Change Detection Analysis Using Geo-Spatial Technique: A Case Study of South Goa

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Abstract Remote sensing is become more important in monitoring local, regional, Global resources and environment [4]. Remote sensing technique has been used to illustrate the land use/cover dynamics of the district of South Goa located between Western Ghats and the Arabian Sea. Land sat seven and eight (ETM+) images were acquired from glovis.usgs and were used to quantify the changes in south Goa from 2005 to 2015. Supervised Classification methodology has been employed using Maximum Likelihood Technique in ERDAS IMAGINE [13], [12], [9]. Land use of the study area were categorized into five different classes, viz. built-up area, vegetation, agricultural land, water bodies and barren land. The results reveled that there has been a significant increase cultivable land in the middle and central areas and a tremendous decrease in natural vegetation area. There has been an increase in built up area around major cities such as Margao and Vasco due to increasing population, upcoming industries and tourism related activities. This study highlights the importance of geo-spatial technology in change detection studies.

Index Terms: Change detection, ETM+, Landsat, Land use, Land cover, supervised classification and remote sensing

1 Introduction

Land use/cover change has become a central and important component in current strategies for managing natural resources and monitoring environmental changes [1], [10], [8]. Land cover in simple terms means the distribution of natural features over the earth's surface. It can be defined as the distribution of the natural landscape over a region along with all the related features and types of features. Land use is the exploitation of the natural land cover using land management strategy that reflect in terms of human activities like industrial zones, settlement zones, agricultural fields etc [10]. Land use/cover change is a dynamic process taking place on the bio-physical surfaces that have taken place over a period of time and space is of enormous importance in natural resource studies [10],[11].

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Land use/cover change dynamics are important elements for monitoring, evaluating, protecting and planning for earth resources [1]. An increase in human activities due to overpopulation and expansion has resulted in faster land use/cover dynamics; this is turning into one of the world's most important issues. Activities such as overgrazing, deforestation, poor irrigation and watershed management, ill-practiced land management plans result in degradation of the environment [2]. Sustainable land use and land cover changes are one of the major challenges for the development of any area [11]. Viewing the earth from space is now crucial in understanding the influence of man's activities on his natural resource base over time. Digital change detection techniques based on multi-temporal and multi-spectral remotely sensed data have demonstrated a great potential as a means to understanding landscape dynamics - detect, identify, map, and monitor differences in land use and land cover patterns over time, irrespective of the causal factors [8],[2],[4]. The present study demonstrate the application of geo-spatial technique to assess the land use and land cover dynamics of the district of south goa, a coastal area located between the Western Ghats and the Arabian Sea. South Goa over the past decade has seen remarkable growth in infrastructure, industry, tourism, agriculture and even in the socio-economic condition of the people. However, this change occurring at an accelerated rate due to faster and more profitable business transactions has resulted in ignorance of the beautiful landscape and its maintenance. To manage this high development, exploitation of the immediate resources of this small region is going unchecked. GIS is the fastest and easiest tool with high accuracy that can be used to identify the changes in the region and provide data for assessment and further research. This study is an attempt to identify the changes both positive and negative, taken place in the region over the past decade and also to probe possible solutions to any existing or lurking problems. The aim of this study is to analyze the Land Use/ Cover changes taken place in the district of South Goa over ten year period of time and to understand the causes and effects of it.

1.2 Study area

For the present study, South Goa was selected as a study area. South Goa is one of the two districts of the state of Goa in western India. It is bordered by the Arabian Sea to the west and the Western Ghats to the east; the region known as the Konkan. It lies between latitudes $15^0$0′00″ N and $15^0$30′00″ N and longitudes $73^0$45′00″ E and $74^0$15′00″ E. comprising of a total area of 1966 km^2

2 Data and Methodology

2.1 Data-

Remote sensing data Landsat 7 and 8 images were acquired in years of 2005 and 2015 from glovis.usgs.gov. Data acquired were as follows for each year.

Table 1. Showing the Land sat imagery data

Month and Year	Satellite	Sensor	Resolution
January 2005	Landsat 7	ETM+	30m
January 2015	Landsat 8	ETM+	30m

2.1.1 GPS: GPS was used to identify points during field survey and which point were overlay on satellite data.

2.1.2 Collateral data: Surveyed land use/cover data was obtained from the Town and Country Planning office Panaji to authenticate digitally generated data.

2.1.3 Software: For the present study ArcGIS 10.1, ERDAS Imagine 9.2 and Microsoft Office 2007 softwares were used.

2.2 Methodology

In present research, Fig. 1 reveals the methodology used to assess the dynamics of the land use and land cover of the South Goa between year 2005 and 2015.

2.2.1 Image Classification

Image classification refers to the task of extracting information classes from a multiband raster image. Image classification is of two type Qualitative (Visual) Image classification and Quantitative (Digital) Image classification. Quantitative (Digital)

Image classification was used in this classification. These techniques aggregate pixels to represent land cover features. Land cover could be forested, urban, agricultural and other types of features. Pixels are the smallest unit represented in an image. Image classification uses the reflectance statistics for individual pixels. Unsupervised and supervised image classification techniques are the two most common approaches [13], [9]. However, we have used supervised image classification as this was the most convenient method and precise method to carry out our study.

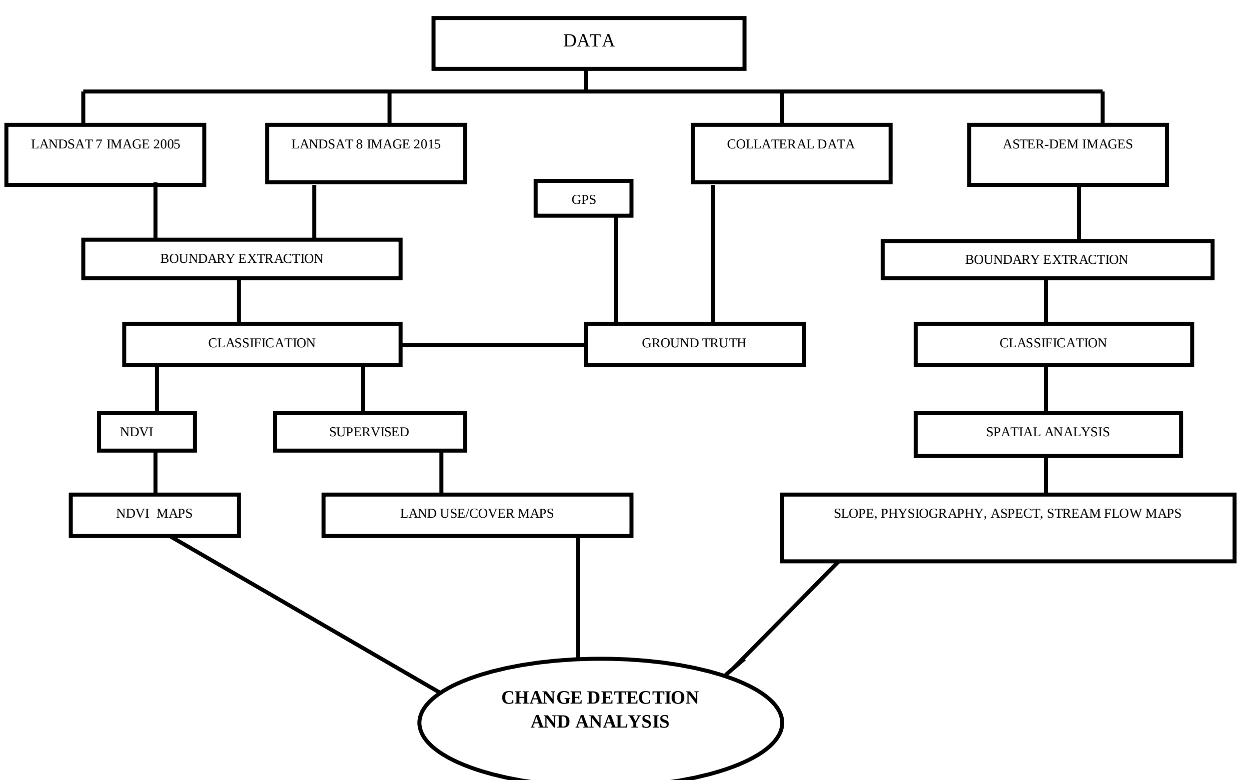
2.2.2 Supervised Classification

The user selects representative samples for each land cover class in the digital image called "training sites". The image classification software uses the training sites to identify the land cover classes in the entire image. The classification of land cover is based on the spectral signature defined in the training set. The digital image classification software determines each class on what it resembles most in the training set. The common supervised classification algorithms are maximum likelihood and minimum-distance to mean classification. For the present study we have used maximum likelihood classification. Maximum likelihood classification is a statistical decision criterion to assist in the classification of overlapping signatures; pixels are assigned to the class of highest probability [9].

2.2.3 Normalized Difference Vegetation Index

The Normalized Difference Vegetation Index (NDVI) is a standardized index allowing you to generate an image displaying greenness (relative biomass) [9], [10]. This index takes advantage of the contrast of the characteristics of two bands from a multispectral raster dataset—the chlorophyll pigment absorptions in the red band and the high reflectivity of plant materials in the near-infrared (NIR) band. NDVI is often used worldwide to monitor drought, monitor and predict agricultural production, assist in predicting hazardous fire zones, and map desert encroachment [6]. The NDVI is recommended for global vegetation monitoring because it helps to compensate for changing illumination conditions, surface slope,

Fig. 1. Flow chart of the methodology



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aspect, and other extraneous factors [10]. The differential reflection in the red and infrared (IR) bands enables to monitor density and intensity of green vegetation growth using the spectral reflectivity of solar radiation. Green leaves commonly show better reflection in the near-infrared wavelength range than in visible wavelength ranges. When leaves are water stressed, affected by the disease, or dead, they become more yellow and reflect significantly less in the near-infrared range. Clouds, water, and snow show better reflection in the visible range than in the near-infrared range, while the difference is almost zero for rock and bare soil. The NDVI process creates a single-band dataset that mainly represents greenery. The negative values represent clouds, water, and snow, and values near zero represent rock and bare soil. NDVI values are represented as a ratio ranging in value from -1 to 1 but in practice extreme negative values represent water; values around 0 represent bare soil and values over 0.3 represent dense vegetation.

3 Result and discussion

3.1 Land Use/Cover Data Analysis

Land Use/Cover data was analyzed using ERDAS IMAGINE 9.2 software. Five categories of classification were used (fig. 2) i.e. vegetation, built up area, barren land, cultivable land and water bodies. Land Use/Cover maps were generated for the images and analyzed using graphs and visual interpretation keys to determine the static land use/cover and the changes were studied using tables.

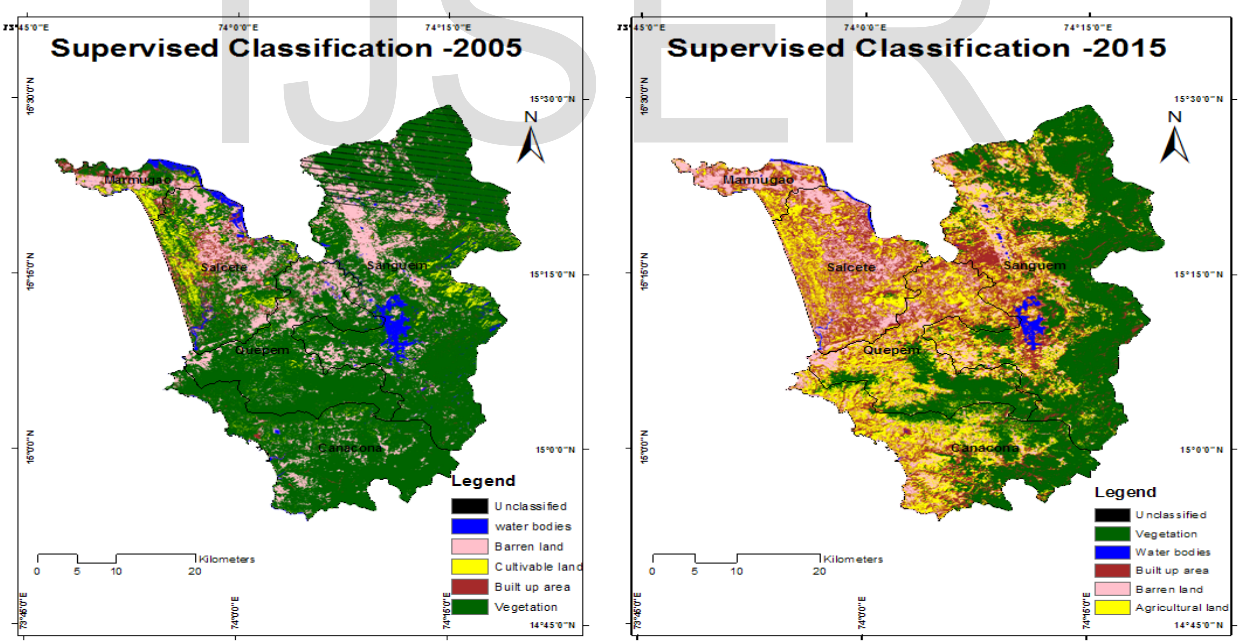

Fig. 2. Land use/cover in 2005 and 2015

Table 2.Showing the Land Use/Cover distribution in 2005 and 2015

Class Name	2005 Area in acreage	2015 Area in acreage	2005 Area covered %	2015 Area covered %
Vegetation	242726	176583	50.66100627	36.85492455
Water Bodies	12010	4821	2.506689375	1.006198735
Built up Area	77000	95000	16.07119749	19.8276042
Barren Land	70246	87904	14.66152388	18.34658652
Cultivable Land	77136	114822	16.09958298	23.96468599
Total	**479118**	**479118**	**100**	**100**

3.2 Land Use/Cover in 2005

In 2005, the area under land cover was much higher than the area under land use. (Table 2) Natural vegetation occupied more than half the area of the whole region. Water bodies made up for about 2.5% of the total land cover. Built up area was mostly situated closer to the coast and in villages and small towns' further inland. Cultivation was carried out by families on small scale and little or no large scale/ commercial cultivation was carried out. Human activities were high but the land still had a good amount of natural cover as the mainly focused activities were fishing and small scale farming and small scale plantations. Tourism was mainly concentrated in the North Goa district which thereby had an unequal distribution of both population as well as development. Only certain major sectors in this region were developed to a good extent. Natural vegetation was prominent due to less invasive and exploitative activities of man. Mining activities were also not so prominent due to which the talukas of Sanguem, Quepem and Canacona had a dense natural vegetation cover. Salcete was the most developed talukas at the time with higher concentration of built up area along the coastal belt. The port area of Vasco was also another developed region. Being a port and also as a Naval Base, the area had a faster growth strata than other areas. South Goa was developing at a moderate rate with an excellent natural cover.

3.3 Land Use/Cover in 2015

In 2015, the land use dominates over land cover by a substantial amount (Table 2). Natural vegetation and water bodies both are having a total area wise percentage of 37%. Built up area has touched 24% while cultivable land has reached 19%. Barren land has come up to 18%. Agriculture is not only confined to traditional paddy and other crops, but also to plantations and orchards and other such viable crops. This has led to an increase in the area under cultivation for a variety of profitable crops. Population increase and expansion of towns has resulted in encroachment on the natural vegetation and increase in built up area. A spike of unchecked and uncontrolled mining activities till 2013 had led to decrease in the many dense vegetative regions of the talukas of Sanguem, Canacona, and Quepem. Salcete has increased in concentration of built up areas and cultivable land as many areas were cleared out to be used as farms and plantations and orchards and construction of settlement zones and industries. The concentration of population is high along the National Highway 17 especially in and around the cities of Margao and Vasco. Leftover mining sites have now turned into barren lands with infertile soil and polluted surroundings, leaving them neither useful for agriculture nor for settlements.

3.4 Changes in Land Use/Cover

Table 3. Showing the percentage of changes in Land Use/Cover from 2005 to 2015

Class Names	Percentage Change	Positive Change	Negative Change
Vegetation	14%		-
Water Bodies	1.5%		-
Built up Area	3%	+	
Barren Land	4%	+	
Cultivable Land	7%	+	

The above table (table 3) shows the percentage of change taken place in each of the respective classes from the year 2005 to 2015. Natural cover has declined by 15.5%, while built up areas and cultivable land has increased by 10% each. Barren land has increased by 4%. The number of changes taking place in this region is very vast and at accelerated rates. To manage the growing population and provide for their needs, settlements are expanding and encroaching over natural cover. To provide food and also to act as a source of income, natural vegetation is being cut down for the use of land as commercial farms, plantations etc. Unfavorable and overused lands were left as barren lands. Mining activities that were running in full swing had laid waste to the vegetation in the southern talukas. Now barren and dry, these mining sites have been rendered useless. Expanding tourism in this region has accelerated the growth of the area and has also accelerated the exploitation of the surrounding land cover. The percentage of positive change and negative change is remarkably similar, leading to the observation that the exploitation and depletion of one is leading to the growth of the other. The amount of change that has occurred is a result of expansion, exploitation, development and periodic changes going hand in hand.

3.5 NDVI Change Analysis

The NDVI images were generated using Arc GIS software. The NDVI images of 2005 and 2015 were classified into five classes each. These are water body, marshy land, barren land, cultivation and dense forest. Table 4 shows the NDVI of the district of South Goa in 2005 and 2015.

Table 4. Showing NDVI values of 2005 and 2015

Class	Threshold Values in 2005	Threshold Values in 2015
Water Body	-0.143 – -0.024	-1 – -0.592
Marshy Land	-0.024 – -0.089	-0.592 – -0.098
Barren Land	-0.089 – 0.230	-0.098 – 0.145
Cultivation	0.230 – 0.327	0.145 – 0.380
Dense Forest	0.327 – 0.547	0.380 – 1

As can be observed, the threshold values of water body changed from -0.143 to -0.024 in 2005 to -1 to -0.592 in the year 2015. For marshy land also the range decreased from -0.024 to -0.089 in 2005 and -0.592 – -0.098 in 2015. There was similar change in the NDVI value for barren land in the same period.

The positive change in NDVI value of cultivation shows there is small increase in cultivation in 2015 than 2005. The increase in NDVI value for dense forest from 0.327 to 0.547 in 2005 and 0.380 – 1 in 2015.

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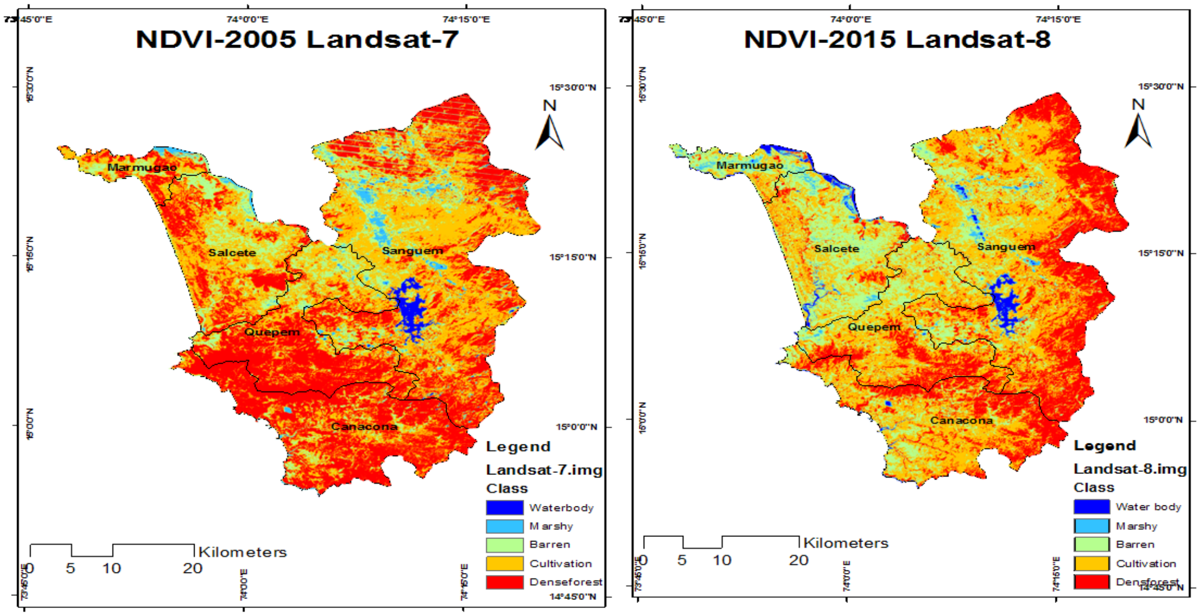

Fig. 3. Illustrates the NDVI index for 2005 and 2015

The NDVI map in 2015 shows occurrence in water body in place of marshy lands which were present in 2005 along the border of Salcete and Mormugao Talukas. (Fig. 3) The marshy lands have also turned into water bodies in the interior of Sanguem taluka. In 2005, almost all of Canacona was covered by dense forest but now in 2015 it is less than 40%, this happened mainly due to mining activities in the region. In 2005, more than 50% of Quepem was covered by dense forest and in 2015 half of the area has reduced due to mining. In 2005 some parts of Salcete and Mormugao were covered by dense forest while in 2015, it is hardly there. Sanguem is the only taluka which shows an increase in forest in 2015 from 2005. Marshy land in South Goa has decreased in this time period, while water bodies in Salcete and Mormugao talukas were converted into marshy areas, some parts of marshy area in Sanguem were converted for cultivation. Sanguem taluka shows decrease in the area covered by barren land. The forests in Canacona and Quepem were cleared for mining but when mining was banned these land area was cultivated and hence about 80% of area is under cultivation. There is hardly any area under cultivation in Salcete and Mormugao talukas left as there was some area under cultivation in 2005. Sanguem shows some decrease in area under forest as it has been converted to agricultural fields.

4 Conclusions

The pattern of land use/cover has changed drastically over the past decade with natural vegetative cover declining at an alarming rate. The total vegetation in the region in the year 2005 comprised more than half of the total land area (50%). Whereas in 2015 the vegetative cover comprises only about 36% of the total area. A negative change of 14% was observed from 2005 to 2015. This is due to the rise in population and encroachment on natural landscapes for setting up settlement zones or expansion of existing cities and enhance in the number of industries. NDVI reveals that cultivation areas have had a high increase; the same is also supported by Land use/cover change analysis. However, the indices also reveal that many small water bodies have been converted into marshy areas and forest cover has declined drastically. This is mostly due to human activities of expansion and mining. Water bodies comprised around 2.5% of the total land cover in 2005 and in 2015 due to rapid encroachment and utilization of immediate resources the area under water bodies has reduced to 1%. Built up area has increased throughout the region, i.e. from 16% of the total area in 2005 to 19% of the total area in 2015. A positive change of 3% this is mainly due to overpopulation and urban expansion. It is a positive change but the expansion is occurring on the natural forest cover. City limits are being expanded to fit the increasing population and surrounding lands are being turned into multi housing projects, urban centers, industrial centers etc. Barren land has increased in area from 14% in 2005 to 18% in 2015. It is a positive change but with negative consequences. This change has had a driving force that is mining. Overuse of land also leads to turning it into barren land. Cultivable land has increased from 16% in 2005 to 23% in 2015, and that's a positive change of 7% in cultivable land. Agriculture and agro-based products are finding a new market in this region which is leading to the increase in cultivable areas. This includes orchards, plantations and farms.

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