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RESEARCH ARTICLE – REMOTE SENSING & GIS

Estimation of Spatiotemporal Variation of Land Use/ Land Cover in Babylon Governorate Using Remote Sensing Data during the Period 1993-2020

Ayad Ali Faris Beg

Mustansiriyah University, College of Education, Dept. of Geography

Corresponding author E-mail: aafbeg64@uomustansiriyah.edu.iq

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Abstract

Land use/ land cover (LULC) changes over time and is a crucial indicator of understanding any region environmental and economic dynamics. Satellite remote sensing data provide a valuable source of information to monitor LULC changes at different spatial and temporal scales. This study used a time series of satellite image outputs to analyze LULC changes in Babylon Governorate over a period extended from 1992 to 2020. The study methodology involved processing and analyzing a time series of classified digital satellite images, calculating the areas of the classes and plotting the time series curves of 13 LULC classes within the study area, based on data prepared by ESRI. The data were processed using ArcGIS Pro. V.3.3, represented by spatiotemporal distribution maps of LULC, and time series curves to understand the driving forces behind these changes. The results identify the changing trend of each class in the area, in an increasing or decreasing manner. The results also, show significant changes in the study area, including a substantial rise and expansion of the urban regions, and fluctuations in vegetation cover and barren lands. A noticeable decrease in the areas of rainfed croplands is recorded. This is due to the rainfall decreasing during the study period, as the region is located in soils characterized by chemical degradation, i.e., increased soil salinity. The information derived from this study can help develop sustainable land management strategies, support urban and regional planning efforts, and contribute to understanding the complex interactions between human activities and the natural environment.

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Keywords: Land use/land cover (LULC); Remote Sensing; Spatiotemporal variation; geographic information systems.

1. Introduction

Climate change is one of the factors affecting the agriculture, environment, human life and occurs over periods [1]. Human activity plays a major role in the degradation of land and the natural environment, as a result of agricultural and industrial activities practiced by humans, which are increasingly affected by population growth, which puts pressure on the land to accommodate agricultural activities. [2-4]. Desertification is an environmental hazard, as it has become a serious threat to the human environment in more than 100 countries, and about 250 million people are affected by this phenomenon, and in the future more than a billion people will be under hazard as a result of the continued expansion of the desertification phenomenon. [5]. Usually, Land use and land cover (LULC) are affected by climate changes. Land use refers to the activities carried out on a piece of land, such as residential, commercial, agricultural, or industrial activities. Land cover describes the physical characteristics of the land surface, including forests, water bodies, urban areas, and agricultural fields[6]. Monitoring changes in land use and land cover over time is essential for understanding environmental changes, assessing urban expansion, monitoring deforestation, and assessing the impact of climate change [7]. The changes in LULC play a vital factor in current actions in natural resource management and environmental monitoring [8]. Land use and vegetation cover changes help in visualize and analyze the impact of different development trends and help decision makers to put scientific strategies and implement reasonable policies that provide ecosystem services and conservation of natural resources [9]. Major causes and factors are drive the global and regional land cover changes, represented by tropical deforestation, rangeland change, increasing agricultural activities, and urban expansion [10, 11]. The increase in modern agricultural methods, including better quality seeds and intensive use of fertilizers and irrigation, has dramatically changed the relationship between ecosystems and humans worldwide [12-14]. Recent techniques represented by remote sensing sciences play a fundamental role in suppling spatially detailed data on ground covers using space-borne platforms. These data are used to prepare LULC maps to aid in making decisions related to land resource management. Remote sensing techniques play an important role in monitoring desertification, land degradation, and temporal variations of land use/ land cover, as un indicators in desertification monitoring, due to providing a large area coverage. [15]. Satellite imageries are used to collect the required data in large areas to monitor the temporal variation of land surface [16, 17]. The availability of high-spatiotemporal satellite imagery from archived Landsat datasets are used for land degradation and desertification monitoring and to extract the pattern of LULC changes [18]. Using geographic information systems (GIS) combined with remote sensing data are important tools for monitoring land use and land cover changes. In particular, the high temporal resolution of remote sensing data enhances the ability of GIS analysis to detect the rate of change and helps identify the driving forces [19, 20].

The current study focused on the Babylon governorate, located in the middle part of Iraq and subjected to severe drought conditions during the study period, so the LULC classes varied due to climate change, increasing population and expansion of urbanization over the other land covers. Understanding how landscapes change over time is essential for sustainable land use planning, natural resource conservation, and mitigation of environmental impacts. The article aims to estimation of spatiotemporal variation of land use/ land cover in Babylon governorate using remote sensing data during the period 1993-2020. By exploring the significance of this analysis which reveals substantial spatiotemporal variability, this study aims to highlight the importance of remote sensing and GIS techniques in addressing the challenges of the dynamic changes of LULC.

2. Location of study area

Babylon Governorate is located in central Iraq between latitudes 32° 6' 53" - 33° 3' 38" N and longitudes 43° 56' 56" - 45° 13' 16" E, and extends over an area of approximately 5335.60 square kilometers within the alluvial plain area of Iraq (Fig. 1). The area covered by four types of soils; most middle parts of study area consist of young soils in alluvial deposits, followed by strongly saline soils in southern parts of areas, in addition to soils with accumulation of secondary gypsum in the northwestern part of the area. The soils of the region suffer from severe chemical deterioration, due to increased soil salinity. The area suffers from high annual evapotranspiration, ranging between 1600-2000 mm (Fig. 2).

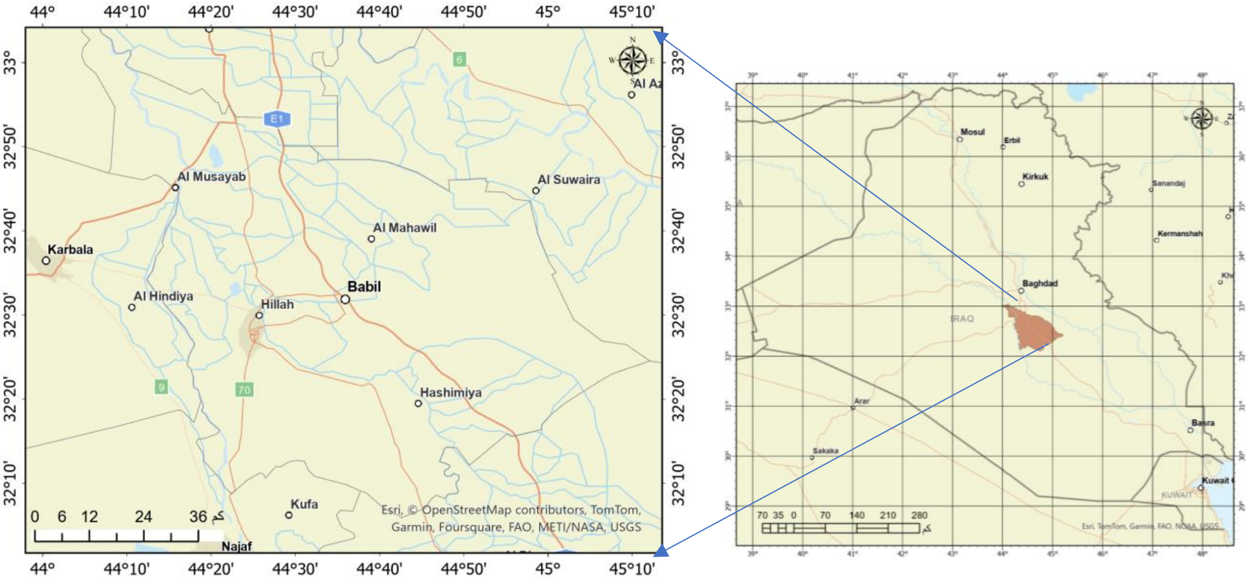

Fig. 1: Location map of study area

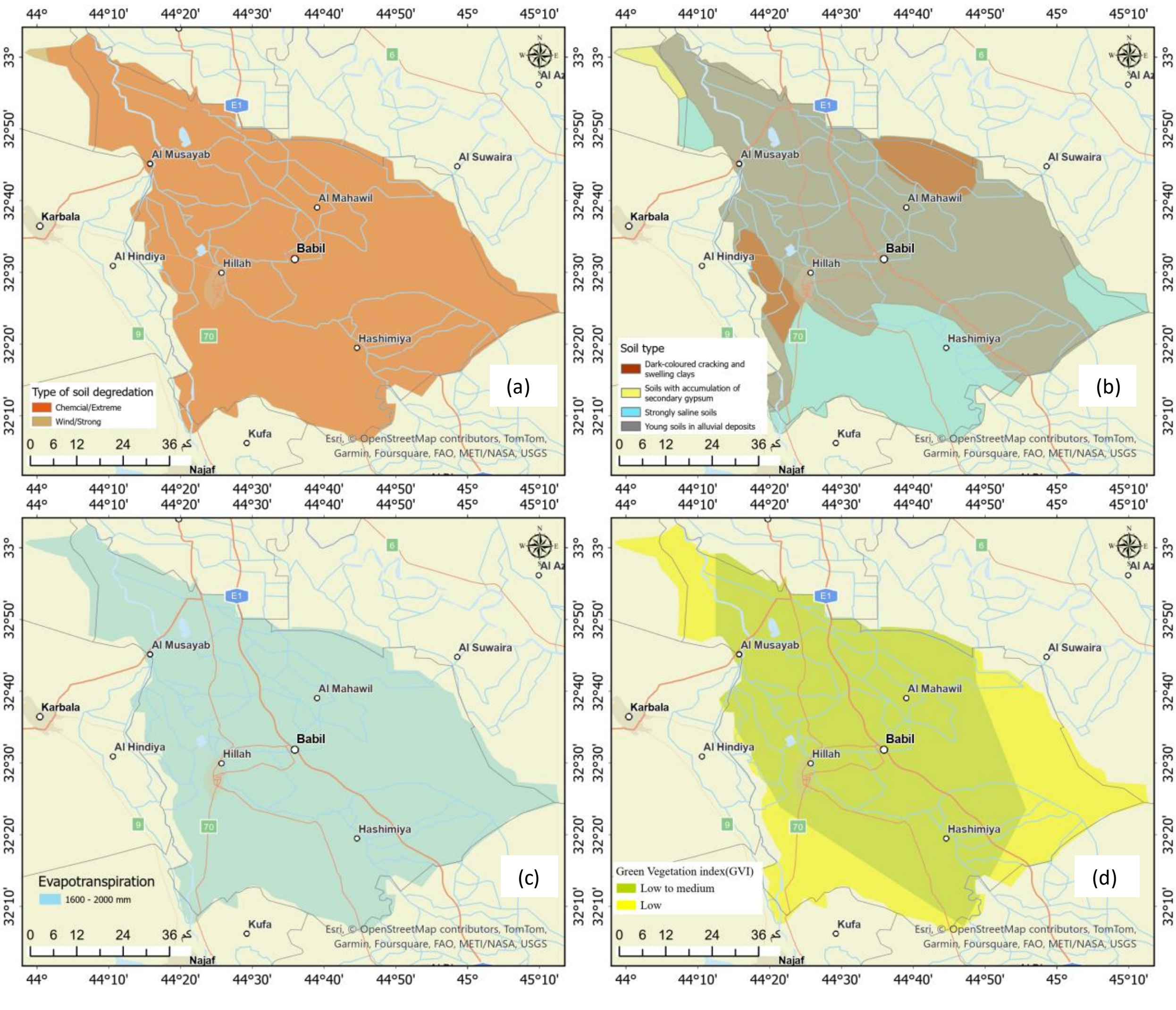

Fig. 2: Physical characteristics of Babylon Governorate: a). Soil types, b). Type of soil degradation, c). Green Vegetation Index (GVI), d). Annual evapotranspiration.

3. Materials and research method

To monitor the temporal and spatial change of land use and land cover in Babylon Governorate, satellite data classified according to the land use and land cover type from 1993-2020 published on the American ESRI website [1] were used. The maps of soil types, soil degradation, Green Vegetation Index, and the amount of evapotranspiration are downloaded from the ArcGIS website [2] . To analyze the data, ArcGIS Pro. V.3.3 license program was used, as the types of land use in the study area were clipped according to the years and the area of each class was calculated and stored in tables. Time series and trend curves were drawn to monitor the change in the area of each class over the study years.

The Green Vegetation Index (GVI) is also used, which reduces the effects of the background soil of the land cover with a focus on green plants. It uses global coefficients that weigh the values of the image element (pixel) to generate new transformed ranges. The index is calculated from Landsat TM, ETM+ satellite data. The GVI values range from -1 to 1 and are calculated according to the following equation [21]:-

$$GVI = (-0.2848 * TM_1) + (-0.2435 * TM_2) + (-0.5436 * TM_3) + (0.7243 * TM_4) + (0.0840 * TM_5) + (-0.1800 * TM_7) \quad (1)$$

Where $TM_{1...7}$ are the bands of Landsat Thematic Mapper.

Calculate a matrix of LULC change in types based on two comparison years i.e., 1993 and 2020. The change matrix was calculated using the compute change raster command in ArcGIS Pro to identify the variation from one class to another.

4. Results and Discussion

The temporal variation of LULC indicates the impact of climate changes, on soil and vegetation degradation in the study area. The current study dealt with two types of analysis: the first is monitoring the temporal changes in LULC by analyzing the changes along the study period, and the second is conducting a comparison between two years to identify the direction of change in the LULC types.

4.1 Temporal change in land use/ land cover

It is clear from the analysis of the land use/ land cover maps of Babylon Governorate (Figures 3_A, B, C, D), the tabulated LULC classes area along the study years (Table 1), and the charts that were prepared according to annual changes of classes area and their trends (Figure 4). The results show a noticeable expansion of urban areas over other LULC types, with area values increasing from 12.1 in 1993 to 68.48 square kilometers in 2020. This expansion of urban areas is increasing environmental pressure on the study area. Herbaceous Crops such as wheat and vegetables, witnessed a slight increase in their general trend, as these crops require irrigation during the growth and maturity period. As for bare areas, they witnessed a slight decrease, which is mainly used for urban expansion. Rainfed cropland, which depends on rain, witnessed a decrease during the study period, except for the years 2003 and 2004, which witnessed a noticeable increase, due to an increase in rainfall during those years, but after that, gradually started decreasing again due to the shortage of rain and increasing of soil salinity. While, sparse vegetation witnessed a relative decrease, as they mostly grow in water depression areas. As for mostly cropland in a mosaic with natural vegetation, as well as trees and

[1] https://must-ayadbeg.maps.arcgis.com/apps/mapviewer/index.html?layers=1453082255024699af55c960bc3dc1fe
[2] https://hub.arcgis.com/datasets/uneplive::desertification/explore?layer=2

shrubs, they witnessed a decrease in their area. When comparing these results with the green vegetation index (GVI), we conclude the impact of climate change and the general trend of drought in the region and its reflection on vegetation growth, in general, appears, as we find that the green vegetation index indicates that the region falls within two categories, low and low-medium in terms of the density of vegetation cover. As for Irrigated or Post-Flooding Cropland, they began to appear in the governorate after 2004, and these lands may represent fields of rice cultivation in a limited manner in the far southwest of Babylon Governorate. Grasslands witnessed a noticeable decrease in their areas over the years of the study, as they covered 3.4 square kilometers to reach 0.7 square kilometers during 2020, represent another indicator of the drought conditions trends in the study area. The rest of the LULC types show unnoticeable changes

4.2 Variation of LULC types

It is clear from comparing LULC types between 1993 and 2020 that several types have been changed to others as shown in the LULC change matrix (Table 2). The most important changes of these types are the rainfed cropland which decreased an area of 45.8 km2 that has been changed into urban areas and 12.4 km2 into bare land. Bare land has also been changed into urban areas by 29.3 km^2, which shows the extent of urban expansion in the Babylon governorate. Main while the mostly cropland in a mosaic with natural vegetation class has been transformed into a bare area by an amount of 7.2 km2. As for the sparse vegetation type 24.2 km2 has been transformed into rainfed cropland, 6.6 km2 into bare area, and 4.9 km2 into herbaceous cropland. The results also showed that the cover type, Mostly herbaceous cover in a mosaic with Trees and shrubs, 4.7 km2 of the area has been transformed into rainfed cropland. The rest of the categories have witnessed unimportant changes.

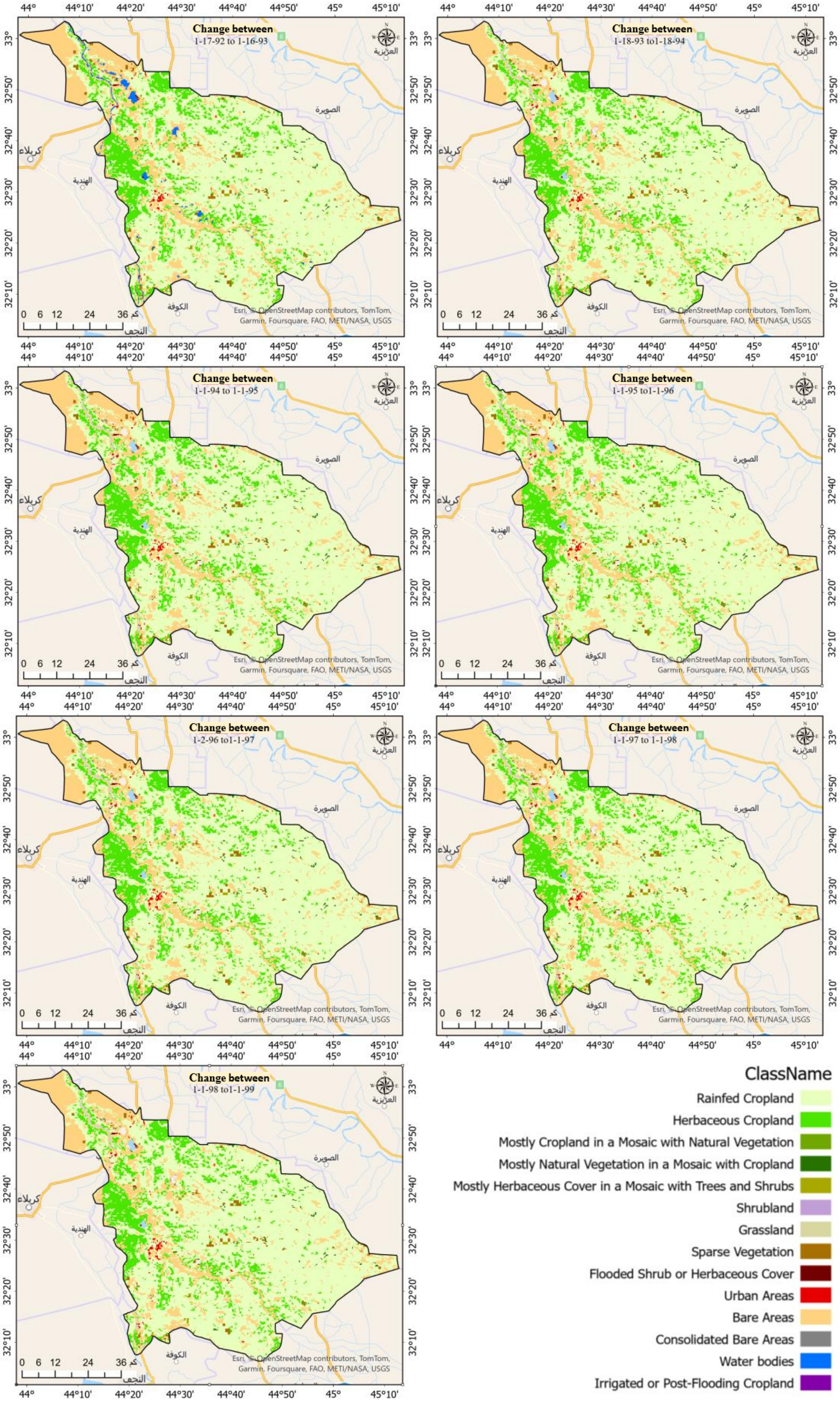

Fig. 3-a: Maps of LULC change in Babylon Governorate from 1993 to 1999.

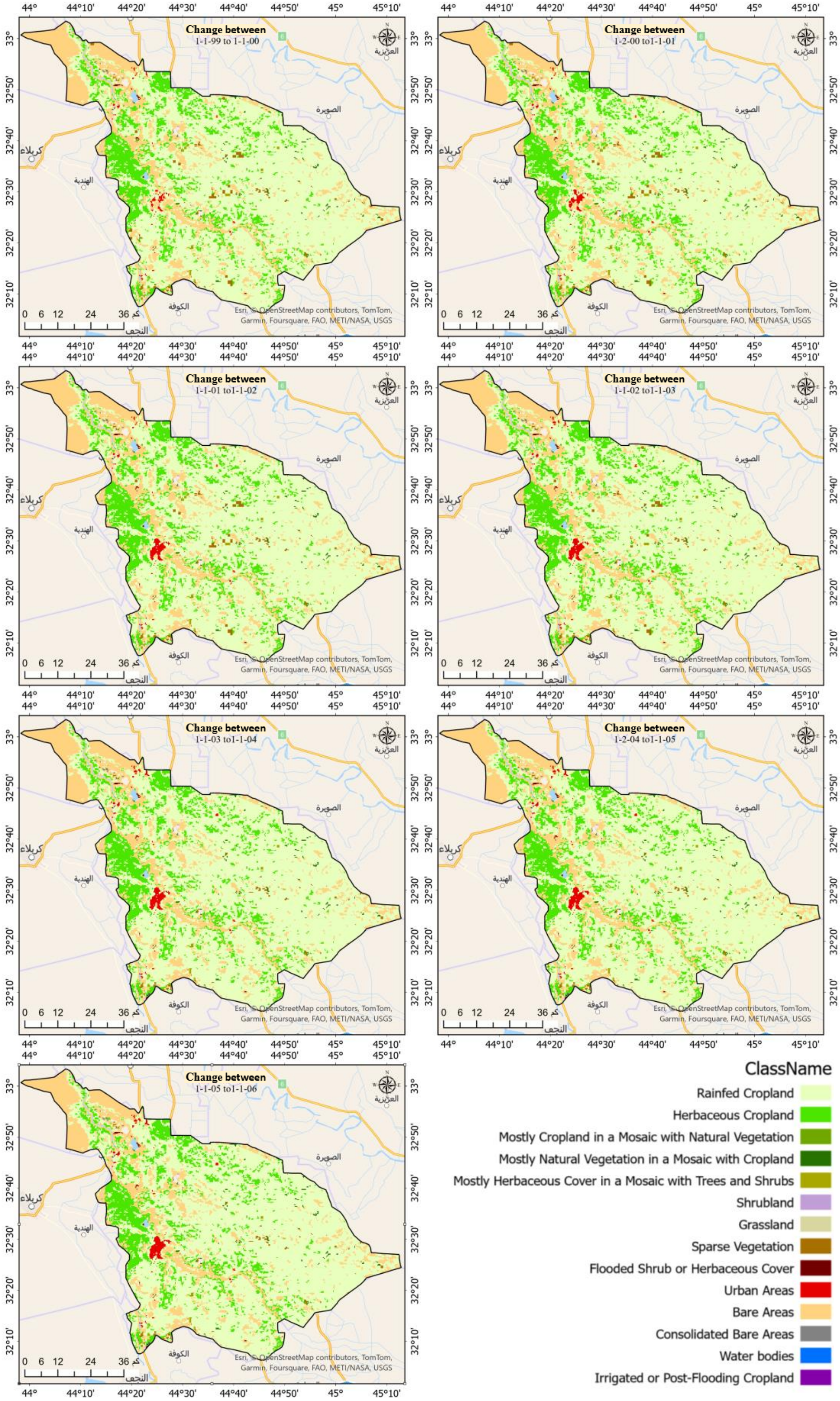

Fig. 3-b: Maps of LULC change in Babylon Governorate from 2000 to 2006.

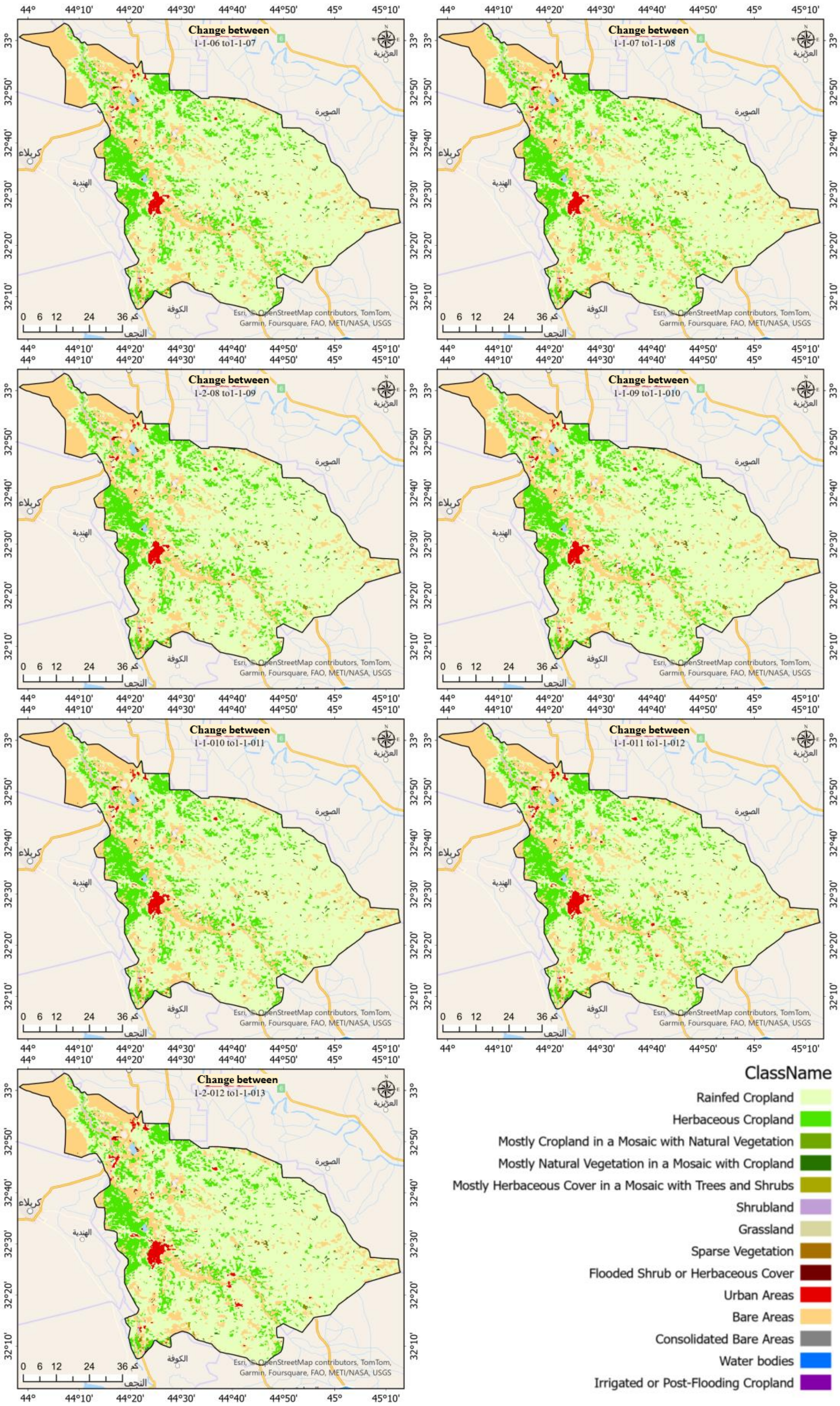

Fig. 3-c: Maps of LULC change in Babylon Governorate from 2007 to 2013.

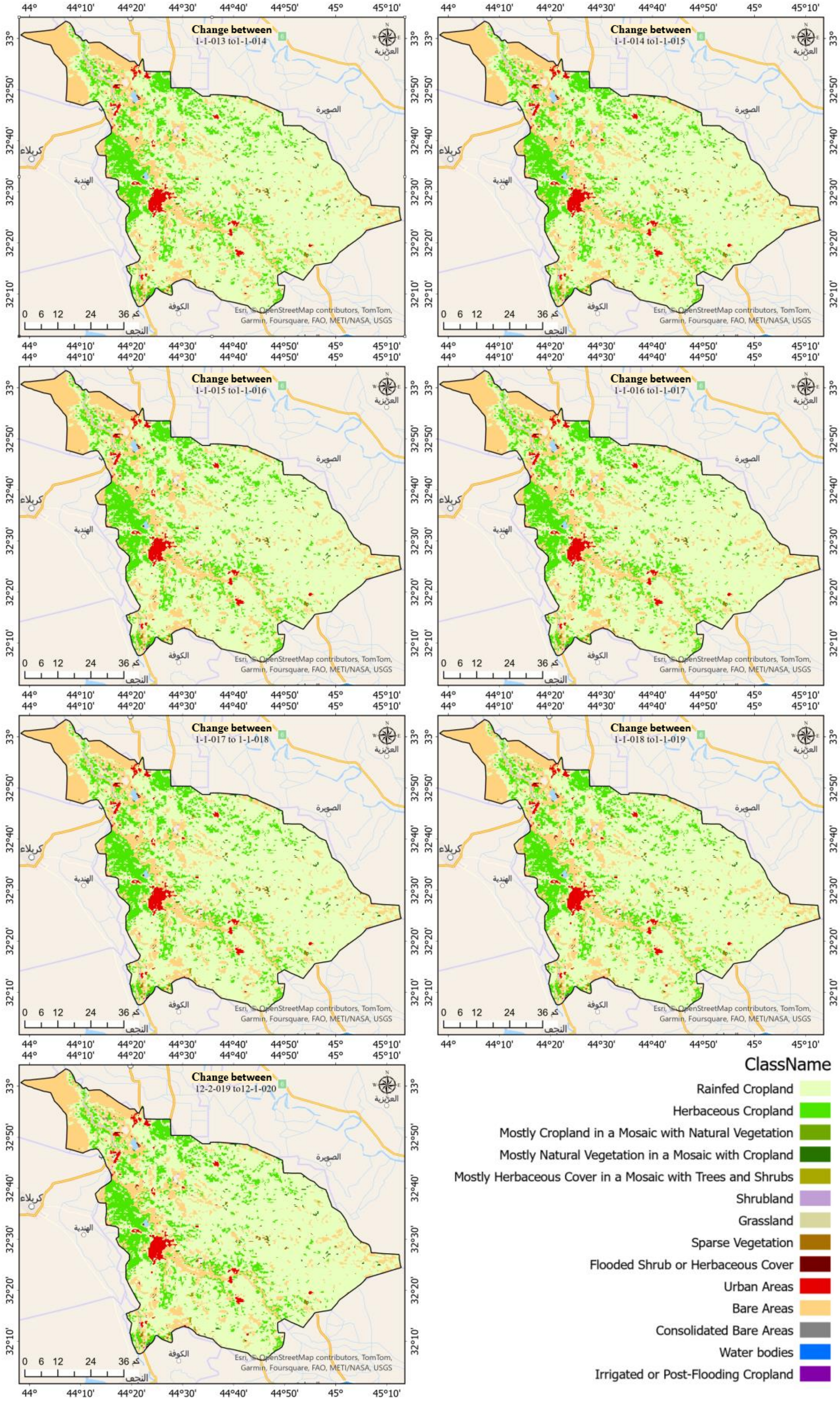

Fig. 3-d: Maps of LULC change in Babylon Governorate from 2014 to 2020.

Table 1: Spatiotemporal changes of LULC in Babylon Governorate during the period from 1992 to 2020.

Class Name	LULC Area change (km2)									
	92_93	93_94	94_95	95_96	96_97	97_98	98_99	99_00	00_01	01_02
Irrigated or Post-Flooding Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shrubland	0.3	0.3	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Consolidated Bare Areas	2.3	2.3	2.33	2.33	2.33	2.33	2.33	2.41	2.41	2.41
Flooded Shrub or Herbaceous Cover	3.1	3.1	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05
Grassland	3.4	3.4	3.37	3.37	3.45	3.45	3.45	3.45	3.45	3.45
Mostly Herbaceous Cover in a Mosaic with Trees and Shrubs	4.9	4.9	4.90	4.90	4.90	4.90	6.35	7.95	7.95	7.95
Mostly Cropland in a Mosaic with Natural Vegetation	12.0	12.0	11.25	10.60	9.64	9.64	8.27	5.86	3.13	2.97
Urban Areas	12.1	12.4	12.61	13.09	13.50	14.06	14.94	15.75	20.97	26.99
Mostly Natural Vegetation in a Mosaic with Cropland	15.3	15.3	15.34	15.34	15.34	15.34	15.34	15.34	15.34	15.34
Sparse Vegetation	46.8	46.8	45.23	45.47	44.91	44.91	42.74	40.33	39.12	38.16
Water bodies	52.5	52.5	52.46	52.46	52.46	52.46	52.46	52.46	52.46	52.46
Herbaceous Cropland	724.5	724.5	725.7	725.7	725.6	725.9	726.6	726.8	727.2	727.2
Bare Areas	940.2	940.0	940.0	941.1	941.9	941.8	943.9	948.8	950.9	948.8
Rainfed Cropland	3518.2	3518.2	3518.96	3517.84	3518.08	3517.68	3515.91	3513.10	3509.24	3506.43

Class Name	LULC Area change (km2									
	02_03	03_04	04_05	05_06	06_07	07_08	08_09	09_10	10_11	11_12
Irrigated or Post-Flooding Cropland	0.00	0.96	0.96	0.96	0.96	0.96	0.96	1.0	0.96	0.96
Shrubland	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.4	0.40	0.40
Consolidated Bare Areas	2.41	2.42	2.25	2.25	2.25	2.25	2.25	2.3	2.25	2.25
Flooded Shrub or Herbaceous Cover	3.05	3.06	3.06	3.06	3.06	3.06	3.06	3.1	3.06	3.06
Grassland	3.45	1.29	1.29	1.29	0.72	0.72	0.72	0.7	0.72	0.72
Mostly Herbaceous Cover in a Mosaic with Trees and Shrubs	6.27	3.78	3.78	3.06	2.33	2.33	2.33	2.3	2.33	2.33
Mostly Cropland in a Mosaic with Natural Vegetation	2.97	2.97	2.73	2.73	2.73	2.73	2.73	2.7	2.73	2.73
Urban Areas	29.72	31.39	33.24	35.89	38.95	41.20	43.54	45.4	49.25	55.93
Mostly Natural Vegetation in a Mosaic with Cropland	15.34	15.35	15.35	15.35	15.35	15.35	15.44	15.4	15.44	15.44
Sparse Vegetation	32.46	19.23	19.23	18.82	16.33	15.77	15.12	15.1	15.20	14.96
Water bodies	52.46	52.58	52.58	52.58	52.58	52.58	52.58	52.6	52.58	52.58
Herbaceous Cropland	727.7	732.2	732.8	733.3	736.6	738.4	738.6	738.7	738.6	739.8
Bare Areas	947.8	946.1	945.3	944.3	941.4	938.74	937.9	937.3	935.7	932.8
Rainfed Cropland	3511.57	3526.11	3524.83	3523.86	3524.18	3523.30	3522.17	3520.8	3518.48	3513.66

Class Name	LULC Area change (km2							
	12_13	13_14	14_15	15_16	16_17	17_18	18_19	19_20
Irrigated or Post-Flooding Cropland	0.96	1.04	1.04	1.04	1.04	1.0	1.0	1.0
Shrubland	0.40	0.40	0.40	0.40	0.40	0.4	0.3	0.3
Consolidated Bare Areas	2.25	2.25	2.25	2.25	2.25	2.3	2.3	2.3
Flooded Shrub or Herbaceous Cover	3.06	3.06	3.06	3.06	3.06	3.1	3.1	3.1
Grassland	0.72	0.72	0.72	0.72	0.72	0.7	0.7	0.7
Mostly Herbaceous Cover in a Mosaic with Trees and Shrubs	2.33	2.33	2.33	2.33	2.33	2.3	2.3	2.3
Mostly Cropland in a Mosaic with Natural Vegetation	2.73	2.89	2.89	2.89	2.89	2.9	2.9	2.9
Urban Areas	68.48	79.43	83.29	83.29	83.61	84.4	88.3	88.3
Mostly Natural Vegetation in a Mosaic with	15.44	15.52	15.52	15.52	15.52	15.5	15.5	15.5

Cropland								
Sparse Vegetation	15.04	15.04	15.04	16.17	16.17	16.2	16.0	16.0
Water bodies	52.58	52.58	52.58	52.58	52.58	52.6	52.6	52.6
Herbaceous Cropland	739.8	742.5	742.5	741.9	742.4	742.5	743.3	743.3
Bare Areas	928.7	922.4	921.4	925.9	925.3	925.5	925.1	925.1
Rainfed Cropland	3505.38	3497.59	3494.70	3489.64	3489.48	3488.4	3484.3	3484.3

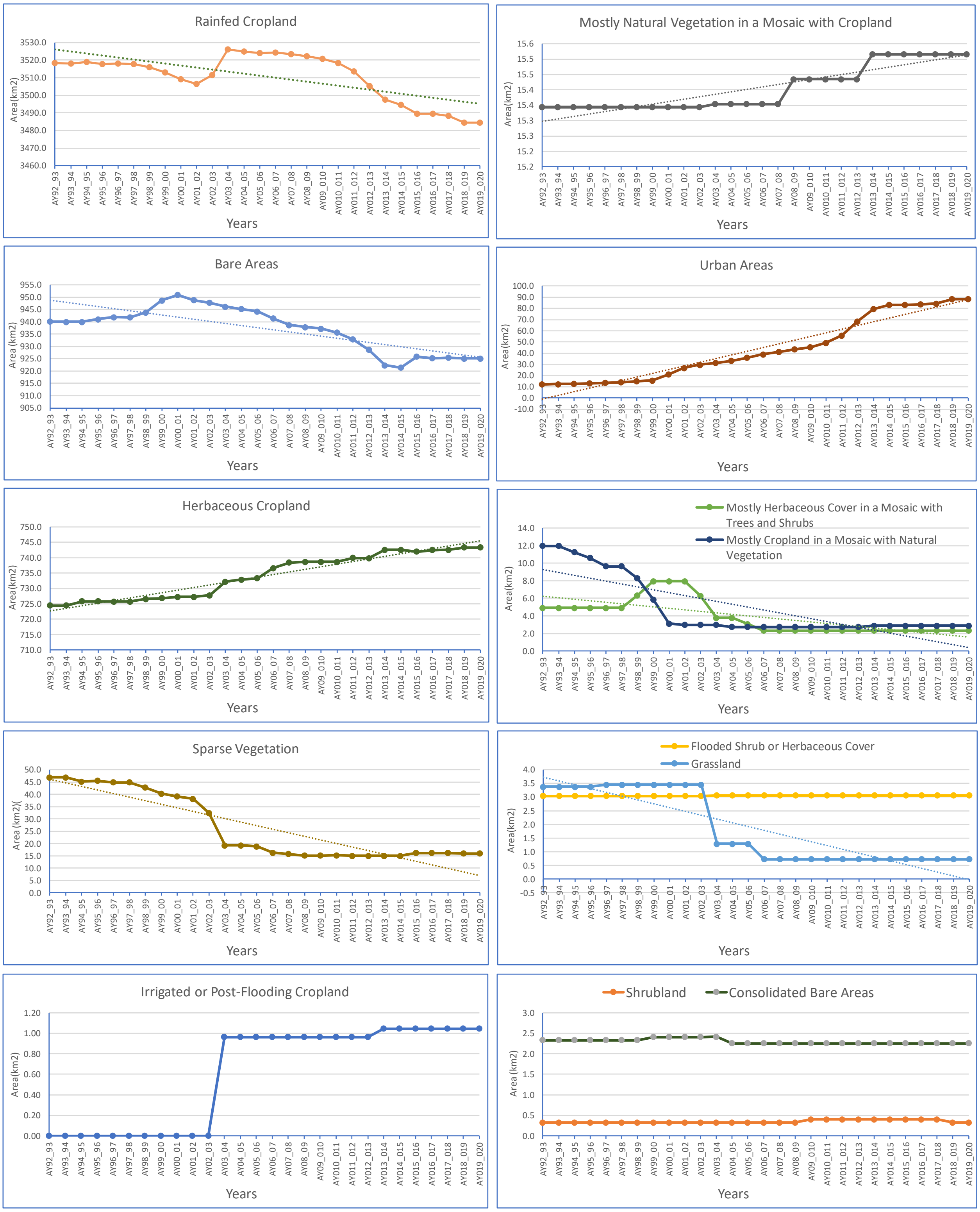

Fig. 4: Time series curves and trends of LULC change in Babylon Governorate from 1993 to 020.

Table 2: LULC changes matrix between 1993 and 2020 in Babylon Governorate.

1993 \ 2020	Irrigated or Post-Flooding Cropland	Shrubland	Consolidated Bare Areas	Flooded Shrub or Herbaceous Cover	Grassland	Mostly Herbaceous Cover in a Mosaic with Trees and Shrubs	Mostly Cropland in a Mosaic with Natural Vegetation	Urban Areas	Mostly Natural Vegetation in a Mosaic with Cropland	Sparse Vegetation	Water bodies	Herbaceous Cropland	Bare Areas	Rainfed Cropland
Irrigated or Post-Flooding Cropland	0.1				1.0									
Shrubland		0.2						0.1						
Consolidated Bare Areas			2.2									0.2		
Flooded Shrub or Herbaceous Cover				3.1										
Grassland	1.0				0.6							1.5		0.3
Mostly Herbaceous Cover in a Mosaic with Trees and Shrubs						0.0						0.2		4.7
Mostly Cropland in a Mosaic with Natural Vegetation							2.5	0.7		0.2			7.2	0.9
Urban Areas								12.1						
Mostly Natural Vegetation in a Mosaic with Cropland									15.3					
Sparse Vegetation										11.1		4.9	6.6	24.2
Water bodies											52.5			
Herbaceous Cropland								0.32		0.88		722.5	0.72	
Bare Areas	0.08	0.08					0.40	29.2	0.08	0.32			896.5	0.1
Rainfed Cropland					0.08	2.33		45.8		3.53			12.4	3454.1

5. Conclusions

The geographical information systems (GIS) and remote sensing data are used to assess the spatiotemporal changes of LULC in the Babylon governorate. Analysis of the results shows the importance of using a time series of satellite images to identify the changes in LULC from 1993 to 2020. Analysis of time series LULC classification maps and graphs and tabulated areas during the study period; revealed the extent, direction and patterns of spatial change of LULC in the study area. The results show crucial insights into the dynamic nature of the study area i.e., the Urban expansion mainly at the expense of rainfed croplands and bare lands, the decline in tree-covered lands, the fluctuations in vegetation cover and the decrease of rainfed croplands; all these factors shed light on drought conditions and climate change impact on the area. The concluded information from the current study can support decision-makers and planners in sustainable development and management of land strategy, urban development plans, and environmental conservation initiatives. By monitoring the LULC over time, decision makers can identify areas of interest, anticipate future trends, and implement appropriate policies and interventions to address the complex interactions between human activities and the environment.

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