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TEMPORAL CHANGE DETECTION OF LAND USE/LAND COVER USING GIS AND REMOTE SENSING TECHNIQUES IN SOUTH GHOR REGIONS, AL-KARAK, JORDAN

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ABSTRACT

This study examines the spatial and temporal changes of land use and land cover in South Ghor, Jordan. Satellite images for the years 1972, 1989, 1999 and 2016 were used for LULC supervised classification techniques, four LULC classes were decided: built-up areas, pastures and bare land, agricultural land and water bodies. For the accuracy of assessment classifications, matrix error and KAPPA analysis have been used in this paper. The analysis detected by supervised classification techniques show that agricultural land and built-up land have increased, while barren land and water bodies have decreased. It is predicted that the study would significantly contribute to better policy making, sustainable development and developing useful change detection planes for the south ghor regions and similar regions of the country.

Keywords: land use/land cover change; change detection; classification; remote sensing; GIS.

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1. INTRODUCTION

The expressions land use and land cover are closely interrelated. A settlement, an example of land cover but if we include buildings whether they are being used for commercial, residential or industrial practices, it reveals the land use element [1-2]. Land cover alludes to the physical (natural) features of the land surface, taken in the distribution of agricultural land, soil, pastures land, water and other natural landscapes. Land use alludes to the method in which land has been utilized by humans and their environments (such as agriculture, settlements, industry, etc.).

Land use/land cover change has become a main element in current policies for managing natural resources and examining environmental changes. Monitoring the earth from the space is now essential for understanding the human actions on the natural resources base over time. Watching and monitoring the land from space produce real information of human uses and practices on the earth. In recent decades, satellites data and records have become vital in mapping land features, infrastructures, natural resources managing and ecological changes studies [3-6].

In [7] studied the land use/land cover changes that have occurred in Lagos, Nigeria for the past two decades due to rapid urbanization. A post-classification method was adopted by [7] with a supervised classification (maximum likelihood classifier algorithm). Various Landsat images of different times (1972, 1982, 1987, 2000, 2003 and 2008) have used by [8] those images treated in Erdas and ArcGIS techniques to analyze and examine the changes in the coast of lake and in its water capacity. A study conducted by [9] to evaluate the changes of land use/land cover in Kathmandu City, India based on analyses taken from the four land use/land cover maps by using GIS. According to [9], measurements and the transition matrices are very essential for examining and monitoring the changes of the land.

In India, studies on land use/land cover have been done by several scholars, particularly by using geographic information system (GIS) applications and remote sensing techniques. In [10] have computed land use/land cover of Gaga's watershed in the Almora area using a survey of an Indian topographic map for the year 1965 and some satellite records for the year 2008 over a timescale of 43 years. In [11] have conducted a study of the changes in land use/land cover of five major metropolises, namley (Bhimtal, Nainital, Ramnagar, Almora and the Haldwani district) of Kumaun Himalaya regions in Uttarakhand. According to 20 years of satellite records from 1990 to 2010 of land use/land cover change, they found that the urban area has dramatically increased due to the construction of new structures in vegetation and agricultural lands [12]. In [13] conducted a study of the changes in land use/land cover in Srinagar, Kashmir Valley. They noted that the Srinagar city has experienced significant changes from 1990 to 2007. The analysis also displayed that the changes in the land use pattern have resulted in the loss of forest area, open areas, etc. In [14] presented an integrated method for remote sensing associated with GIS techniques for the studying land cover and land use changes of the dry environment of Kutch district in Gujarat among the years 1999-2009. In [15] presented Land Absorption Coefficient and Land Consumption rate (LCR) to assist in the quantitative estimation of changes among the years 1976-2008 in Bhagalpu R, Bihar. Others researchers used recent easily accessible satellite records of Landsat-8 to evaluate the land use model and their spatial changes on the Orr watershed in the Ashok Nagar region of M.P. An attempt is made in this study to map out the situation of land use/land cover of one of the developing regions of the Uttarakhand state, viz., Hawalbagh region of District Almora with the intention to reveal the land utilization rate and the major changes that has occurred throughout the last two decades using geospatial applications.

In current practices, remote sensing in integrating with GIS techniques can provide powerful, advanced synoptic tools to utilize better monitoring and understanding the spatial, temporal and spectral features of land use and land cover changes at global, continental and national balances [16-18]. Furthermore, remote sensing and GIS techniques are extremely beneficial in the recurrent assessment of urban land covers, allowing monitoring and better land management [19-20]. The use of satellite data in observing urban growth and the resultant land cover changes has become a common approach in recent time and techniques are extensive among practitioners and researchers [21-24].

However, recent settlements in the south region were established and developed in spaces that were reformed and transformed into urban areas and agricultural lands. The Amman-Aqaba Highway, which connects south Al-Ghor with the other nearby regions. The population of the region was rapidly increasing in the study area as a result of the new linking roads, agricultural activities and industrialization. While the total population of south Al-Ghor was about 6,000 in 1972, they became about 60,000 in 2016. Increasing population pressure and economic activities produced changes in the land cover and land use. The main objective of this study is to determine the land use land cover changes from 1972 to 2016 using an integrated approach of remote sensing and GIS in order to examine the spatial and temporal changes of the south Al-Ghor plain and its surroundings. This study provides a recent assessment for different land cover categories found in the south Al-Ghor. It is also predictable that the study would go a long way in better policy making, sustainable development and developing useful change detection plans and for south Ghor Regions and other similar regions in the country.

2. METHODOLOGY

The main objective of this study is to evaluate and examines the spatial and temporal changes of the land use and land cover in south Ghor, Jordan. South Ghor block is one of the 6 developmental blocks of Al-Karak, province of Jordan. It is located in the south of Jordan, Karak province and it extends along Jordanian-Palestinian borders between 31° 00′-31° 25′ N and 35° 25′-35° 35′ E (Fig. 1). As mentioned earlier, villages in south Ghor regions have become important sites for built-up development in order to disperse the population of south Jordan. Moreover, high accessibility with highways crossing south has led to the urbanizing more rapidly. Population growth initiatives have changed the landscape. Long-term urban development plans have been applied in south Ghor. Therefore, residential areas will continue to increase.

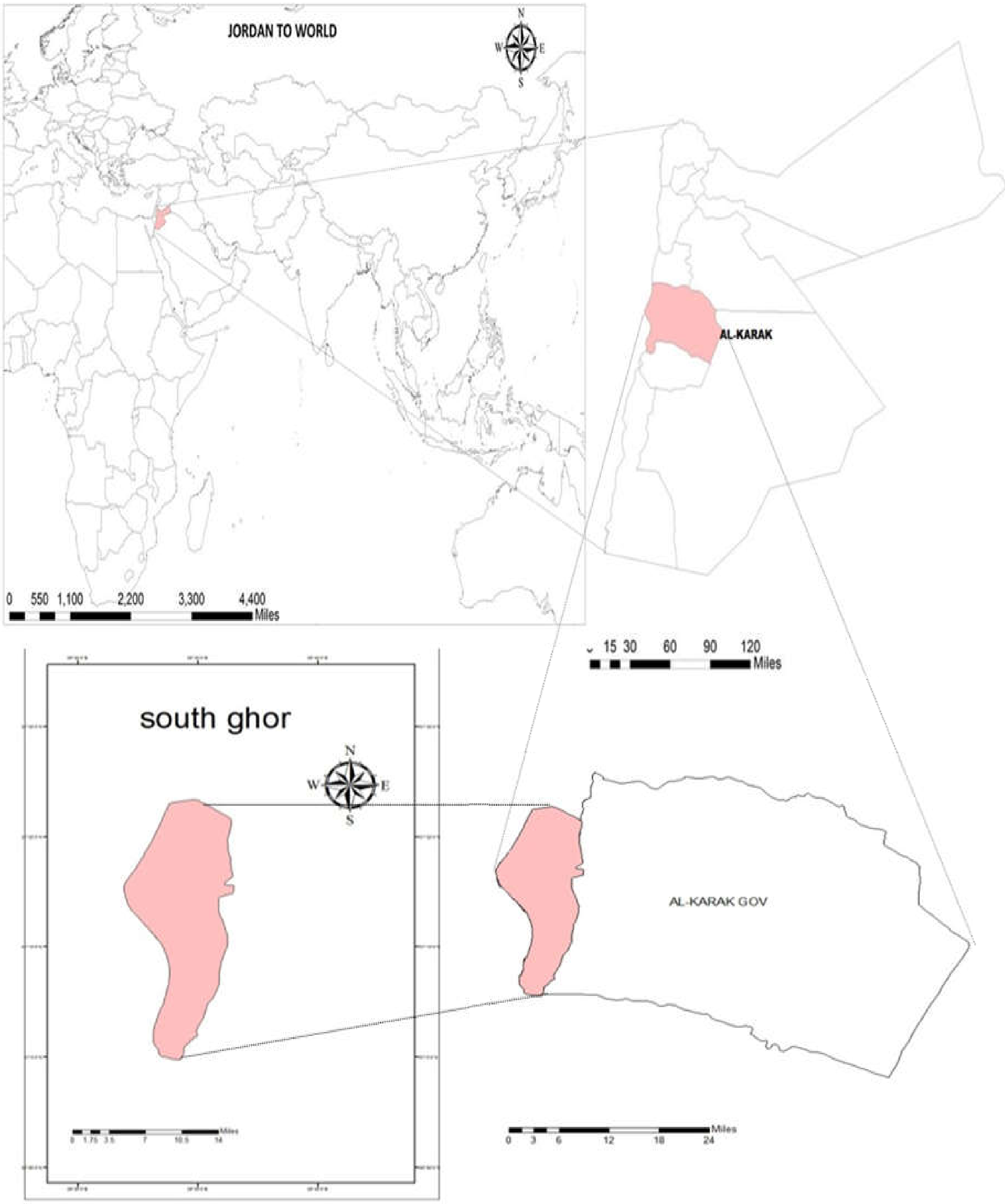

Fig.1. Study areas in South Ghor Regions, Al-Karak, Jordan

2.1. Database Design

In this study, the Landsat images (l 1-5 MSS, l 4-5TM) with 30 m spatial resolution will be used. One of them was acquired in 1972 and the second was acquired in 1989, the third was acquired in 1999 and the fourth was acquired in 2016. All of them were provided by the United States Geological Survey Earth Resources Observation Systems data center (USGS).

The other data used in this study for references and analyses mainly include (1) topographic maps at a scale of 1/100,000, (2) the detailed land use map is obtained from Jordan valley authority and (3) ground reference data is obtained from a land survey with Global Positioning System (GPS) handheld.

2.1.1. Image Pre-Processing

The image processing was implemented in four steps: (1) pre-processing, (2) determination of land covers categories, (3) classification and (4) accuracy assessment. Error matrix and KAPPA analysis were prepared. The flowchart of the image processing procedures was represented in Fig. 2. All images were clipped out according to the study area by using the "extract by mask" function in ArcGIS. All images were geometrically corrected using linear polynomial approach based on topographic map (Royal Jordanian Geographic Center) with 8 control points and an RMS error of fewer than 0.5 pixels. All images were geo-referenced into the Universal Transverse Mercator-UTM, WGS-84.

The images were chosen in the same vegetation season with a cloud cover of 0 %. The images were so obvious but for developed image interpretation, the common contrast was applied through histogram equalization method.

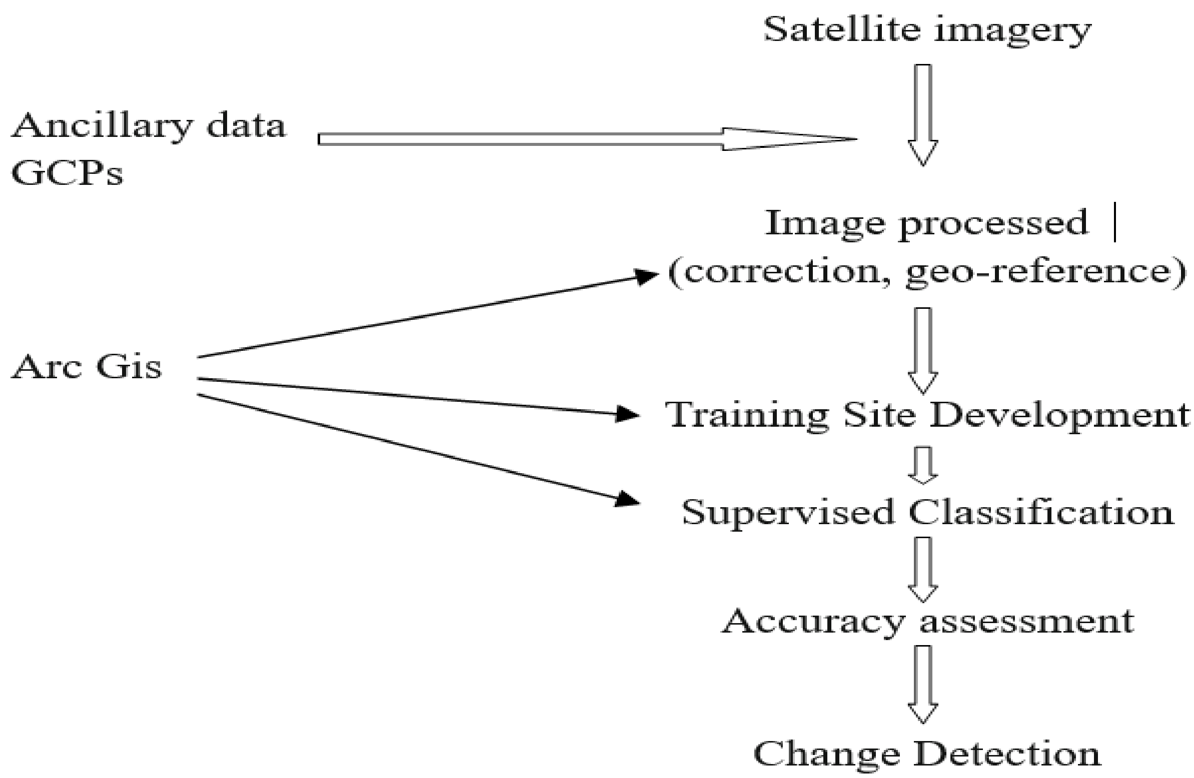

Fig.2. The LULC flowchart image processing procedures

2.1.2. Image Classification

A good knowledge of the study area was achieved by a suitable image enhancement and related literature. In a similar line, in [26] suggest a fieldwork that develops knowledge of the area with interviews, photography of characteristic surfaces and a ground truth data in order to validate the classification. In this study, all images were independently classified using the supervised classification method of maximum likelihood algorithm. Although many different approaches have been devised to implement supervised classification, the maximum likelihood is still one of the most widely used classification algorithms.

In supervised classification, a specific number of spectral signatures are gathered from identified locations in the image by digitizing several polygons overlaying different land types. The spectral signatures are then used to categorize all pixels in the scene. Over 160 "user-defined polygon" were selected from the whole study area by drawing an area of interest (AOI). In supervised classification process, AOI function reduces the chance of underestimating class variance since it included a high level of user control. After the classification procedure, all signature sample points were grouped as a class by "recode" function according to the determined land cover classification types in this study.

2.1.3. Accuracy Assessment

An accuracy assessment tool was utilized to evaluate the accuracy of the classified images. It is based on a random sampling method that selected the points from the referenced map. After the application, a report showing the error matrix of the results is obtained. An error matrix is the most common way to present the accuracy of the classification results. Overall accuracy and the Kappa statistics were extracted from the error matrices. The overall accuracy and the Kappa analysis were used to implement the classification accuracy assessment depending on an error matrix analysis. Using the simple descriptive statistics method, overall accuracy is calculated by dividing the number of correct pixels (sum of the major diagonal line) by the total number of classified pixels in the error matrix. Kappa analysis is a separate multivariate method used in accuracy assessments. It produces a Khat statistic (an estimation of Kappa) that is a quantity of agreement or accuracy. The formula of Khat value is shown in Equation (1):

$$\hat{K} = (\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} * x_{+i}))/(N^2 - \sum_{i=1}^{r}(x_{i+} * x_{+i})) \quad (1)$$

where r is the number of rows in the matrix, xii is the number of observations in row i and column i, xi+ and x+i are the marginal totals for row i and column i respectively and N is the total number of pixels.

Individually, classified images were matched with each other to reveal the changes of land cover types. Accuracy plans of more than 80 % are considered sufficient enough for dependable classification of land cover types. Accuracy assessment was calculated through error matrices. Overall accuracy was measured using Equation (2):

Total (overall) accuracy = ((number of correct pixels)/ (total number of pixels)) × 100 (2)

Accuracy analysis was done to the classified satellite images (1972-2016) with an aim of confirming the accuracy of the classification. To do this, over 160 reference control points (Truth) were identified on the study area map for 4 classes. The point distributions were made in proportion to the field distributions of the classes. 160 pixels were identified for the land cover change map of every period. Overall classification accuracy was detected as 95.62 %, 96.87 %, 95.00 %, 94.37 % respectively and overall Kappa statistics value was 94.23%, 95.87, 93.45 %, 90.24 % respectively (Table 1).

Table 1. Overall classification accuracy and Kappa statistics from error matrix

Year	Overall Classification Accuracy (%)	Kappa Statistics
1972	95.62	0.94
1989	96.87	0.96
1999	95.00	0.93
2016	94.37	0.90

3. RESULTS AND DISCUSSION

The results obtained from the analysis of multi-temporal satellite images are diagrammatically illustrated in Fig. 3 and 4 and data are registered in Tables 5 and 6. Fig. 3 depicts land use/cover status, Fig. 4 depicts land use/cover change in different periods and illustrates the magnitude of change in different land categories. A brief illustration of these results is discussed in the following paragraphs.

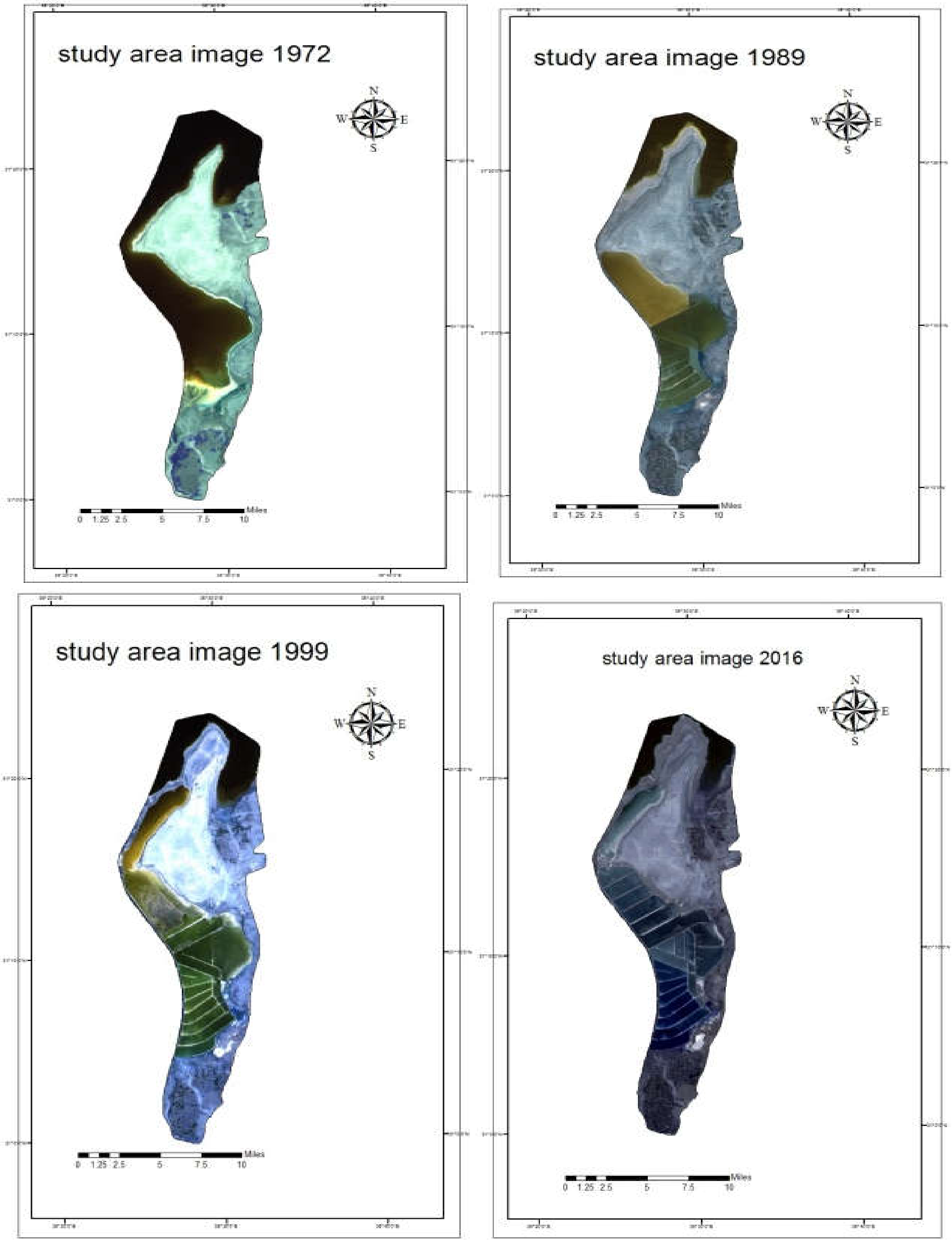

Fig.3. Multi-temporal satellite images for years 1972, 1989, 1999 and 2016 in south Ghor, Jordan

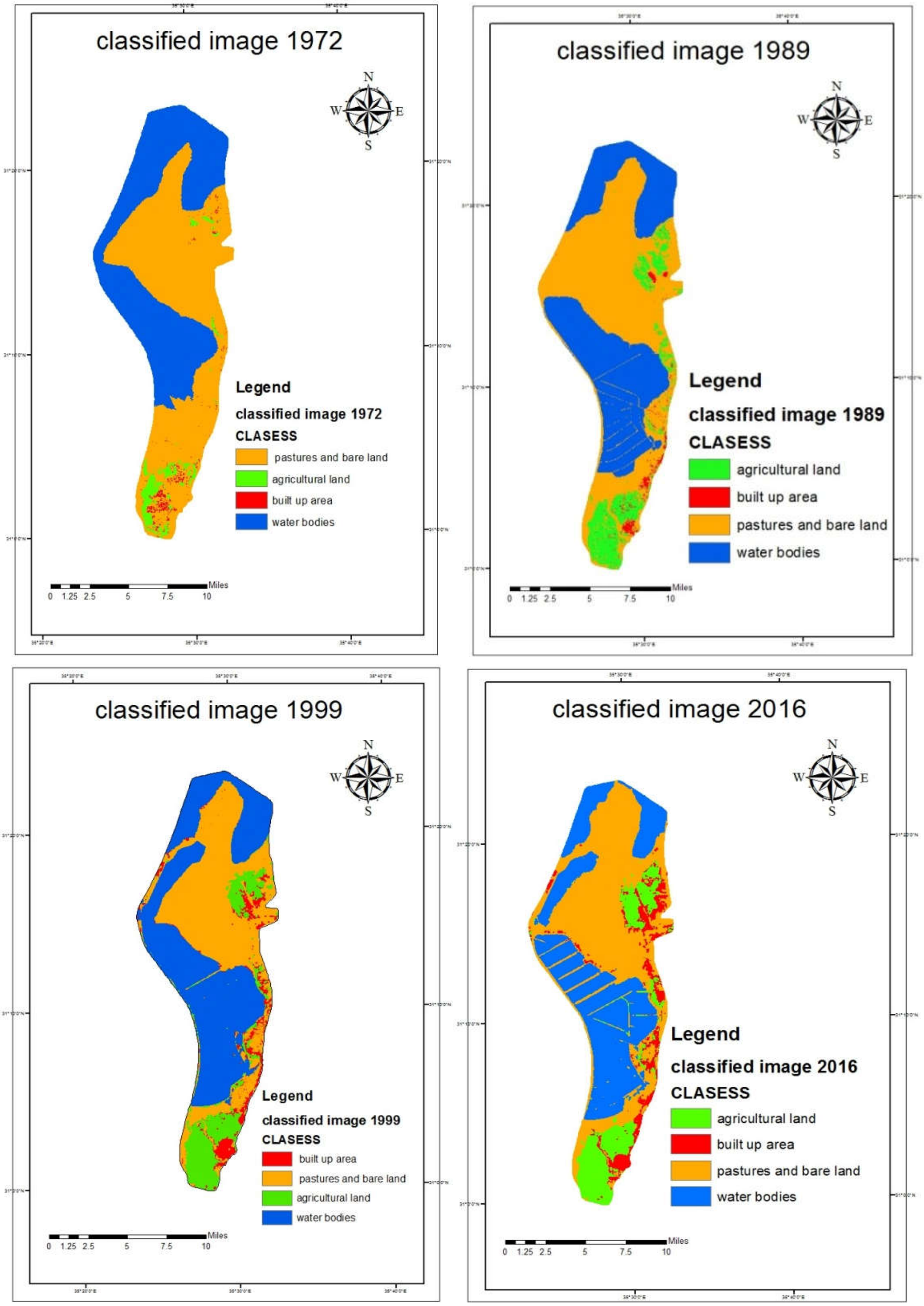

Fig.4. Multi-temporal images classification for years 1972, 1989, 1999 and 2016 in south Ghor, Jordan

3.1. Land Use/Cover Changes

Data registered in Table 2-4 and Fig. 5-7 show that both positive and negative changes happened in the land use/cover pattern of the south Al-Ghor during the last four decades. The agriculture in the study area has noticeably increased from 3.30% (1239.12) hectares in 1972 to 8.94% (3347.82) hectares in 1989 to 10.78% (4033.35) hectares in 1999 to (4765.86) hectares in 2016 which accounts for (12.73%) of the total study area.

The pastures and bare areas have decreased from 53.60% (20072.2) hectares in 1972 to 50.22% (18806.1) hectares in 1989 to 44.67% (16728.7) in 1999 to (16761.4) in 2016 which accounts for 44.76%. The inhabitant area has increased from 0.77% (289.8) hectares in 1972 to1.38% (515.7) hectares in 1989 to 2.96% (1107.99) hectares in 1999 to (1802.52) hectares in 2016 which accounts for (4.81%). The water bodies of the study area have changed from 42.31 % (15842.5) hectares in 1972 to 39.46% (14776.7) hectares in 1989 to 41.60% (15576.7) hectares in 1999 to (14116.9) hectares in 2016 which accounts for (37.70%). To understand land changes for different land categories during the last four decades was prepared which reveals that:

Table 2. Area change and rate by hectares at every study period

	1972		**1989**		**1999**		**2016**	
Classes	**Area**	**Rate**	**Area**	**Rate**	**Area**	**Rate**	**Area**	**Rate**
Built area	289.80	0.77	515.7	1.38	1107.9	2.96	1802.5	4.81
Agriculture	1239.12	3.3	33478.2	8.94	40333.5	10.78	4765.86	12.73
Water	15842.5	42.31	14776.7	39.46	15576.7	41.60	14116.9	37.70
Pastures	20075.2	53.6	18806.1	50.22	16728.7	44.67	16761.4	44.76

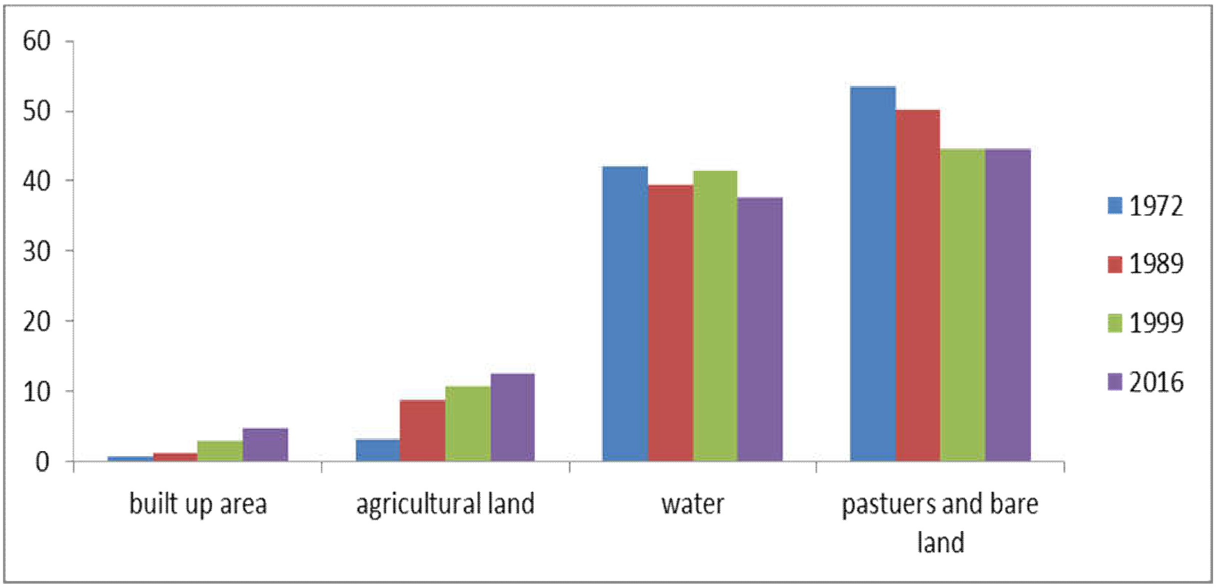

Fig.5. Area change and rate by hectares at every study periods

Table 3. Rate change at every study periods for every class according to origin area for each class (*100%)

	Rate Change 1972-1989	Rate Change 1989-1999	Rate Change 1999-2016	Total Change 1972-2016
Built up area	0.78	1.15	0.63	5.23
Agricultural land	1.70	0.20	0.18	2.85
Water bodies	-0.07	0.05	-0.10	-0.11
Pastures	-0.06	-0.11	0.003	-0.17

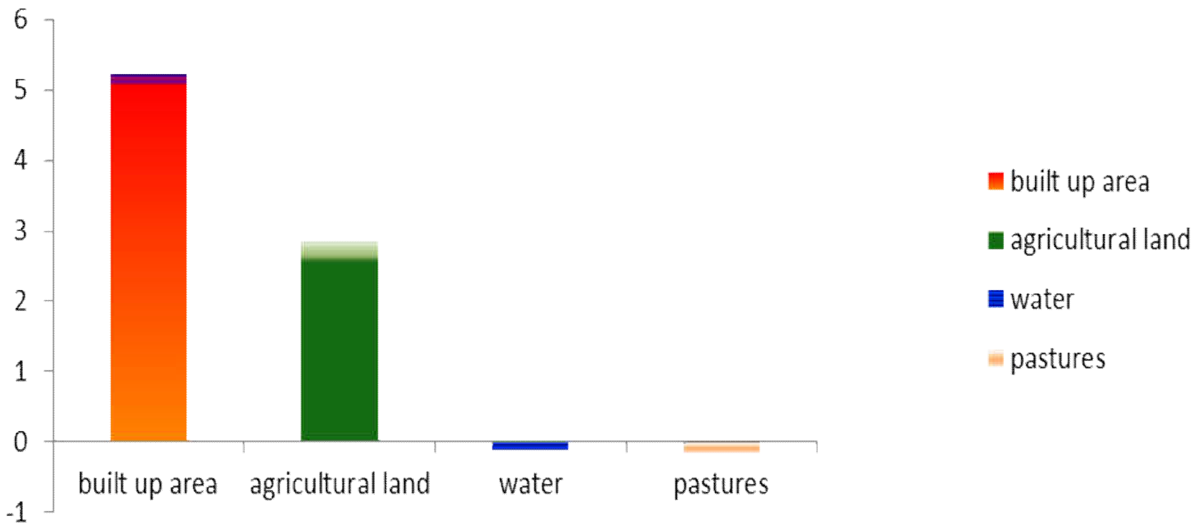

Fig.6. Rate change *(100%) at every study period for every class according to origin area for each class

Table 4. Area and rate for every class in study region 2016

	Area	Rate (%)
Built up area (hec)	18025.2	4.81
Agricultural land	47658.6	12.73
Water bodies	141168.6	37.70
Pastures and bare land	167614.2	44.76
total	374466.6	100

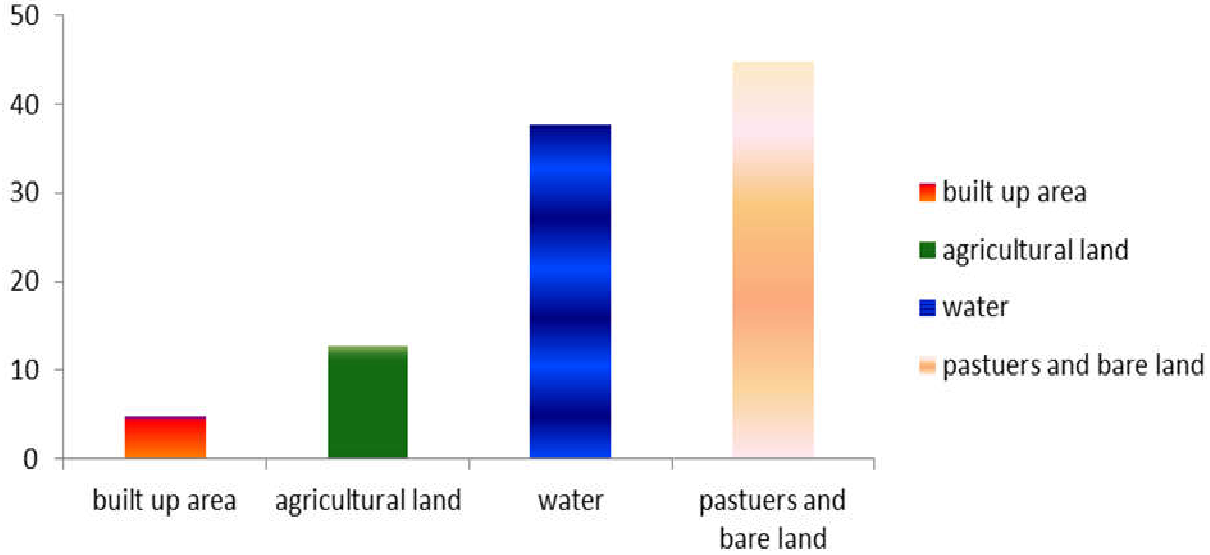

Fig.7. Diagram explains lastly area and rate for every class in study region 2016

The main causes for these changes are the increasing of population and the developing economic activities. Built-up areas are expected to increase in the future. These determined changes provide information about the changing directions of the future in the study area, which can be valuable information that can accelerate development strategies and the decision-support systems.

4. CONCLUSION

The study is conducted in one of the developing regions in Jordan, south ghor district in Al-Karak province. It shows that multi-temporal satellite images play an essential role in counting for spatial and temporal phenomena, which is otherwise not possible to bid through conventional mapping. The first change of the land in the study area is agricultural land, which has been rapidly increasing. Throughout the study epoch (i.e., 1972-2016), agricultural land has been increased by 9.42% (3526.74) due to the conversion of pastures and bare land. The second change of land in the study area is pastures and bare land which has decreasing by 8.85% (3313.8) due to the conversions of agricultural land and inhabitant area during the study time (i.e., 1972-2016).

The third change of land in the study area is water bodies. They were decreased and increased according to the governmental policies, some mining and manufacturing companies like Arab Potash Company and Jordan Bromine Company, these companies are primarily involved in mining and extracting minerals from the Dead Sea like potash and bromine. Those aforementioned gigantic companies are considered to be internationally the largest minerals and potash producers. The fourth change of land in the study area is built up area which has also increased due to conversion in pastures and arid land.

The area under the built-up land has increased by 4.04% (1512.72) due to the mainly expansion and population growth of the south Ghor district during the last four decades and by sustainable development in projects south Ghor. Thus, the present study illustrates that remote sensing and GIS [25] are important technologies for temporal analysis and quantification of spatial phenomena which is otherwise not possible to attempt through conventional mapping techniques. Change detection is made possible by these technologies in less time, at low cost and with better accuracy.

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