Utilization of Remote Sensing Data and GIS Applications for Determination of the Land Cover Change in Karbala Governorate

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Received on: 25/10/2012 & Accepted on: 9/5/2013

ABSTRACT

This study was conducted to determine the land cover changes between year 1976 and year 2011 in Karbala Governorate by using an integrated approach of remote sensing data and GIS applications for investigation of the spatial and temporal changes. A part of Karbala Governorate, whose Area is 768 km^2 was selected as study area.

Four cloud free Landsat MSS, TM, ETM+, and SPOT scenes covering the study area were selected for analysis. Images were acquired in years 1976, 1990, 2001, and 2011 respectively. All images which mentioned above are rectified and registered in Universal Transverse Mercator (UTM) projection zone 38 N and supervised image classification system has been observed to classify the images in different land cover categories. Six land cover classes have been identified and used to determine the change in land cover in study area and these classes are: Agricultural land, Water bodies, Urban Area, Sand dunes, Bare soil, and Waterlogged Area. According to the results obtained from statistics of classification, it was observed that most changes occurred in heterogeneous agricultural areas. It is thought that the main reasons of this change are increasing population pressure, increasing sand dunes, appearance and increasing waterlogged area and changing economic activities. Those reasons have been led to the decrease of the agricultural areas in study area during period from year 2001 to 2011.

Keywords: Land cover, Remote Sensing, GIS, Landsat, SPOT.

https://doi.org/10.30684/etj.31.15A.1
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أستخدام بيانات التحسس النائي و تطبيقات نظم المعلومات الجغرافية لتحديد تغيرات الغطاء الارضي في محافظة كربلاء

الخلاصة

اجريت هذه الدراسة لتحديد التغيرات في الغطاء الارضي للفترة بين سنة ١٩٧٦ و لغاية سنة ٢٠١١ في محافظة كربلاء باستخدام أسلوب التكامل لبيانات التحسس النائي و تطبيقات نظم المعلومات الجغرافية للتحقق من التغيرات المكانية و الزمانية . جزء من محافظة كربلاء أختير ليكون منطقة للدراسة و بمساحة ٧٦٨ كيلومتر مربع . تم اختيار أربعة مشاهد خالية من تأثيرات الغيوم تغطي منطقة الدراسة الحالية للقمر الصناعي لاندسات و للمتحسسات (MSS , TM , ETM+) و القمر الصناعي سبوت (SPOT5) للسنوات ١٩٧٦ و ١٩٩٠ و ٢٠٠١ و سنة ٢٠١١ على التوالي لغرض تحليلها .

جميع الصور التي أشير اليها في اعلاه صححت هندسيا و سجلت في مسقط مركيتر المستعرض العالمي (UTM) و ضمن النطاق ٣٨ شمالا و استخدم نظام التصنيف الموجة لتصنيف الصور في أصناف مختلفة . ستة أصناف للغطاء الارضي تم استخدامها لتحديد التغير في الغطاء الارضي في منطقة الدراسة و هذه الاصناف هي : الارض الزراعية ، المسطحات المائية ، المنطقة الحضرية ، الكثبان الرملية ، الارض الجرداء ، الاراضي المتغدقة (المشبعة بالمياه) .

طبقاً للنتائج التي حصلت من احصائيات التصنيف رصدت ان معظم التغييرات حدثت في المساحات الزراعية . الاسباب الرئيسية لهذا التغيير هي زيادة الضغط السكاني ، زيادة كثبان الرمل ، ظهور و زيادة الاراضي المتغدقة ، النشاطات الاقتصادية المتغيرة . هذه الاسباب ادت الى تقليل المساحات الزراعية في منطقة الدراسة خلال الفترة من سنة ٢٠٠١ الى سنة ٢٠١١.

INTRODUCTION

Land cover is described as “vegetational and artificial constructions covering the land surface” by Anderson et al. (1976). Land cover changes can be used to identify direct and indirect processes of land degradation. Human/natural modifications on land cover have resulted in degradation, deforestation, biodiversity loss, global warming and increase in natural disasters. Growing population, urban expansion, cropland loss and etc. create a pressure on land cover. This pressure results in unplanned and uncontrolled changes in land cover. Land cover changes leading to severe environmental problem are generally caused by mismanagement of agricultural, urban, and forest lands. Therefore, available data on land cover changes can provide critical insights in the decision-making process for environmental management and planning the future.(Ikiel C.,2011)

Land-use and land-cover change, as one of the main driving forces of global environmental change, is central to the sustainable development debate. Land use and land-cover changes have impacts on a wide range of environmental and landscape attributes including the quality of water, land and air resources, ecosystem processes and function, and the climate system itself through greenhouse gas fluxes and surface albedo effects (Rimal,B.,2011).In recent decades, remote sensing with multi-temporal high resolution satellite data have been widely used to obtain land cover information such as degradation level of forests and wetlands, rate of urbanization, intensity of agricultural activities, and other human-induced changes. Geographical Information Systems (GIS) provide a flexible environment and a powerful tool in analyzing spatial information. The integration of the Remote Sensing (RS) and Geographical Information Systems (GIS) are important tools to study changes in land cover patterns and dynamics in order to obtain rapid, economical, reliable, and accurate results. In remote sensing technology, classification as a common image processing technique is utilized to obtain data regarding land cover types. In classification process, supervised classification with the maximum likelihood method, which is also utilized in this study, has been widely used in remote sensing applications. (Ikiel C., 2011).

Studying changes in land cover pattern using remotely-sensed data is based on the comparison of time-sequential data. In this study four different satellite images were used, Landsat MSS, Landsat TM, Landsat ETM, and SPOT 5 which have different dates. Land cover patterns were evaluated separately for each image and a comparative analysis was conducted for the study period (1976-2011) with using supervised classification approach. The main objective of this study is to determine the land cover changes between 1976 and 2011 using remote sensing data and GIS applications for investigation of the spatial and temporal changes.

STUDY AREA

The study area is a part of Karbala Governorate in the south of Iraq. The study area is bounded by the coordinate (from 43° 57' 31.98" E to 44° 15' 12.09" E) longitude and (from 32° 20' 51.05" N to 32° 35' 52.16" N) latitude in zone 38N according to UTM projected coordinate system. It covers an area of 768Km^2. The selected area could be recognized in Figure (1), which illustrates the Iraq map with selection window representing the study area**.**

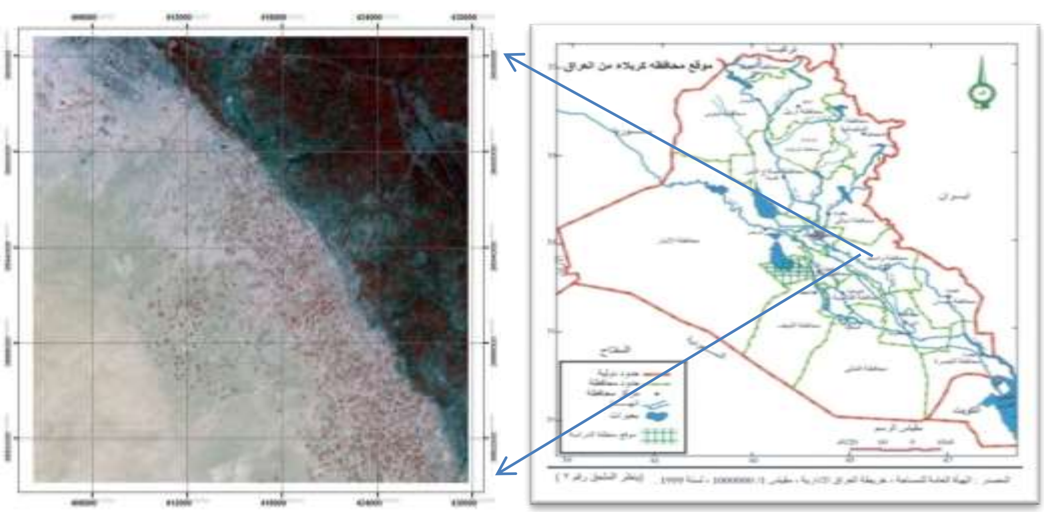

Figure (1) The map of Iraq with selection window represents the selected study area.

MATERIAL AND METHOD

Methodology

The image processing was performed in three stages: 1) image pre-processing, 2) image classification, 3) accuracy assessment. These applications were performed using ERDAS Imagine 9.2 software and ArcGIS 9.3 program.

Satellite Remote Sensing Data and Processing

The following Multi-temporal Landsat imageries were assembled for the study area, then pre-processed ,processed, and analyzed for this study: MSS image (dated march 10, 1976), TM image (dated August 28, 1990) , ETM+ image (dated March 23, 2001), and SPOT (dated May 15,2011).

The pre-processing for the dataset included image registration, radiometric calibration, and radiometric normalization. Rectification and registration of MSS, TM, and ETM+ imageries were based on twenty ground control points (GCP) collected from intersection of roads, rivers, and buildings at the study area. The remotely sensed dataset were geometrically corrected in the datum WGS84 and projection UTM zone 38N using the first order (linear) of polynomial function and Nearest Neighbor rectification re-sampling, which was chosen in order to preserve the radiometry and spectral information in the imagery . Image to image registration was done in order to register the MSS dated 1976, TM dated 1990, and ETM+ dated 2001 image with geocoded SPOT image dated 2011 (master or reference image). The RMS error of the image-to-image was 0.43, 0.39, and 0.33 pixels for MSS, TM, and ETM+ respectively.

Image classification

In this study supervised classification is used, within this classification the maximum-laklihood method is used, this method depends on variance and difference in classification of impersonal pixels (Lillesand and Keifer, 2000).

Supervised classification

Supervised classification is the process of using samples of known identity (training data) to classify the unknown identity. Knowledge of data and the desired classes are required prior to the classification process and must be obtained from ground truths, aerial photos, or maps. Figure (2) summarizes three basic steps involved in a typical supervised classification procedure.

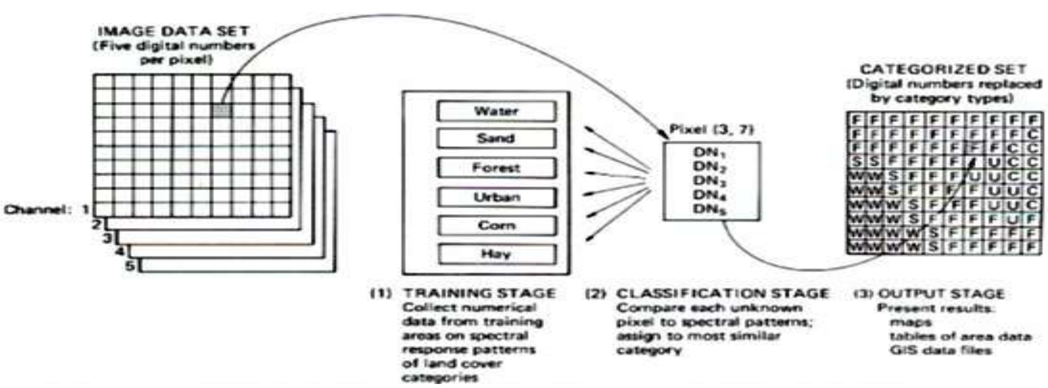

Figure (2) Basic steps in supervised classification (Kumar, 2003).

In the training stage (1), the representative training area was identified and developed a numerical description of the spectral attributes of each land cover type of interest in the scene. Next, in the classification stage (2), each pixel in the image data set, is categorized into the land cover class it most closely resembles. If the pixel is insufficiently similar to any training data set it is usually labeled "unknown." The category label assigned to each pixel in this process is then recorded in the corresponding cell of an interpreted data set. Thus, the multidimensional image matrix is used to develop a corresponding matrix of interpreted land cover category types. After the entire data set has been categorized, the results were presented in the output stage (3). Being digital in character, the results may be used in a number of different ways. (Kumar, 2003)

There are several classification algorithms that can be applied in supervised classification. The most common and well-known supervised classification uses the maximum likelihood technique which employs a decision rule based on the probability that pixels belong to a particular class (Campbell, 1996).

In order to provide an accurate Land cover classification of the study area, supervised classification of MSS 1976, TM 1990, ETM+ 2001, and SPOT 2011 was used in this study and performed in three stages.

Training Sample stage

In order to provide an accurate Land cover classification, a series of steps were implemented that help in the separation of the classes in the images. Training sites containing areas of known land cover classes were selected, and then each of the pixels is classified based upon which of the training sites that is matched most closely. Each class was selected based on information gathered from the field survey, and maps.

The areas of known identify was delineated by a set of pixels usually by specifying the polygonal area using line and column numbers within the coordinate of the digital image. The objective is to identify a set of pixels that accurately represents spectral variation present within each information region. Five categories to (1976, 1990) and six categories to (2001 and 2011) were selected in the study area, for each category has a number of field locations throughout the area, which have been determined on the four images. It is necessary to document the connection between the extracted signatures in satellite data and the appearance of the classes' in-situ to make this classification system usable. . Figure (3) represents the spectral properties extracted from the mean values of training samples for the classes of the study area based on MSS, TM, ETM and SPOT data.

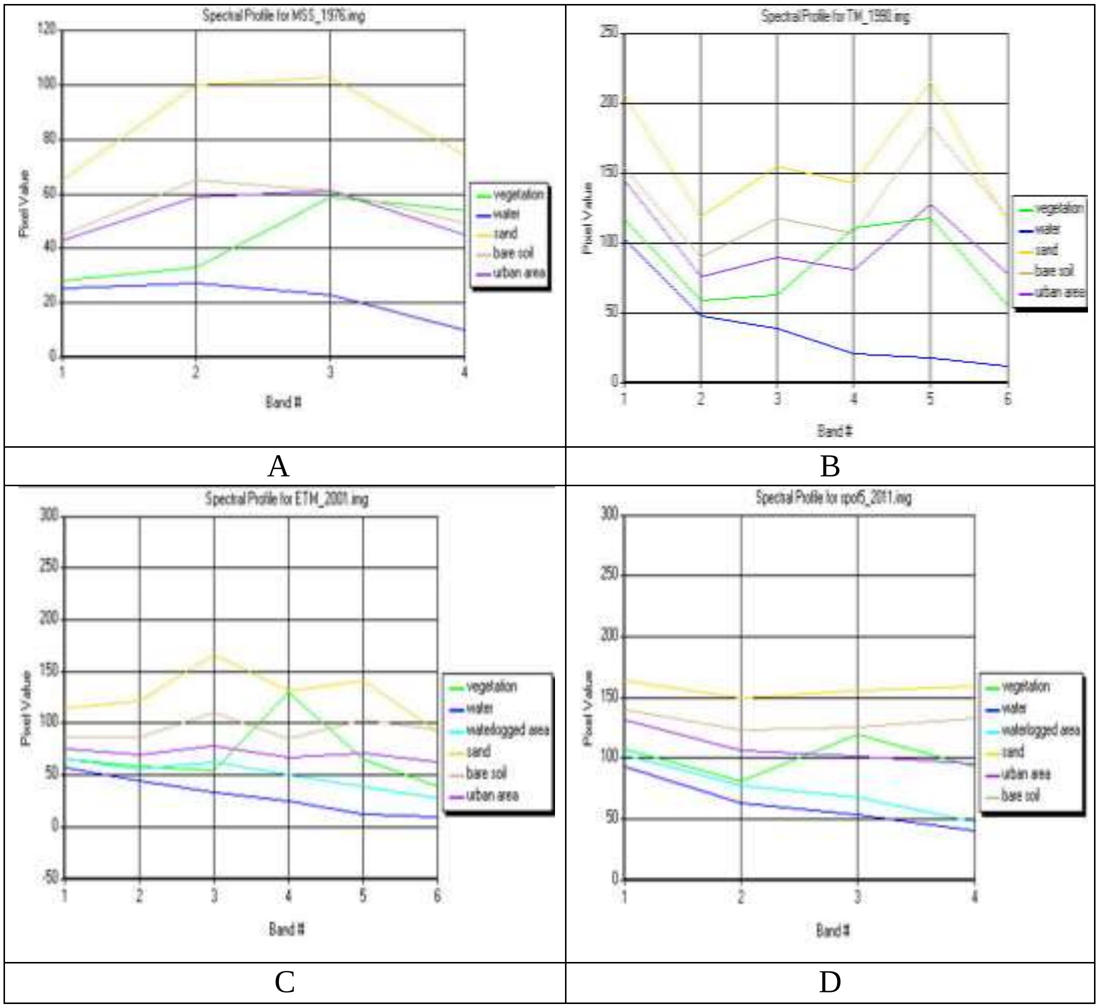

Figure (3) Mean spectral radiance extracted for the land cover classes for A-1976, B-1990, C-2001, and D-2011.

Classification stage

The result of classification stage is represented by the Land cover maps shown in Figures (4, 5, 6 and 7). These maps are produced by maximum likelihood classifier. This map includes five classes for MSS 1976, TM 1990, and six classes for ETM 2001, and SPOT 2011 which represent the land cover classes in the study area. The supervised classification of bands 5, 3 and 4 produced a result for land cover classification in the area. In this classification, maximum likelihood classifier was used, which is generally regarded as standard to which other classification routines are compared and based on statistical probabilities. The maximum likelihood algorithm assumes that pixels, which comprise target classes, are normally distributed and that each class may be completely described by its mean vector and covariance matrix of all bands included in the data set (Campbell, 1996).

Accuracy assessment stage

Accuracy assessment tool was utilized to evaluate the accuracy of the classified images. It is based on random sampling method that selected the points from referenced map. After the application, a report showing error matrix of the results is obtained. Error matrix is the most common way to present the accuracy of the classification results. Overall accuracy, user's and producer's accuracies, and the Kappa statistic were then derived from the error matrices. The overall accuracy and a KAPPA analysis were used to perform classification accuracy assessment based on error matrix analysis. Using the simple descriptive statistics technique, overall accuracy is computed by dividing the total correct (sum of the major diagonal) by the total number of pixels in the error matrix. KAPPA analysis is a discrete multivariate technique used in accuracy assessments. KAPPAanalysis yields a K_{hat} statistic (an estimate of KAPPA) that is a measure of agreement or accuracy (Jensen, 1996, Ikiel C., 2011). The K_{hat} statistic is computed as:

$$K_{hat} = [N \Sigma^{r}_{i=1} x_{ii} – \Sigma^{r}_{i=1} x_{i+} x_{+i}] / [(N^2 – \Sigma^{r}_{i=1} x_{i+} x_{+i}] \qquad \ldots\ldots\ldots\ldots.. (1)$$

Where: r is the number of rows in the matrix , xii is the number of observations in row i and column i, and x_{i+} and x_{+i} are the marginal totals for row i and column i , respectively , and N is the total number of observations.

Independently classified images were compared with each other to determine the changes of landcover types. Over all Accuracy levels of more than 80 % are considered adequate enough for reliable classification of land cover types (Sabins, 1997).Values of KAPPA greater than 75% represent strong agreement or accuracy between the classification map and the ground reference information. Values between 40% and 75% indicate fair to good agreement or accuracy between the classification map and the ground reference information, and values below 40 % indicate poor agreement (Maingi, 2002 and El Hassan, 2007).The accuracy assessment was done by using the classification of 1976, 1990, 2001, and 2011 image data. The numbers of random points were chosen to the four images were 53, 49, 58, and 67 respectively. The best guess of a reference relating to the perceived class value for the pixel below each reference point is stored in the Accuracy Assessment Cell Array Reference Column. In the Accuracy Assessment dialog, the Error Matrix, and Accuracy totals, was calculated in the accuracy report. Table (1), Table (2), Table (3), and Table (4) show the error matrix used to calculate the accuracy reports. These matrix stems from classifying the sampled training set pixels and listing the known cover types used for training (columns) versus the Pixels actually classified into each land cover category by the classifier (rows).

Table (1) Error Matrix results from classification of MSS 1976.

	Agricultural land	water	Sand dunes	Bare soil	Urban area	Row total
Agricultural land	13	0	0	0	1	14
water	0	5	0	0	0	5
Sand dunes	0	0	10	1	0	11
Bare soil	0	0	1	11	2	14
Urban area	1	0	0	1	7	9
Column total	14	5	11	13	10	53

Table (2) Error Matrix results from classification of TM 1990.

	Agricultural land	water	Sand dunes	Bare soil	Urban area	Row total
Agricultural land	10	0	0	0	2	12
water	0	5	0	1	0	6
Sand dunes	0	0	8	2	0	10
Bare soil	0	1	2	11	0	14
Urban area	1	0	0	0	6	7
Column total	11	6	10	14	8	49

Table (3) Error Matrix results from classification of ETM 2001.

	Agricultural land	water	Sand dunes	Bare soil	Urban area	Waterlogged area	Row total
Agricultural land	11	0	0	0	0	0	11
water	0	7	0	0	0	2	9
Sand dunes	0	0	8	1	0	0	9
Bare soil	0	0	1	9	1	0	11
Urban area	0	0	0	1	5	0	6
Waterlogged area	0	2	0	0	0	10	12
Column total	11	9	9	11	6	12	58

Table (4): Error Matrix results from classification of SPOT 2011

	Agricultural land	water	Sand dunes	Bare soil	Urban area	Waterlogged area	Row total
Agricultural land	16	0	0	0	2	0	18
water	0	4	0	0	0	1	5
Sand dunes	0	0	12	1	0	0	13
Bare soil	0	0	1	9	1	0	11
Urban area	1	0	0	1	6	0	8
Waterlogged area	0	2	0	0	0	10	12
Column total	17	6	13	11	9	11	67

The producer's accuracy, user's accuracy, overall accuracy, and kappa coefficient (k) of the four classified images data are shown in Tables (5, 6, 7 and 8) respectively. Producers accuracy which indicates how well the training sets pixels of the classified given cover type can be determined by dividing the number of correctly classified pixels in each category by number of training sets used for that category (column total). User's accuracy is computed by dividing the number of correctly classified pixels in each category by the total number of pixels that were classified in that category (row total). Measure of commission error is indicates the probability that a pixel classified into a given category actually represents that category on ground (Congalton and Green 2009). The overall accuracy of the MSS 1976 classification map is 87%, TM 1990 classification map is 82%, ETM 2001classification map is 86 %, and SPOT 2011 classification map is 85 %.The kappa coefficient(k) of the MSS 1976 classification map is 83%, TM 1990 classification map is 77%, ETM 2001classification map is 83 %, and SPOT 2011 classification map is 81 %.According to the values of the overall accuracy (more than 80%) and kappa coefficient found more than 75% for these reasons , the accuracy assessment of classification has strong agreement and reliable.

Table (5) Accuracy Assessment Report of MSS 1976.

Classification	users' Accuracy	Producers Accuracy
Agricultural land	13/14= 93%	13/14= 93 %
Water	5/5= 100%	5/5 = 100 %
Sand dunes	10/11= 91%	10/11= 91 %
Bare soil	11/14= 79 %	11/13 = 85 %
Urban area	7/9= 78 %	7/10= 70 %
Overall accuracy=(13+5+10+11+7)/53= 87%		
kappa coefficient (k) =83%		

Table (6) Accuracy Assessment Report of TM 1990.

Classification	users' Accuracy	Producers Accuracy
Agricultural land	10/12=83 %	10/11=91 %
Water	5/6=83 %	5/6=83 %
Sand dunes	8/10= 80 %	8/10= 80 %
Bare soil	11/14= 79 %	11/14= 79 %
Urban area	6/7=86 %	6/8=75 %
Overall accuracy=(10+5+8+11+6)/49= 82 %		
kappa coefficient (k) =77%		

Table (7) Accuracy Assessment Report of ETM 2001.

Classification	users' Accuracy	Producers Accuracy
Agricultural land	11/11 = 100 %	11/11 = 100 %
Water	7/9= 78%	7/9= 78 %
Sand dunes	8/9= 89%	8/9= 89%
Bare soil	9/11= 82%	9/11= 82 %
Urban area	5/6= 83 %	5/6= 83 %
Waterlogged area	10/12 = 83 %	10/12 =83 %
Overall accuracy=(11+7+8+9+5+10)/58= 86 %		
kappa coefficient (k) = 83%		

Table (8) Accuracy Assessment Report of SPOT 2011.

Classification	users' Accuracy	Producers Accuracy
Agricultural land	16/18 = 89 %	16/17 = 94 %
water	4/5= 80 %	4/6 = 67 %
Sand dunes	12/13 = 92 %	12/13 = 92 %
Bare soil	9/11 = 82 %	9/11 = 82 %
Urban area	6/8 = 75 %	6/9 = 67 %
Waterlogged area	10/12 = 83 %	10/11 = 91 %
Overall accuracy= (16+4+12+9+6+10)/67=85 %		
kappa coefficient (k) = 81%		

RESULTS AND DISCUSSION

The Land is one of the most important natural resources. All agricultural, animal and forestry productions depend on the productivity of the land. The entire eco-system of the land, which comprises of soil, water and plant, meets the community demand for food, energy and other needs of livelihood. The land-use and landcover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. In situations of rapid and often undocumented and unrecorded land use change, observations of the earth from space provide objective information of human activities and utilization of the landscape. Land use statistics and transition matrices are important information to analyze the changes of land use. (Rimal, B., 2011)

The change analysis presented in this paper is based on the statistics extracted from the four land cover maps with using GIS. The urban/built-up areas in the study area had a noticeable increase, from the Table (9) and Figures (4 to 8) we observed that the urban development change is very high in the study area, from 0.7% (5.97sq.km) of the total land in1976 to 1.5% (11.27 sq.km) in 2011, population growth in study area is the cause of such increase the urban area. On the other hand the study observed the dramatic increase of the agricultural area in the years between 1976 and 2001. It seems19% in 1976, 23% in 1990, 32% in 2001, and decreased in 2011 to become about26%. Analysis shows that water covered area seems 0.3%, 0.3%, 0.5% and 0.2 % in 1976, 1990, 2001, and 2011respectively which signifies the fluctuating ratio of water covered area. Sand dunes cover29%, 23%, 12% and 24% in the year 1976, 1990, 2001 and 2011 respectively this refers to that sand dunes have been largely decreased between 1976 and 2001.Waterlogged area covers 0 %, 0 %, 2.7%, and 3.6 % in the year 1976, 1990, 2001 and 2011 respectively. This area has been appeared in 2001 and increased in 2011. In general the reason of land cover change in area of study caused by humans and water sources activities.

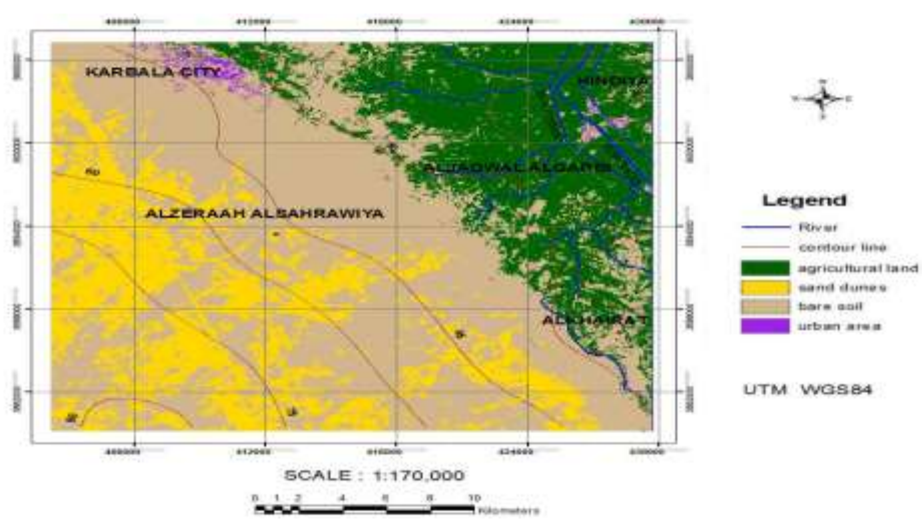

Figure (4) Land cover map of the area ander consideration 1976.

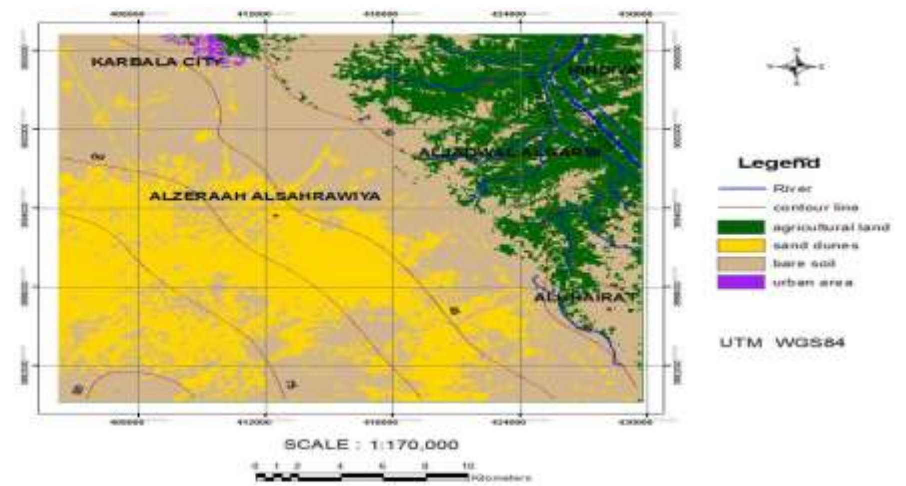

Figure (5) Land cover map of the are under consideration 1990.

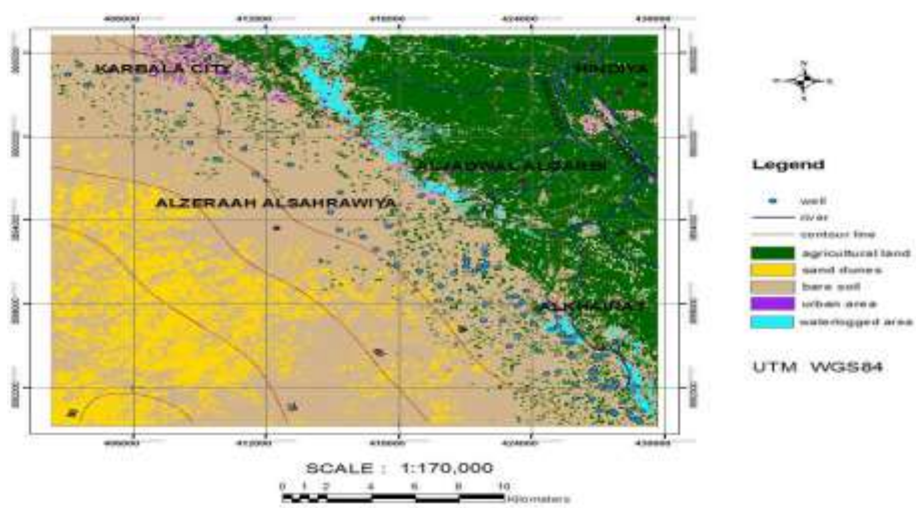

Figure (6) Land cover map of the area under consideration 2001.

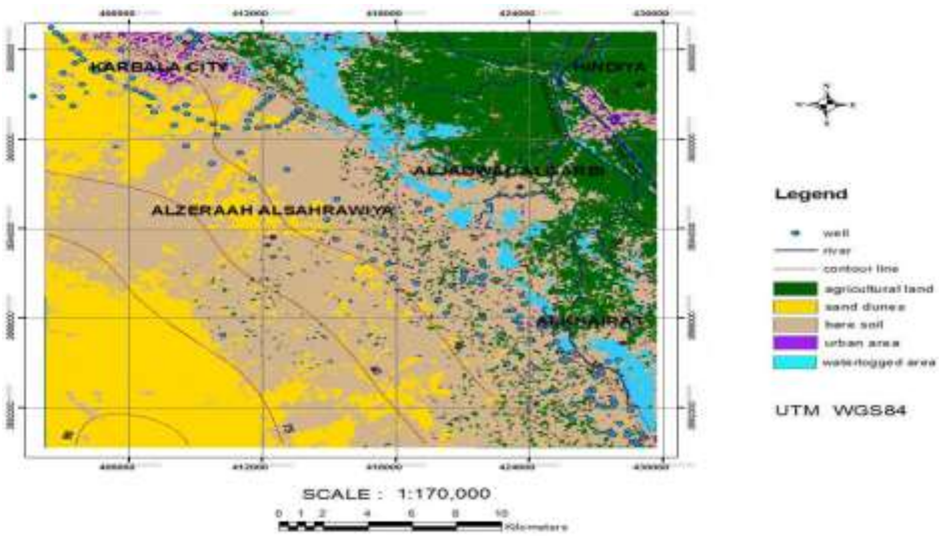

Figure (7) Land cover map of the area under consideration 2011.

Table (9): Land cover statistic of study Area, 1976 – 2011

Classes	1976		1990		2001		2011	
	Area Km^2	%	Area Km^2	%	Area Km^2	%	Area Km^2	%
Agricultural land	149.44	19	175.51	23	215.87	32	186.67	26
Water	2.6	0.3	3	0.3	3.9	0.5	2.32	0.2
Sand dunes	219.441	29	174.675	23	93.53	12	181.30	24
Urban area	5.97	0.7	6.38	0.8	7.43	0.9	11.27	1.5
Waterlogged area	-	-	-	-	20.69	2.7	27.28	3.6

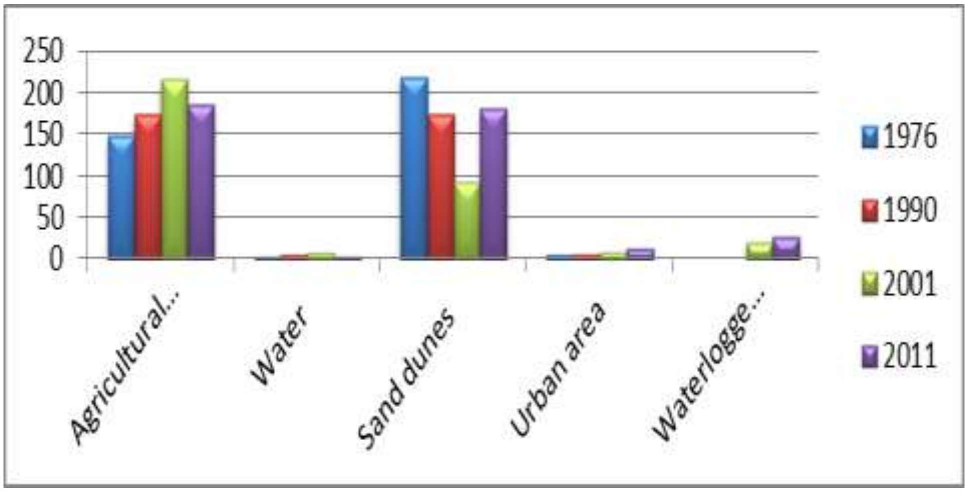

Figure (8) Trend of Land Use Land covers Change, 1976-2011

CONCLUSIONS

1. Remote sensing has the capability of monitoring such changes, extracting the change information from satellite data relies on effective and accurate change detection techniques.
2. The accurate and updated land cover change information is necessary for understanding main factors causes and environmental consequences of such changes.
3. The supervised classification process used for land cover classification shows six main lands cover classified maps that were identified and used to determine the change in land cover in study area.
4. According to the results obtained, it was observed that most changes occurred in heterogeneous agricultural areas. It is thought that the main reasons of this change are increasing population pressure, increasing sand dunes, appearance and increasing waterlogged area and changing economic activities. Those reasons have been led to decrease the agricultural areas during period 2001 to 2011.

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