM Imageries) and 12 percent in 2007 (Land sat, ETM+ Imageries), it is worth reporting that in the last 15 years, almost 60 percent of the forest lands have transformed to Agricultural land, habitats and water bodies. It was also observed that habitats which covered 9% of the total area in the year 1992, increased up to 12 percent in the year 2007. In certain areas, agricultural land also got transformed in to Habitats. Moreover, water bodies which covered about 5 percent of land in 1992, increased to 6 percent in 2007 (Fig 2, 3, & Table2, 3).

Thematic Classification TM (1992):

The land use and land cover map clearly shows that area of Agricultural land is higher than others i.e., 217587.80 ha. Forest land has occupied about 168066 ha followed by habitats (46889 ha), Open land (46126 ha), Water Bodies (25711 ha) and Sand (8501 ha). The total area occupied is of 512881 ha.

Enhanced Thematic Classification ETM+ (2007):

The land use and land cover map clearly shows that area of Agricultural land is higher than others i.e., 306769.04 ha. Forest land occupied 63253 ha followed by habitats (62605 ha), Open land (38928 ha), Water Bodies (29291 ha) and rest

Table 1. Spatial data sources.

Data	Year of Observation	Spatial Resolution / Scale
Land sat-1 (TM)	1992	30m
Land sat-1 (ETM+)	2007	30m
SOI Toposheet MAP	Krishna River	1:50000

Table 2. Data showing land use and land cover area.

Land Use Land Cover (TM)	Area (ha)	Area (%)
Water Body	25711	5
Sand	8501	2
Agriculture Land	217588	42
Habitats	46889	9
Forest	168066	33
Open Land	46126	9

Table 3. Data showing land use and land cover area.

Land Use Land Cover (ETM)	Area (ha)	Area (%)
Water Body	29291	6
Sand	12038	2
Agriculture Land	306769	60
Habitats	62605	12
Forest	63253	12
Open Land	38928	8

Figure: 1 Location Map of the Study area in Andhra Pradesh at Wadenapally, Paleru Bridge, Keesara and Vijayawada gauging stations in Krishna River

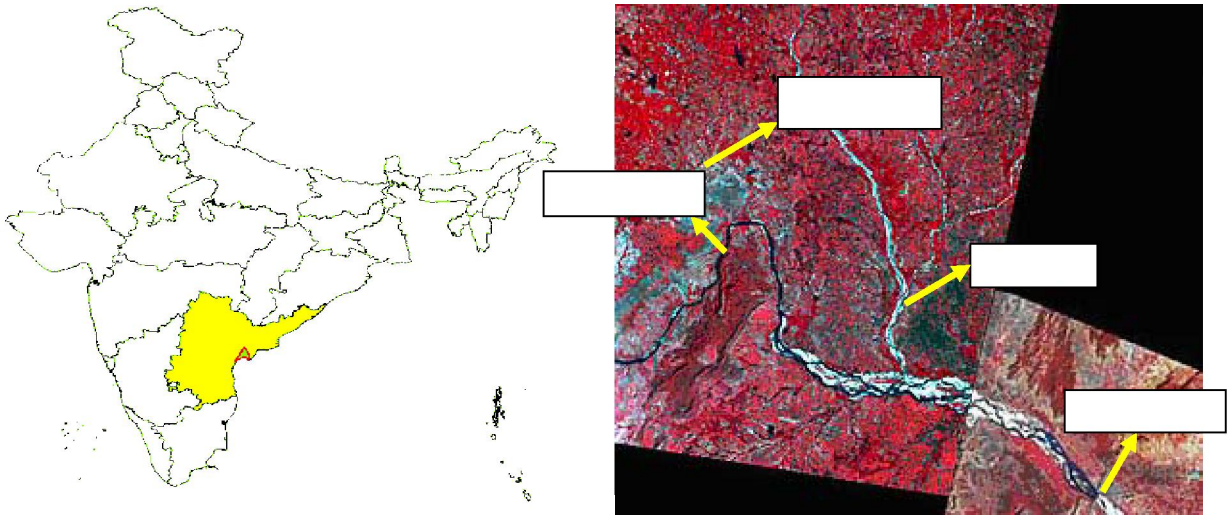


Table 4. Accuracy results classification for the years 1992 and 2007.

Images	Overall classification Accuracy (%)	Kappa (%)
1992 Landsat TM	75.45	66.58
2007 Landsat ETM+	80.00	67.07

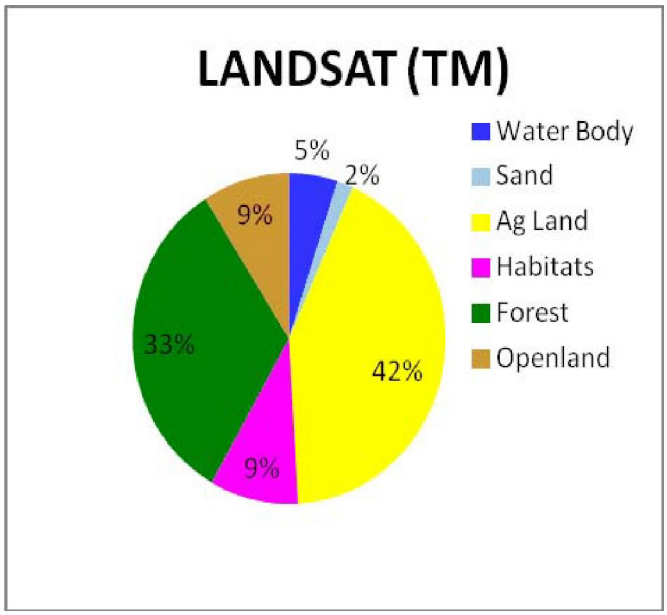


Figure 2. Percentage of land use and land cover classification in the year 1992

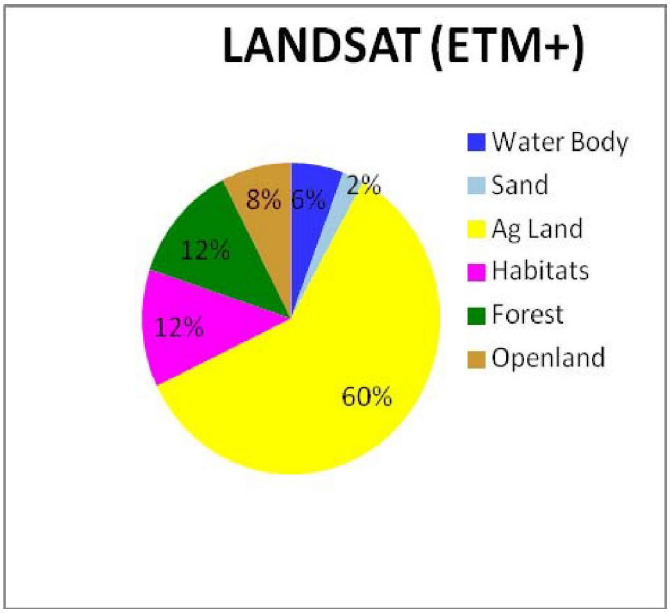


Figure. 3 Percentage of land use and land cover classification in the year 2007

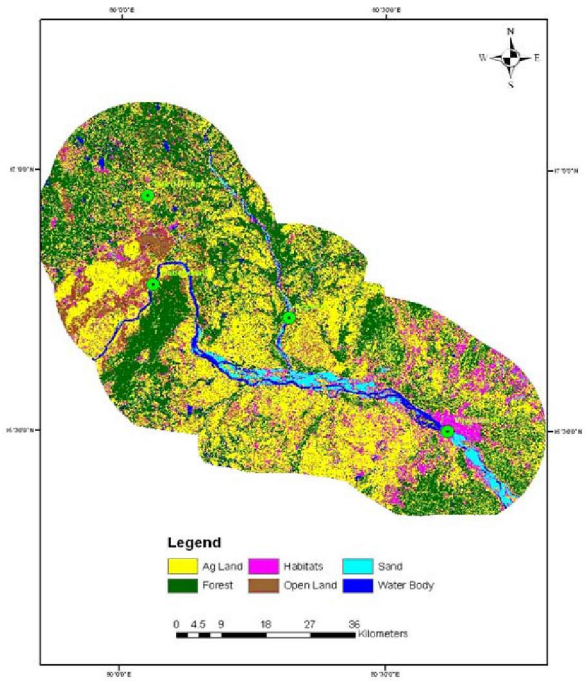


Figure. 4 Land use and land cover classification of Land sat-1 (TM) in the year 1992

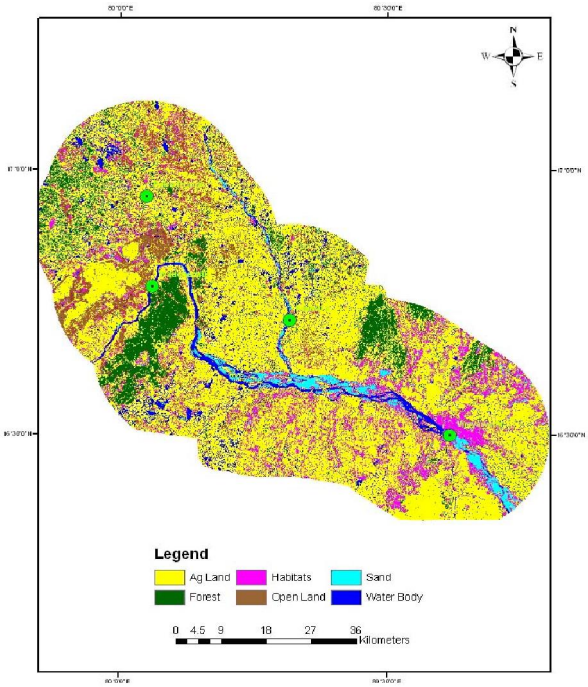
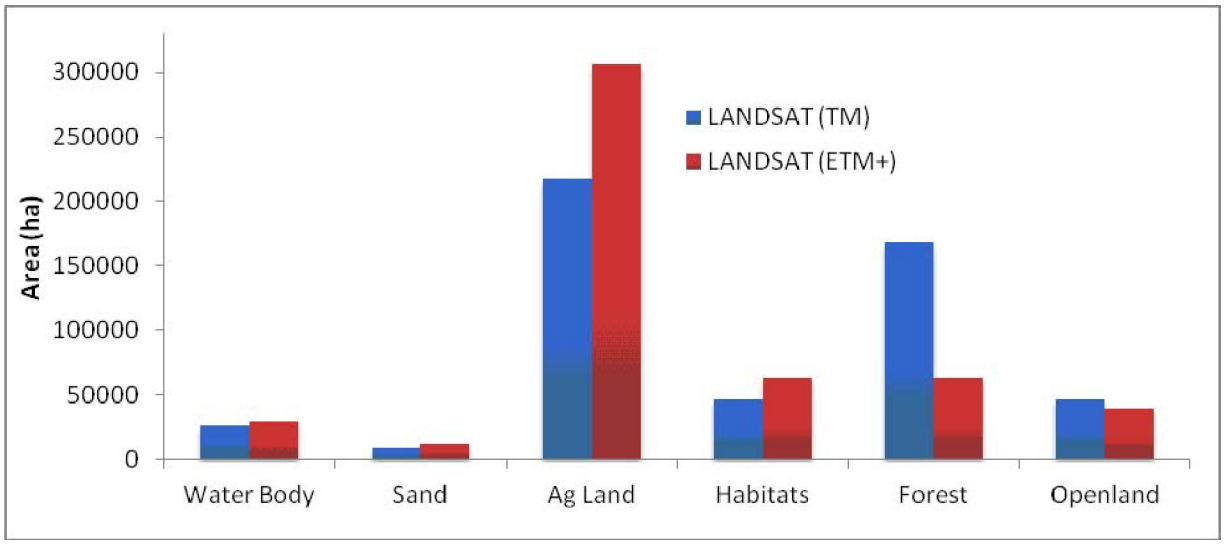


Figure. 5 Land use and land cover classification of Land sat-1 (ETM+) in the year 2007

Figure 6. Distribution of land use land cover distribution during the two periods in the study area.



is of Sand (12038 ha). Finally, it was observed that on average, major changes have been occurred in both the years in the agriculture land followed by forest land, habitants, open lands, water bodies and sand respectively. The increase in the agricultural land from 217588 to 306769 ha was noticed and where as forest land decreased from 168066 ha and 63253 ha. Similarly, habitats increase is noticed from 46889 ha to 62605 ha and then Open land has decreased from 46126 ha and 38928 ha. Water Bodies occupies 25711 ha and 29291 ha and Sand has 8501 ha and 12038 ha area. Altogether, finally the total area can be occupied in this study area is 512884 ha. Finally the land changes (1992 to 2007) are clearly shown on the figures 4 and 5.

Accuracy Assessment

To assess the classification accuracy, a total number of around 110 ground truth observations have been collected using Global Position System (GPS) from the entire study area. Table 4 shows the classification dates and the Kappa co-efficient achieved. It is estimated that the overall classification accuracies of 75.45% for 1992 and 80.00% for 2007 years with overall kappa coefficient is 66.58% for 1992 and 67.07% for 2007 years. The results are in quite agreement with the statistical measure of accuracy range of 0to1 (Miller and Pool, 2002).

Conclusion

Krishna river is one of largest river in India and the major land use is Agriculture. The results of the land use and land cover performed during the years from 1992 and 2007, experienced a declining in the past fifteen years. Most of the forest land is converted to Agricultural land, Habitats, and sand respectively. The increase in agricultural land is a welcoming trend, but increase in the cost of cultivation due to shortage of labour, supply of low quality spurious fertilizers and price .To sum up, it could be stated that, Krishna River being one of the major river of the country is under ecological problems due to improper management of land. Hence, Andhra Pradesh government should initiate necessary steps to protect the land and forest covers for maintaining environmental and ecological balance.

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