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Monitoring land use /land cover using multi-temporal Landsat images in Al-Jabal Al-Akhdar area in Libya between 1984 and 2003

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Abstract

This study investigated the change in land cover of Al-Jabal Al-Akhdar from 1984 to 2003 by using satellite images. Four categories of land-cover (forest, rangeland, urban area and desert) were studied to determine the change between 1984 and 2003. Supervised classifications were performed on the Landsat 5 images. The land resources database showed that the rangeland and forest recorded negative change over the years under study while it was a significant positive change in the urban areas. The most significant change was the desert expanding. Rangeland surface proportions were 43.34% in 1984 but were decreased to 28.63% in 2003. Forest surface proportions were 22.13% in 1984 but were decreased to 10.17% in 2003. This can be attributed to human activities, which includes over- grazing, indiscriminate bush burning, fire and urban areas. This is a clear indication of an increase in population and infrastructure development in the study area, regardless of use or pattern. Information from satellite remote sensing can play a useful role in understanding the nature of land use and land cover changes (LULCC), where they are occurring, and projecting possible or likely future changes.

Key Words: rangeland; satellite images; land cover change; Libya.

Introduction

Land-use change and land-cover change (LULCC) are terms often used interchangeably but the two have different meanings. Land cover describes the natural and anthropogenic features that can be observed on the Earth's surface. Examples include deciduous forests, wetlands, developed/built areas, grasslands, water, etc. Land use, by contrast, describes activities that take place on the land and represent the current use of property. Examples include residential homes, shopping centers, tree nurseries, state parks, reservoirs, etc. In land change science, land cover and land use are often

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studied in conjunction with each other, especially in studies involving remote sensing, because satellite imagery and aerial photography can identify land-cover, however inferring land-use often requires more knowledge of the study region, and therefore some compromise is often made between identifying the variable of interest (land use) and the related proxy (land cover). LULCC, especially those caused by human activities, is one of the most important components of global environmental change (Jensen *et al*., 2005).

Imagery in the form of aerial photographs and satellite images have been demonstrated to be the most cost effective method for land cover mapping throughout the world (Trisurat *et al*., 2000). Historically, remote sensing in the form of aerial photography has been an important source of land cover and land use information. (Meliadis, 2005; Meliadis *et al*., 2005).

GIS is the systematic introduction of numerous different disciplinary spatial and statistical data that can be used in inventorying the environment, observation of change, constituent processes, prediction based on current practices and management plans (Ramachandra and Kumar, 2004). Change detection as defined by Hoffer (1978) is temporal effects as variation in spectral response involves situations where the spectral characteristics of the vegetation or other cover type in a given location change over time. Singh (1989) described change detection as a process that observes the differences of an object or phenomenon at different times.

Digital change detection is the process that helps in determining the changes associated with land use and land cover properties with reference to geo-registered multi-temporal remote sensing data (Papadopoulou and Tsakiri-Strati, 1993; Lu *et al*., 2004). It helps in identifying changes between two or more than two dates of the area under study. Change detection is useful in many applications such as land cover/land use changes, rate of deforestation, rate and success of reforestation, habitat fragmentation, landscape evolution, through the synergetic use of the spatial and temporal analysis techniques of Geographic Information System (GIS) and Remote Sensing along with digital image processing techniques (Foody, 2002; Malinverni *et al*., 2003). So, the remote sensing data at different time interval help in analyzing the rate of changes as well as the causal factors or drivers of changes. Hence it has a significant role in regional planning at different spatial and temporal scales. This along with the spatial and temporal analysis technologies of GIS and Global Positioning System (GPS) help in maintaining up-to date land-use dynamics information for a sound planning and a cost-effective decision. In such a way it is possible to develop a multi-temporal atlas of the area under investigation with all the metadata needed for the record of the area. Science and reporting information need for monitoring dynamics in land cover over time have prompted research, and made operational, a wide variety of change detection methods utilizing multiple dates of remotely sensed data. Change detection procedures based upon spectral values are common; however, landscape pattern analysis approaches which utilize spatial information inherent within imagery present opportunities for the generation of unique and ecologically important information (Gitas *et al*., 2009). While the use of two images may provide the means to identify change, the use of more than two images for long-term monitoring affords the ability to identify a greater range of processes of landscape change, including rates and dynamics (Frey and Butenuth, 2009).

The objectives of this study were to include identification of land cover and the spatial distribution, development of digital land cover database, create a digitally historical atlas of Al-Jabal Al-Akhdar with the different land cover changes, and continuation of the multi–temporal research of the environmental changes.

Materials and Methods

Study Area

The study area represents Al-Jabal Al-Akhdar, which is, true to its name, green and also the most vegetated part in Libya (Johnson,1973), where it extends from a latitude 32°00\` to 33°00\`N. and a longitude of 20°00\` to 23° 00\`E (Figure 1).

Satellite imagery

Six multispectral images for each of 1984 and 2003 were applied from Landsat 5 (Landsat Thematic Mapper: http://glovis.usgs.gov/) to cover the entire study area, which is cloudless, enables simple processing and accurate classification.

Multi-temporal Landsat (Thematic Mapper/Enhanced Thematic Mapper) data acquired on early and mid to late summer dates in 1984 and 2003 were used to classify the land cover. The study found that the combination of early summer (late May or early June) with mid to late summer (August or early September) images provides the highest classification accuracy. The main goal of this study was to reveal environmental changes using multi- temporal satellite data, in order to extract changes. The digital image-processing software Envi 4.8 was used for the processing, analysis and integration of spatial data to reach the objectives of the study.

Classification

Classification was carried out for the years 1984 and 2003. Classification was produced for the study area by supervised classifications using a spectral angle mapper. Four major land cover classes were mapped which are forest, urban area, rangeland, and desert. To be able to detect possible details, change trajectory of classification comparison was used to map the patterns and extents of land use and land cover in the study area, as well as determine the magnitude of changes between the years of interest.

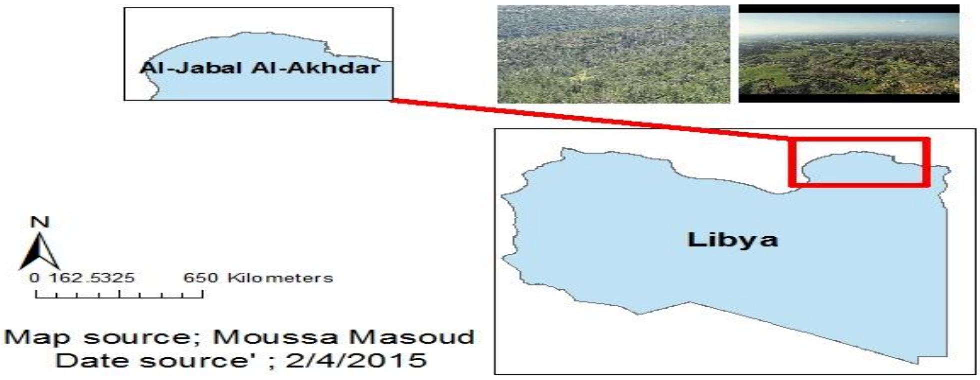

Figure 1. Al-Jabal Al-Akhdar, Libya.

Assessment of Classification Results Using Error Matrix
The error matrix-based accuracy assessment method is the most common and valuable method for the evaluation of change detection results. Thus, an error matrix and a Kappa analysis were used to assess change accuracy. Kappa analysis is a discrete multivariate technique used in accuracy assessments (Congalton and mead, 1983; Jensen, 1996).

The GIS software used to assist planners in the analysis of such changes, by combining the maps derived from the classified images from the years 1984 to 2003, and integrating the multiple (spatial and attribute) databases.

Results

The outcome of the data processing and analysis were presented in form of digital maps, layout and attribute tables. The area covered by the two-class land cover maps of 1984 and 2003 are shown in Figure 2.

In LULC mapping, the post comparison technique is the only method that resulted in a change matrix that provided information. The land cover changes were computed between 1984 and 2003 (Table 1). The capability of the re-sampled topographic map was assessed from the results of Landsat 5 images. The overall result of change detection shows that as urbanization is increasing, the vegetation is decreasing.

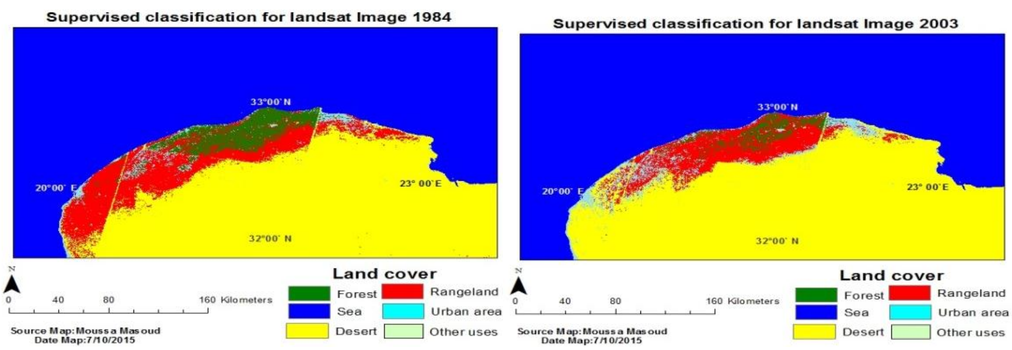

Figure 2. Supervised classification of satellite images of the Al-Jabal Al-Akhdar for the years1984 and 2003, respectively.

Table 1. Result of change detection between: 1984 and 2003 in percentage (%)

Classes	Landsat (1984)	Landsat (2003)	Change Detection (1984-2003)	Annual Rate of Change	Projection (2035)
Forest	22.13	10.17	-11.96	-0.62947	1.986842
Rangeland	43.34	28.63	-14.71	-0.77421	18.56526
Urban area	8.37	10.74	2.37	0.124737	12.36158
Desert	26.16	50.46	24.3	1.278947	67.08632

Results have showed clearly the amount of LULCC of Al-Jabal Al-Akhdar during the period 1984 and 2003. The most significant change was the desert expanding. A notable increase was remarked in urban area from 1703.96 square Km in 1984 to 1956.85 square Km in 2003. Expanding urban areas occurred on the account of forest and rangeland land. Forest which significantly decreased from 2080.5 square Km in 1984 to 1571.11 square Km in 2003 as well as the rangeland which decreased similarly from 6779.38 square Km in 1984 to 6066.49 square Km in 2003 (Figure. 3, Table 2).

The standard summaries are reported for the accuracy assessment: the error matrix, the overall accuracy and the Kappa coefficient (Congalton, 1991). Error matrices quantitatively compare the relationship between the classified maps and reference data. The overall accuracy for the 2003 classified map based on the supervised classification was 91.34% which is considered good, and it is above the limit set by USGS guideline (85%). Because

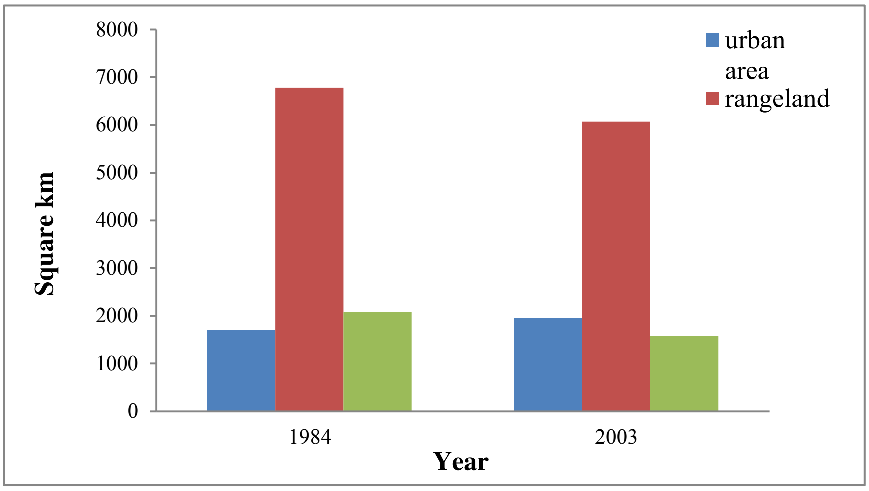

Figure 3. Land-cover classes and area represented by each class in square kilometers for 1984 and 2003.

Table 2. Land-cover classes and area represented by each class in square kilometers for 1984 and 2003

Land cover class	Area in square km in1984	Area in square km in 2003
Forest	2080.5	1571.11
Rangeland	6779.38	6066.49
Urban Area	1703.96	1956.85

the overall accuracy assessment tends to overestimate the actual performance, a more useful representation of performance is the Kappa coefficient (Cohen 1960). The Kappa coefficient for the supervised 2003 image was 0.876 which means that 87.6% of the classification is better than a random classification. This is considered good because a Kappa value above 80% is considered to have a strong agreement (Ramita et al., 2009). Table 3 shows the results for the accuracy assessment for the supervised classification of the 2003 image.

Discussion

The result of LULCC as was analyzed using object-oriented approach which was based on a supervised and spectral angle mapper classification method. Statistical data showed

Table 3. Matrixes of changes (Square Km) in land cover of 2003

Land cover/ land use categories	Other uses	Rangeland	Forest	Urban area	Desert	Sea	Total	Producerṡ accuracy
Other uses	3196.7	0	2.66	4.78	2.85	2147.43	34122.5	93.68
Rangeland	399.19	5445.3	102	120	0	0	6066.49	89.76
Forest	253	4.59	1313.52	0	0	0	1571.11	83.60
Urban area	46.43	342	0	1568.42	0	0	1956.85	80.15
Desert	3609	444	0	234	54190.27	276.94	58754.21	92.23
Sea	3442.51	1.13	0	0	54.58	89392.7	92890.9	96.23
Total	39714.9	6237.02	1418.18	1927.2	54247.7	91817.1	195362	
Userṡ accuracy	80.4856	87.30612	92.6201	81.3833	99.8941	97.3596		

Average accuracy 89.28
Overall accuracy 91.34
Overall Kappa statistics = 0.876

there were both positive and negative changes. The most significant change was the desert expanding. Desert surface proportions were 26.16% in 1984 but were increased to 50.46% in 2003. The statistical analysis showed a significant positive change in the urban areas which formerly occupied a proportion of 8.37% in 1984 and increased to 10.74% in 2003 (Figure 4). This was a clear indication of increased population and infrastructure development in the study area, regardless of use or pattern. The natural vegetation reduced in the Al-Jabal Al-Akhdar may be attributed to the process of logging, urbanization, overgrazing, agricultural expansion, especially wheat and barley, which would entail removing large areas of natural vegetation, and which the area was rich in many places. This seems clear from the comparison between the two satellite images. Compounding the matter is complicated by continuing these subversive activities faster than it was in the past, without taking into account the amount of environmental damage to the region's resources. The removal of vegetation is followed by soil erosion and the appearance of desertification degrees.

Rangeland and forest recorded negative change over the years under study. Rangeland surface proportions were 43.34% in 1984 but were decreased to 28.63% in 2003. Forest surface proportions were 22.13% in 1984 but were decreased to 10.17% in 2003. This can be attributed to human activities, which includes, over grazing, indiscriminate bush burning, fire and urban area.

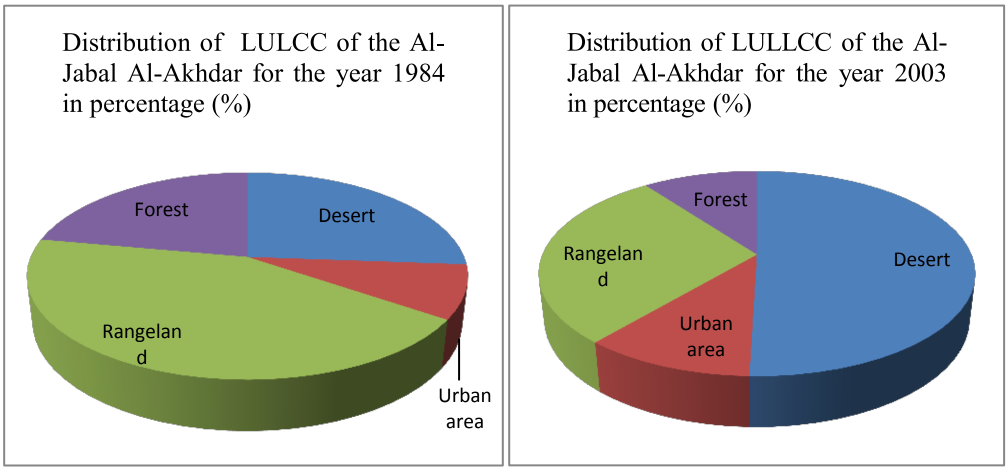

Figure 4. Distribution of LULCC categories of Al-Jabal Al-Akhdar for the years 1984 and 2003 respectively.

The growth of the size of urban area, often at rates exceeding the population growth rate, and the accompanying loss of rangeland lands and forests, escalating infrastructure costs, increases in traffic congestion, and degraded environments, is of growing concern to citizens and public agencies responsible for planning and managing growth and development. Information from satellite remote sensing can play a useful role in understanding the nature of LULCC, where they are occurring, and projecting possible or likely future changes.

Conclusion

LULCC monitoring in Al-Jabal Al-Akhdar was achieved using supervised classifications. The results demonstrate how remote sensing can be used to assess, monitor and quantify LULCC in large areas where traditional methods (such as field observation) may not be possible. The most significant land cover change experienced in the study area was the desert cover increase. The percent of desert cover gain between 1984 and 2003 was 24.3%. The percent of forest cover loss between 1984 and 2003 was 11.96%. While, the percent of rangeland loss was 14.71% and the percent of urban area gain over the same time period was 2.37%. Much of this change can be attributed to human activities.

Detecting changes in areas based on a subject (E.g. urban area increase, vegetation etc.,) over a period of years both spatial and in quantitative way, integrating remote sensing data and GIS techniques will be useful, such information is essential in planning for development and preserving our natural resources and environment, and is needed by urban planners and citizens. Moreover, satellite remote sensing approaches provide a cost effective alternative when more information is needed, but budgets are decreasing.

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مراقبة استخدام الأراضِي / الغطاء الارضِي باستعمال صور لاندسات متعددة الاطياف في منطقة الجبل الأخضر في ليبيا من 1984م- 2003 م

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الملخص

هذه الدراسة تحقق في ظاهرة تغير غطاء الأرض في الجبل الأخضر، من سنة 1984م إلي سنة 2003م عن طريق إستخدام الصور الفضائية حيث تمت مراقبة أربع أصناف من غطاء الأرض وهي الغابات، المراعي، المناطق الحضارية والصحراء.

تمت دراسة التغيرات التي حدثت في الفترة من 1984 م إلي 2003 م. كما أجريت التصنيفات على صور لاندسات 5، وأظهرت بيانات موارد الأرض أن المراعي والغابات سجلت تغيرا سلبياً على مدى السنوات التي تمت فيها دراسة هذه الظاهرة، بينما في نفس الوقت حدث تزايد كبير في مساحة الصحراء والمناطق الحضرية.

كانت نسب مساحة المراعي 43.34٪ في عام 1984م. ولكنها انخفضت إلى 28.63٪ في عام 2003م. اما بالنسبة لمساحة الغابة فكانت تغطي 22.13٪ في عام 1984م. ولكنها بعد ذلك انخفضت مساحتها إلى 10.17٪ في عام 2003م. يمكن أن يعزى ذلك إلى الأنشطة البشرية والتي تتضمن الرعي الجائر، الحرائق والتوسع العمراني والذي قد يكون مؤشراً واضحاً على زيادة عدد السكان وتطوير البنية التحتية في المنطقة التي تمت فيها هذه الدراسة. إن المعلومات التي اكتسبت من الأقمار الصناعية والاستشعار عن بعد يمكن أن تلعب دورا مفيداً في فهم طبيعة استخدام الأراض والتغيرات التي حدثت وتحدث لغطاء الأرض ويمكن الاعتماد عليها في توقع التغييرات المحتملة او الممكن حدوثها في المستقبل.

مفتاح الكلمات: غابة، مراعي، صور أقمار صناعية، تغيرات غطاء الأرض، ليبيا.