JOURNAL OF KUFA–PHYSICS
journal.uokufa.edu.iq/index.php/jkp/index | ISSN: 2077–5830

Changes Detection Using Multispectral Satellite Images for Sustainable Development in some Regions of Al-Najaf Al-Ashraf, Iraq

Ali Salih Mahdi[1], Ahmed Asal Kzar[2]

[1,2] Physics Department, Faculty of Science, University of Kufa, Najaf, Iraq.
[1]Corresponding Author E-mail : Alis.yaqoub@uokufa.edu.iq

ARTICLE INF.

Article history:
Received: 4 AUG., 2023
Revised: 26 NOV., 2023
Accepted: 28 NOV., 2023
Available Online: 24 JUN., 2023

Keywords:

Najaf,
Satellite Image
LULC
LULCG
Sustainable

ABSTRACT

The change detection in urban and surrounding areas, such as vegetation and bare, is a significant achievement for sustainable development, especially nowadays. The research used a supervised classification technique of two images representing two time periods (1973 and 2023) by applying the technique of land cover and land use (LCLU) using the ArcGIS 10.8.2 program. The classified pixels were converted into digital data to compare the using of the land cover method and land use change (LCLUG). The results showed a significant expansion in the urban areas of Najaf and Kufa districts, from 5.72 km^2 to 134.95 km^2, with a decrease in the area of green areas, from 17.26 km^2 to 15.16 km^2, and the absence of water areas, in addition to the transformation of most of the barren areas to urban areas (215.64 km^2 to 88.51 km^2). The study concluded that there was a significant decrease in green areas and the absence of water bodies in urban areas, and these are two indicators - along with the increase in urban areas can harm the environment of the region and the quality of environmental influences on the lives of the people who live in it. Finally, this, in turn, would negatively affect its sustainable development plans.

DOI: https://doi.org/10.31257/2018/JKP/2024/v16.i01.14155

كشف التغيرات لبعض مناطق محافظة النجف الاشرف – العراق, باستخدام صور الأقمار الصناعية متعددة الاطياف لأغراض التنمية المستدامة.

علي صالح مهدي[1] أحمد عسل كزار[2]

قسم الفيزياء، كلية العلوم، جامعة الكوفة، النجف الاشرف، العراق

الكلمات المفتاحية:

النجف
صورة القمر الصناعي الأرض المستخدمة والغطاء الأرضي
التنمية المستدامة

الـــخُـــلاصـــة

يعد الكشف عن التغيرات في المناطق الحضرية والمناطق المحيطة بها، كالغطاء النباتي والمناطق الجرداء، إنجازًا كبيرًا للتنمية المستدامة، خاصة في الوقت الحاضر. حيث استخدم البحث التصنيف الخاضع للإشراف لصورتين تمثلان فترتين زمنيتين (1973 و2023) بتطبيق تقنية الغطاء الأرضي والأرض المستخدمة (LCLU) باستخدام برنامج ArcGIS 10.8.2. حيث تم تحويل

البكسلات المصنفة إلى بيانات رقمية لمقارنة التغيرات بالغطاء الأرضي والأرض المستخدمة (LCLUG). وأظهرت النتائج توسعاً كبيراً في المناطق الحضرية في قضائي النجف والكوفة من 5.72 كم2 إلى 134.95 كم2، مع انخفاض مساحة المسطحات الخضراء من 17.26 كم2 إلى 15.16 كم2، وغياب المساحات المائية، إضافة إلى تحول معظم المناطق القاحلة إلى مناطق حضرية (215.64 كم2 إلى 88.51 كم2). وخلصت الدراسة إلى أن هناك انخفاض كبير في المساحات الخضراء وغياب المسطحات المائية في المناطق الحضرية، وهذان مؤشران - إلى جانب زيادة المناطق الحضرية يمكن أن يضر في بيئة منطقة الدراسة ونوع التأثيرات البيئية على حياة الناس الذين يعيشون فيه، والذي يؤثر بدوره سلباً على خططها للتنمية المستدامة.

1. INTRODUCTION

In 2015, all member states of the United Nations agreed to the Paris Declaration, which represents a collective plan to achieve peace and prosperity for humanity and the environment in which they live [1]. This plan included 17 primary goals to eradicate poverty, raise health and education, and preserve the environment and climate. [2]. Successful sustainable development in any region depends mainly on knowing the environmental and climatic risks surrounding this region and planning correctly and scientifically to manage its resources [3]. Although many means and techniques are available to monitor environmental risks and provide sufficient data for resource management, remote sensing methods are the most widely used due to their low cost and ability to collect reasonable amounts of data [4], which will be used in this research; the LULC classification has a pivotal and essential role in the region's development process because of the accurate and vital information that this classification provides [5]. This has enabled researchers to analyze this region's various economic and social events and activities, such as city planning, agriculture, and sustainable development. In this regards, remote sensing technology is used extensively to analyze the changes provided by LULC [6]. To achieve the LULC classification and obtain the best picture of the Earth's surface features, multispectral satellite images containing different wavelength ranges were used, as each of the Earth's surface features has better spectral reflectance at specific wavelengths [7]. Much previous researches have indicated the importance of using land and land cover in determining the categories of a particular area and discovering the changes that occur in these categories. In one of the previous studies (Al-Abudi Bushra, 2016) discovered changes in five land cover types for Baghdad, Iraq. The researcher divided the urban areas into two parts, Urban 1 and Urban 2. She had studied the change in land use and land cover for 1985, 2000, and 2015. The study determined the number of changes in the five categories during thirty years [8]. In another research, in which the Kathmandu region of Nepal (Wang Sonam Wangyel, 2020) was studied, the researcher has also used the land use land cover technique in managing and monitoring natural resources and development, especially in the field of urban planning for this city, which is one of the most vulnerable and fastest growing cities in the world. The researcher attempted to investigate a change in the four categories he considered in the study, which included forests, vegetarian areas, water bodies, and urban areas, during the past 20 years. He also tried to predict the amount of changes that will occur in these categories during the next twenty years [9]. The researcher (Mohammed Kawther,2021) also made a classification for the Landsat satellite images for Najaf, Iraq, and detected changes in the land used and land cover, after classifying the images into four categories (urban, vegetative, water, and barren) [10]. Using the same classification technique in the previous study, which is maximum likelihood classification, (Wdaah Enas & Kzar Ahmed,2022)**,** the authors adopted this technique to investigate the changes in urban, vegetarian, and barren areas. In addition to the water body of Karbala, Iraq, the study used Landsat 5 and Sentinel 2 satellite images [11]. To discover and evaluate changes in LULC of the city of Khanaqin in Iraq, the researchers (Qanbari & Fadhel ,2023) used the remote sensing techniques and satellite images of the Landsat satellite for 2000, 2010, and 2020.

Using supervised classification and the maximum likelihood algorithm, the study concluded that water lands and areas built-up and vegetation cover have increased over the past twenty years while arid lands and mixed agricultural lands have decreased [12]. In this study, multispectral Landsat images were used within selected bands to determine a classification for each image through the use of supervised classification using maximum likelihood via ArcGIS 10.8.2 software, which constitutes the primary image processing tool for each multispectral Landsat image to be produced. This study is aimed to classify the adopted study area (Najaf and Kufa districts) into three classes: urban lands, vegetarian lands, and bare lands, with a total area about 238 square kilometers, then to find the changing in each class of the study area in the period (1973-2023), for achieving the main purpose of this study which is considered as part of achieving of sustainable development goals.

1. Area for research

Al-Najaf Al-Ashraf is one of the central governorates of the Republic of Iraq, located on the western plateau southwest of the capital Baghdad approximately 161 kilometers away. This study was focused on a part of Al Najaf Governorate that represented by Al-Najaf and Kufa Districts, confined between the longitude lines (44º 09′ 59″- 44º 27′ 56″ E) and latitude lines (31º 57′ 03″- 32º 08′ 21″ N). The city rises 70 meters above sea level. It is bordered to the north and northeast by Karbala governorates and to the northwest by Anbar Governorate, to the north by Babil Governorate, to the east by Al-Qadisiyah Governorate, and to the south by Al-Muthanna Governorate [13]. The population of Al-Najaf city is about 1,221,248 people [14]. By contrast, the population of Kufa city is about 230 thousand people [15]. The climate of this governorate is characterized by being hot and dry in the summer, in which the temperatures may reach 45 degrees Celsius. Nevertheless, the temperatures may drop to zero degrees Celsius in the winter. The average rainfall ranges from 1 to 5 drops per trickle [16]. The importance of the choosing this study area is because Al-Najaf Al-Ashraf is considered as one of the essential central cities in Iraq and the world through the presence of shrine of Imam Ali bin Abi Talib (peace be upon him). Moreover, this governorate contains several historical landmarks, most of them are Islamic landmarks [17]. In addition to, it contains the second largest cemetery in the world after the Chinese cemetery. While the city of Kufa is no less important than its predecessor, it is a city administratively affiliated to the Najaf Governorate and is located in its northeastern part, 10 km away from it. It has great religious and economic importance since it was historically the capital of the Islamic Caliphate during the time of Imam Ali bin Abi Talib (peace be upon him) [18].

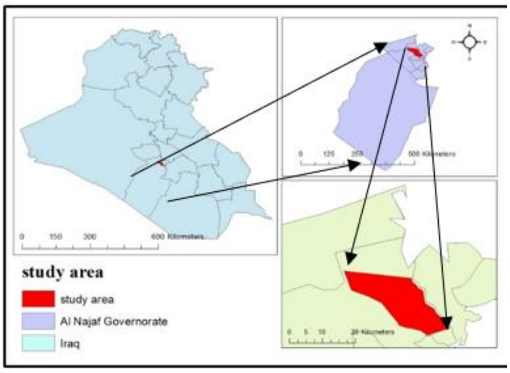


Fig. 1: The study Area.

Fig. 2: the study area with its longitude and latitude lines by Google Earth.

2. Sustainable Development

Sustainability pertains to implementing practices concerning environmental utilization and management that enable a satisfactory standard of living for the current population while not impeding the environment's ability to provide the needs of future generations [19]. The idea behind the sustainability is focusing on the utilization of natural resources encompasses the notion that the yields obtained, whether from land, water, or air, can be generated continuously over time and that a balance can be established between the pace of economic growth, the utilization of resources, and environmental quality, hence mitigating the danger of enduring environmental deterioration [20]. Sustainable practices consider ecological limitations and strive to minimize the adverse effects of exploitation and utilization that may have detrimental impacts on the long-term sustainability of a resource [21].

3.1 Urban Sustainability

Urban sustainability is a concept to define a sustainable urban form, which can also be seen from a planning and landscape perspective [22]. From a planning point of view, a sustainable urban form is defined by its cohesion, mixed-use, density, sustainable transportation, diversity and greening [23]. Growth in cities is putting increased pressure on many aspects of the urban environment. According to the World Health Organization, 54% of the world's population in 2014 lived in cities, growing annually at more than 1.5%. Studies show how humans are increasingly consuming most of the Earth's resources and how the human burden of cities is increasing over time for many developed countries. Most studies have also concluded that "no city or urban area can achieve sustainability alone" because cities depend on resources from remote areas and extend from neighboring regions to the world through exports and imports [24].

3.1.1 Application of Remote Sensing for Urban Sustainability

Remote sensing technology has the potential to offer a multitude of environmental data across various spatial and temporal scales. As such, it can significantly contribute to providing indicators that reflect environmental conditions in the context of sustainable development and decision-making. However, the under-representation of remote sensing technology as an essential tool for assessing the sustainability of urban environments may be partly due to the need for more data availability with appropriate resolutions[25]. Recent advancements in high-resolution sensors have opened up new possibilities for remote sensing technologies to play a significant role in assessing sustainable or unsustainable practices. Moreover, the availability of repeat coverage with satellite remote sensing at current high spatial resolutions is expected to enhance their usefulness in evaluating trends in the sustainability of urban areas [26].

3.2 Agriculture Sustainability

Sustainable agriculture means growing food crops in sustainable ways that meet human nutritional needs without compromising the natural resources and capabilities that provide food for future generations [27]. There is a great need to shift to sustainable agriculture because it significantly reduces greenhouse gas emissions (as human food causes a third of these gases) [28]. Sustainable agriculture also reduces water scarcity, pollution, land damage, deforestation, etc. [29].

3.2.1 Application of Remote Sensing for Agriculture Sustainability

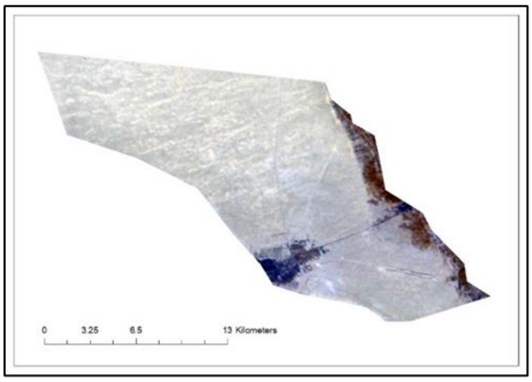
Remote sensing technology has an essential role in sustainable agriculture, as this technology can provide accurate data on soil type, temperature, and amount of yield, evaluate plant quality, and detect vegetarian pests and harmful weeds [30]. Among the most critical indicators in the field of remote sensing for monitoring and analyzing sustainable agriculture are the natural difference vegetation index (NDVI), the vegetation condition index (VCI), the leaf area index (LAI), and others [31].

3. Work data

Satellite data has a distinct advantage in performing Land Use and Land Cover (LULC) change studies. Moreover, it facilitates the determination of the precision of both LULC classification and prediction outcomes [6]. Within the scope of this investigation, satellites serve as the primary data source for LULC mapping and land use and land cover change analysis. Specifically, Landsat 1 and 8 satellite images obtained from the USGS online image database (http://earthexplorer.usgs.gov) were employed. The first image within the research area (1973) (Fig. 3) was captured on a winter day (because there was no excellent satellite image of the city of Najaf in 1973 except in the winter), and the other image (2023) (Fig. 4) was captured on a spring day (This is the preferred day to highlight green areas). The two pictures were subsequently processed utilizing ArcMap 10.8.2 software. The data is shown in Table 1.

Table 1: The adopted satellites properties.

year	Date of photography	Capture hour	Sensor	Spatial Resolution of Reflective Bands	Number of Bands	Format
1973	13-1-1973	07:08:13 am	Landsat 1 MSS	60 m	4	TIF
2023	16-3-2023	07:33:58 am	Landsat 8 OLI	30 m	11	TIF



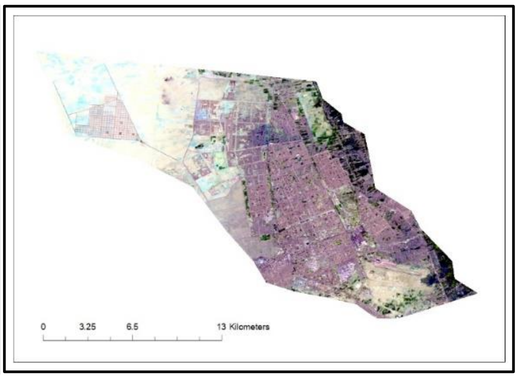


Fig. 3: The cropped image of the study area in 1973.

4. Materials and Methods

5.1 Download Images

The United States Geological Survey (USGS) provides free images of a different group of satellites via the

website where the Landsat satellite was adopted. Downloading any images

Fig. 4: The cropped image of the study area in 2023

from the aforementioned site requires registering a free official account.

5.2 ArcGIS Software

A software that helps create maps, perform spatial analysis, and manage geographic data [32].

5.3 Composite Bands

The satellite image consists of a group of bands. Three of these bands are combined to form an RGB image (Fig. 5 and 6) according to the type of information extracted from the image.

Table 2 presents the typical bands of the adopted satellite, this study used the 7,6,5 bands for both images.

Table 2: Common bands combinations of the adopted satellites [33].

satellite	Combinations	Bands

		R	G	B
Landsat 1	Natural color	N/A		
	False color (Urban)	N/A		
	False color (vegetative analysis)	7	6	5
Landsat 8	Natural color	4	3	2
	False color (Urban)	7	6	5
	False color (vegetative analysis)	6	5	4

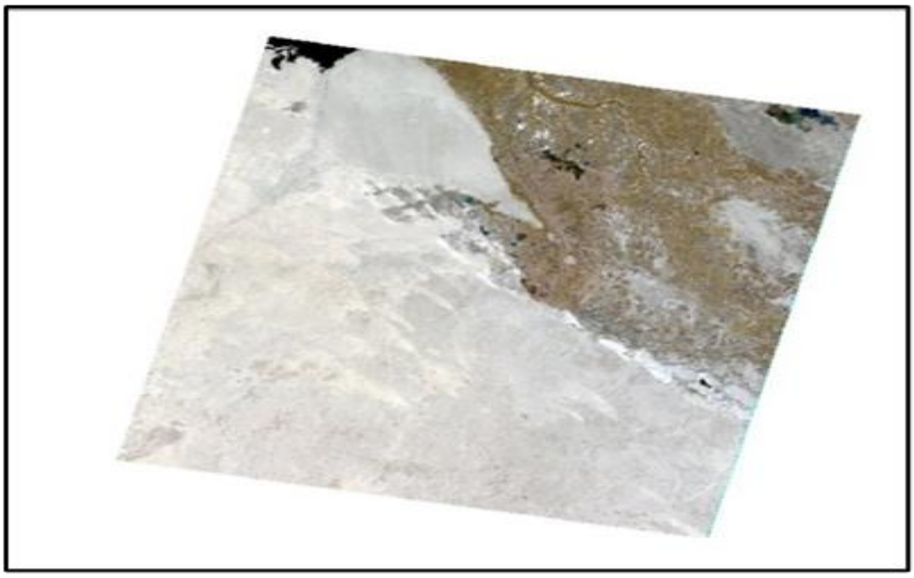


Fig. 5: The composite image bands (7,6,5) for the study area in 1973

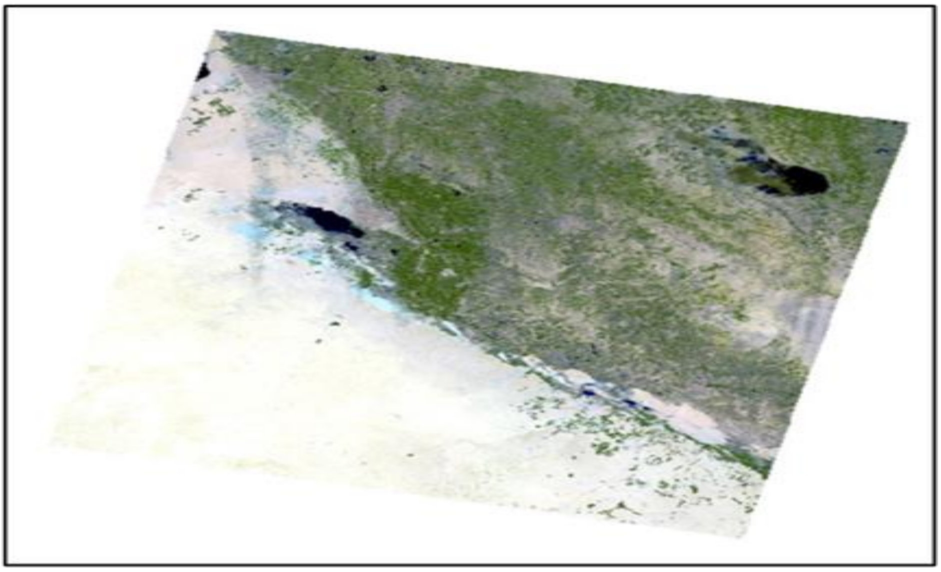
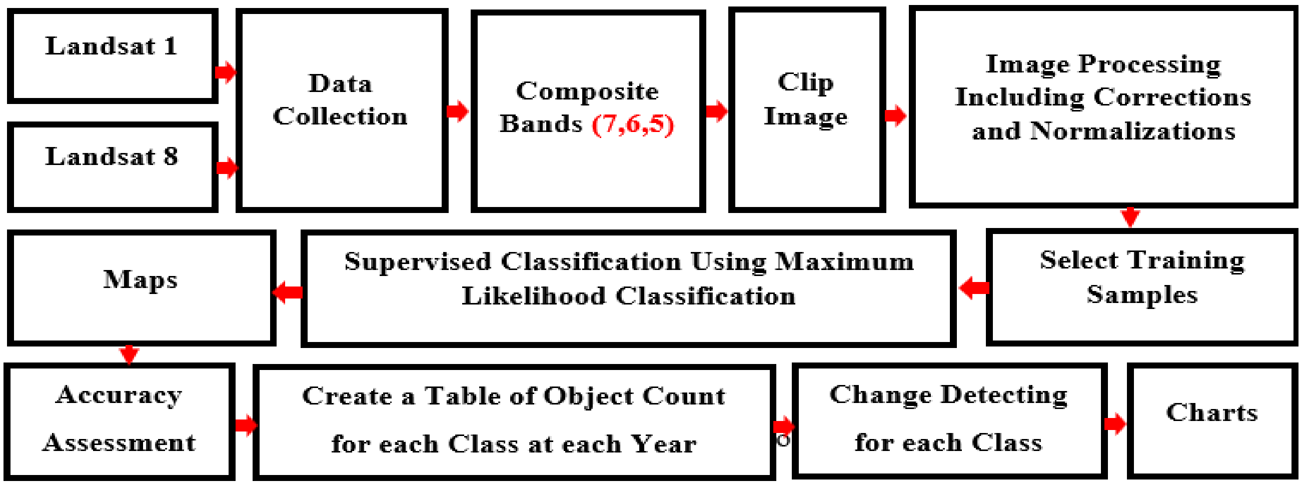


Fig 6: the composite image bands (7, 6, 5) for the study area in 2023.



1.

6.Result and Discussion

6.1 Land Use/Land Cover Mapping

Land cover mapping is essential to identify changes accurately. Developing land cover maps involves analyzing the spectral reflectance of pixels in satellite images [37]. Different methods can be used to classify each pixel individually. The difference in the number of pixels classified into a particular class between the two images under study shows the change occurring in this class during the study period. The maps demonstrated in Figures 8 and 9 show the classification of urban areas in Najaf and Kufa District in Najaf Al-Ashraf Governorate, using satellite images from Landsat 1 and 8 for 1973 and 2023, respectively.

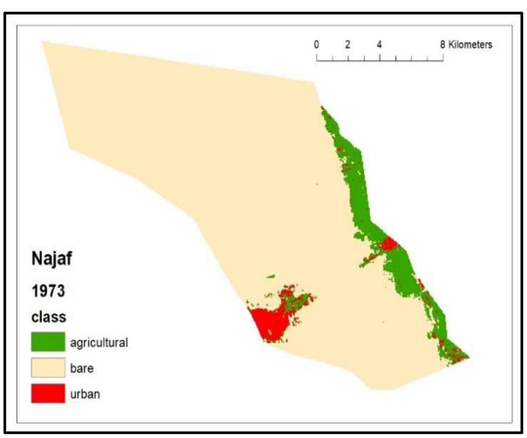


Fig. 8: Classified Image of 1973

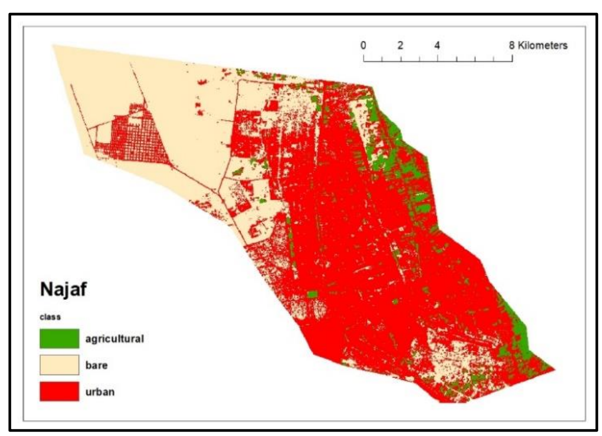


Fig. 9: Classified Image of 2023

6.2 Accuracy Assessment

The process of classifying land cover from remote sensing data can take a long time, so after the algorithm finishes its work, the classified image is divided into a small group of classes that reduce the many groups of classes, and therefore it is necessary - and before moving to the subsequent steps - to conduct a process Evaluation to ensure the validity of the classified classes [38].

6.2.1 Classification Error Matrix

One of the prevailing methods for conveying the extent of classification accuracy is the creation of a matrix that represents the errors in classification (occasionally referred to as a confusion matrix or a contingency table). On a per-category basis, these matrices analyze the connection between the known reference data (commonly known as ground truth) and the corresponding outcomes of automated classification. These matrices are square, with the number of rows and columns proportional to the number of categories evaluated for their classification accuracy [39]. Tables 3 and 4 show the confusion matrix for the two classified images in this study.

6.2.2 Accuracy assessment using Google Earth

To increase the efficiency of evaluating the accuracy of the satellite image, a Google Earth Pro (version 7.3.6) was used, where the accuracy assessment points were reconnected to the program (Fig. 10) , and then a visual evaluation of each point was performed to be sure the classification of its category was correct (Fig. 11).

Fig. 10: Connecting Assessment Points by Google Earth.

Fig. 11: Visual evaluation of each Accuracy Assessment point individually.

6.3 Change Detection

LULCC maps were acquired for 1973 and 2023 after applying supervised classification via the maximum likelihood algorithm. These techniques were utilized to classify the study area into three distinct classes: urban land, vegetarian land, and bare land.

Table 3: Confusion Matrix for 1973

class	vegetarian	urban	bare	Total	User Accuracy	Producer's Accuracy	Overall accuracy
vegetarian	7	2	1	10	0.70	0.88	0.95
urban	1	8	1	10	0.80	0.73	
bare	0	1	89	90	0.99	0.98	
kappa							
0.82							

Table 4: Confusion matrix for 2023.

class	vegetarian	urban	bare	Total	User Accuracy	Producer's Accuracy	overall accuracy
vegetarian	8	1	1	10	0.80	0.73	0.90
urban	2	50	3	55	0.91	0.94	
bare	1	2	29	32	0.91	0.88	
kappa							
0.82							

Table 5 and Figure 12 show the area of each class in the years 1973 and 2023, and we noticed from Fig. 12 the amount of variation between these two years.

Table 5: The area of each class in the years 1973 and 2023,

LCLU Class	1973		2023		change %
	Area (km^2)	Area %	Area (km^2)	Area %	
Urban land	5.72	2.40	134.95	56.55	54.16
Vegetarian lands	17.26	7.23	15.16	6.35	-0.88
Bare lands	215.64	90.37	88.51	37.09	-53.28
total	238.62		238.62		

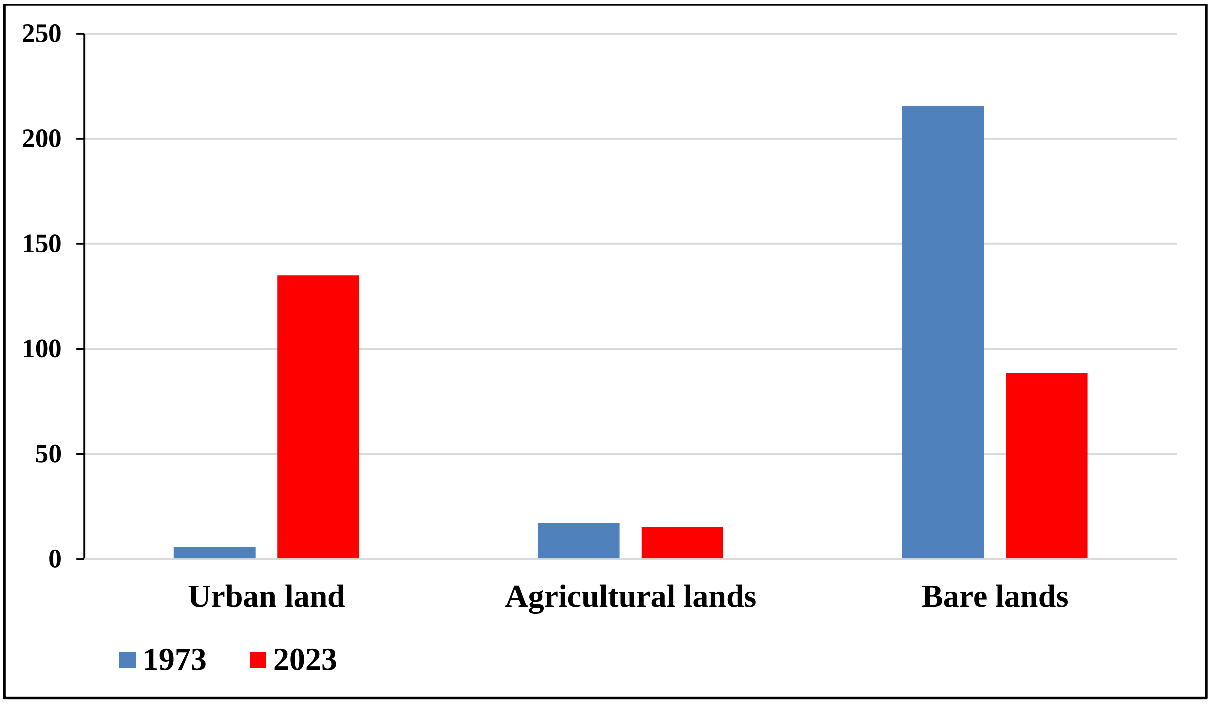


Fig. 12: LULCC for The Adopted Classes in The Study Area in Period (1973 – 2023).

From the Table above, we can note that the areas of the classes, urban land, green land, and bare land of the study area in square kilometers for 1973 are 5.72, 17.26, and 215.64, respectively. On the other hand, one can observe that the areas of the same classes in square kilometers for 2023 are 134.95, 15.19, and 88.51, respectively. When comparing each class separately between 1973 and 2023, we found that the urban area increased from 5 km^2 to 134 km^2 during the adopted period (fifty years) by a rate of more than twenty-seven times. By contrast, we noticed a decrease in vegetarian areas from 17 km^2 to 15 km^2, and this refers to a dangerous indicator of deterioration in green areas in Najaf and Kufa districts with a high population density as a direct result of the increase in the urban, while we foud a decrease in the barren area due to the transformation of many of them into an urban area, as is apparent in Fig. 8 and 9.

5. Conclusions

The adopted successful methodology proved the main purpose of this study which is detecting the changes for sustainability development of regions in Al-Najaf Al-Ashraf, Iraq. This achievement based mainly on the obtained high accuracies of classification for the three classes (urban area, vegetation area, and bare area) of both adopted two satellite images for the years 1973 and 2023. The results revealed increasing in the urban area with decreasing in vegetation and bare areas. These results give a critical indicator on the effect of the sustainability development in Al-Najaf Al-shraf unless handle by scientists and decision makers, because it part of sustainability development goals that must be achieved in 2030.

6. References

[1] G. Assembly, "Resolution adopted by the General Assembly on 11 September 2015," New York: United Nations, 2015.

[2] D. o. E. a. S. A. i. u. nation. "The 2030 Agenda for Sustainable Development." https://sdgs.un.org/goals (accessed.

[3] M. A. Massoud, A. Tarhini, and J. A. Nasr, "Decentralized approaches to wastewater treatment and management: applicability in developing countries," Journal of environmental management, vol. 90, no. 1, pp. 652-659, 2009.

[4] R. Avtar et al., "Assessing sustainable development prospects through remote sensing: A review," Remote sensing applications: Society and environment, vol. 20, p. 100402, 2020. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7470744/pdf/main.pdf.

[5] R. Khatami, G. Mountrakis, and S. V. Stehman, "A meta-analysis of remote sensing research on supervised pixel-based land-cover image classification processes: General guidelines for practitioners and future research," Remote sensing of environment, vol. 177, pp. 89-100, 2016.

[6] J. Sharma, R. Prasad, V. Mishra, V. Yadav, and R. Bala, "Land use and land cover classification of multispectral LANDSAT-8 satellite imagery using discrete wavelet transform," The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. 42, pp. 703-706, 2018.

[7] K. Coulson and D. W. Reynolds, "The spectral reflectance of natural surfaces," Journal of Applied Meteorology and Climatology, vol. 10, no. 6, pp. 1285-1295, 1971.

[8] B. Q. Al-Abudi, M. S. Mahdi, and Y. C. Bukheet, "Study of Land Cover Changes of Baghdad Using Multi-Temporal Landsat Satellite Images," Iraqi Journal of Science, pp. 2146-2160, 2016.

[9] S. W. Wang, B. M. Gebru, M. Lamchin, R. B. Kayastha, and W.-K. Lee, "Land use and land cover change detection and prediction in the Kathmandu district of Nepal using remote sensing and GIS," Sustainability, vol. 12, no. 9, p. 3925, 2020.

[10] K. H. Mohammed, "Using Multispectral Satellite Images for Sustainable Development of Selected Areas of An-Najaf Governorate," master, physics, Al Kufa, Iraq, 2021.

[11] E. R. Wdaah and A. A. Kzar, "Change Detection in Land Use/Cover (LULC) for the Sustainable Development in Karbala, Iraq," 2022.

[12] Qanbari, A. L. Kamran, Khalil, and M. Fadhel, "Urban land use/cover mapping and change detection analysis using time series satellite images," نشریه سنجش از دور و سیستم اطلاعات جغرافیایی در علوم محیطی, vol. 2, no. 5, pp. 129-112, 2023.

[13] J. Dujayli, "Encyclopedia of Najaf Al-Ashraf," in Encyclopedia of Najaf Al-Ashraf vol. 1, ed. University of California: dar al'adwa'i, 1993.

[14] W. Al-Madi, "STUDY OF THE RANDOM AREAS OF THE CITY OF NAJAF DURING TEN YEARS (2003-2013) BY

GEOGRAPHIC INFORMATION SYSTEMS (GIS)," 2018.

[15] I. c. encyclopedia. "City of Kufa." Wayback Machine. https://web.archive.org/web/20170907231207/http://www.m-alhassanain.com/modon/kofeh.htm (accessed.

[16] c. S. Organization. "Najaf Statistical Summary 2018." Ministry of Planning - Central Bureau of Statistics. https://cosit.gov.iq/ar/?option=com_content&view=article&layout=edit&id=1219 (accessed.

[17] S. L. Farhan, D. Antón, V. S. Akef, S. L. Zubaidi, and K. S. Hashim, "Factors influencing the transformation of Iraqi holy cities: the case of Al-Najaf," Przegląd Naukowy. Inżynieria i Kształtowanie Środowiska, vol. 30, no. 2 [92], 2021.

[18] A. M. A.-P. D. Hamid and R. Bekdli, "The Reasons For The Transfer Of The Caliphate From Medina To Kufa In The Caliphate Of Imam Ali (Peace Be Upon Him)," Iraqi Journal of Humanitarian, Social and Scientific Research, vol. 3, no. 9, 2023.

[19] A. M. Mensah and L. C. Castro, "Sustainable resource use & sustainable development: a contradiction," Center for Development Research, University of Bonn, vol. 1, p. 22, 2004.

[20] P. Glavič and R. Lukman, "Review of sustainability terms and their definitions," Journal of cleaner production, vol. 15, no. 18, pp. 1875-1885, 2007.

[21] Q. Weng, Remote Sensing for Sustainability. CRC Press LLC, 2019.

[22] P. Puchol-Salort, J. O'Keeffe, M. van Reeuwijk, and A. Mijic, "An urban planning sustainability framework: Systems approach to blue green urban design," Sustainable Cities and Society, vol. 66, p. 102677, 2021.

[23] S. H. Alipour and K. Galal Ahmed, "Assessing the effect of urban form on social sustainability: A proposed 'Integrated Measuring Tools Method'for urban neighborhoods in Dubai," City, Territory and Architecture, vol. 8, pp. 1-21, 2021.

[24] L. Huang, J. Wu, and L. Yan, "Defining and measuring urban sustainability: a review of indicators," Landscape ecology, vol. 30, pp. 1175-1193, 2015.

[25] Y. Zhang and N. Kerle, "Satellite remote sensing for near-real time data collection," Geospatial information technology for emergency response, vol. 6, pp. 75-102, 2008.

[26] A. M. Melesse, Q. Weng, P. S. Thenkabail, and G. B. Senay, "Remote sensing sensors and applications in environmental resources mapping and modelling," Sensors, vol. 7, no. 12, pp. 3209-3241, 2007.

[27] M. Purvis and R. Smith, "Sustainable agriculture for the 21st century," in Exploring Sustainable Development: Routledge, 2013, pp. 179-206.

[28] I. Stavi and R. Lal, "Agriculture and greenhouse gases, a common tragedy. A review," Agronomy for sustainable development, vol. 33, pp. 275-289, 2013.

[29] S. Sarvade, V. Upadhyay, M. Kumar, and M. Imran Khan, "Soil and water conservation techniques for sustainable agriculture," Sustainable Agriculture, Forest and Environmental Management, pp. 133-188, 2019.

[30] M. H. M. Roslim et al., "Using remote sensing and an unmanned aerial system for weed management in agricultural crops: A review," Agronomy, vol. 11, no. 9, p. 1809, 2021.

[31] L. Wang, P. Wang, S. Liang, X. Qi, L. Li, and L. Xu, "Monitoring maize growth conditions by training a BP neural network with remotely sensed vegetation temperature condition index and leaf area index," Computers and Electronics in Agriculture, vol. 160, pp. 82-90, 2019.

[32] "ArcMap." esri. https://www.esri.com/en-us/arcgis/products/arcgis-desktop/resources (accessed.

[33] U. S. G. Survey. "Common Landsat Band Combinations." https://www.usgs.gov/landsat-missions/landsat-satellite-missions (accessed.

[34] F. Ghazouani, I. R. Farah, and B. Solaiman, "A multi-level semantic scene interpretation strategy for change interpretation in remote sensing imagery," IEEE Transactions on Geoscience and Remote Sensing, vol. 57, no. 11, pp. 8775-8795, 2019.

[35] D. R. Panuju, D. J. Paull, and A. L. Griffin, "Change detection techniques based on multispectral images for investigating land cover dynamics," Remote Sensing, vol. 12, no. 11, p. 1781, 2020.

[36] P. Mather and B. Tso, Classification methods for remotely sensed data. CRC press, 2016.

[37] P. Potapov et al., "Landsat analysis ready data for global land cover and land cover change mapping," Remote Sensing, vol. 12, no. 3, p. 426, 2020.

[38] T. Lillesand, R. W. Kiefer, and J. Chipman, Remote sensing and image interpretation. John Wiley & Sons, 2015.

[39] J. De Leeuw, H. Jia, L. Yang, X. Liu, K. Schmidt, and A. Skidmore, "Comparing accuracy assessments to infer superiority of image classification methods," International Journal of Remote Sensing, vol. 27, no. 1, pp. 223-232, 2006.