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Land Use/Land Cover Change Detection in the Baer and Al-Bassit Region, Latakia, Syria, 1972–2018

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كشف تغير استعمالات الأراضي/الغطاء الأرضي في منطقة الباير والبسيط، اللاذقية، سورية خلال الفترة 1972- 2018

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Abstract

Monitoring land use/ land cover (LULC) changes is important for assessing the dynamics between land cover types and understanding the anthropogenic impact on these changes. Remote sensing techniques also represent important tools to achieve this goal. This paper aimed at mapping and analysing LULC changes in the Baer and Al-Bassit region of the Latakia Governorate in Syria. For this goal, 15 multi-temporal Landsat images from the period of 1972–2018 were used, and each image was classified using maximum likelihood algorithm-supervised classification into four categories of land use: forests, agricultural land, water and urban areas. Accuracy assessment of all images was performed; the average value of the overall accuracy of the classification was 89%, and the average value of the Kappa index was 0.85. The area of each land use category was calculated in each LULC map, and each category's trends over the study period were analysed using linear regression analysis. The forest category was the only group that decreased (by 21.8% between 1972 and 2018), compared to an increase in all other categories over the same period (0.6%, 4.3% and 16.8% for water, urban areas and agricultural land, respectively). This indicates a conversion of forests into agricultural land and urban areas. The results of this study can be used as an efficient tool to manage and improve the Baer and Al-Bassit forests in terms of physiographical and human characteristics; they could also facilitate the creation of a database for LULC changes in this region.

الملخص

تعد مراقبة تغيرات الغطاء الأرضي / استخدام الأرض أمراً مهماً لتقييم الديناميات بين أنواع الغطاء الأرضي وفهم التأثير البشري المنشأ على هذه التغييرات، وتمثل تقنيات الاستشعار عن بعد أدوات هامة لتحقيق هذا الهدف. تهدف هذه الورقة إلى رسم خرائط وتحليل تغير استعمالات الأراضي/ الغطاء الأرضي في منطقة الباير والبسيط، محافظة اللاذقية، سورية. استخدمت 15 صورة لاندسات متعددة الأزمنة للفترة 1972- 2018 وتم تصنيف كل صورة باستخدام خوارزمية الاحتمالية القصوى للتصنيف المراقب إلى أربع فئات من استعمالات الأراضي هي: الغابات، الأراضي الزراعية، المياه والمناطق الحضرية. تم تقييم دقة التصنيف لجميع الصور وبلغ متوسط قيم الدقة الإجمالية للتصنيف (89%) ومتوسط قيمة مؤشر كابا (0.85). حُسبت مساحة كل فئة من فئات استعمالات الأراضي في كل صورة وتم تحليل اتجاه التغيير لهذه الفئات خلال فترة الدراسة باستخدام علاقات الانحدار الخطي. كانت الغابات هي الفئة الوحيدة التي تعرضت للانخفاض بين عامي 1972 و2018 بنسبة (21.8%) في مقابل زيادة لجميع الفئات الأخرى (0.6، 4.3، 16.8 % للمياه، المناطق الحضرية وللزراعة، على الترتيب)، مما يشير إلى كسر أراضي الغابة لصالح الأراضي الزراعية والمناطق الحضرية. يمكن استخدام نتائج هذه الدراسة كأداة فعالة لإدارة وتحسين غابات الباير والبسيط فيما يتعلق بالخصائص الفيزيائية والبشرية ويمكن أن تسهل إنشاء قاعدة بيانات لتغيرات LULC في هذه المنطقة.

KEYWORDS
الكلمات المفتاحية

Landsat, linear regression, LULC dynamic, remote sensing, satellite Images, supervised classification

الاستشعار عن بعد، الانحدار الخطي، التصنيف المراقب، تغير استعمالات الأراضي، صور الأقمار الاصطناعية، لاندسات

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1. Introduction

Land cover refers to the physical attributes of the earth's surface, including those made by human activities (e.g., settlements). Land use refers to the manner in which land has been used by people, usually with an emphasis on its functional role for economic activities (Ramachandra and Kumar, 2004). The land use/land cover (LULC) patterns of a region are a result of natural and socio-economic factors and their utilisation by humans in time and space (Rawat and Kumar, 2015).

It is increasingly acknowledged that LULC changes have become a key subject that urgently needs to be addressed in the study of global environmental changes (Hu et al., 2019). This is particularly true in light of major current environmental issues such as desertification, biodiversity loss and climate change, which in turn cause the loss of related environmental services to such a degree that more than half of the world's forest cover has been lost (FAO, 2010).

Many actions of local populations and government organisations (e.g., urban extension, expansion of agricultural land, forest fires) have resulted in the loss of extensive amounts of forest cover and other land use. LULC change analysis is a vital step in managing natural resources, monitoring environmental changes and protecting and planning for the future of Earth's resources (Torahi and Rai, 2011).

Geographic information systems (GIS) and remote sensing techniques are widely used to analyse the distribution, patterns and trends of the LULC processes. These tools have proven to be very valuable for obtaining exact, coherent information according to spatial reality (Monjardín et al., 2017). Another important tool that planners use to control the trends of forest cover changes is regression relations. Because environmental science deals with different phenomena, multiple regression is very important in dealing with ecological issues (Jahanifar et al., 2018).

In the last few decades, many specialists (Batar et al., 2017; Ramachandran and Reddy, 2017; Teka et al., 2018) have studied LULC changes explicitly, using LULC maps with the application of GIS and remote sensing data. In Syria, Ibrahim et al. (2014) used a time series of Landsat images of the Tartous Governorate to study the relationship between the applied agricultural policy and land use changes in this region. The study showed an expansion in the cultivation of citrus and greenhouses as a result of the agricultural plan implemented in the

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same time period. It also confirmed the possibility of determining the spatial relationship between LULC changes and agricultural policies through remote sensing applications. Al-Fares (2013) also relied on Landsat-MSS, TM and ETM+ images and Terra: Aster for mapping LULC and irrigated agricultural projects for the years 1975, 1987, 2005 and 2007 in the Euphrates River Basin in Syria. The results showed that the area of irrigated agricultural projects in the Euphrates basin increased by 148% between 1975 and 2007.

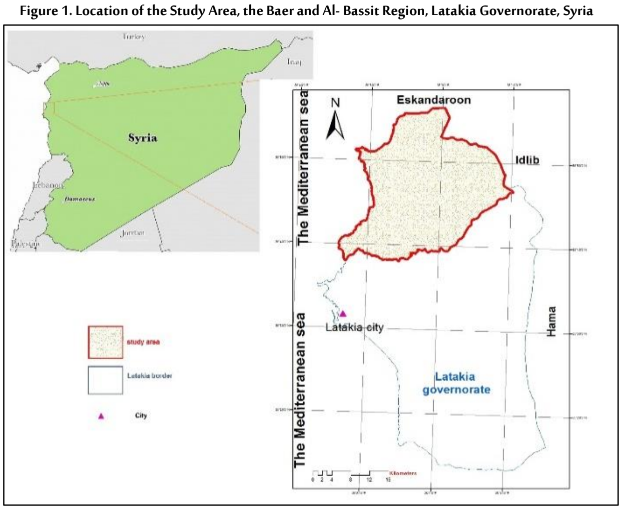
Although the Baer and Al-Bassit region is among the most important forested areas of Syria, it suffers from different human encroachments. Therefore, detecting forest land cover changes can provide enough knowledge to design a forest management strategy. This study attempts to identify the spatio-temporal patterns of land cover changes in the last five decades using multi-temporal Landsat images. The main objectives of this research are (a) to accurately map the extent of the different LULC classes from 1972 to 2018 and (b) to detect the deforestation rate and the changes that have taken place during the study period.

2. Materials and Methods

The Baer and Al-Bassit region extends between longitudes (350 47' 49.2", 360 15' 57.44" E) and latitudes (350 57' 0.6", 350 35' 42.7" N) and encompasses an area of 73,000 hectares. It lies in the north-western part of the coastal mountains in the north and north-west of Latakia, Syria (Figure 1). The study area is characterised by brown Mediterranean soils and a Mediterranean climate type with a rainy winter and a long dry summer. The altitude above sea level is between 300 and 1,400 meters, and the average rainfall ranges between 800 and 1,200 mm/year.

The area is characterised by forest cover over more than 70% of its surface and has the most important forests in terms of area and diversity in Syria, consisting mainly of conifers and oak. Villages are located in the western and southern parts of the study area, and the majority of people living there depend on agriculture for their livelihoods, so agricultural land is mostly concentrated around the villages.

Figure 1. Location of the Study Area, the Baer and Al- Bassit Region, Latakia Governorate, Syria



The Landsat data are available freely on NASA's website (USGS, 2018), and we directly downloaded 15 images for the period of 1972–2018 from the website. Because the changes that have occurred in this region are so frequent, we have chosen one image for every 2 or 3 years. The selected time period was in the summer (June to October) to avoid changes due to different seasons and to obtain cloud-free images as much as possible. Table 1 shows the resolution and other specifications of these images.

Image pre-processing is very important for LULC analysis because different sensors were used, so geometric and radiometric corrections were applied (e.g., in Ali *et al.* [2018]), and because of the differences in spatial resolution between MSS and other images, the resampling process was applied using Erdas Imagine 2015 software.

Google Earth images for different years, a set of topographic maps of northern Latakia at 1:25000 and a 1969 image from the Corona KH-4A satellite with a 9-foot resolution, black-and-white spatial resolution were used to assess the accuracy of the Landsat images classification.

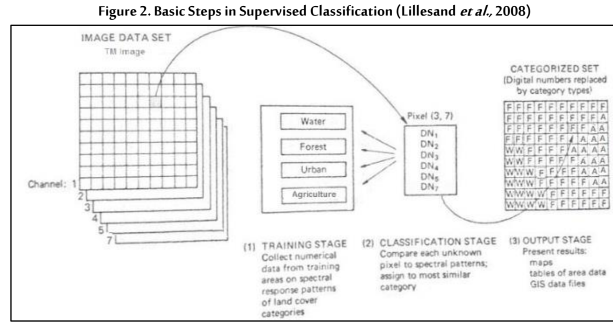
The overall goal of image classification procedures is to automatically classify all pixels in an image into categories or features of land cover, and, typically, multi-spectral data are used to make a classification. In fact, the spectral pattern within the data for each pixel is used as a numerical basis for classification (Lillesand *et al.*, 2008).

Table 1. Characteristics of Landsat Scenes Used in the Classification

SENSOR_ID	Date Acquired	Spatial Resolution (m)	Spectral Resolution	Used Bands
L1 MSS	22/10/1972	80	4	4 to 7
L5 TM	04/07/1984	30	8	1 to 5 + 7
L5 TM	15/09/1987	30	8	1 to 5 + 7
L5 TM	20/09/1989	30	8	1 to 5 + 7
L5 TM	12/09/1992	30	8	1 to 5 + 7
L5 TM	15/10/1998	30	8	1 to 5 + 7
L5 TM	04/10/2000	30	8	1 to 5 + 7
L5 TM	20/06/2002	30	8	1 to 5 + 7
L5 TM	16/09/2005	30	8	1 to 5 + 7
L5 TM	21/08/2007	30	8	1 to 5 + 7
L5 TM	11/11/2008	30	8	1 to 5 + 7
L5 TM	31/07/2011	30	8	1 to 5 + 7
OLI_TIRS	08/10/2013	30	11	2 to 7
OLI_TIRS	12/09/2015	30	11	2 to 7
OLI_TIRS	19/10/2017	30	11	2 to 7
OLI_TIRS	06/10/2018	30	11	2 to 7

To determine the classification of LULC, the supervised classification method was applied in the Erdas Imagine 2015 software using the reflective bands in each image (Table 1). Supervised classification is based primarily on pre-determination of training areas and samples; Figure 2 summarises the three basic steps involved in a typical supervised classification procedure (Lillesand *et al.*, 2008).

Figure 2. Basic Steps in Supervised Classification (Lillesand *et al.*, 2008)



The training samples were taken from each image individually, and a spectral signature file of each image was created using a signature editor tool which sampled each of the studied areas according to Congalton (1991) for the number of samples.

Four categories of land use for all images were identified and mapped: agricultural areas, urban areas, water and forests. The maximum likelihood classification (MLC) method, as the most widely used in the scientific literature, is fast and easy to apply and enables a clear interpretation of the results (Bolstad and Lillesand, 1991). This algorithm can obtain a spectral image of each land use class through variance and covariance statistics of the set of training sites identified in the image and calculates the probability of belonging to each class according to the spectral signature; this method has been proven in works such as those of Hassan et al. (2016) and López and Plata (2009), with satisfactory results.

The classification is not fully considered until its accuracy is assessed (Lillesand et al., 2008). Therefore, to verify the validity of the results obtained, we assessed the accuracy using the accuracy assessment tool in Erdas Imagine by distributing random points representing all classes of land use in the image and then comparing the classification of these points with the facts provided by a Corona image and topographic maps for 1972, the 1980s and the 1990s, respectively. For the remaining images, we used Google Earth imagery with no field survey because the study area has not been accessible since 2011 (it is out of government control).

The Kappa index shows the level of similarity between a set of control fields and the classified image. It is utilised as a standard part of precision evaluation to measure the accuracy between the remote sensing-derived classification map and the reference data, referred to as row and column totals (Jensen, 2003).

The value of Kappa is between 0 and 1. If the value is equal to 0, then there is no agreement between the map and the reference. If Kappa is equal to 1, it shows that there is a strong agreement between the map and the reference.

The general overall accuracy indicates the percentage of pixels that are properly classified. The percentage of producer's accuracy signifies the percentage of a particular land use change that is correctly classified in the image. The percentage of user's accuracy provides the percentage of a land use class in the image that matches with the class that corresponds to the land (Congalton et al., 1983).

The simple linear regression is a technique used to analyse the relationships between two quantitative variables. In linear regression, we assume that there is a linear relationship between dependent and independent variables (Salman-Mahini and Kamyab, 2012). It is used in this study to determine the general trend of the land use change and its significance during the period of 1972–2018, where the dependent variable was time, the independent variable was LULC class area and the calculation was done by SPSS V25 software.

3. Results and Discussion

3.1. Land Use/Land Cover Maps:

LULC maps were prepared and presented for all the images in Figure 3. The maps show that there is an increase and a decrease in different land use categories. We noted a decline in the extent of forest area during this period of 1972 to 2018.

Figure 3. LULC Maps for the Study Area (Baer and Al-Bassit) Between 1972 and 2018

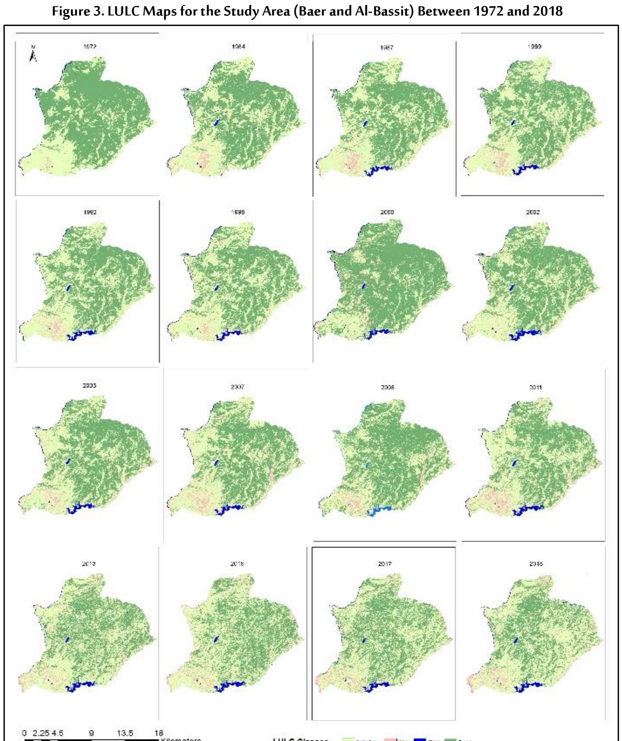


Table 2 clarifies the area and percentage of each land cover category derived from the LULC maps.

The total area of the Baer and Al-Bassit region is 72,300 hectares (Ha), divided into the four LULC categories. In 1972, the largest percentage of the study area fell into the forest category, which accounted for 55.23% of the total area, followed by agricultural land (39.43%).

Table 2. Area (Ha) and Percentage of the Land Use Classes

Land Cover Class		Water	Forest	Urban	Agriculture	Total
1972	Area	820.0	39,959.6	3,045.6	28,529.01	72,354.15
	%	1.13	55.23	4.21	39.43	100
1984	Area	818.46	35,794.62	3,406.77	32,334.3	72,354.15
	%	1.1	49.5	4.7	44.7	100
1987	Area	1,066.5	32,325.39	7,545.33	31,365.81	72,303.03
	%	1.5	44.7	10.4	43.4	100
1989	Area	1,115.73	29,648.52	7,079.04	34,396.20	72,239.49
	%	1.5	41.0	9.8	47.6	100
1992	Area	1,209.15	32,372.28	6,196.86	32,575.86	72,354.15
	%	1.671155	44.741428	8.564623	45.022794	100
1998	Area	1,174.59	34,729.56	5,191.74	31,268.25	72,364.14
	%	1.623166	47.992777	7.174465	43.209592	100
2000	Area	1,164.42	48,763.8	4,084.29	18,218.34	72,230.85
	%	1.612081	67.511043	5.654495	25.222381	100
2002	Area	1,276.38	37,067.67	3,397.59	30,612.51	72,354.15
	%	1.764073	51.230883	4.695778	42.309266	100
2005	Area	1,154.97	34,180.74	4,111.2	32,867.37	72,314.28
	%	1.597153	47.26693	5.685184	45.450733	100
2007	Area	1,151.82	31,157.73	6,302.7	33,690.78	72,303.03
	%	1.593045	43.093256	8.717062	46.596636	100
2008	Area	1,029.06	36,508.95	2,980.08	31,802.76	72,320.85
	%	1.422909	50.481915	4.120637	43.974538	100
2011	Area	1,266.39	35,630.1	1,989.9	33,416.64	72,303.03
	%	1.751503	49.278848	2.752167	46.217482	100
2013	Area	1,235.34	26,915.58	5,450.58	38,730.87	72,332.37
	%	1.707866	37.210975	7.535464	53.545695	100
2015	Area	926.37	27,661.32	5,213.43	38,519.73	72,320.85
	%	1.280917	38.248057	7.208751	53.262275	100
2017	Area	1,136.79	27,809.82	4,952.52	38,455.02	72,354.15
	%	1.571147	38.435694	6.844832	53.148327	100
2018	Area	1,247.94	24,205.14	6,154.11	40,713.66	72,320.85
	%	1.72556	33.469103	8.509455	56.295881	100

Water bodies accounted for 1.1 % of the study area in 1972, which is the lowest among land use categories, but this does not make the study area water-poor. The water area changed only slightly from year to year, except for the period of 1984–1987, when the water area increased by 0.4% (from 818.46 to 1,066 hectares). This increase was due to the construction of the 16 October Dam on Kabeer Shemali River. The dam was built at the expense of agricultural land and surrounding forests. In contrast, the decline in water area (from 1,235.34 to 926.37 hectares) between 2013 and 2015 was due to the drought recorded during those two years.

Forested areas rotated with the agriculture class by occupying the largest proportion of land use categories during the study period (Table 2). The forest area decreased in favour of agricultural land from 1972 to 1992 (from 39,959.6 hectares to 32,372.28 hectares), while the other categories increased. In the 1990s, the proposed afforestation projects began to show results, with an increase of about 7% in forest area in 1992, 1998 and 2000; after the 2004 Bassit fire, forest area decreased again (from 51.23% of the study area in 2002 to 43.1% in 2007).

Maps of 2005 and 2007 show the effects of the Bassit fire: the affected area has been turned into agricultural land, due to the decline of vegetation biomass in the region. This land returned to forest class in 2008 after the increase of this biomass thanks to regeneration of pine forests and reforestation with several forest species (Kassas, 2008).

The sharp decline in forest area in the years after 2011 is due to war and large forest fires in northern Latakia. In the crisis years (since 2011), the forest area has declined in different parts of the study area, especially in the Hafah region, where armed operations took place, in addition to fires and over-cutting for heating and cooking (Figure 3). The forest area decreased from 35,630.1 hectares in 2011 to 26,915.58 hectares in 2013 and continued to decline to its lowest value in 2018, with an area of 24,205 hectares (equivalent to 33.47% of the study area). This corresponds to the study of the borders and areas of fire in northern Latakia between 2002 and 2017, whereas the normalised burn ratio values were low in Bassit in 2005 and 2006, and in Hafah in 2014 and 2015 (Merhej *et al.*, 2019).

The largest proportion of forest area (22%[1]) lost between 1972 and 2000 has been turned into low forms of vegetation (maquis), while some parts have also been lost for agricultural use.

In the Tartous Governorate, which is climatically similar to the Baer and Al-Bassit region and has a variety of vegetation types and human activities, forest area decreased by 262.4 km^2 during the period of 1987–2017 (651.84 km^2 in 1987, 389.44 km^2 in 2017). The majority of the decline (72.5%) occurred during the period of 2002–2017 due to excessive logging for fuel by the local communities, especially during the war, and it was accompanied by a significant increase in the area of agricultural land (Hammad *et al.*, 2018).

After the water class, urban areas accounted for the lowest percentage among the land use categories, with a percentage of 4.21% in 1972. The values of the urban category fluctuated widely, but we can say that it increased from 3,045.6 hectares in 1972 to 6,154.11 hectares in 2018. The largest increase was between 1984 and 1987 (from 3,406.77 to 7,545.33 hectares). In contrast, there was a decline in the area of urban sites in the period of 2007–2011 of about 6% (from 6,302.7 hectares to 1,989.9 hectares), and then in 2018 they increased to 8.5% of the study area (6,154.11 hectares). This is again due to the spectral confusion (Yang, 2002). This finding is consistent with the results of Aragrande and Argenti's (2001) study, which concluded that urban expansion causes a loss of agricultural land due to high competition for other uses (e.g., housing, industry).

The difference in the proportion of the urban class may be due to the lower accuracy of the classification of this category, which represents a lower producer's accuracy in most classified images. This can be attributed to the similarity between the spectral reflection of urban and agricultural land, leading to low accuracy of the maps (Seto *et al.,* 2002), especially since most of the urban areas in the study area are agricultural villages comprising both houses and cultivated land. Natural and agricultural ecosystems are rapidly being converted into urban/built-up areas to meet the residential and economic needs of the ever-increasing urban populace (Yang and Liu, 2005).

It is evident from Table 2 that agricultural land occupied 39.43% of the study area in 1972, and that number increased by about 17% between 1972 and 2018 (from 28,529.01 hectares in 1972 to 40,713.66 hectares in 2018). The increase in agricultural land can be linked to the war and the rapidly resulting poverty in the last several years, which caused increases in forest cutting to convert land for agriculture use and to sell fuel woods.

3.2. Accuracy Assessment of Supervised Classification:

The accuracy of the classification images was evaluated; Table 3 shows the accuracy assessment details for all the images used in the study in terms of overall accuracy and Kappa index, respectively. The results show that the Kappa index gave very good values for the applicable classification, ranging from 0.8 in 2015 to 0.91 in 2005. The overall accuracy ranged from 87.36% in 1972 to 92.94% in 2005.

Deriving signatures from multiple images can make the signatures more robust in the sense that they result in reasonably good classifications across years, but on the other hand, it does not necessarily produce the best classification in any single year (Laborte *et al.*, 2010). The different values of the Kappa index and overall accuracy may be due to the fact that each image is classified according to its spectral profile. The absence of field surveys and dependence on Google Earth images to evaluate accuracy may be the reasons for the consistent accuracy of the OLI images with the images from the 1970s and 1980s that used an aerial Corona image and a set of topographic maps.

Table 3. Overall Accuracy and Kappa Values for the Images Used in the Study Period

Year	1972	1984	1987	1989	1992	1998	2000	2002	2005	2007	2008	2011	2013	2015	2017	2018
Overall Accuracy %	87.36	88.46	89.23	90.85	92.31	88.59	92.5	92.07	92.94	89.38	91.08	91.95	88.28	88.16	89.78	88.13
Kappa (K^)	0.84	0.84	0.85	0.88	0.89	0.84	0.86	0.89	0.91	0.86	0.85	0.89	0.84	0.8	0.85	0.84

The producer's accuracy values were lowest for the urban and agricultural land classes compared to higher values for the water category; the producer's accuracy of the urban category was 61.54% and 66.67% in 2015 and 2017, respectively. This is due to the spectral confusion, where farms at the beginning of the agricultural seasons show a spectral reflection similar to that of urban areas (Yang, 2002).

3.3. LULC Change Analyses Between 1972 and 2018:

The coefficient of determination R^2 describes the relationship between the LULC area and time and determines how much variable variation (the LULC area) is dependent on the independent variable (the year; Bihamta and Zare, 2011; Zar, 1984). Figures 4, 5 and 6 illustrate the LULC change trends and the linear regression analysis for 1972–2018.

The regression analysis showed a significant trend towards an increase in water surface area during the study period (ANOVA, $F = 5.85$, $P < 0.05$; Figure 4).

Figure 4. General Trend for Water Surface Area During the Period of 1972—2018

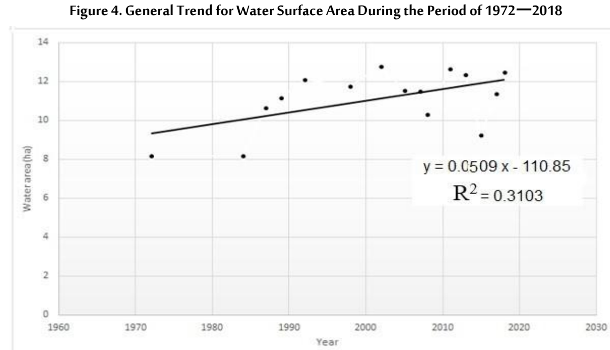
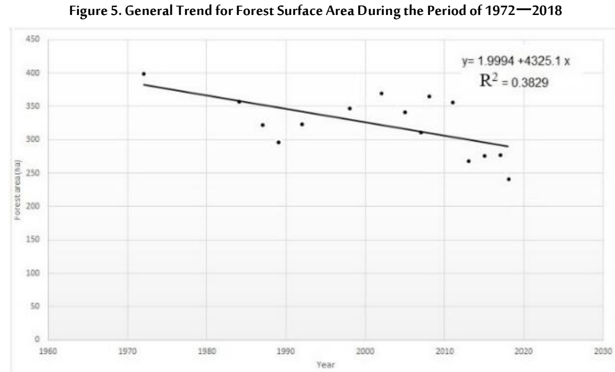


Figure 5 presents forest area changes between 1972 and 2018, during which period the overall forest area decreased. The regression analysis also showed a significant general trend towards decreasing forest area (ANOVA, $F = 8.068$, $P < 0.05$). According to the value of the determination coefficient (0.38), we can say that 38% of the decreases in forest land cover were made by the independent variable (time).

The regression analysis for urban areas, however, showed no significant general trend during the study period (ANOVA, $F = 0.001$, $P > 0.05$).

Figure 5. General Trend for Forest Surface Area During the Period of 1972—2018



[1] (24200- 39960/72354)*100

Figure 6 presents the changes in agriculture land area that occurred between 1972 and 2018. The value of R^2 was the highest, indicating that the trend of increases in the area of agricultural land was consistent throughout the study period; 57% of increases in agriculture were made by time.

The regression analysis shows a significant general trend towards an increase in agricultural land area during the study period (ANOVA, F = 17.378, P <0.05).

These changes are not systematic for most types of land use in the study area, where the greater the area of the land type and its importance, the greater the magnitude of the calculated changes. Currently, the main factor in reducing forest cover in the region is human activity. Residents of residential districts in the area are busy removing and cutting down the forests to cover their fuel consumption and the expansion of their agricultural lands.

Figure 6. General Trend for Agricultural Areas During the Period of 1972—2018

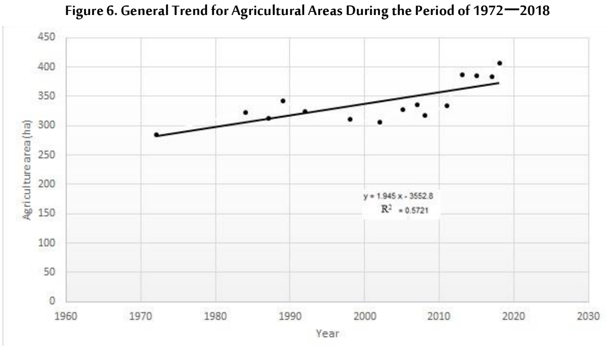


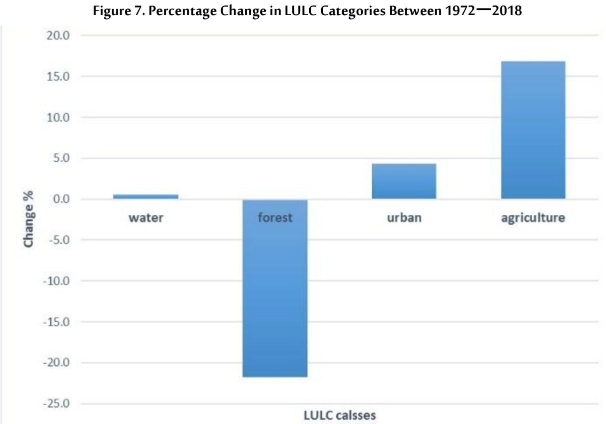
Table 4 shows the analysis of changes between 1972 and 2018. Figure 7 provides a chart for a better understanding of this change.

Table 4. LULC Changes in the Baer and Al-Bassit Region Between 1972—2018

Land Cover Class	Area in Ha (1972)	% of Total Area (1972)	Area in Ha (2018)	% of Total Area (2018)	Change in Ha
Water	820.0	1.13	1,247.94	1.7	427.95
Forest	39,959.6	55.23	24,205.14	33.5	-15,754.4
Urban	3,045.6	4.21	6,154.11	8.5	3,108.51
Agriculture	28,529.01	39.43	40,713.66	56.3	12,184.65
Total	72,354.15	100	72,320.85	100	

The results show that the forest category is the only category that decreased during the study period, while agriculture was the category that increased the most significantly. Statistical analysis shows a 21.8% decline in forest area between 1972 and 2018 (about 15,755 hectares). Agricultural land, on the other hand, increased by 16.87% (about 12,185 hectares). Therefore, we concluded that the rapid increase in agriculture is primarily due to the conversion of forest cover to agricultural land.

Figure 7. Percentage Change in LULC Categories Between 1972—2018



4. Conclusion

In situations of rapid land use changes, satellite remote sensing provides detailed information that aids in understanding a region's LULC. This study used images from the same season each year to produce a series of land use classification maps.

The accuracy coefficients obtained in this study indicate that the classification methods used were a good reflection of the real LULC changes that took place during the study period. Nevertheless, when possible, the classification procedure should still be enriched with field verification.

The LULC changes that occurred in the Baer and Al-Bassit region between 1972 and 2018 were quantified using multi-temporal Landsat data. It became clear that the change is threatening the forests, of which more than 150 km^2 were affected by deforestation between 1972 and 2018; this value has an impact on future environment and urban management. The agricultural lands were found to have increased by 16.8% between 1972 and 2018. The majority of this change, however, occurred after 2011 with the beginning of the war, when the increase in agricultural areas happened at the expense of the forests.

Our results suggest that large-scale agricultural activities should be restricted in the Baer and Al-Bassit region. In addition, while the success of forest restoration programs and conservation measures depends on the availability of quality assistive data, these are important steps that should be initiated and implemented in the study area.

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