SATELLITE-BASED MULTITEMPORAL CHANGE DETECTION IN IGNEADA FLOODED FORESTS

ALIYE GONCA BOZKAYA*, FILIZ BEKTAS BALCIK**, CIGDEM GOKSEL**, AHMET OZGUR DOGRU**, NESIBE NECLA ULUGTEKIN**, SEVAL SOZEN***

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Monitoring land use/land cover changes is a very important component for sustainable management of sensitive regions. Because of their ecological, biological, environmental and economic importance, Igneada flooded **(longos)** forests have a multiple role in the landscape. This study is conducted to detect and monitor land use and land cover changes of Igneada region using multi-temporal remotely sensed data. For this purpose, Landsat 5 TM satellite data were used, including four scenes acquired from 1984 to 2010. Change detection methodology of land use/land cover has four main stages: 1) Preprocessing of satellite images, 2) Classifying images using maximum likelihood method, 3) Accuracy assessment of the classification, 4) Comparing classified images in GIS environment and 5) Change detection.

1. INTRODUCTION

"Flooded (longos/alluvial/floodplain) forests are forests in which the water table is usually at or near the surface, and the land is covered periodically or at least occasionally with shallow water" (Čermák et al. 2001, Pivec 2002, Tepley et al. 2004, Paal et al. 2007, Kavgaci et al. 2011). Because of their ecological, biological, environmental and economic importance longos forests have a multiple role in the landscape (Kavgaci et al. 2011). These forests are one of the most fragile and threatened ecosystems in the world. Typically, these types of ecosystems have high biological diversity, high productivity, and high habitat dynamism (Hughes et al. 2003). There are limited numbers of these areas in the world and Igneada Longos Forest is one of the largest longos forest in Europe (Özyavuz 2008). Igneada and the surrounding environment have unique characteristics; these types (Igneada Longos Forests) of wild forest in other parts of Turkey and in Europe have been damaged due to anthropogenic effects (Özyavuz, Yazgan 2010, Bektas Balcik et al. 2011) such as excessive and irrational use of resources, natural or consciously fires, unconscious hunting, agricultural activities, residential development and population growth. Accurate detection of these changes is important for the development of protection strategies for the area. For monitoring and determining the types and extent of environmental changes of sensitive areas, change detection techniques can be applied widely with a repetitive satellite image acquisition as a reliable and cost effective approach (Bektas, Goksel 2005, Balik Sanli et al. 2008).

Many remote sensing change detection methods have been developed (Coppin et al. 2004, Lu et al. 2004, Jin et al. 2012) to identify and observe an object at different times (Singh 1989). Land use/cover change (LUCC) detection is a rapidly growing scientific field because land use change is one of the most important ways that humans influence the environment (Marsik et al. 2011). LUCC is a dynamic, wide-spread and accelerating process, mainly driven by natural phenomena and

* Associate Profesor, Mimar Sinan Fine Arts University, Urban and Regional Planning, Istanbul, Turkey, goncabozkaya@gmail.com.

** Istanbul Technical University, Geomatics Engineering Department, 34469, Maslak, Istanbul, Turkey, bektasfi@itu.edu.tr, goksel@itu.edu.tr, ozgur.dogru@itu.edu.tr, ulugtek@itu.edu.tr.

*** Professor, Istanbul Technical University, Environmental Engineering Department, 34469, Maslak, Istanbul, Turkey, sozens@itu.edu.tr.

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anthropogenic activities, which in turn drive change that would impact the natural ecosystems (Serra et al. 2008). Hence, LUCC detection for spatial patterns is essential for a better understanding of landscape dynamics over a given period of time for sustainable management.

Human induced effects such as uncontrolled and unplanned development of urbanization, unconscious hunting and agricultural activities have become serious problems of Igneada. The main objective of this study is to assess and detect temporal land use/cover changes that have occurred between the years of 1984 and 2010 by using maximum likelihood supervised classification change detection method to protect natural life resources such as mixed forest areas, wetlands, flooded forests, sand dunes and flora and fauna of the region using multi temporal Landsat 5 TM data set.

2. STUDY AREA

Igneada, located on the Black Sea coast 15 km from the Turkish-Bulgarian border, lies in an area that is approximately 5,757 ha between the northern latitudes $41^{o}44'43''$ and $41^{o}58'27''$ and the eastern longitudes $27^{o}44'52''$ and $28^{o}39'17''$ (Fig. 1). In the classification stage, for the 1984, 1990 and 2010 dated images, 653, 640, 638 and 670 training areas respectively were determined. Igneada Flooded Forest is one of the most important protected areas of Turkey. Longos forests with associated aquatic and coastal ecosystems include freshwater and saline lakes, coastal dunes, freshwater and low salinity marshes, and mixed forests of deciduous tall trees (Özhatay et al. 2003). Igneada Longos Forest and its surrounding environment are very valuable and recognized both for its protection of regional biodiversity and for contributions to scientific research (Kavgaci 2007, URL 1). Igneada was classified by Conservation International as one of the world's top 25 biodiversity hotspots, and named by the World Wildlife Fund (WWF) as one of its Global 200 ecoregions (Bozkaya 2013).

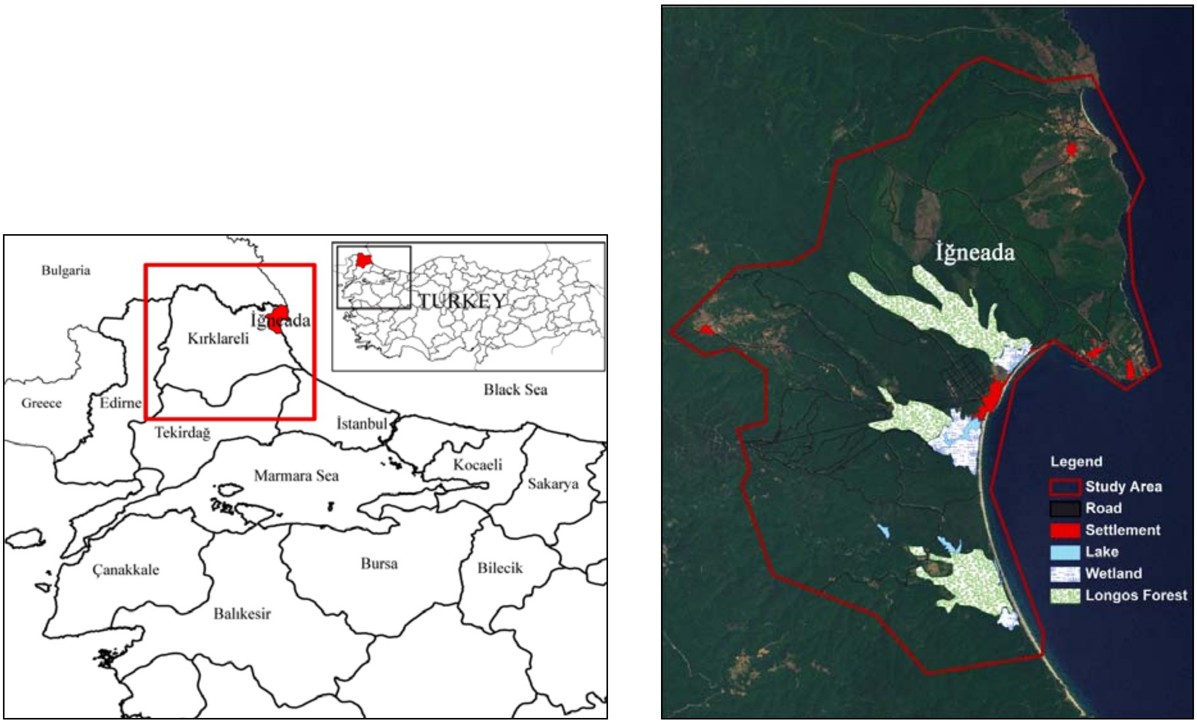

Fig. 1 – Study area in Igneada, Turkey.

The area hosts different kinds of ecosystems and a wide range of biodiversity; some parts of it have previously been protected as Nature Protection Park, Natural Site, and Wildlife Protection Area. The Igneada Longos Forest is confirmed as a very important plant richness center, and was already designated as National Park in 2007 (URL 2). These areas are home to several rare and endemic plant species and are sensitive to human use. Despite its ecological sensitivity and importance, Igneada has been under serious threats, as was the project of supplying drinking water to Istanbul using upstream water sources. Upstream forests and water resources are critical to maintain the delicate balance of the alluvial forest and wetland ecosystem of Igneada.

3. DATA

Landsat 5 TM images used in the study were acquired on September 7th 1984, August 7th 1990, August 18th 2000, and September 15th 2010 to examine land use/land cover changes in Igneada. Landsat 5 TM sensor acquires data in 7 spectral bands that cover a wavelength range from 450 nm–2350 nm with a spatial resolution of 30 m. In addition, topographic maps at the scale of 1: 25 000 and field collected hand hold GPS data, 2003 dated IKONOS images and 2009 dated Aster images were used for pre-processing and accuracy assessment of the derived thematic information.

4. METHODOLOGY

Image pre-processing steps were conducted to eliminate atmospheric distortions, sensor problems and geometric distortions. The original digital numbers (DN) of Landsat 5 TM images were converted to exo-atmospheric reflectance based on the methods provided by Chander and Markham (2003) and the Landsat 7 Science Data Users Handbook (2006). The widely used Dark Object Subtraction (DOS) atmospheric correction method was used to minimize contamination effects of atmospheric particles (Chavez 1988, Liang 2004). After atmospheric correction, multi-temporal Landsat images were geometrically registered to the Universal Transverse Mercator (UTM) projection system (ellipsoid WGS 84, datum WGS 84, and zone 35) by using ground control points, primarily highway intersections, evenly distributed across the image. A first-order polynomial model was used for the rectification with nearest neighbour resampling method. The Root Mean Square (RMS) errors were less than 0.5 pixels (15 m) for each of the four images. Figure 2 gives the flowchart of the study to derive land use/land cover categories of 4 different years.

Classification is a process of grouping pixels that have similar spectral values to transfer data into information for determining earth resources (Balik Sanli et al. 2008). In this study, Maximum Likelihood supervised classification method was used to derive land use/cover categories. Supervised classification is a technique that is based on the statistics of training areas representing different ground objects selected subjectively by users on the basis of their own knowledge or experience (Liu, Mason 2009). In the classification stage, for the 1984, 1990, 2000 and 2010 dated images, 653, 640, 638 and 670 training areas were determined respectively. The nine spectrally separable, different land cover classes identified by Maximum Likelihood were: i) water surfaces, ii) forest areas, iii) flooded (longos) forest, iv) wetland / bulrush, v) plantation area, vi) agriculture / bare ground / grassland, vii) sand dunes, viii) artificial surfaces, and ix) cloud (Fig. 3). The statistical results of the classification are given in Fig. 4. The classified data were compared with ASTER and IKONOS images of the study area to determine the identity and informational value of the spectral classes.

Many methods for assessing the accuracy of classification have been assessment discussed and used in remote sensing (Foody 2002). Confusion or error matrix is the most widely mentioned and conducted method for accuracy assessment by using reference data, such as aerial photographs and field collected data. Different measures can be calculated from confusion matrix to examine classification accuracy, including errors of omission and commission, producer's and user's accuracies and the KAPPA coefficient (Foody 2002).

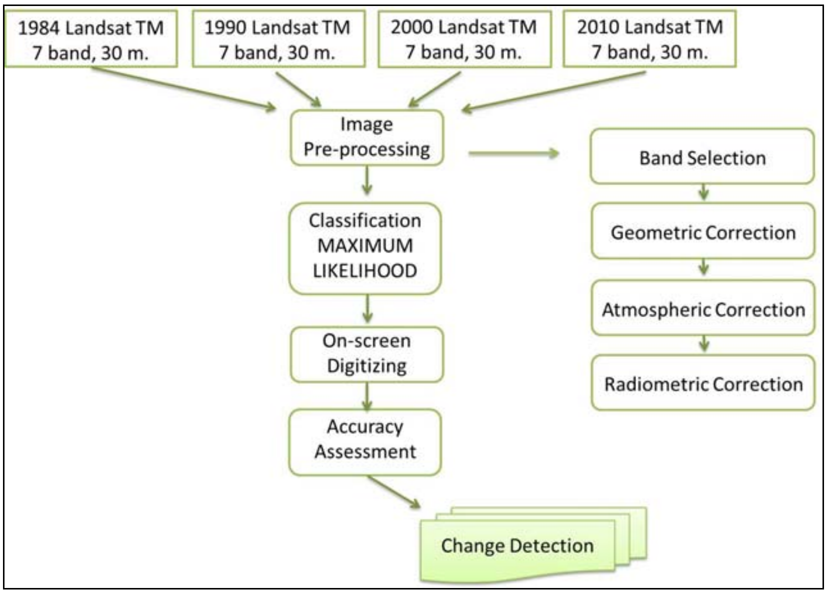

Fig. 2 – Flowchart of methodology.

Totally 1,216 random points were selected for nine classes to assess the accuracy of the four classified images. The overall accuracy and a KAPPA analysis were used to perform classification accuracy based on error matrix (Table 1). The results show that there is a mixed pixel problem between land cover categories such as flooded forest – forest, settlement – agriculture – bare ground – grassland and road in the study area. Because of the mixed pixel problems, the accuracy of the resultant images needs be improved. On-screen digitizing method was conducted in order to solve the mixed pixel problem and improve the accuracy rates. Digitized data combined with classification results lead to an overall accuracy of classified images for the years 1984, 1990, 2000 and 2010 of: 96.57%, 96.24%, 83.33%, and 90.74%, respectively.

Change detection was applied by comparing these base maps using **from-to** analysis. According to the change matrix, the rate of change in residential areas is the highest. A simultaneous analysis of multi-temporal data (i.e. an image-to-image comparison) was applied. The comparison was done between the years of 1984 and 2010. The results showed that major changes occurred on settlement and agricultural areas of the Igneada (Table 2).

The change statistics below gives an explanation on the question of where land use/cover changes are occurring (Table 2). Forest and flooded forest of the study region were changed to agriculture / bare ground, grassland as a result of economic development. As seen from the post classification change processing 1,158 ha areas changed from forest to plantation area, 1,206 ha area changed from forest to agriculture / bare ground, grassland, 278 ha area changed from flooded forest to agriculture / bare ground, grassland and 152 ha area changed from sand dune to agriculture / bare ground, grassland (Table 2).

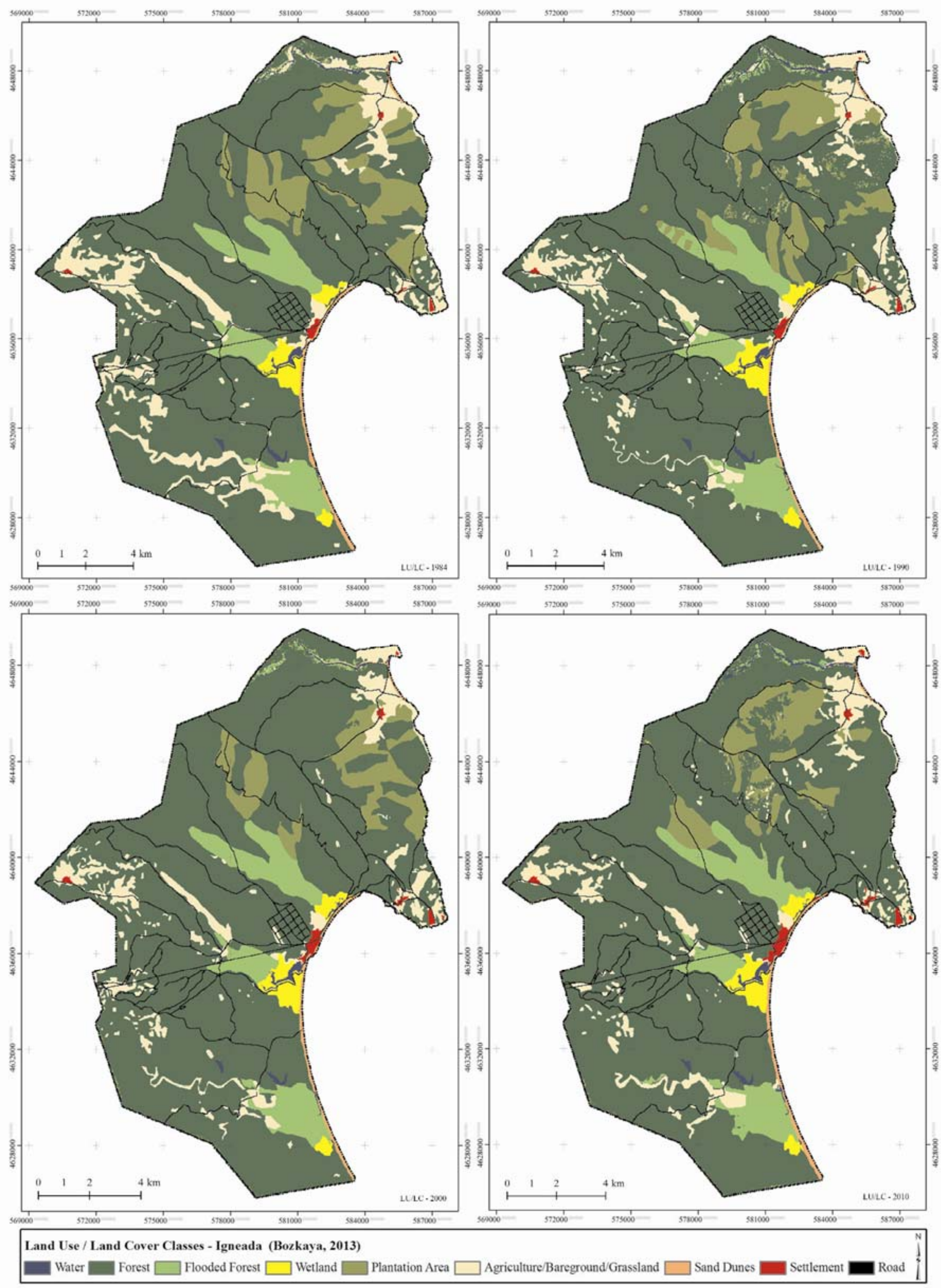

Fig. 3 – Results of the supervised classification using Maximum Likelihood method:
a) 1984, b) 1990, c) 2000, d) 2010.

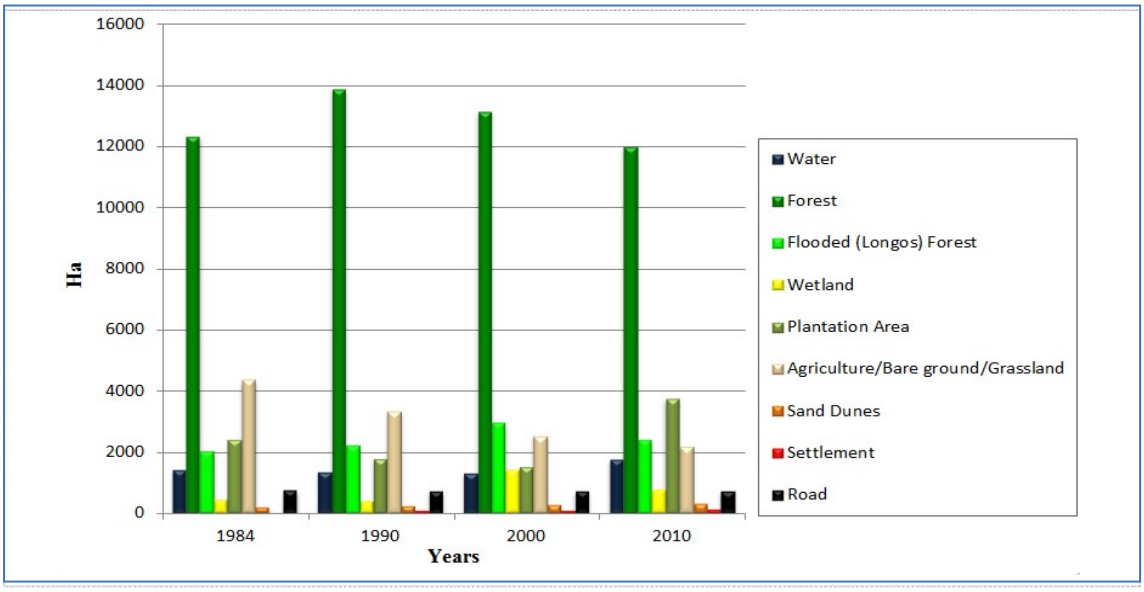

Fig. 4 – Supervised classification results in hectare for the year 1984, 1990, 2000 and 2010.

Table 1

Assessment of the Classification Accuracy.

Year	1984	1990	2000	2010
Overall classification accuracy	96,57%	96,24%	83,33%	90,74%
Overall Kappa statistics	0.9614	0.9576	0.8126	0.895834

Table 2

Area of nine major land covers on the Igneada, from-to changes for the year 1984 and 2010

Year	1984 (ha)										
2010 (ha)	***LU / LC Classes***	1	2	3	4	5	6	7	8	9	∑	**%**
	1	**1,279**	234	29	17	22	165	17	1	1	1,764	23
	2	60	**9,123**	401	27	1,158	1,206	0	0	5	11,979	-7
	3	15	1,126	**929**	11	39	278	0	0	1	2,399	63
	4	21	128	8	**325**	107	183	4	1	1	778	79
	5	11	1,981	38	27	**954**	719	0	0	10	3,742	53
	6	31	229	66	19	146	**1,663**	7	5	7	2,174	-50
	7	12	21	1	7	24	77	**152**	3	4	302	60
	8	0	1	0	1	0	71	9	**59**	0	142	104
	9	0	0	0	0	0	1	0	0	**709**	711	-4
	∑	1,430	12,843	1,472	435	2,452	4,363	189	70	738	23,991	

LU: Land use, LC: Land cover, 1: Water, 2: Forest, 3: Flooded (Longos) Forest, 4: Wetland, 5: Plantation Area, 6: Agriculture / Bare ground, Grassland, 7: Sand Dunes, 8: Settlement, 9: Road.

5. RESULTS AND CONCLUSION

The results showed that Landsat 5 TM images could be used to produce land use/cover maps and statistics. General pattern and trajectories of land use and land cover in the Igneada area were evaluated through the years 1984, 1990, 2000 and 2010.

Land use/cover maps were produced with an overall accuracy of over 83.30% by using Maximum Likelihood supervised classification method. The magnitude of change was calculated and "from–to" change information derived from classified images. The results showed that major damage occurred on bare ground/grassland/agriculture areas of the selected region. The area was 2,532 ha in 1984 and 1,584 ha in 2010. The area of flooded forest was 497 ha in 1984 and 1,589 ha in 2010 because of new plantations in the region. Mixed forest and flooded forest categories converted to bare land and plantation area. The result shows that approximately 7% decreased over the 26-year period. These results and analyses can be used for sustainable natural resource management. To keep sustainable management under control, this kind of monitoring should be done in certain periods. As a result of the land use/cover change and human activities, environmental degradation affected especially the forest areas between 1984 and 2010. Therefore, in order for the Igneada region to keep the sustainability of natural life resources, effective management strategies should be followed. Especially human activities should be planned carefully.

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