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# Land Use and Land Cover Change Detection Study at Pennar River Estuary, Nellore District, Andhra Pradesh, Southeast Coast of India

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### *Abstract*

*Coastal zones are the most valuable and dynamic places on Earth. A large portion of the world's population has habitat coastal areas. Fertile coastal low lands, abundant marine resources, water transportation, aesthetic beauty and intrinsic values have long motivated coastal habitation. Two-thirds of the world's fish catch, and many marine species, depend on coastal wetlands for their survival. The process of coastal morpho-dynamics has resulted in environmental problems such as coastal wetland loss, habitat degradation, water pollution and destruction of forest vegetation as well as host of other issues. In the study, remote sensing (RS) and geographic information system (GIS) were used in order to study land use/land cover changes by using three years (2005, 2007 and 2012) satellite images IRS-P6, LISS-III data of Pennar river estuary in Nellore District, Andhra Pradesh, India. Land use/land cover maps for three years (2005, 2007 and 2012) were prepared. It is observed that the important land use features like coastal wetlands, agricultural crop and plantation lands, waste lands or uncultivated lands, swamps and water bodies and its changes. The result shows a rapid growth in agricultural lands from 44.20 (2005) to 57.45% (2012) due to the annual rainfall. The water bodies and wetlands decreased from 34.53 (2005) to 21.10% (2012). Built-up lands increased 0.17% between 2005 and 2012. Uncultivated or waste lands and swamps got decreased. The reason for these changes can be attributed to urbanization, industrialization and modern civilization.*

***Keywords:*** *Change detection study, coastal zones, remote sensing, GIS*

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## INTRODUCTION

Periodic and precise change detection of Earth's surface features is extremely important for understanding relationships and interactions between human and natural phenomena in order to promote better decision making. Remote sensing data are primary source extensively used for change detection in recent decades on meso scales. Many change detection techniques have been developed. Geographic information system (GIS) and remote sensing can play an important role in the management of coastal resources [1]. Remote sensing data represent a powerful tool to understand the dynamics of the coastal processes where the images allow a synoptic view of the area and establish relationship between coastal environment and vegetation on a multi temporal basis [2, 3]. In addition to an integrated data base, a geographic information system (GIS) combines different data sets and simultaneously facilities spatial and temporal analysis [4]. It also permits the establishment of relationship between various coastal environments that all allow for a more comprehensive, accurate and easier interpretation of coastal environmental features.

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times [5, 6]. Information about land use change is necessary to update land cover maps and for effective management and planning of the resources for sustainable development [7]. The basic premise in using remote sensing data for change detection is that the process can identify change between two or more dates that is uncharacteristic of normal variation [8]. Preparing landscape characteristics maps can help in change detection. Understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for proper land management and decision improvement [9]. Today, Earth resources satellites data are very applicable and useful for land use/cover change detection studies.

In this paper, an attempt is made to know the changes like increasing and decreasing of land use and land cover feature classes of Pennar river estuary by using remote sensing and GIS techniques. Pennar river estuary has attracted people from other places of Nellore coast over the past years due to its abundant marine resources, water transportation, aesthetic beauty and intrinsic values have long motivated coastal habitation. Aquaculture has mostly been carried out at a few places by making ponds. The area is spread along the east coast of Nellore district and is densely populated. As a result, the population growth and the process of coastal morpho-dynamics have resulted in environmental problems such as coastal wetland loss, habitat degradation, water pollution and destruction of forest vegetation as well as host of other issues. The objective of the study is to know the changing pattern of land use and land cover of Pennar river estuary, Nellore coast, Andhra Pradesh, southeast coast of India by using remote sensing satellite data and GIS, as a tool is the main objective of this paper and to identify the governing factors behind these changes.

## STUDY AREA

The study area is geographically located in eastern part of Nellore district, lying between latitude 14°30’24” – 14°38’38” N and longitude 80°04’18”– 80°13’08”E in Andhra Pradesh, falling in Survey of India toposheet No: 66B02 (Figure 1). The total area covered is approximately 177.54 km$^2$. The study area comprises the entire area sprawling of river Pennar. The density of population is 182 km$^2$. The eastern portion of the study area is fairly fertile and prosperous. The sandy coastal belt extends from the sea for 5 to 6 km into the interior. Average annual rainfall in the study area is 1041 mm and the average maximum and minimum temperatures are 39.6 and 20 °C respectively.

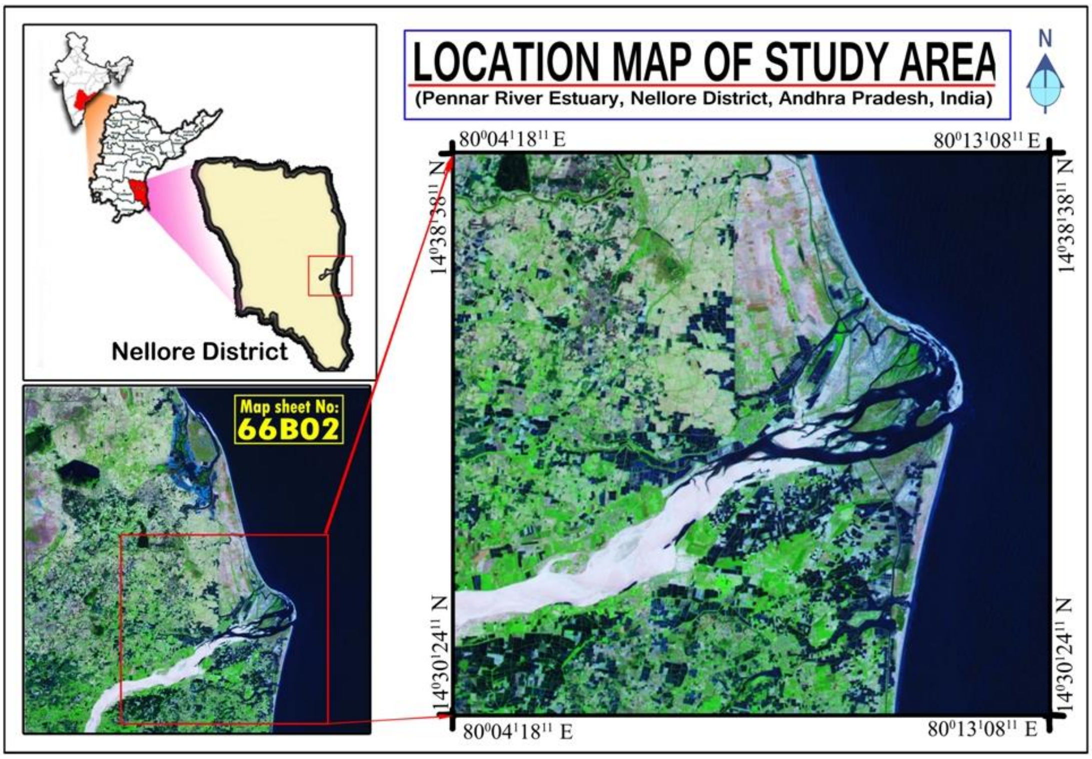


***Fig. 1:*** *Location Map of Study Area.*

### Data Used
Geocoded false color composite scene of IRS-P6 LISS III data on 1:50,000 scale (year 2005, 2007 and 2012 respectively) coinciding with Survey of India (SOI) toposheet No. 66B02 is used in the present study. Annual rainfall data for the period of 2005–2012 has been used.

## METHODOLOGY
The work is done by visual image interpretation. The following steps are involved in the classification procedure. Preprocessing has involved scanning and digitization of Survey of India toposheets at 1:50000 scale to serve as the base map [10]. Scanned maps do not usually contain information as to where the area represented on the map fits on the surface of the Earth, for these images have to register coordinates. To establish the relationship between an image (row, column) coordinate system and a map (x, y) coordinate system we need to align or geo-reference the raster data (image). Processing has involved application of various GIS functions and advanced digital image processing technique including contrast manipulation, edge enhancement, and image registered. The images were geometrically rectified and registered to the same projection namely, Transverse Mercator WGS 1984 to lay them over each other [11, 12].

The initial LandSat 2005, 2007 and final 2012 IRS P6 LISS III imageries were subjected to classification zones. Visual image interpretation was utilized to classify the images to different land use categories. In order to classify the rectified images, six classes were delineated in the images namely, cultivated/agricultural lands, built-up lands, wetlands/water bodies, uncultivated lands, rivers and swamps. The land use/land cover maps prepared for the year 2005, 2007 and 2012 are given in Figures 2, 4 and 6, respectively [13].

Change detection analysis encompasses a broad range of methods used to identify, describe and quantity differences between images of the some scene at different times or under different conditions many of the tools can be used independently or in combination or in combination as part of a change detection analysis. Change detection menu after a straight forward approach to measuring changes between a pair of images that represent a pair of images that represent on initial stage and final stage. The change detection statistics for classification images averages are used for computing difference map for images [14].

## RESULTS AND DISCUSSIONS
The objective of this study forms the basis of all the analysis carried out. The results are presented in the form of maps, charts and statistical tables. They include the static, change and projected land use land cover of each class. The static land use/land cover distribution for each study year as derived from the maps is presented in Table 1.

***Table 1:*** *Land Use/Land Cover Distribution (2005, 2007, 2012).*

| **Feature class** | **2005** | | **2007** | | **2012** | |
|---|---|---|---|---|---|---|
| | **Area ($Km^2$)** | **%** | **Area ($Km^2$)** | **%** | **Area ($Km^2$)** | **%** |
| Water bodies | 61.30 | 34.53 | 51.71 | 29.13 | 37.46 | 21.10 |
| Cultivated/Agricultural land | 78.49 | 44.20 | 92.56 | 52.13 | 102 | 57.45 |
| Built-up land | 5.41 | 3.05 | 5.46 | 3.08 | 5.71 | 3.22 |
| Uncultivated land | 6.42 | 3.62 | 5.39 | 3.04 | 3.21 | 1.81 |
| Rivers | 22.68 | 12.78 | 19.26 | 10.85 | 21.67 | 12.21 |
| Swamps | 3.24 | 1.83 | 2.29 | 1.29 | 1.93 | 1.09 |

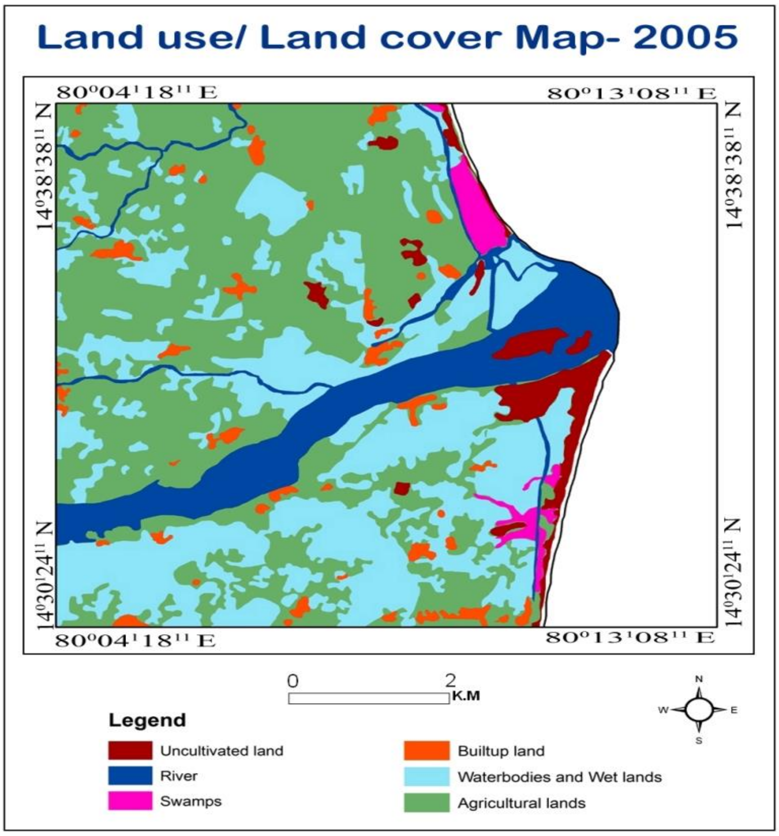


***Fig. 2:*** *Land Use/Land Cover Map of Study Area-2005.*

The land use/land cover categories and change detection study of the study area were mapped using IRS P6 LISS-III data of 1:50,000 scale. The satellite data was visually interpreted and after making thorough field checks, the maps were finalized. The various land use and land cover classes are interpreted in the study area in three years, i.e., 2005, 2007 and 2012 respectively. The fallowing features were interpreted in the study area: they are water bodies, cultivated/agricultural lands, built-up land, uncultivated land, rivers and swamps (Figure 3).

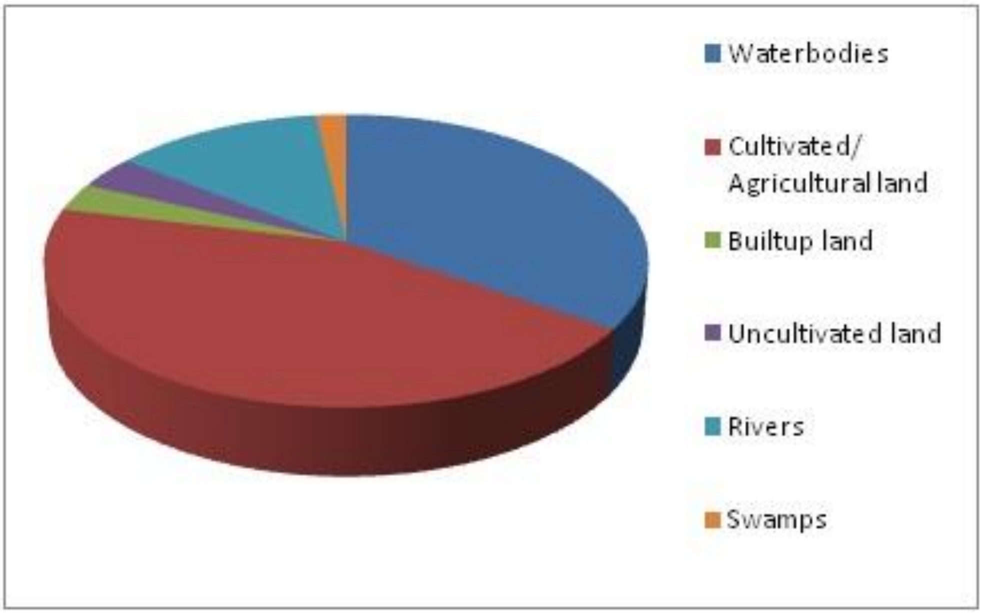


***Fig. 3:*** *Pie Diagram of Land Use/Land Cover in 2005.*

In 2005, agricultural lands/cultivated lands are crop lands under crop. In the study area, crop lands have wet cultivation and dry cultivation. It occupies the highest class with 44.20% (78.49 km$^2$) of the total class, taking up more than half of the total area. The water bodies include both natural and man-made water features namely lakes/tanks and reservoirs occupy 34.53% (61.30 km$^2$) of total area. Built-up land occupied 3.05% (5.41 km$^2$). It composed of areas of intensive with much of the land covered by structures. Included in this category are cities, towns, villages, industrial and commercial complexes and institutions. Lands, which do not support any vegetation are known as uncultivated lands or waste lands. Barren rocky, salt-affected land, land with and without scrub, sandy area, sheet rocks and stony regions are included in this category. Uncultivated land occupies 3.62% (6.42 km$^2$). Pennar river and its streams occupy 12.78% (22.68 km$^2$) of total area. Swamps are tract of wet, spongy land, often having a growth of certain types of trees and other vegetation, but unfit for cultivation. It occupies 1.83% (3.24 km$^2$) of the area.

The land use/land cover study in 2007 in the study area showed the following results: water bodies occupy 29.13% (51.71 km$^2$) of the study area; cultivated/agricultural lands occupy 52.13% (92.56 km$^2$); and other features like built-up land, uncultivated lands, rivers and swamps occupy 3.08% (5.46 km$^2$), 3.04% (5.39 km$^2$), 10.85% (19.26 km$^2$) and 1.29% (2.29 km$^2$) of the area respectively.

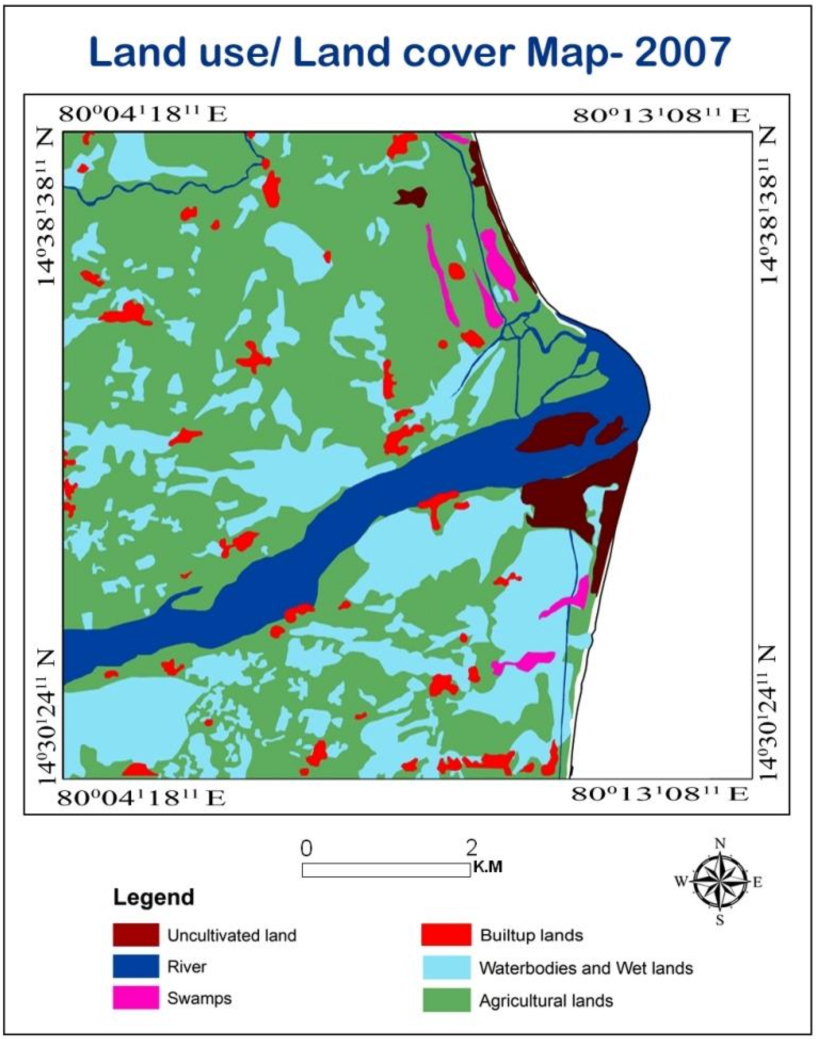


***Fig. 4:*** *Land Use/Land Cover Map of Study Area-2007.*

  

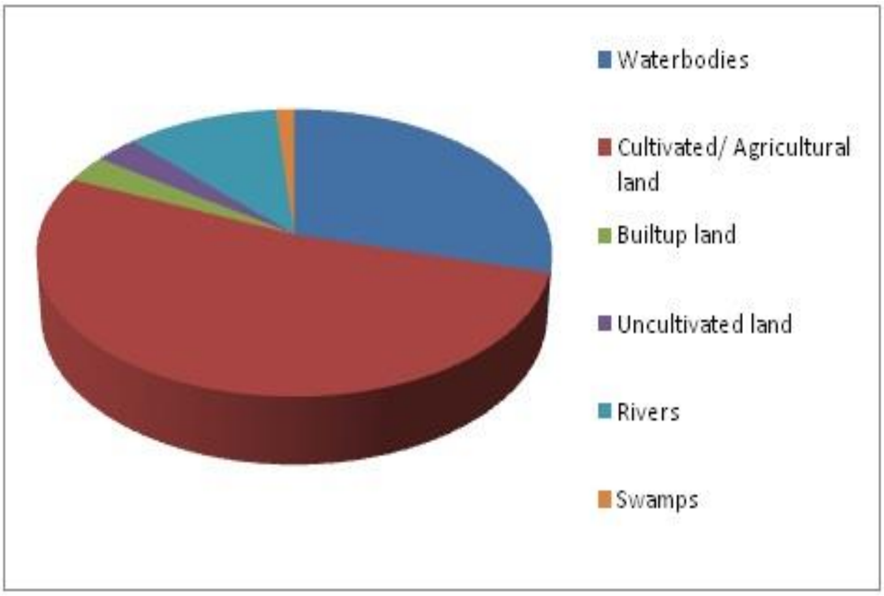


***Fig. 5:*** *Pie Diagram of Land Use/Land Cover in 2007.*

Figure 6 shows the land use/land cover classification derived from independently classified image of 2012. The change is calculated in area (square kilometers) and percentage within each land use class. Water bodies cover 37.46 $km^2$ (21.10%), cultivated/ agricultural land occupies greater than half of the study area 102 $km^2$ (57.45%). Builtup land covers 5.71 $km^2$ (3.22%). Uncultivated or waste land covers 3.21 $km^2$ (1.81%), rivers cover 21.67 $km^2$ (12.21%) and swamps occupy 1.93 $km^2$ (1.09%) of the total study area.

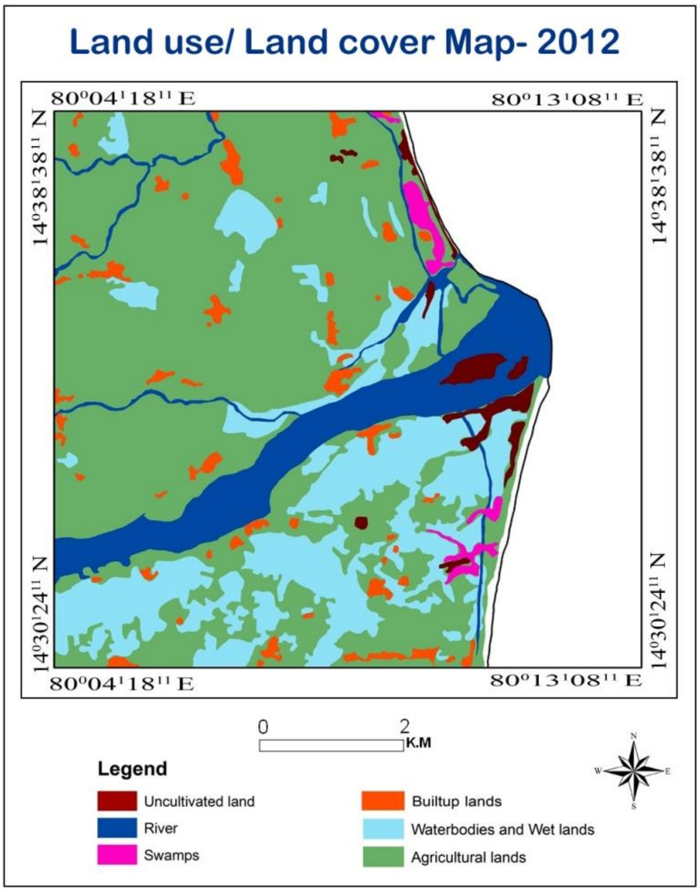


***Fig. 6:*** *Land Use/Land Cover Map of Study Area-2012.*

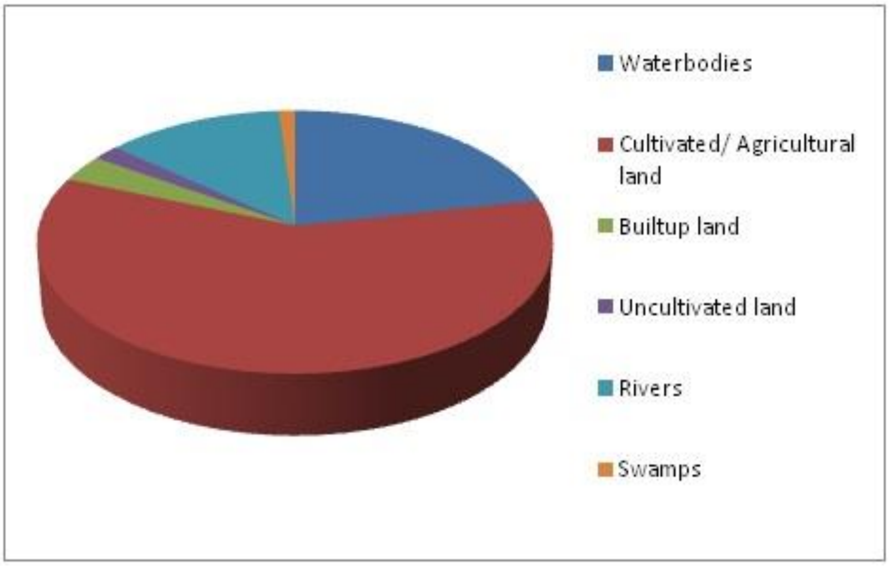


***Fig. 7:*** *Pie Diagram of Land Use/Land Cover in 2012.*

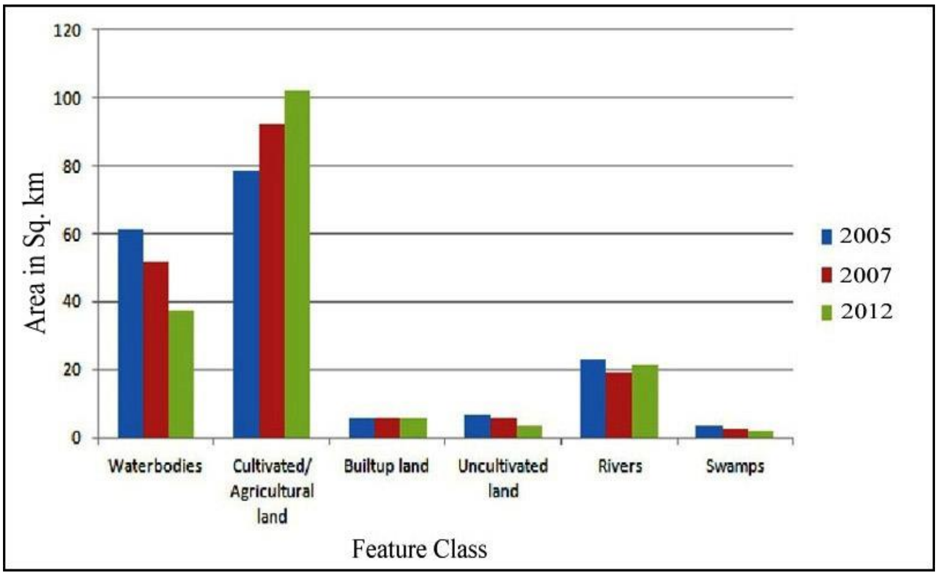


***Fig. 8:*** *Graphical Representation of Change Detection.*

## Land Use/Land Cover Change Analysis

***Table 2:*** *Land Use Land Cover Change: 2005, 2007 and 2012.*

| Land use/ land cover class | 2005–2007 | | 2007–2012 | | 2005–2012 | |
|---|---|---|---|---|---|---|
| | **Area ($km^2$)** | **%** | **Area ($km^2$)** | **%** | **Area ($km^2$)** | **%** |
| Water bodies | −9.59 | 5.4 | −14.25 | 8.03 | −23.90 | 13.43 |
| Cultivated/agricultural land | 14.07 | 7.93 | 9.44 | 5.32 | 23.51 | 13.25 |
| Built-up land | 0.05 | 0.03 | 0.25 | 0.14 | 0.30 | 0.17 |
| Uncultivated land | −1.03 | 0.58 | −2.18 | 1.23 | −3.21 | 1.81 |
| Rivers | −3.42 | 1.93 | 2.41 | 1.36 | −1.01 | 0.57 |
| Swamps | −0.95 | 0.54 | −0.36 | 0.2 | −1.31 | 0.74 |

From Table 2, there seems to be a negative change in the feature class. The reduction in water bodies 5.4% (9.57 $km^2$), uncultivated land 0.58% (1.03 $km^2$), rivers 1.93% (3.42 $km^2$) and swamps between 2005 and 2007. Subsequently, cultivated/agricultural land and built-up land both increased by 7.93% (14.07 $km^2$) and 0.03% (0.05 $km^2$) respectively. Between the years 2007 and 2012, there was a reduction in water bodies 8.03% (14.25 $km^2$), uncultivated land 1.23% (2.18 $km^2$) and swamps 0.2% (0.36 $km^2$) of the area. The features of cultivated/agricultural lands, built-up land and rivers were increased 5.32% (9.44 $km^2$), 0.14% (0.25 $km^2$) and 1.36% (2.41 $km^2$) of the area respectively.

The reduction in water bodies 13.43% (23.90 $km^2$), at the same cultivated/agricultural lands increased 13.25% (23.51 $km^2$) from the year 2005 to 2012, were also seen the rainfall data (Table 3) which is the main source for decreasing of wet land/water bodies. It was seen that decreasing trends of rainfall is directly useful for increasing the crop area by the decreasing of water bodies and wet lands. Width of river also decreased 0.57% (1.01 $km^2$). Cultivated lands increased, swamp and uncultivated lands decreased 0.74 and 1.81% respectively. Built-up land increased 0.17% due to its abundant marine resources, water transportation, aesthetic beauty and intrinsic values have long motivated coastal habitation.

**Annual Rainfall Analysis**

Annual rainfall data of three years 2005, 2007 and 2012 (Hydromet Division, Indian Meteorological Department) show that annual rainfall recorded as 1404, 853, and 911 mm in the years of 2005, 2007 and 2012 respectively. Significant decrease trend was observed graphically in the rainfall from the year 2005 to 2012 (Figure 9). It was seen that decreasing trends of rainfall have been directly useful for increasing the crop area by the decreasing of water bodies and wet lands.

***Table 3:*** *Annual Rainfall.*

| S. No. | Year | Annual rainfall (mm) |
|---|---|---|
| 1. | 2005 | 1404 |
| 2. | 2007 | 853 |
| 3. | 2012 | 911 |

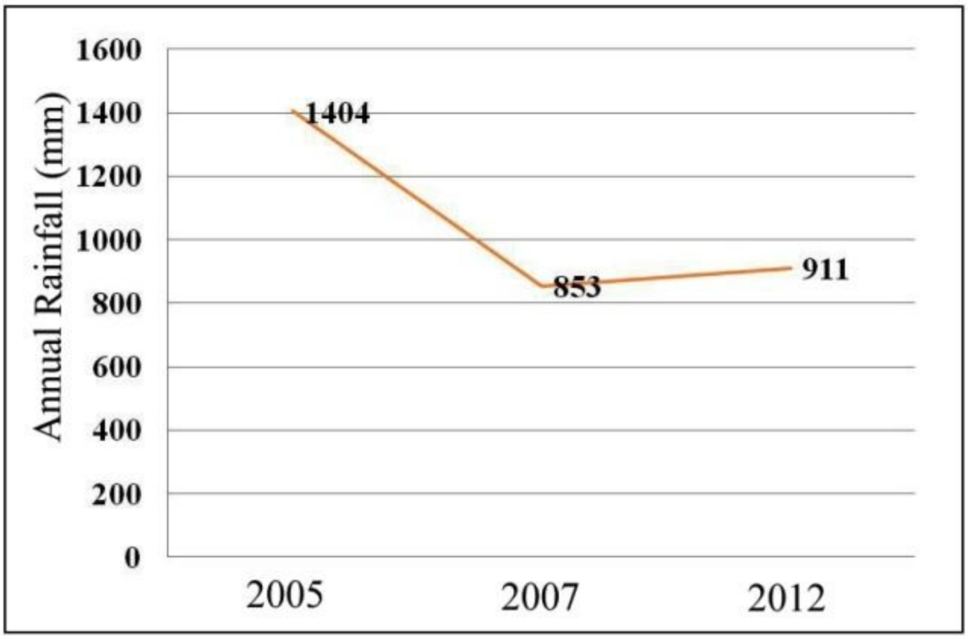


***Fig. 9:*** *Graphical Representation of Annual Rainfall.*

When rainfall decreases, water availability is not a problem in most part of the district for domestic and agricultural purposes. Because of the coastline, all the area within short distance from the coast face no shortage of water for their domestic, agricultural and industrial needs. Pennar river is perennial and most of the people use it as a major water source. Majority of water resources are being used extensively in aquaculture.

## CONCLUSIONS

Looking at the results of this study, change detection techniques using temporal remote sensing data provide detailed information for detecting and assessing land cover and land use dynamics. Different change detection techniques were applied to monitor the changes. The change analysis was based on three years data (2005, 2007 and 2012). The reduction in water bodies 13.43% (23.90 $km^2$), at the same time cultivated/ agricultural lands increased 13.25% (23.51 $km^2$) from the year 2005 to 2012, were also seen the rainfall data (Table 3) which is the main source for decreasing of wet land/water bodies, It was seen that decreasing trend of rainfall has been directly useful for increasing the crop area by the decreasing of water bodies and wet lands. Width of river also decreased 0.57% (1.01 $km^2$). Cultivated lands increased, swamp and uncultivated lands decreased 0.74 and 1.81% respectively. Built-up land increased 0.17% due to its abundant marine resources, water transportation, aesthetic beauty and intrinsic values have long motivated coastal habitation.

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