Land covers monitoring for Bahar-Al-Najaf (Iraq) based on sentinel-2 imagery

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Abstract. The last four years have seen a remarkable rise in water levels to the Bahar-Al-Najaf, which led to some areas adjacent to the Al-Bahar region. This creates a state of confusion in the subject of future planning for land uses within the study area. To examine this problem in practice, the images of the Sentinel-2 satellite (within the period 2016-2020) were selected. The resulted thematic maps included six classes of land use and land cover LULC, these classes are (agricultural areas, built up areas, gypsum soil, clay soil, sandy soil, and water areas). With regard to the accuracy of the performed classification process, the so-called confusion matrix indicates that the overall classification accuracy is about 85%. The study concluded that some of the important land use, both the road pilgrimage, the strategic line and its oil transfer accessories had been overwhelmed by water, as well as water approaches a newly built residential complex near the Bahar Al-Najaf. It is imposed by the study; the federal and local government agencies must take rapid measures and procedures to avoid potential future flood risk.

1. Introduction
The interpretation and analysis of land cover changes and the dynamical transformation of the land use are the most important factors that must be taken into account when developing regional and urban planning policies and strategies at various levels [1]. In the other hand, the study of land cover is one of the most important means that are used to study the methods of managing and developing resources, this issue has great significance due to the rapid increasing in population [2]. Some argue that Population growth leads to urban and land expansion, the rapid change in land cover and land use refers to the higher demographic variables; Were Agricultural, reclaiming forest and range lands areas [3, 4]. Moreover, the economic, political and natural factors have to be considered in studying the changing of land covers and land use as investigated by [5]; Some studies showed the effect of topographic factors on land cover distribution and its change [6, 7]. The ecosystem in the arid regions is one of the most common environmental impacted by natural and human changes and facing significant challenges in the field of sustainable development; Where it is exposed to environmental degradation, soil degradation and
biodiversity under the influence of social, economic and political pressure [8, 9,10]. Remote sensing techniques and Geographic Information Systems helped in studying the classification and dynamics of land cover and land uses, studying the factors affecting the change in land cover and land uses, knowing the nature of the distribution of their places, and defining the relationship between them in a more accurate, less effort and less cost compared to the traditional methods [11]. The province of Najaf is facing a complex pattern between urban expansion and agricultural activities to counter the increase in population, as it is an important religious center, which prompted many residents of the Iraqi governorates (especially the central and southern governorates) to migrate to it, for the purpose of family stability and the availability of job opportunities [12]. During the last five years, the Bahr al-Najaf region witnessed a remarkable change in land use, this was due to the rise in water levels in the Najaf Sea. Many parts of the overland pilgrimage road and the strategic oil line, and many brick factories within the region, were submerged, and the water approached much of the residential complexes in the villages there, which negatively affected the future directions of development and reconstruction projects within the study area. The current study aims to analysis the uses of the land during the last four years (2016-2020) using remote sensing methods, namely the implementation of spectral classification processes on Sentinel-2 satellite images.

2. Literature review
By relying on remote sensing techniques represented by the spectral classification of satellite images, and within the province of Najaf, and for the purpose of detecting the level of changes in the land cover and land use, during different periods of time, several studies have been conducted. As it explained, the study of [9] which relied on the use of Landsat 5, 7, 8 images during the period from 1990 to 2017. It is indicated that, there was an increase in vegetation cover areas from 0.64% to 1.47%. The built-up area also increased from 0.41% to 0.93% [13].
As for the study of (Nawal Khalaf Ghazal and Ali Kazem Hussein), it is obtained a thematic map (with an overall classification accuracy of 85%) for the entirety of Najaf Governorate based on Landsat 8 satellite images in 2016. The resultant thematic map has six classes, namely: residential complexes, water bodies, orchards, agricultural lands, green parcels and barren lands [14].
Amani Kh., and Mustafa Abdul Jalil assessed in their study, the changes in the land use and land cover within the city of Najaf. From this study, it is concluded that, these changes were caused by the conditions of wars and the economic siege that Iraq has witnessed over the past decades, in addition to the increase in the city's population growth and migration to the governorate (Najaf Governorate) as it is an important religious and commercial center in southern Iraq. In this study, the specialized software package Remote Sensing and GIS (Al-Idrisi) has been used, the changes of LULC of the region during the time period extending from 1986 to 2016 have been investigated. The study concluded that, the axes of the urban expansion of the city are in the northern and northwestern direction. Moreover, noticeable increasing has been indicated in built up areas and agricultural lands at the expense of a decrease in the areas of barren lands [15].
Moreover, for the study conducted by Adel Jaber and Ali Abd Abu Jassim, the purpose of this study was to monitor the change of LULC within the Najaf Governorate during the period from 2013 to 2019, and based on the satellite images of the Landsat 8. It is concluded from this study that, each of the agricultural lands, water bodies, and orchards has been increased by 5.43 percent, %, 0.22% and 1.5%, respectively. Whereas, residential complexes and barren lands are decreased their areas to a rate of -3.56% and -3.57%, respectively [16].
In addition to the relevant studies that were conducted in the Middle Euphrates region, which is the study conducted by (Imzahim, Abdul Razzaq and Alaa). This study was conducted to monitor the agricultural drought in the Middle Euphrates area, Iraq during the period from 1988 to 2018. Multispectral Landsat TM, ETM4+, and OLI images were used. The images dated 1988, 1993, 2000, 2005, 2010, and 2018,
environments to process and analysis the data. The results revealed that percentage of no-drought area ranged between (7%) and (17%) during the period from 1988 to 2018. The extremely and severely drought classes recorded high percentage followed by moderately and mild drought in the region. From this study can be concluded that there is a high rate of drought in the region, especially in its southern and western parts [17].

Finally, it is worth noting the diversity of the algorithms used in the process of spectral classification, and the multiplicity of mathematical methods, for example (Amjad,Tay). In this paper, to utilize the complementary capabilities of LULC spatial mapping data obtained from LandSat 8 OLI sensor images captured in 2019. It has been corrected, improved and then classified according to Random Forest (RF) and Artificial Neural Network (ANN)[18]. Also (Imzahim, Nadia) this study used three classification methods were used aimed at comparing their accuracy, using multispectral satellite images with a spatial resolution of 10 m. The classification process was performed using three different algorithms, namely: Maximum Likelihood Classification (MLC), Artificial Neural Networks (ANN), and Support Vector Machine (SVM) [19].

3. Fundamental Theoretical Concepts

In order to perform the best future planning for Land Use and Land Cover (LULC) for the study area, it is necessary to study its current and previous usage - cover situation. The method of spectral classification of satellite images provides a great help to planners and those concerned with the issue of the LULC in this regard. The spectral classification of satellite images can be defined as that digital process whose main input is the A multi-spectral band satellite image, and its outputs are a thematic map that represents the LULC. Generally, the process of spectral classification depends in its work on implementing statistical algorithms with different levels of mathematical complexity. Whatever the efficiency, accuracy and level of complexity of the statistical algorithms of the classification process, the resulting thematic map must include a specific level of error. This is due to the probability based of the used algorithms. The accuracy of the thematic map, and the possibility of its acceptance is determined through the implementation of the so-called accuracy assessment methods. For more details on the subject, you can review [20,21].

Regarding the used satellite images, they belong to the Sentinel2 satellite, which was launched by the European Space Agency (ESA). The references [22, 23] explained the technical details of this satellite and the sensors carried in it, in addition to the specifications of the resulting satellite images from the acquisition process, in terms of resolution (spatial, spectral, radiometric and temporal), in addition to the levels of geometric and radiometric pre-processing.

4. Methodology

4.1. Study area

The governorate of A Najaf is located in south-western Iraq about 161 km southwest the capital Baghdad and it borders Saudi Arabia. It also shares internal boundaries with the governorates of Anbar, Karbala, Babel, Qadisiya and Muthanna, see to (Figure 1). It has an area of about 28,824 km2 which is approximately 7% of Iraq’s total area. The study area is located in Baher Al-Najaf, Iraq. The geographic coordinates of this area are longitude (31° 40' 00'' N - 32° 10' 00'' N), latitude (44° 00' 00'' E - 44° 30' 00'' E). The subset area occupies an area of 3186.913 km2, see to (Table 1). This area was selected for this research to study the change detection from 2016 to 2020s on the Baher Al-Najaf.
Figure 1. The study area boundaries.

| Study Area Shape | Study Area Area | Study Area Coordinates |
|------------------|-----------------|------------------------|
| rectangle        | 3186913 Km²     |                        |
|                  |                 | 1                      |
|                  |                 | 455000 E              |
|                  |                 | 3561342 N             |
|                  |                 | 2                      |
|                  |                 | 400562 E              |
|                  |                 | 3561342 N             |
|                  |                 | 3                      |
|                  |                 | 400562 E              |
|                  |                 | 3502800 N             |
|                  |                 | 4                      |
|                  |                 | 455000 E              |
|                  |                 | 3502800 N             |

4.2. Data sets and the study period

Five images belong to Sentinel-2 satellite are downloaded and prepared for the current study (Figure 2), the date of acquisition for each image has been illustrated as mentioned in Table 2.
4.3. Processing steps of the work
In the current study, the main stages of processing have been illustrated as shown in the figure 3. While, other detailed practical steps are listed as follows:

Figure 2. Map of the Sentinel (from 2016-2020) images.

Table 2. Date of acquisition for the sentinel-2 data sets.

| Image # | Date of Acquisition |
|---------|---------------------|
| #1      | 16-8-2016           |
| #2      | 25-9-2017           |
| #3      | 26-9-2018           |
| #4      | 26-9-2019           |
| #5      | 26-9-2020           |
Figure 3. The overall sequence of processing.
I. Downloading, reformatting and extracting the Sentinel2 satellite images of the study area.

II. Gathering the preliminary information about LULC through the following:

A. Reviewing the relevant government departments (urban planning, municipal services, water resources, agriculture, environment, roads and bridges).

B. Conducting a preliminary field survey of the entire study area.

C. Conducting a detailed field survey of specific sites within the study area (training area for the classes).

III. To find out the level of discrepancy between the different classes in the study area. The spectral classification process will be performed (according to unsupervised approach), and it is repeated for several times, until reaching the best results, in terms of the absence of mixing among the classes of the resulted initial thematic maps.

IV. The number and the type of the classes that are to be included in the final thematic map shall be determined, depending on steps II.C and III referred to above.

V. Implementing the spectral classification process according to Maximum Likelihood algorithm, and obtaining the semi-final thematic map for the LULC.

VI. Checking the accuracy level (for each class) of the thematic map (resulting from step V above), the checking process is performed by carrying out what is called the accuracy assessment.

VII. Depending on the results (Step VI above), there are two possibilities, as follows:

VIII. A. The first possibility: the results are acceptable

The semi-final thematic map is approved as the final thematic map

B. The second possibility: the results are not acceptable

Step V will be repeated after making the required adjustments to the desired classes or their training areas (size and/or positions).

Digital preparation and cartographic layouting of the final thematic maps that represent LULC for the last four years (2016-2020).

Examining, comparing and discussing the level of changes among the LULC varieties that have occurred on the study area during these four years.

Drawing out the most important conclusions that can be reached from the study as a whole, and from Step IX above specifically.
5. Results and Discussion

Depending up on the preliminary results of unsupervised classification that are supported with priory knowledge and visiting for some sites within the study area. The supervised classification with maximum likelihood algorithm has been used in this study. To form the LULC's, six classes have been determined to form the final required thematic maps, these classes are (water bodies, Vegetation-agricultural land, built up area, barren land, soil-sandy and soil-gypsum). Depending on the confusion matrix that has been used for the accuracy assessment of the classification process, the resultant average overall accuracy is about 85 % as shown in table 3. The main results concerning the resultant thematic maps for the study period (2016-2020) have been illustrated as shown in figure 4 and figure 5. Other related important comments and discussion that have been extracted from these main results supported with (visual interpretation of the raw and enhanced used sentinel-2 images, visiting for some sites within study area, Interviews with officials in the relevant government departments) are listed as follows:

- The regions of the northern Najaf Sea witnessed during the past few years the establishment of many unlicensed artificial ponds, which are used for the purpose of raising fish, and these ponds depend on drilling artesian wells, as many of these wells have been dug, without obtaining fundamentalist approvals from the concerned authorities. Which led to a noticeable increase in water levels in the region.
- The study area includes about 57 natural water springs. These springs have supplied the area with water since ancient times.
- The southern part of the Najaf Sea is a drainage for most of the neighborhoods of the city of Najaf, as the main drainage station is located on the river (Abu Ju’), which supplies Bahr al-Najaf with water through the Euphrates, starting from the Al-Hirah region.
- The south of the Najaf Sea is supplied with drainage water that is carried by three taps, which are (the national drainage - the right trunks Abu - the left Abu Trunks).
- Large quantities of torrential water flow into the Najaf Sea that are carried by the valleys to the west and southwest during the rainy seasons.
- The lands adjacent to the Najaf Sea from the northern and western sides are sebakh lands, except for the lands on which the city of light was built in 2012, with 15,000 housing units, and the increase in the water level of the region posed a great threat to this city.
- From the southwestern side, the Najaf Sea is bordered by gypsum lands and sandy lands, which are a natural extension of the Najaf Badia region.
- Agricultural lands extend over vast areas to the east and southeast of the Sea region, and the people of these areas have started to make earth payments to avoid the risk of rising water levels and the sinking of their farms.
- Within the southern regions of the sea, some brick factories and the manufacture of building materials are spread, and it has been noticed that these areas are submerged in water during the last three years.

- Increasing the water level in the Najaf Sea, negatively affecting the overland pilgrimage route, which is a vital artery for transport movement inside and outside the governorate. At the governorate level, flights between Najaf city center and the cities and villages in the west of the governorate (Najaf governorate) have been affected. As for trips outside the governorate, they were also negatively affected by the fact that this road represents a crossing for many cities within the governorates of the central Euphrates region (Diwaniyah, Kut, Samawah, Karbala, Hilla).
- Among the important areas that were flooded as a result of the increase in the water level are the areas adjacent to the strategic line (the main oil pipeline and its annexes). There is no doubt that this will negatively affect the production, distribution and export of oil, which is considered harmful to the national economy and wealth.
- The vegetation cover is mainly distributed within the lands east of the Euphrates River, where the soils of this region are characterized by their fertility, due to the fact that they are mixed soils (mud and sand). In general, there is a state of stability in vegetation areas, being somewhat far from the Bahr al-Najaf depression.

- As for the built areas, most of them are concentrated to the east of the Najaf Sea depression, which greatly reduced the risk of flooding in the event of an increase in water levels in the Najaf Sea, with the exception of some areas (the residential city of Al-Noor, which was established in 2012) to the west of the sea (Bahr al-Najaf) it is at risk of flooding in the event of high-water levels.

- With regard to the future planning of the land uses within the study area, it was noticed that there is a lack of coordination and a conflict of visions between the concerned authorities. The Ministry of Water Resources prefers to go towards projects that promise the Najaf Sea to be an evaporative lake and a source of environmental balance. This trend reinforces the vision of the Ministry of Environment, which prefers to consider the Najaf Sea depression as a natural reserve due to the availability of biological diversity within the region. The municipality prepares to implement housing complex projects there. As for the Najaf Investment Commission, and within the same region, it has granted many investment opportunities to agricultural projects of hundreds of dunams, and industrial ones to establish factories for bricks and building materials, which negatively affects the environment of the region and greatly increases the rates of pollution in it.

### Table 3. The confusion matrix as accuracy assessment for the classification process.

| Class       | 2016 Year | 2017 Year | 2018 Year | 2019 Year |
|-------------|-----------|-----------|-----------|-----------|
|             | Sum of Diagonal Entries | Total Observation | PERCENTAGE CORRECT | Sum of Diagonal Entries | Total Observation | PERCENTAGE CORRECT | Sum of Diagonal Entries | Total Observation | PERCENTAGE CORRECT |
| Water Bodies| 33        | 34        | 36        | 41        |
| Agricultural Land | 5       | 6        | 3         | 62        |
| Built Up Area | 3       | 2       | 4         | 2         |
| Barren Land | 20       | 24       | 22        | 1        |
| Soil-Sandy | 2        | 1        | 1         | 4         |
| Soil-Gypsum | 1        | 5        | 1         | 4         |
| Total       | 43       | 43       | 43        | 43        |
### Table 1: Land Use Classification

|          | Land Use Categories | 2020 Year |  |  |  |  |  |  | Total Observation | PERCENTAGE CORRECT |
|----------|--------------------|-----------|---|---|---|---|---|---|------------------|-------------------|
| Built Up | 6                  | 5         | 25 | 2 | 1 | 29 | 31 | 21 | 58               | 89.72             |
| Barren   |                    |           | 20 | 21 |   |    |    |    | 253              |                   |
| Soil-Sandy |                 |           |    |    |    |    |    |    | 58               | 93.28             |
| Soil-Gypsum |               |           |    |    |    |    |    |    | 253              |                   |

**Figure 4.** The classification map using the maximum likelihood classification method on Sentinel-2 image.
6. Conclusions
The study concluded the following:
- The rise in water levels in the Bahar-Al-Najaf has led to the flooding of many lands with water, as the areas of flooded lands increased in 2020 to about 50% than they were in 2016. As some lands near the main water body of Bahar-ALNajaf were submerged with water, which was used for various purposes such as: roads, brick factories, clay soil, and the water came very close to some residential complexes within the region, which makes it imperative for the concerned authorities to move quickly to ward off potential future floods.
- The movement of urban growth in the study area is very slow, and this is evident from the indicator of the change in the areas of constructed areas, as the year 2020 witnessed a very slight increase (only 2%) than it was in 2016.
- With regard to the change in the areas of cultivated areas, we can distinguish three periods, the period of little agricultural production, and it may be represented by the year 2018, in which the cultivated areas did not exceed more than 192 km². And the period of average agricultural production (for the years 2016 and 2017), where the cultivated areas were 150% higher than they were in 2018. Finally, the period of abundant agricultural production was represented in the years 2019 and 2020, as the areas of agricultural land increased by 276% over what they were in 2018, and this is due to the policy of reducing the agricultural plan for the year 2018, as this year witnessed a scarcity of water due to the lack of rain.
- The accuracy of the classification process depended on the accuracy and timeliness of the training samples, as it reached 93% for the year 2020, because these samples were collected within this year, while it decreased dramatically to the limits of 76% for the year 2018 due to the significant decline in vegetation cover in this year.
- The sandy soil areas and the gypsum soil areas were not significantly affected during the four years (2016-2020), due to their being relatively far from the Najaf sea, in addition to their high ground levels.
- Due to the fact that the type of clay soils is close and sometimes adjacent to the Najaf sea, parts of these land have been submerged in water during the two years (2019 and 2020).
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