

## The Change in the Land Cover of Mahmudiyah City in Iraq for the Last Three Decades

**Mushtaq A Majed**

Department of Physics, College of  
Education for Pure Science \ Ibn Al-Haitham, University  
of Baghdad, Baghdad, Iraq.

[mushtaq.abdulkareem1204a@ihcoedu.uobaghdad.edu.iq](mailto:mushtaq.abdulkareem1204a@ihcoedu.uobaghdad.edu.iq)

**Hameed M.Abduljabbar**

Department of Physics, College of  
Education for Pure Science \ Ibn Al-Haitham,  
University of Baghdad, Baghdad, Iraq.

[hameed.m.aj@ihcoedu.uobaghdad.edu.iq](mailto:hameed.m.aj@ihcoedu.uobaghdad.edu.iq)

**Article history: Received 27 March 2022, Accepted 8 May 2022, Published in July 2022.**

**Doi:10.30526\35.3.2831**

### Abstract

The land cover of Mahmudiyah city, located south of the capital, Baghdad - Iraq, was studied for the period from 1986 to 2021 with five years between every two successive scenes, where Landsat scenes were used downloaded from the US Geological Survey (USGS ) website with low cloud cover for sensors TM and OLI. The land cover of the study area was classified. The total accuracy of the classification was calculated, as well as the analysis of the user accuracy and the classifier accuracy (maximum likelihood) and its impact on the overall classification accuracy. The lowest accuracy value in 2009 was (85.101% (and the highest accuracy value in 1995) was 95.654%). The constancy percentage of the class for the adopted years was calculated and compared to 1986 as a reference year to determine the changes in the land cover of the study area. It was found that there were changes in the classes influencing one the other, and the constancy percentage of the class was low due to environmental influences and human factors. The constancy percentage of the urban class was recorded at 50%, while the other classes did not exceed this rate since they suffered from the overlap of their spectral response. The low spatial resolution of the Landsat scenes (30 meters per pixel) led to recording omissions and commission, which decreased the overall classification accuracy.

**Keywords:** kappa coefficient, Constancy rate, Omission, Commission.

### 1. Introduction



Geographical information systems and remote sensing are sciences that have gained great importance for their ability to provide the necessary environmental data obtained from analyzing satellite images in various applications that contribute to the development of our information about the environment around us[1]. They provide us with the ability to measure the characteristics, identify the land cover features, and analyze them offline without direct contact with the target or object concerned by employing physical phenomena such as reflection and emission [2]. Mostly remote sensors record wavelengths within different ranges, such as visible and infrared rays (near, medium, and far), part of ultraviolet rays, and some other types. These energies are processed and recorded in the form of data stored for later use [3].

Remote sensing is important as it has the potential to provide us with a huge amount of data and organizational information effectively replicated at a cost-effective level covering large areas. The emergence of remote sensing is an application in many disciplines, like agriculture, hydrology, deforestation, land cover and geology applications, beach monitoring, ocean mapping, urban and regional planning, population growth and pollution detection, and others[4-5].

The classifications of the land cover classes must conform to the criteria used for the basic classifications approved by the US Geological Survey(USGS) in classifying the land cover classes(Anderson classification), and each major class contains a set of subclasses[6-7].

The change in land cover is a set of changes that appear on the main land cover types, as these components represent certain percentages of the total land cover area. The natural factor represents all the influences that occur due to the effects of the environment and its changes. For example, when the amount of rain decreases, the lands covered with natural vegetation turn into barren land, but in areas where the temperatures are high, the wet soil turns dry. The second factor is related to human activity, which is usually due to the urban expansion, changing the paths of rivers or water bodies, or the formation of artificial lakes, all of these factors have a significant impact on changing the types of cover from one type to another [8-10].

Tracking the characteristics of the change and the accompanying changes within the study area is carried out by detecting and identifying differences and similarities and comparing the scenes captured for the same area for different years or periods[11],[3].

Change detection needs comprehensive statistical information during certain periods about the changes that occurred over a certain time. This information is of great importance in explaining the reasons for those changes and the ability to find equations that predict the behavior of these changes during a period in the future, which helps in processing and making interim and future decisions [12-13].

There are three basic criteria in any assessment process for change detection accuracy. These parameters are (1) the reference data, (2) the samples obtained, and (3) the covariance detection error of the calculation matrix [3],[14].

Monitoring the dynamics of changes in the land cover is one of the complex and intertwined processes, but it has been noted that this change at the global level has a rapidly increasing pace. The change affected about one-third of the world during the past six decades [14-15].

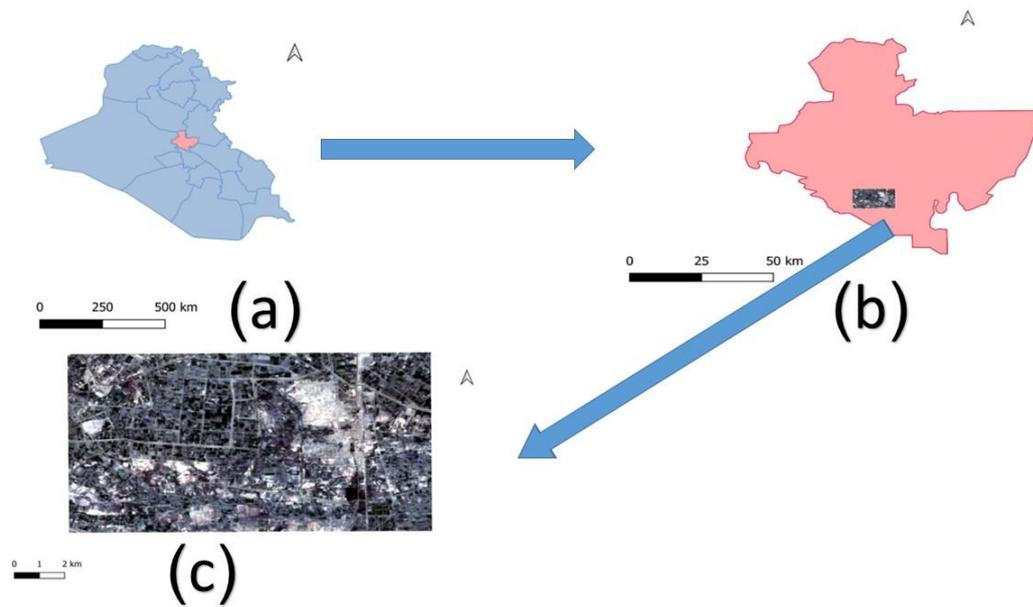
The following is a review of the most important previous studies researched in this direction:

- Qassim et al. (2020)[16]: The scope of this study includes the administrative borders of the city of Baghdad from the years (1986 to 2019). This is done through Landsat satellite scenes, with an average of five years for the difference between one scene and another, using the maximum likelihood classification. She referred to 2019, when the amount of rain was higher than the general average, affecting land cover types. She calculated the changes that occurred in each category during that period. This study concluded that the urbanization category changes at the expense of other categories due to human and environmental factors
- Hamoodi et al. (2006)[17]: In this study, there was the urban growth of the city of Baghdad from 1961 to 2004 using a set of geographic information systems (GIS) techniques, as well as using Landsat 5 satellite scenes with a TM sensor. The researcher concluded that the urban expansion increased by about seven times compared to the urban reality in Baghdad in 1961, according to official maps, because of rapid economic growth.
- Mahmoud et al. [2017][18], Observations in which the Landsat satellite scenes were used to reveal the heterogeneity in urban areas in the Republic of Egypt, specifically Assiut. The results indicated a change in favor of urban growth, where the net urban growth amounted to 36.22%. The router (system) rating was relied upon, as the user rating accuracy for the years 1990, 2003, and 2015 appeared to be 88%, 93%, and 84%, respectively. Presenting these results helps decision-makers in governments to develop strategies to reduce urban expansion.
- Bukheet et al. (2016)[8], the study aims to reveal the changes that occurred in the land cover by using the supervised classification algorithm and the maximum likelihood classifier for the years (1984-2015) for the study area of Baghdad, through satellite scenes for thirty years with the help of the program (ENVI 5.1) to obtain the results that reveal changes in the land cover. In addition, five main categories were monitored (water bodies, vegetation, two types of urban lands, and soil). The results emerged the detection of heterogeneity in urban lands.

This study focuses on detecting the Change in the Land Cover of Mahmudiyah City within the Baghdad province for the period 1986 to 2021 to determine the constancy percentage of the class for the adopted years in the land cover of Mahmudiyah city.

## 2. Description of the study site

The study area is defined within the city of Mahmudiyah, which is located within the administrative boundaries of the capital, Baghdad, in the center of the state of Iraq, approximately between the longitude [44° 14' 32.63"] to [44° 23' 50.67"] and latitude [33° 5' 32.63"] to [33° 0' 39.51"]. The total area of the study area is (131.4855 km<sup>2</sup>). The study area is a specific part of the administrative boundaries of the Mahmudiyah district with the densest urban distribution compared to the rest of the district, as shown in **Figure 1**.



(a) Administrative map of Iraq (b) Administrative map of Baghdad city  
 (c) study area specified within the Mahmudiyah district

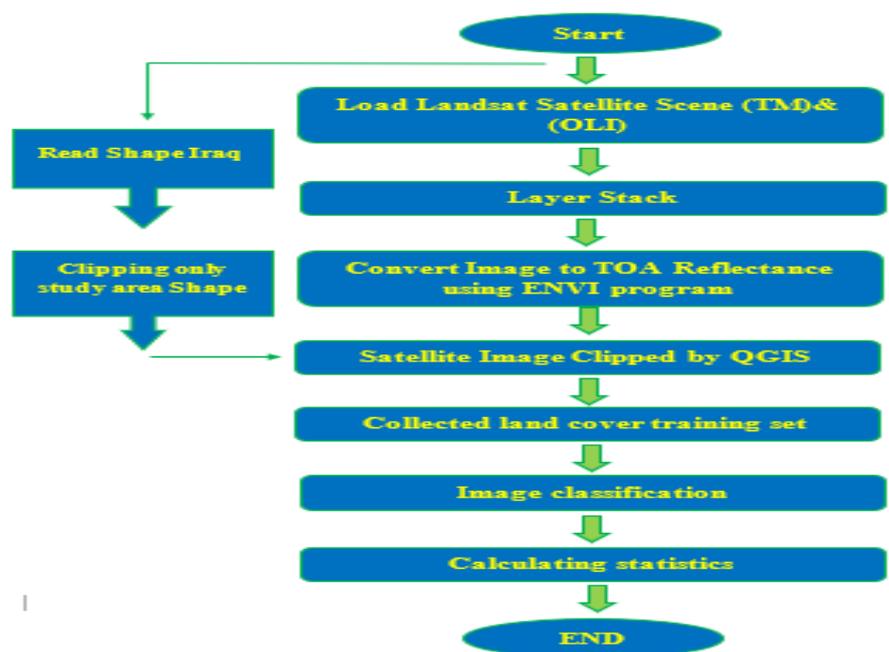
**Figure 1.** The study site location is on Iraq’s Map [19].

Obtaining the appropriate scenes for the selected years for the Landsat satellite was done through USGS Web (USGS source). The study site is located at path 168, row 37, and path 169, row 37, depending on the available indexing of Landsat scenes.

The predominant land cover types in the study site are the vegetation cover of various types and the urban type. There are small rivers in the study area, the first of which is the main drainage project in Iraq (the general estuary or the third river), the Yusufiya River, and the Sheshbar River. It is a small tributary of the Euphrates River

### 3. Methodology

The following flowchart represents the main steps that were adopted in the research



**Figure 2.** Pre-Processing Landsat-5 & 8 Images flowchart.

**4. Results and Discussion**

The scenes used in this research are for Landsat 5 and 8 satellites for certain years. All scenes were acquired during the spring of each year, with a 5-year interval between every two consecutive scenes, as shown in **Table 1**.

**Table 1.** shows the details of the scenes used in this research

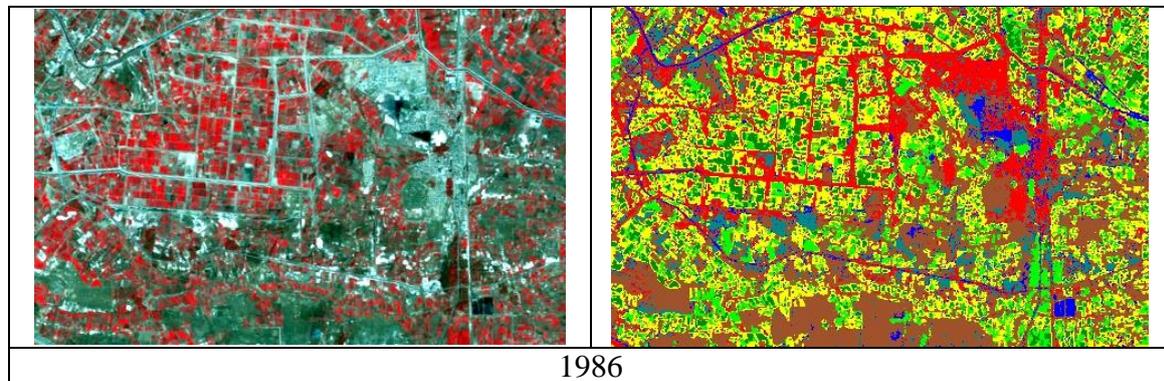
DATE	TIME (GMT)	LANDSAT SENSOR	PATH, ROW
22/2/1986	7:00:09 AM	TM -5	168, 37
21/3/1990	6:53:56 AM	TM -5	168, 37
26/3/1995	6:49:34 AM	TM -5	169, 37
29/2/2000	7:06:59 AM	TM -5	168, 37
14/3/2005	7:20:34 AM	TM -5	168, 37
25/3/2009	7:20:22 AM	TM -5	168, 37
10/3/2015	7:33:16 AM	OLI-8	168, 37
10/3/2021	7:33:31 AM	OLI-8	168, 37

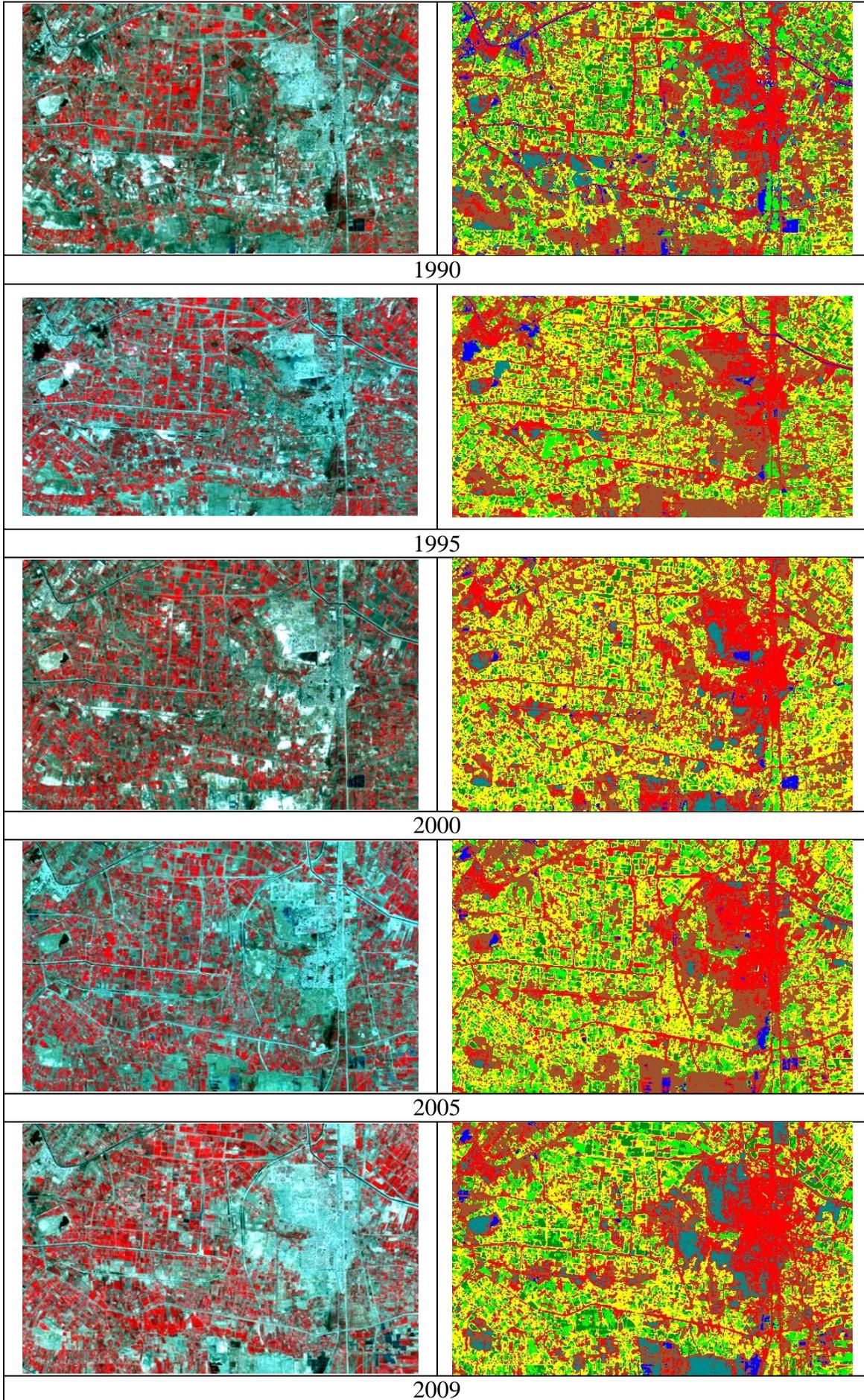
The land cover of the study area consists of four main classes: soil, water, urban, and vegetation. These classes are divided into sub-class within each main class, including dark soil. The urban area is highlighted to notice the variance in the urban category on Calculate the rest of the classes that make up the land cover. A list of major and subclasses is shown in **Table 2**, representing a set of false colors to differentiate them and give ease of distinction in the classification results.

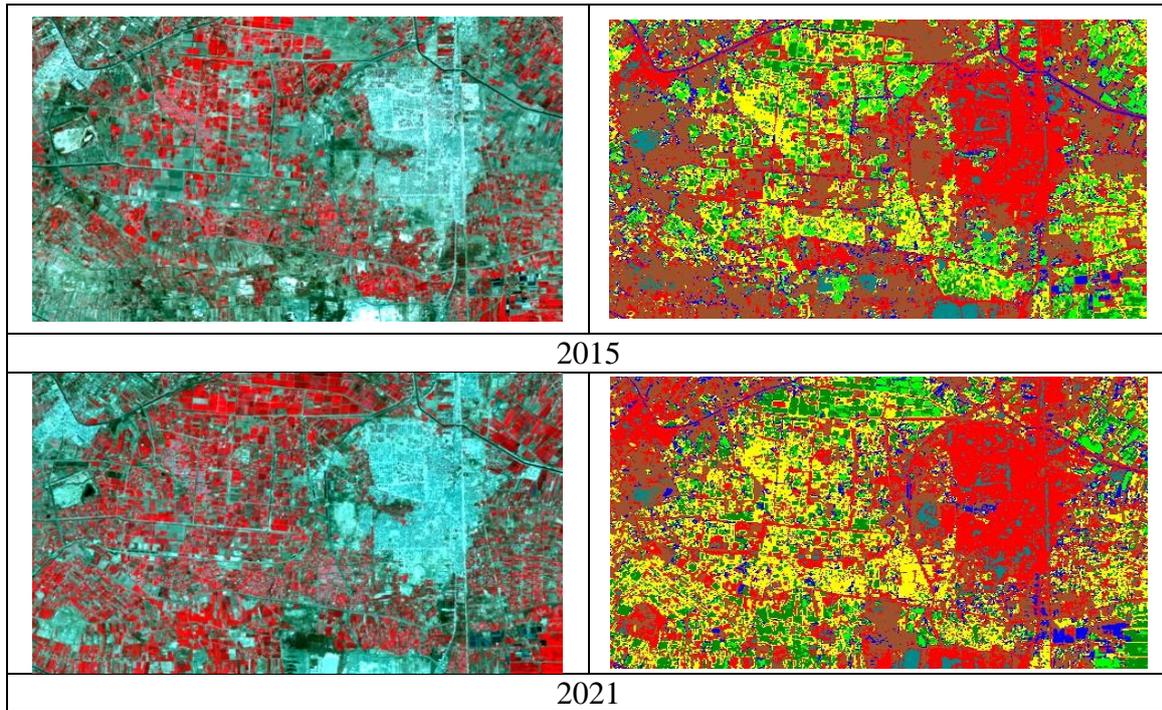
**Table 2.**Sub-classes of the land cover with their color representation.

Subclasses	Color
URBAN	Red
DRAK SOIL	Brown
WHIT SOIL	Cyan
TREE	Light Green
GRASS	Dark Green
NATURAL PLANT	Yellow
WATER	Blue

The maximum likelihood is used to classify the satellite scenes; the combined training sets representing the land cover of the study site were used, as shown in **Figure 3**.







**Figure3.**The study area image after clipping using pseudo colors using band combine 4,3 and 2 for TM and 5,4 and 3 for OLI compare with Classification results of this Scenes

The overall classification accuracy is calculated by the equation

$$\text{Overall Accuracy} = \frac{\text{digit of right categorized}}{\text{total number of pixels}} \times 100\% \quad (1)[20],[21]$$

The other parameter of classification accuracy is the Kappa coefficient, which can be defined as [22].

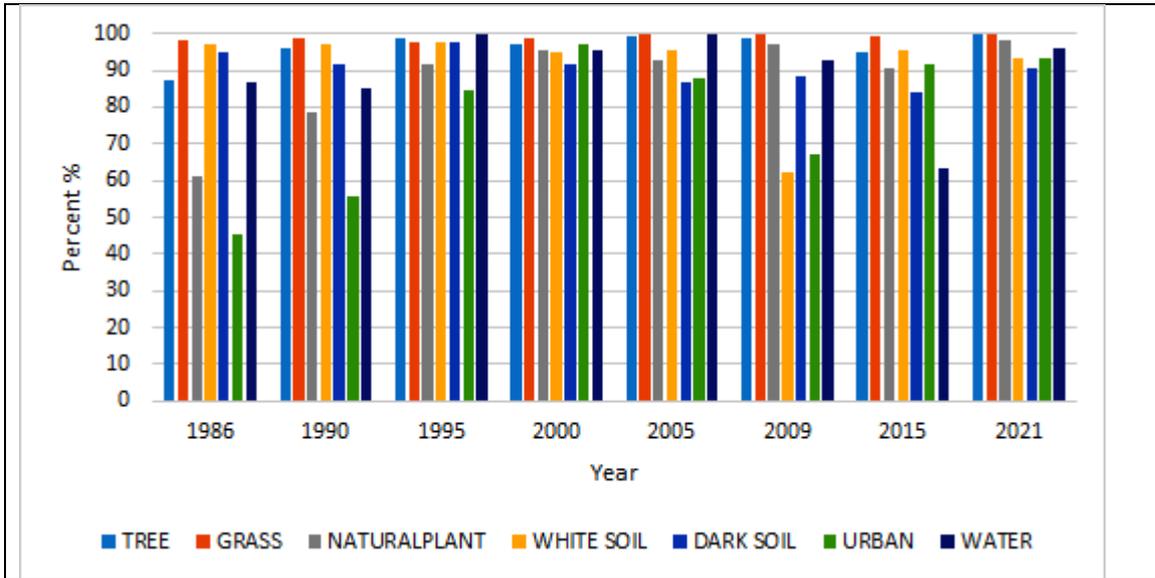
$$K = \frac{\text{observed accuracy} - \text{chance agreement}}{1 - \text{chance agreement}} \quad (2) [23]$$

Classification accuracy was calculated by comparing it with the training sets and as shown in Table 3, where the overall accuracy values were higher than 85%, and the kappa coefficient was higher than 0.8, indicating the classification results' validity.

**Table 3.** Overall Classification accuracy percent and Kappa coefficient value

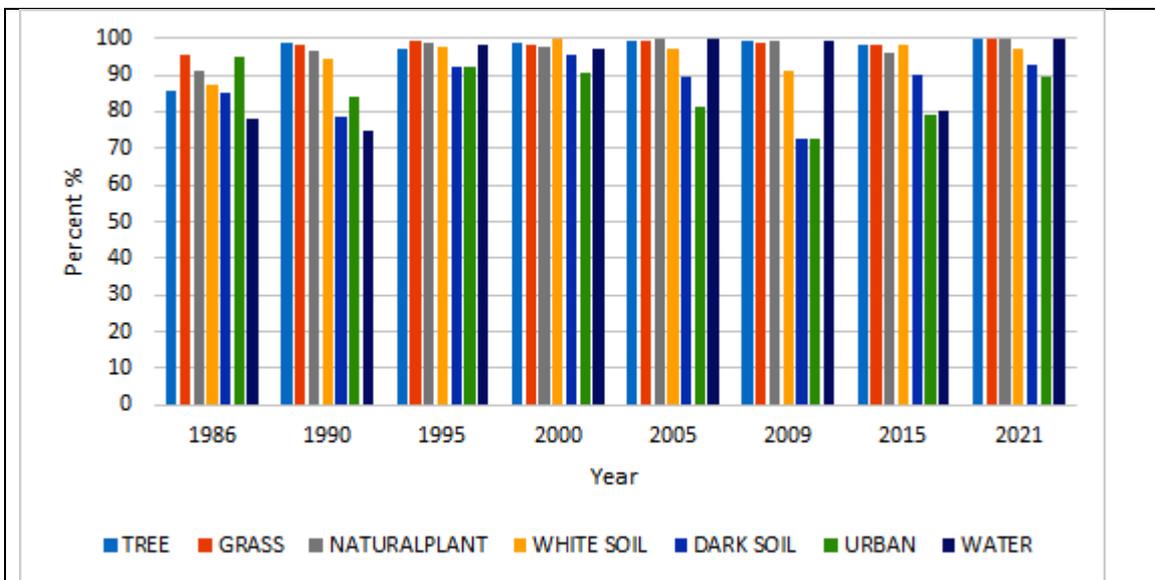
Year	Accuracy percent	Kappa Coefficient
1986	88.7465	0.8587
1990	86.2692	0.8304
1995	95.6543	0.9477
2000	95.3631	0.9426
2005	93.6494	0.9248
2009	85.101	0.818
2015	88.9218	0.8628
2021	94.8222	0.9352

Due to the importance of classification accuracy, it has been studied with more attention, as the user's accuracy in selecting training groups and the accuracy of the classifier in the classification process for each class were calculated as shown in **Figures 4** and **5**, respectively.



**Figure4.** User accuracy percent

In **Figure 4**, we can notice two distinct behaviors. The first is that the urban class achieved the worst results due to the interference of soil types and lack of satellite accuracy (30 meters), which affected the user's ability to choose the training groups more accurately, which caused this apparent regression in the results. The second behavior is that the percentage of the natural plant class is low since the natural plants are few in some years.

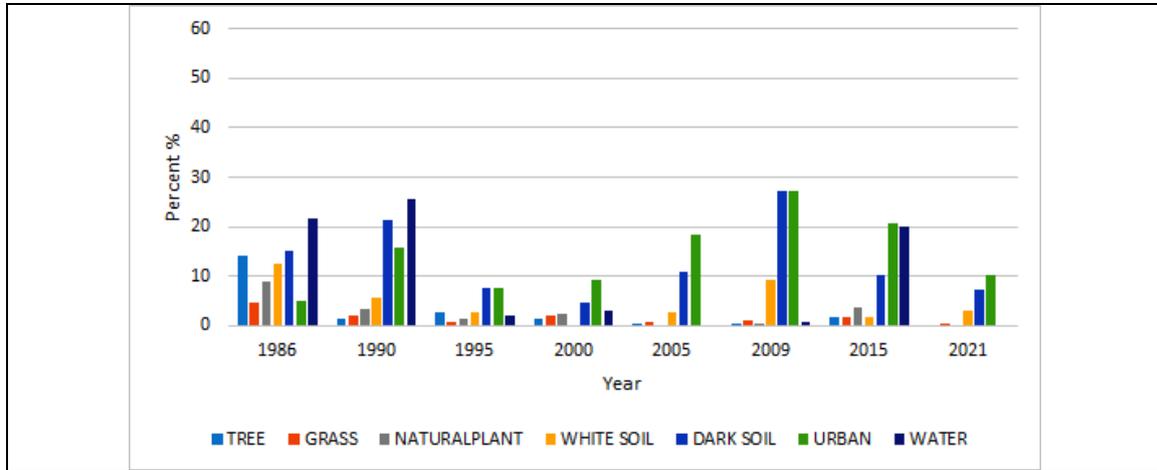


**Figure5.** Producer accuracy percent

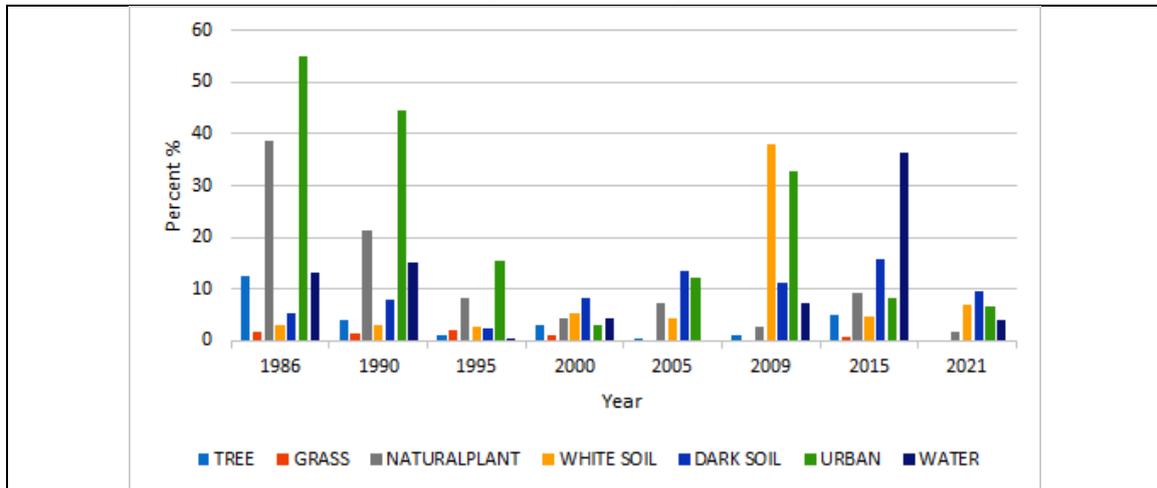
We note in **Figure 5** that the failures that were evident in the user accuracy, the maximum likelihood classifier was able to exceed these failures and cross to 70% as the lowest accuracy value, which is an acceptable percentage. However, despite that, we noted that the urbanization and natural plant classes were still in the lowest rank of the results of the classes.

The defect in the accuracy of classification caused some of the classes to be omitted to be classified within the correct class to which they belong (omission) and to be added to other

classes (commission), which led to a section of the classes being calculated more or less than the correct ratio of representing the class in the land cover of the study area. **Figures 6 and 7** illustrate the percentage of omissions and commission for each class and all adopted years, respectively.



**Figure 6.**Omission percent



**Figure7.**Commission percent

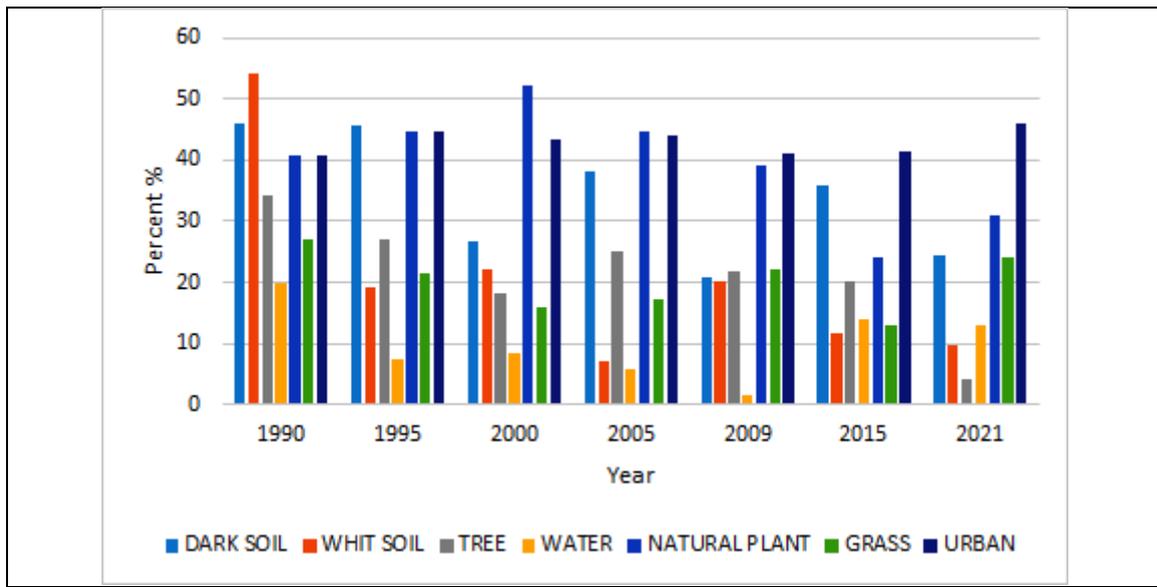
To identify the errors of omission and commission in the classification process, and based on the values of omission and commission, 20% for commission and 10% for omission were chosen as critical limits. The errors that accompanied the classification process, such as commission or omission between the classes and the reasons for that, were identified, as shown in **Table 4.**

**Table 4.** The omission and the commission between the classes

Year	Omission	Commission	Notes
1986	WATER	→	Commission to different classes
	DARK SOIL	→ URBAN	The two classes are interfering
	WHITE SOIL	→	
	TREE	→ NATURALPLANT	Belong to the same main class
1990	WATER	→	Commission to different classes
	DARK SOIL	→ URBAN	The two classes are interfering
2005	URBAN	→ DARK SOIL	The two classes are interfering
	DARK SOIL	→ URBAN	The two classes are interfering

2009	URBAN	→	WHITE SOIL	The two classes are interfering
	DARK SOIL	→	URBAN	The two classes are interfering
2015	URBAN	→	DARK SOIL	The two classes are interfering
	WATER			Commission to different classes

To determine the changes in the land cover of the city of Mahmudiyah during the past three decades, the year 1986 was chosen as a reference year to compare the constancy of each class of land cover with time, as shown in **Figure 8**.



**Figure 8.** The constancy percentage of the class for the adopted years

Furthermore, we noted that the urban class was one of the most constancy classes. However, the percentage is less than 50%, which is due to the urban expansion of the city as well as the errors that occurred in the classification process due to omission and commission between the classes. The natural plant is one of the classes whose constancy was good compared to the rest. This is due to the largely uninhabited areas in the Mahmudiyah area suitable for the growth of natural plants characterized by their resistance to drought despite the decrease in these areas due to human activity in the city. As for the class of water, grass, and trees, it has gradually declined due to the drought period that Iraq suffered in general. The constancy rate of soil classes continued to fluctuate, increasing and decreasing, due to its impact on climatic conditions and human activity in the study area.

### 5. Conclusions

The land cover of Mahmudiyah city suffered from changes due to climatic conditions and human activity, so the highest percentage of constancy compared to 1986 was for the urban class, which was less than 50%. Because of a large number of varieties in the study area, some of which have similar spectral responses, as well as the lack of spatial resolution of the scenes (30 m). This led to varieties (especially the urban and soil classes) that suffered from omission and commission in the classification process, which decreased the classification accuracy of the component's land cover.

## References

1. Abduljabbar, H.; Hatem, A.; Al-Jasim, A.; Desertification Monitoring in the South-West of Iraq Using Fuzzy Inference System. *NeuroQuantology* **2020**, *18*, 1–11.
2. Barrett, E.C.; Introduction to environmental remote sensing; Fourth Edition.; *Routledge*: New York, **2006**; ISBN ISBN 0 412 37170 7.
3. Mohammed, M.A.; Hatem, A.J.; Change detection of the land cover for three decades using remote sensing data and geographic information system. *AIP Conference Proceedings*, **2020**, *2307*, 020029.
4. Abduljabbar, H.M.; Satellite Images Fusion Using Modified PCA Substitution Method. *Ibn AL-Haitham Journal For Pure and Applied Science* **2017**, *30*, 29–37.
5. Richards, J.A.; Richards, J.; Remote sensing digital image analysis, *Springer*, **1999**, *3*.
6. Anderson, J. R.; A land use and land cover classification system for use with remote sensor data, *US Government Printing Office*, **1976**, 964.
7. Naji, T.A.; Hatem, A.J. New adaptive satellite image classification technique for al Habbinya region west of Iraq. *Ibn AL-Haitham Journal For Pure and Applied Science* **2017**, *26*, 143–149.
8. Bukheet, Y.C.; Al-Abudi, B.Q.; Mahdi, M.S.; Land Cover Change Detection of Baghdad City Using Multi-Spectral Remote Sensing Imagery. *Iraqi Journal of Science* **2016**, 195–214.
9. Abbas, H.N.; Abdulameer, I. M. A.; A study of the climate change impacts on Al Shuwaija Marsh-Wasit province using satellite remote sensing. In Proceedings of the AIP Conference Proceedings, **2020**, *2307*, 020048.
10. Raheem, M.A.; Hatem, A. J.; Calculation of Salinity and Soil Moisture indices in south of Iraq - Using Satellite Image Data. *Energy Procedia* **2019**, *157*, 228–233.
11. Muhsin, I. J.; Monitoring of south Iraq marshes using classification and change detection techniques. *Iraqi Journal of Physics*. **2017**, *15*, 78–86.
12. Naji, T.A.; Abduljabbar, H. M.; others The seasonal effect on the water bodies in Iraqi Marshlands. *Plant Archives* **2019**, *19*, 4397–4403.
13. Asmael, N.M.; A GIs Based Weight of Evidence for Prediction Urban Growth of Baghdad City by Using Remote Sensing Data. *Al-Nahrain Journal for Engineering Sciences* **2015**, *18*, 168–178.
14. Congalton, R.G.; Green, K.; Assessing the accuracy of remotely sensed data. *principles and practices*, CRC press, **2019**.
15. Winkler, K.; Fuchs, R.; Rounsevell, M.; Herold, M.; Global land use changes are four times greater than previously estimated. *Nature communications* **2021**, *12*, 1–10.
16. Qassim, Z.H.; Abduljabbar, H. M.; Land cover change for Baghdad City in the period 1986 to 2019. *AIP Conference Proceedings*, **2020**, *2307*, 020031.
17. Bhatta, B.; Analysis of urban growth and sprawl from remote sensing data, 1st ed., *Springer Science & Business Media: London*. **2018**, *14*, 13-25.

- 18.Mahmoud, H.; Divigalpitiya, P.; Spatiotemporal variation analysis of urban land expansion in the establishment of new communities in Upper Egypt: A case study of New Asyut city.*The Egyptian Journal of Remote Sensing and Space Science*. **2019**, 22, 59–66.
- 19.Merhej, S.; Administrative boundaries map; Baghdad, Iraq: Ministry of Water Resources, *General Directorate of Surveying* **2007**.
- 20.Pradhan, B.; Spatial Modeling and Assessment of Urban Form Analysis of Urban Growth: From Sprawl to Compact Using Geospatial Data. *Cham: Springer* **2017**.
- 21.Peacock,R.;Missouri, M.; Accuracy assessment of supervised and unsupervised classification using Landsat imagery of Little Rock, Arkansas.*Master of Science thesis*. **2014**.
- 22.Mohammed, M.A.; Naji, T.A.; Abduljabbar, H.M.; The effect of the activation functions on the classification accuracy of satellite image by artificial neural network.*Energy Procedia***2019**, 157, 164–170.
- 23.Lillesand,T.; Kiefer, R.W.; Chipman, J.; *Remote sensing and image interpretation*; seventh. *John Wiley & Sons: Danvers*, **2015**.