Middle-East Journal of Scientific Research 22 (3): 390-394, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.22.03.21913

Using Remote Sensing and GIS to Detect and Monitor Land Use and Land Cover Change in Iskandar Malaysia During 2007–2014

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Abstract: The robust rate of industrial advancement and urban growth in the recent times has posed serious threats to sustainable landscape development. Thus, the development of robust mechanisms for achieving the actual land use/land cover (LU/LC) maps is needed, for the detection and avoidance of over utilization and damage beyond limits. One of the techniques that can be used to afford this purpose is remote sensing technology. Remote sensing technique is a suitable tool used to monitor and assess land use across a wide expanse of land over a long period. In this research, satellite images were utilized to indicate the result of land use/cover change in Iskandar Malaysia between 2007 and 2014. Here, data were derived from the satellite data via the Maximum likelihood supervised classification technique and a post-classification change detection strategy was employed for spotting and monitoring land use/cover changes. Validation of land use/cover maps was also afforded by means of field data and historical land use data. Both Land sat TM (2007) and Landsat 8 (2014) was investigated by means of ERDAS Imagine software and ArcGIS. The Images obtained were categorized into four LU/LC types; forest, oil palm, urban and water. A significant change in land cover was detected during the period of the study. The results obtained between 2007 and 2014 indicate an increase in the forest cover and urban area by almost 16.74, 3.94 and a decrease oil palm by almost 8.57. The study computed the trends of land use/cover change for a period of 7 years in Iskandar Malaysia, which forms a valuable resource for urban planners as well as policy makers in the development of sustainable land use policies.

Key words: Iskandar · Land use/Land cover · Remote Sensing · Change Detection · Landsat

INTRODUCTION

Over the centuries, humans in the quest to produce food have altered the earth's surface through agriculture. Almost one-third of the surface of the earth is occupied by farmlands and grassland and about half of these cultivated areas have been cleared within the last century [1]. The transformation of these vegetative areas into farmlands continues to increase drastically during the past few decades [2]. This marked increase has provoked the interest of researchers on the phenomenon of land-use changes over time, resulting in considerable distortions to the balanced ecosystem, soil fertility, water supply, as well as air quality. With these concerns in place, numerous researchers became interested in the studies on causes and effects of land use/land cover changes (LULCC) [3].

The investigation into LULCC at various spatial–temporal scales constitutes an important research effort. At the global level, high population density exerts excessive pressure on the land, which weakens the environmental dynamics [4]. The swift changes in LU/LC, especially in the third world nations, is often caused increasing urbanization, degradations in the natural land form due to agriculture and tourism [5], or the reclaiming of agricultural lands into aquaculture centers [6]; all of which have their associated impacts on the environment. The changes in vegetation are often due to anthropogenic pressure such as population growth, as well as the naturally induced factors such as climate [7]. There are many reasons that result in the exploitation of tropical forests. These include its use as firewood, timber as well as pasture. The rate of population growth has caused a rapid change in the forest and woodlands into mainly

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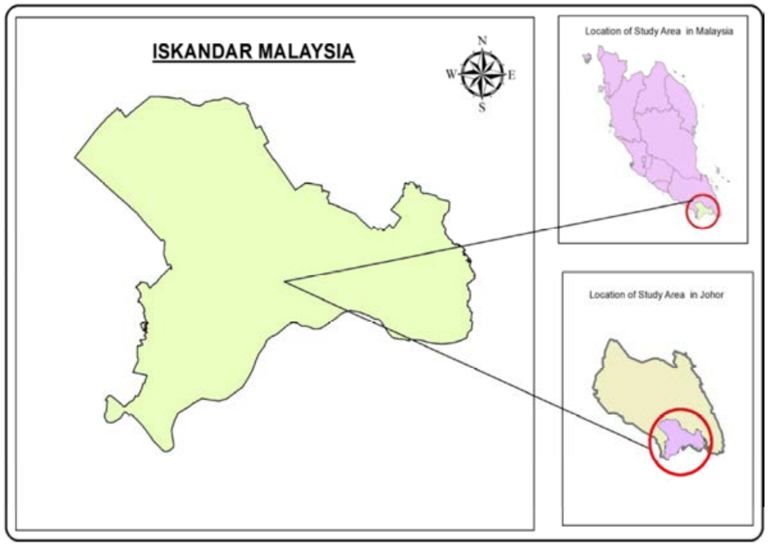

Fig. 1: Study area and location in Johor and Malaysia

slash and burn farming practice in most of the developing countries of the world. This degradation of forests and woodlands has seriously affected the catchment processes as well as the biochemical cycles [8].

Remote sensing (RS) techniques have proved to be a powerful tool for the monitoring of various environmental features, such as vegetation cover, soil erosion, as well as urban expansion and more generally, the variations in the LU/LC over a period of time [9]. Compared to the terrestrial data acquisition, RS enables the attainment of valuable data within a relatively short period and in a cost-effective manner. RS and Geographical Information Systems (GIS) constitute vital tools for examining the dynamics of land use patterns. Land use changes, in many cases, have been associated with such human activities as agriculture, oil exploration and mining. Examining the changes of land-use pattern through remote sensing depends mainly on the comparison of time-series data.

Detecting changes through the use of satellite data allows for timely and reliable estimation of changes in the trend of land use across a vast area of land. Moreover, it also enables simple data capture into the GIS system [10].The primary aim of the current study is to investigate the impact of changes in LULC in the Iskandar Malaysia. Among the objectives of the study are: 1) to investigate the possibility of variations in the land use and land cover; and to further assess the extent of such changes in Iskandar; 2) to quantify the changes in land use and land cover; 3) to investigate the causal factors of land use and land cover change. The lack of credible data on land use, coupled with the restrictions associated with access to aerial photographs has prompted the use of satellite data in the study of land cover and land use changes.

Description of Study Area: Iskandar Malaysia, previously referred to as Iskandar Development Region and South Johor Economic Region, constitutes the primary southern development corridor in Johor, Malaysia. The idea of this corridor is to attract investment and business opportunities to Johor and is one of the largest development projects in Malaysia (Johor is one of the most developed states in Malaysia located in the southern edge of Peninsular Malaysia. The area covered by this development agenda is about 2079.95 Km sq. including the city of Johor Bahru. Coordinate wise, the region lies within latitudes 1° 25’ to 1° 42’N and longitude 103° 21’ to 104° 00’ E along the 48N zone (Fig.1). The region experiences a tropical rainforest climate with monsoon rain (from November to February) which emanates from the South China Sea.

MATERIALS AND METHODS

The study used Land Sat TM (2007) and Land sat 8 images (2014) together with thematic maps to indicate the roads, towns and drainage systems within the area. The website (www.earthexplorer.com) was used to download images used in the research. The most widely used quantitative method in change detection i.e. Post-classification comparison for change detection was carried out using the LU/LC change detection; in which the individual remotely sensed images are rectified and classified. U pon individually classifying the images, they undergo image comparison using a pixel-by-pixel change detection procedure. Specifically, the images were processed using the following procedure; 1) the pre-processing stage 2) development of the technique 3) preparing the Normalized Difference Vegetation Index (NDVI) – False Color (FC) band composition and unsupervised classification for collecting the training data, 4) classifying the images 5) accuracy assessment and 6) detecting the changes. Here, both ArcGIS and ERDAS Imagine software were employed for classifying the land use/cover using the multi-temporal method.

Image Pre-Processing: The Radiometric correction of the images was not applied because it has already been performed. Geometric rectification is important in the production of spatially corrected maps of LU/LC changes with time. Satellite images of 2007 were also geometrically corrected at the scale of 1/25000 while the GPS technology was used to generate the control points. To prevent the alteration of the pixels of the originally collected 2007 images, the nearest neighbor sampling scheme with 25 coordinates were used. The root mean square error (RMSE) was 0.45 pixels while the other images were corrected geometrically using the image-to-image rectification technique in accordance with the 2007 images. The images of 2014 in the study area were also geometrically corrected using 18 coordinate points and the RMSE was 0.61 pixels.

Design of Classification Scheme: A classification technique has been developed which readily incorporates LU/LC data generated by the interpreted remote sensing data (e.g. PU.S. Geological Survey LU/LC Classification System, US Fish & Wildlife Service Wetland Classification System, NOAA Coast Watch Land Cover Classification System and Asian Land Cover Classification System).A variant of the Anderson Scheme Level I [11] was designed for studying the LULCC. Despite the fact that this model was initially designed for the USA, it has been extensively employed in classifying LULCC around the world. The technique uses multilevel land use/cover classification, where the level I classes mapping can be afforded through the use of Landsat data or from other forms of high-altitude imagery, while level II, III and IV requires imagery at high, medium and low-altitude levels, respectively. From the current study, there are four identifiable kinds of land use/cover. These are Forest, Oil palm, Urban and Water body.

Training Data Collection: In assessing supervised classification and accuracy, the collection o f training and testing data were afforded using the following: false color composite, NDVI image, unsupervised classified image and fieldwork approximation to a stratified random sampling. The sample was partitioned into a pair of subsets: training and testing data. Without any enhancement process, the false color composites may be helpful in the visualization of land use/cover effectively. Here, the false color images were retrieved using, bands for both the Landsat TM and Landsat 8 [12].

The vegetation index depicts the quantity of green vegetation available, which is relevant to the LU/LC identification, since a substantial portion of the surface of the earth is vegetative. The natural spectral cluster was defined using the unsupervised classification approach; while the ISODATA (Iterative Self-Organizing Data Analysis) scheme was utilized for identifying the clusters of the Landsat data. A minimum spectral distance was used in the assignment of clusters to individual candidate pixels. A straight forward approach with a considerable intuitive appeal was used by the algorithm in finding the clusters [13]. The Field investigation technique was employed for generating the training data. A fieldwork was also conducted for suitably interpreting the images of land-cover types mentioned earlier, followed by field observations for providing reference about the accuracy assessment LU/LC in the study area.

Image Classification and Change Detection: Comparative evaluation of the spectral classes constitutes the primary procedure of detecting change within the period’s t1 and t2 which were attained independently of one another. Despite the fact that this technique has a number of limitations, it continues to be the primary method of data comparison of data from various sources and periods [14].One of the important attributes associated with data comparison after classification is its difficulties associated with analyzing images from different sources and periods. In addition, the post-classification technique provides answers to quantity, geography and type of change.

However, the main drawback of this technique is that an accurate change map can only be generated if the individual classifications are accurate and is prone to error propagation [15].These classified maps were then compared pixel-by-pixel. Here, the maximum likelihood algorithm classification method was used to independently classify the Landsat data independently. In reducing the number of misclassified pixels, the images undergo smoothing using a majority filter of 3 × 3 kernel and then compared independently with one another for determining the changes of LU/LC types.

Accuracy Assessment: The key parameter in the accuracy determination of the classification is the quantity of reference pixels. Here, the study showed that over 250 reference pixels are required for estimating the mean accuracy of a class to ±5% [16].

In further validating, the classified land cover maps obtained from satellite data, ground truth data obtained from topographic maps and field data were used. An equalized stratified random sampling technique was employed for assessing the accuracy. In the accuracy assessment of 2007 and 2014 land use/cover maps, reference data attained on site were used. Here, 125 reference data for 2007 and 130 field data for 2014 were utilized in determining the accuracy of the classifications.

RESULT AND DISCUSSION

Result of Land Cover Classification: A total of four land cover categories were identified and classified in the study. These were forest, oil palm, water body and urban as shown in Fig 2.

Land Cover Changes: Table 1 s the changes in the various land use and land cover categories (in hectares and percentages) during the period between 2007and 2014.

Table 1 shows that the most extensive land cover category of Iskandar Malaysia at 2007 was oil palm that covered about 101207.4 hectares(50.21%).The Second most land cover was an urban area that cover 49873.5 hectares (24.74%). Cloud cover appeared on the image during capturing and covered about 511.13 hectares (0.25%). It must be noted that the cloud cover is a distortion and is neglected.

Moreover, as shown in Table 1, the order of magnitude of the spatial extent of the land cover categories in 2014 is different from that in 2007.With 2014, the most extensive land cover changed to forest, which covered 39788.33 hectares (19.73%).It was followed by oil palm with 83932.08 hectares (41.63%). The third land cover was an urban area, which covered about 57834.43 hectares (28.68%).The results obtained between 2007 and 2014 indicate an increase in the forest cover and urban area by almost 16.74% and 3.94 and a decrease oil palm by almost 8.57. Major reasons for deforestation in Malaysia include oil palm plantation, logging and mining, forest fires and

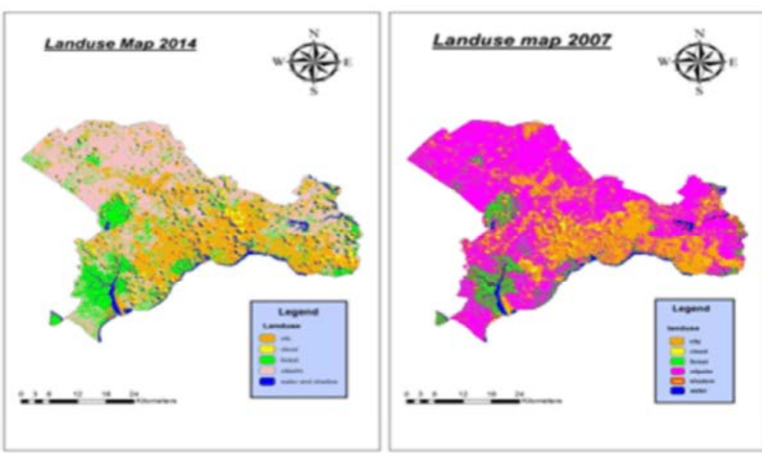

Fig. 2: LU/LC classification maps for each time step

Table 1: Land Cover Changes of the Iskandar Malaysia for the Periods between (2007 -2014)

	2007		2014		2007-2014	
Class Name	Area (ha)	Area (%)	Area (ha)	Area (%)	Change	Change (%)
Forest	35020	2.99	39788.33	19.73	4768.3	16.74
Oilpalm	101207.4	50.21	83932.08	41.63	-17275.3	-8.57
Urban	49873.5	24.74	57834.43	28.68	7960.8	3.94
Water	6027.13	2.99	15423.2(shadow)	7.65	9396	4.66
Cloud	511.13	0.25	4612.2	2.28	4101.1	2.03
Shadow	8915.4	4.42	-	-	-	4.42

tourism, but in our case study population growth is the main reason for land cover change. In can be seen increasing forest area in Mangrove pregion and also decreasing oil palm in the case study because of population and city growth.

CONCLUSION

Land use patterns change over time in response to economic, social and environmental factors. Understanding the nature of change in the use of land resources is essential knowledge to facilitate proper planning, management and regulation of the use of land resources. The analysis of Land Sat TM, Land Sat 8 images of 2007 and 2014 revealed that land use and land cover of the Iskandar Malaysia has changed over the years. Four classes of land use and land cover classes were identified and mapped from satellite images. These were forest, oil palm, urban and water body. The results showed that between 2007 and 2014, forest and urban area increased, whereas oil palm decreased. Changes in land use and land cover of the Iskandar Malaysia were found to be related to population growth, urbanization.

ACKNOWLEDGEMENT

This study is funded by the Ministry of Higher Education, Malaysia and Universiti Teknologi Malaysia research grant (Q.J130000.2527.07H75) and we acknowledge Earth Explorer (http://earthexplorer.usgs.gov) for providing the Landsat images.

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