Using the integration of GIS and RS in the initial selection of the site for the construction of the new Al Diwaniyah city and its alternatives in Iraq

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Abstract. Sustainable development has the highest priority in all parts of the world and developing countries, and one of the most important issues in the field of urban planning is the correct and proper planning for urban expansion and the establishment of new cities and the correct use of land use in these cities and obtaining the best sustainable situation. As Al Diwaniyah Governorate in Iraq suffers from a severe shortage of urban and residential areas, with a significant increase in random growth and encroachment on other lands. From this logic, the integration of both remote sensing (RS) and geographic information systems data and the overlap of these programs between them and the production of analyzes, images and results in this work was made to propose a new city in the Al Diwaniyah governorate for the governorate center with an area of 129 km2. Where more than one area has been studied according to criteria, the most important of which is the lack of transgressions and encroachments in the proposed area and taking into consideration not to overtake agricultural areas, as Al Diwaniyah Governorate is one of the agricultural governorates and it was important to choose areas with the least vegetation cover, and through geographic information systems, an area was chosen Northeast of the old city, with an area of 49 km2, which represents 38% of the area of the old city. And use vegetation indicators to map and define vegetation cover and cultivated land versus urban and barren areas. This indicator is the Normalized difference vegetation index (NDVI), The results obtained indicated that the area of the proposed area is 49 km2 and about 5 km2 of green and cultivated lands are 10.2% of the total area of the proposed area. The size of the proposed area, which constitutes a suitable and good proportion for a new city.

Key Word: Geographic Information System (GIS), Remote Sensing (RS), Normalized Difference Vegetation Index (NDVI).

1. Introduction

In the twenty-first century, one of the most important concepts is sustainable development and its concept. Where he was a successful model for society, the environment and the economy, and a wonderful philosophy that could be emulated, as it found and created the decision-making process and guides the principles of the future and the diversity of the global environment. The concept of sustainable development has been widely used in economics, planning, biology and other fields. It
wants all works and efforts to achieve sustainable development and to establish a balance between the environment, the economy and society [1]. Humanity can achieve even a small part of any sustainable development in order to ensure that all the needs of the present are met without compromising the needs of the future [2]. Geographic information systems are systems that mainly depend on the system of remote sensing, drawing and creating maps, i.e., mainly on geography. Where it is possible to manage any calculation and analyze the information and display the data on the surface of the lands to be worked on, and it is also possible later to number and visualize all the information extracted [3]. Land use appropriateness assessment in land use planning is an important mental work. Determining and evaluating the suitability of lands for various uses and urban and urban planning is a new technique that has been used by geographic information systems. As these technologies provide fast and accurate results of sensor systems and their applications as well as their quantitative analyzes, as well as the availability of new and distinct technology to determine the suitability of land use and evaluate it comprehensively and accurately [4].

The combination of geographic information has been applied in land use suitability analysis in a variety of situations that include environmental approaches to determining land suitability [5]. RS-GIS integration can facilitate extended inventories, greater analytical flexibility, rapid database updating, and broader potential applications [6]. The integration of the geographic information system is the main advantage of the integration of thematic information derived from satellite data and other side data, such as economic, social, and cultural data, etc., which are important factors in all district management practices [7]. Remote sensing satellite data are widely used to analyze changes in vegetation cover. It can provide more accurate information within a short period of time. Several studies using satellite data have proven effective in understanding different processes [8]. Based on the previous studies, the integration of geographic information system and remote sensing will be used to determine the best areas that can be used in creating and nominating a large city to be an alternative to the old city of Al Diwaniyah, in terms of the lack of vegetation cover as well as the presence of the least possible. Where previous studies have shown us the importance of these processes and analyzes in finding the most accurate and successful ways to complete studies and special research in preparing designs and expanding cities, knowing the density of vegetation cover and concluding and knowing all the determinants and obstacles that prevent reaching the best results.

2. Area of Study and Data

2.1 Area and location

The study area is the city of Al Diwaniyah, the center of the province of Al Diwaniyah. It is located in the central region of Iraq, as shown in Figure 1, about 180 km south of the Iraqi capital Baghdad and 320 km north of the richest city and the owner of the oil wells, the city of Basra. The city of Al Diwaniyah is located between latitude - 32.5 degrees to the north and longitude - 44.5 degrees - 46 degrees to the east, and the total area of the city is 129 km², and the number of inhabitants is approximately 534 people in 2019, and that the temperatures in the city are often Maximum temperature is between 46-26 degrees Celsius and the minimum is between 3-20 degrees Celsius. The coldest month is January, and the warmest month is August. The average annual rainfall is approximately 105 mm [9]. Geologically, the governorate consists of the alluvial plain, as well as some depressions, lands, sandy desert, and the western plateau, as well as containing a large marsh, which is the Delmaj Hill [10]. The sedimentary plain forms the proportion of the governorate (about 76%), followed by the depressions (about 16%).
3. Methodology

3.1 Approved criteria for selection the new Al Diwaniyah city

The selection of the appropriate site for the proposed new city of Al Diwaniyah It was supposed to ensure the greatest benefit and the lowest cost in any area, by following some steps in analyzing all the general overlap, based on ARCGIS 10.5 Spatial Analyzer and the ENVI software program:

1. Defining and drawing the area with the least urban overrun
   
   A- The area of agricultural lands and orchards should be as little as possible.
   B- Easy access to the main road network in the city.
   C- How far away from the old city center
   D- The association of new areas with the old urban area.
   E- Presence and availability of water resources.

Figure 1. The study area and its location in Iraq.
3.1.1 Aim and objectives methodology

Areas with vegetation cover, areas without vegetation cover (arid), areas with urban overruns, are calculated and the percentage of vegetation cover and land area chosen for the establishment of the new city are calculated and whether it will be proposed from scratch or the development of the old city, based on the existing results that will determine and finally, choosing the new city of Al Diwaniyah, its area and its borders.

The infographic illustrates the application methodology as shown in Figure 2. Where the steps below are followed:

1. Downloading the aerial Satellite image through the site of the US Survey Authority, a Layer Stacking for the image is done through the ERADAS program.
2. A set of corrections for the image is made to obtain more accurate results and be highly reliable and the most important of these corrections (Radiometric corrections - Atmospheric corrections - Geometric correction) and after that made Image subset for the entire city, the areas that are not desired are shortened.
3. Conducting the Normalized Difference Vegetation Index (NDVI) analysis, which determines the most important areas of vegetation cover and vegetation density through the ENVI program.
4. Through the GIS program, the analysis in point (3) is used to calculate the details of agricultural areas and vegetation density, as well as the percentage of their presence in the selected areas.
5. A set of points is made and defined to find out the accuracy of the results of knowing the vegetation cover and depending on the percentage of vegetation cover and the accuracy of the analysis, the new city is chosen as its proposal to make its urban design plans, which was called the city of New Al Diwaniyah.
Figure 2. The Applied Methodology.

3.2. Data of remote sensing

The study area was relied on by obtaining an image from Landsat (tracks 168 and 167, row 38). The dates for obtaining the image were as in the shown Table 1 and in order No. (1). For the purpose of studying any spatial and temporal changes in agricultural lands, the above image was used for Al Diwaniyah Governorate for the year 2020. It was obtained by downloading from the USGS website: http://earthexplorer.usgs.gov/. Also, the month of October was determined to take the Satellite image in order to obtain the maximum potential vegetation cover and the area to be free of clouds.
Table 1. The time period during which Landsat images was taken.

| Sensor Type           | Acquisition Date |
|-----------------------|------------------|
| Landsat 8 (OLI-TIRS)  | 27/10/2020       |

3.3. Geographic information system data

An important means of obtaining data is geographic information systems, as they play a vital role in assessing the appropriateness of land use. In this study, land use, urban distribution, and by making use of satellite images, it is possible to obtain and extract the environmental elements and the analysis of the satellite images, including:

Satellite images in Al Diwaniyah, obtained in 2020, for the regional investigation of the entire city of Al Diwaniyah.

3.3.1 Maps

Various thematic maps covering the city of Al Diwaniyah were collected at various scales from the relevant departments and organizations. It includes the following:

1) Topographic maps at scale of 1: 500,000
2) The map of the reserves and the borders of the old city were obtained from the municipality of Al Diwaniyah
3) The Master Plan for the city of Al Diwaniyah for the year 2011-2033 of the municipality of Al Diwaniyah.

The maps that were obtained and corrected were locally scanned by the GIS program with the highest possible accuracy and used as a geographical database for the possibility of further analyzes in the future.

3.4. Digital image processing

3.4.1. Atmospheric and radiological corrections

For correcting the Landsat image from the air, the method of subtracting opaque objects was used in the ENVI program. This is for the purpose of reducing atmospheric interference such as dust and fog. In this method, the images were also corrected, and the digital rate of each pixel was converted into a reflection based on the known data associated with each image. The images were then combined to form a single integrated image using the graphic matching process and reconfiguring this image with a resolution of 30 meters per pixel. False color composite (FCC) is shown for the above images as in Figure 3.
Figure 3. Landsat images that have been downloaded and processed for the year 2020 showing False Color Composite (FCC).

3.4.2. Georeferencing image

The studied images had to be corrected to obtain very high-resolution results, and this was done by using 20 ground control points (GCPs). The error rate was very low, only 0.8 pixels. The image was projected with the same projection adopted in the image downloaded to the city of Al-Al Diwaniyah, which is the projection (UTM, Area 38N, Datum WGS (1984), with a resolution of 30 meters for the pixels, as indicated in Figure 4.
3.4.3. Indications for the status are spectral.

To assess and know all the plant changes, lands, and agricultural areas of Al Diwaniyah city center, one botanical index was relied on for this work. This index was the Normalized Difference Vegetation Index (NDVI). This indicator is used for the purpose of obtaining all the amounts and concentrations of green vegetation around the world and analyzing biomass and potency. It differs greatly in the near infrared and red ranges. Where the interpretation of this process is through the absorption of the visible spectrum by plants and reflects the spectrum of infrared radiation, especially near it. On the other
hand, these green plants reflect more visible light and infrared light less. This spectral reversal depends on the chlorophyll pigments in plant leaves, which are mainly responsible for making food for plants. In this paper, we would like to show that NDVI is calculated based on the equation below [11]:

\[
NDVI = \frac{(\text{NIR} - \text{Red})}{(\text{NIR} + \text{Red})}
\]  

(1)

Where, NIR is the near-infrared reflection of the spectrum and red is the reflection in the red part of the spectrum. NDVI values range between -1.0 and +1.0, where positive values refer to vital vegetation on the surface of the land, values close to zero or negative values indicate bare lands and devoid of vegetation cover.

Where the NDVI indicator is very prominent and effective in soils with dense vegetation cover more than 30% [12–14]. With the presentation, we excluded areas that represent water (algae and others) and sabkhas from this study to prevent them from affecting the results, and it was assigned a value of zero. The NDVI index was applied to the reflection image mosaic 2020. The obtained images were classified into binary categories based on the threshold value separating the areas with vegetation, green density, and areas without vegetation. Image processing technologies have been implemented with Envi 5.1, and ArcGIS Desktop 10.5 software programs.

3.4.4. Knowledge of changes in green areas (agricultural lands)

for Knowledge of changes in green areas (agricultural lands) were create simply by subtracting a binary Satellite image (NDVI) 2020. We have two types of change, namely:

1. Agriculture in the proposed city.
2. Arid, barren and non-agricultural lands (barren or urban)

The aim of the application was to reveal the area and amount of vegetation cover in the areas that are selected and nominated to be a new expansion city for the old city of Al Diwaniyah.

4. Result and Discussion

4.1. Spatial distribution of areas with dense vegetation and areas without vegetation cover (barren) in Al-Al Diwaniyah Governorate.

4.1.1. Special spatial distribution based on NDVI index:

When choosing and drawing the proposed new cities for the city of Al Diwaniyah, the comparison was made between two cities, the first is in the northwest of the city of Al Diwaniyah and with an area of 49 km², adjacent to the old city of Al Diwaniyah and linked to a good road network and is surrounded on the east and south by the Al Diwaniyah River, represents an area of approximately 38% of the city’s area the old one, which is 129 km². The second is in the southwest of the city of Al Diwaniyah, with an area of 28 km². It is connected to a good road network and is located on a secondary river called the Shafi‘i River. As shown in Figure 5 and Table 2.
Figure 5. Location map of new Al Diwaniyah city.

Table 2. Features and characteristics of the proposed cities.

| Propose cities | Propose city 1 | Propose city 2 |
|----------------|----------------|----------------|
| Area           | 49 km²         | 28 km²         |
| The percentage of vegetation cover | 10.2% | 23.7% |
| The percentage of existing urbanization | 4.8% | 8.9% |
| Other obstacles exist | none | A large line to transmit high electrical power |

Based on what we obtained above, the first city proposal was adopted because it contains a lower percentage of vegetation cover, as well as a lower old urbanization rate, and the total area for it is greater and does not contain any other obstacles as shown in Figure 6.
Figure 6. Location map of proposed Al Diwaniyah city.

Special spatial distribution of green areas in Al Diwaniyah Governorate based on the NDVI index in 2020 is represented in Figure 8 and Figure 7. Estimated agricultural lands were about 5 km$^2$ respectively and their percentages were about 10.2%. On the other hand, non-agricultural lands (Barren) were about 44 km$^2$ and their percentages were about 89.8%. These results indicate that the percentage of agricultural areas in the proposed city is very small. It is possible to use areas of intensive agriculture as green areas or picnic parks and others when preparing the basic and urban design of the city.
Figure 7. Agricultural lands and their percentage in Al Diwaniyah new city in 2020 based on the NDVI index.

Figure 8. Special spatial distribution of densely green lands versus low- or low-density green (barren) lands in the city of New Al Diwaniyah based on the NDVI index for the year 2020.
5. Conclusion

It can be concluded that both geographic information systems and remote sensing data can play an important role in proposing and finding new cities and studying and monitoring changes in land cover. It can provide more accurate information, less cost and time.

The proposed new city was one of the best areas in the vicinity of the old city of Al Diwaniyah, which is connected by a road network with the old city and has a good area relative to the area of the old city and is surrounded by the Al Diwaniyah Bahr on two sides. And the knowledge of agricultural areas is neglected in relation to barren and non-agricultural areas.

New large areas for housing may be proposed or new cities may be found in Al Diwaniyah Governorate, based on their proximity to old cities, their connection to road networks, and the availability of water and rivers.

This city was chosen after several areas were studied through its proximity or distance to the old city, as well as its connection to a good road network, in addition to the density of vegetation and urban encroachments, and all these matters had the largest role in choosing the new city.

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