Planning Indicators for Prospective Expansion Urban Areas in Mosul City Using (GIS)

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Abstract
This study aims to examine the potential for urban expansion in Mosul and surrounding areas, based on geological and topographic factors. It identifies planning indicators, such as geological deposits and topography, that affect sound planning and decision-making. These issues are addressed by considering a master plan developed by the SCET French consulting company in the 1970s.

The study sets forth a method for identifying potential expansion areas for residential and other purposes. It uses few geographic information systems (GIS) tools. After extracting the results from the data, analysis will be performed to determine planning directions to ensure that each of the potential expansion areas has a suitable land use. The data will be made available to decision makers who will draft a new base plan for Mosul in 2030.

Keywords: Urban expansion, residential, master plan, land use, GIS

INTRODUCTION
Urban planning:
Urbanization, the process of moving from a rural to an urban lifestyle, has become a reality across the world. A major portion of people now live in cities [1, 2]. This is causing a number of problems for the world's ecosystem because it is affecting the echo system and posing major socio-economic challenges.

Mosul is one of Iraq's principal cities and the capital of the northern Iraqi Governorate of Nineveh. It is located in the center-north part of Iraq, on the banks of the Tigris River. The city has a population of approximately 2 million people and is famous for its historic landmarks, tourist attractions and recreational opportunities as well as religious sites. Mosul consists of two parts: a right bank and a left bank separated by the Tigris River. The right bank's 91 neighborhoods are located west of the river while the left bank's 160 neighborhoods are located east of it. Generally, services in the left bank are better than those in the right bank; however, this trend has been changing over recent years due to increased urbanization on both sides of the river [3].

In 1972 and 1973, the Iraqi company Dar Al-Imara and the French consulting firm S.C.E.T International created the first master plan for the city of Mosul [4]. This plan divided the city into various land-use zones and indicated where urban growth will take place up to 2000. The update of the master plan was postponed despite the significant population expansion and informal city growth because of the unsteady political climate and the international sanctions placed on Iraq (1990–2003). The city's master plan was updated in December 2008 using funding provided by the Iraqi government, and a new master plan was created to oversee city expansion until the year 2030. The new master plan should have expanded on the existing one in compliance with the Iraqi Municipalities Management Law (No. 165 of 1964).

A brief history of urban change:
After 1914 and up until year 2000, changes have been made to the city's plans for contemporary Mosul. The city underwent a few morphological stages of urban development, which shaped the city's planned turning points. Figure (1). In accordance with the basic architectural principles, new residential suburbs were created in the areas between the main street corridors. The master plan's implementation produced a spatial pattern that may be referred to as the "planned pattern". Under the influence of the very flexible car movements in all directions and the lack of restrictions on the spatial expansion on the main axes, the new suburbs that were separated from the main streets were combined.
In the period of the economic embargo on Iraq (1990-2003), the government’s decisions to transform designated spaces like gardens, parks, public buildings, and markets, toward residential use. It leads to the growth of unauthorized and unplanned businesses, especially in residential areas. They lack detailed planning regulations, and multiple public routes have been converted from residential to commercial streets. [5]

In order to accommodate the demand for housing units, local planners in Mosul converted a number of land uses that were designated as parks, green areas, stadiums, or government administrative buildings to residential usage. Lands close to the state-owned master plan have also been integrated. Due to the loss of open and green spaces in many neighborhoods, the proportions of these uses have decreased. An uneven ratio of developed to open space is a result of this condition’s effects. Additionally, there has been a rise in population density and the development of congestion, which strains the availability of basic services including water, power, retail, healthcare, and elementary and secondary education.

Land use in the city has changed as a result of the deteriorated security conditions that the city was subjected to after the 2003 events, which were characterized by terrorism attacks and forceful displacement into and out of the city. The following aspects of this shift are crucial [6].

1- As a result of gun attacks in the city, main streets were closed to vehicular traffic. There was difficulties of traffic access due to the large number of security checkpoints, which contributed to prolonged journeys and the danger of moving towards the city center, many owners of commercial, service, and craft shops have abandoned their commercial centers in the city center and transfer into residential neighborhoods.

2- The industrial zones on the right and left sides of the city have become hot combat zones. This has led industrial workshop owners regardless of their professional activity to move to the outskirts of the city.

3- In the absence of law, violations have occurred in open areas such as gardens, playgrounds and vacant land and have been exploited for various purposes.

4- Increased population density and higher prices of real estate and rents for various uses due to the reduced supply of suitable land.

Despite of all these adverse effects resulting from the large percentage of job units moving from the city center to residential areas, a balance was observed in the distribution of the functional units that were stationed in the city center and dispersed towards the suburbs. Newly created service centers were nearly complete, but they lacked the planning bases. Mixed uses also appeared within residential areas combining residential, commercial, service, and craft use, thus reducing the volume of trips that took long times to reach old centers and industrial areas. See Figure (2).
The role of GIS:
GIS manages spatial data consisting of raster, vector, and descriptive information and stores it in layers. New maps can be prepared out of these processes. In the case of city planning, all information with an impact on basic design could be included as factors in shaping the results. The final planning decisions are discussed and adjusted depending on the situation in each urban society being studied. GIS provides planners powerful tools to make better decisions through query and visualization of geographic information [7, 8]. In this study, the Idrisi GIS software is used in analyzing data and interpreting results [9, 10].

Remote sensing data is commonly used in this context. The most authoritative sources in this field are space imagery of various types, which can provide experts with information about the topography of the Earth's surface and the classification of land cover and its areas, which in turn can be added as an additional component of GIS.

In this context, GIS employs a variety of mathematical and logical operations both within and across layers to generate meaningful findings and create maps that meet the relevant requirements. Because it enables the user to specify levels of priority that vary based on many criteria, weighting layers is an important step in GIS analysis. This study employs GIS principles to build a framework in a way that can support the decision-making process because its primary goal is to identify prospective regions for the city's future expansion.

Based on the aforementioned, we observe significant departures from the plan brought on by the uncertain conditions in Iraq. The inefficacy of the processes for putting the ideas, conceptions, and guiding principles of the original designs into practice, as well as the city's submission to the influence of ill-considered policies.

Since land is a natural resource that was not created by humans, it cannot be replaced by other resources [11]. In order to make sound planning decisions for the potential expansion trends of urban areas leading to the new master plan goal of 2030, this study addressed additional land planning indicators, geological and topographic factors, and patterns of the various land uses (agricultural, industrial, forestry, etc.).

This study is expected to offer prospective directions for each location, along with benefits, drawbacks, and potential hurdles. These include the economic implications stating that some places are not suited for cultivation or reclamation and the validity of the placement of the green belts. The abovementioned belt is unable to shield the city from the south and southwest, which is where the sandstorms from the nearby deserts originate.

The study is based on the most recent planning efforts for the Mosul Master Plan in 2030. The research problem is founded on the fact that each region proposed for urban expansion has different advantages and potentialities, and that each place also has constraints, challenges, and constraints present. The examination of whether certain

Figure 2. Land use map of Mosul city in 2016 [3].
lands and places are suitable for expansion, whether residential, industrial, or other, is influenced by topographical, geological, and agricultural variables. The study is likely to yield findings that will help decision-makers decide on potential expansion trends and zones for urban land use, as well as whether or not they are appropriate for each region.

STUDY AREA, MATERIALS AND DATA ANALYSIS
Mosul city and its neighboring rural outskirts make up the research area. The majority of the information used in this study is acquired from the creation of digital maps that are GIS-ready and derived from relevant sources or from space-based data. To find construct knowledge that are considered as indications, these data are analyzed. To reflect actual reality on the ground, these findings are reviewed and modified.

Using data from the Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER), we created a digital elevation model (DEM) with a 30 m resolution. The city's slope layer was therefore created. Moreover, city authorities provided vector data for the main roadways and waterways in the study region.

Topography, Geology and Agriculture:
Preliminary surveys showed that there are two areas of very steep and rough topography, the most in the south of Mosul, adjacent to the river, heading towards the area of Hammam Al-Alil (the old road) heading west. The second area is located north of the city and sandwiched between the Arabi neighborhood and the village of Sada and Bawiza, and stretching to the Telkef-Faida road junction. Apart from these two regions, the rest of areas have a smoother slope and contour lines are regularly graded with an acceptable slope. As shown in figures (3, 4)

![Figure 3. (a) DEM, and (b) slope map of Mosul city, brighter is steeper.](image)

![Figure 4. Distance map (in pixels) to water bodies prepared from GIS functions.](image)

The geology is based on the type of soil prevalent in the candidate area for expansion. The soil is either a sandy soil, or a rocky land, in this case it is mostly a sedimentary rocky land (limestone or sand). It is believed that the sand or soil land is more economical for residential use than rocks. It is also more suitable for providing land for gardens, plants, trees, and forests at economic cost if it is selected by the city planner. The cost increases in the rocky land. In any case, determining the suitability of the land occupied by geological determinants to the nature of the geological parameters is dealt with in order to achieve the objectives of the planner.

Since there are uncultivated land, which can be reclaimed for agricultural purposes, it is important to know whether it is part of an irrigation project in the province. This is happening today on the outskirts of the city of Mosul,
where Aljazeera irrigation project is under construction. Figure (5).

Figure 5. Areas covered by Aljazeera irrigation project.

Defining candidate expansion zones:
As per the aforementioned rationale, the classification elements of the candidate expansion regions out of the territories surrounding Mosul's city limits determine the specific considerations for choosing expansion areas for residential or other uses. These factors are:

1- Topography is demonstrated by determining the slope and ruggedness of the land surface.
2- The geological nature of each region (earth, sand, rock...)
3- Current land use classification of the neighbor urban area.
4- Land ownership factor.

Figure 6. The eight expansion zones surrounding the existing city.

Eight potential expansion zones were recommended based on our research as well as on awareness of the city, as shown in Figure (6). Based on the aforementioned variables, each zone has a dominant land use. Each zone is more likely to imitate the land use of the nearby area of the city, which is a key concept here.

CONCLUSIONS AND RECOMMENDATIONS
In this research, we devise a methodology for predicting the spatial extension of the Iraqi city of Mosul. In order to introduce expert perspectives for selecting the potential causes of urban expansion in the area, we blended data from multiple sources and GIS techniques. The study put an attempt to identify and anticipate the future expansion tendencies up to 2030 based on the past and existing land uses.

In this work we conclude the following landmarks.

- To renew the master plan for the city of Mosul, define the features, benefits, and drawbacks of the districts that are candidates for the growth prospects. This will allow the decision-maker to choose the best expansion paths for residential or commercial use, green belts, or industrial zones as needed.

- Due to the high cost of building housing units and excavating the foundations for the buildings, the expansion of housing is more cost-effective in agricultural or fertile terrain than in rocky lands [5].

- The best sites for industrial use should ideally be on non-agricultural terrain.

Our paper shows a considerable addition by combining the factors distance to road, distance to CBD, distance to water bodies, slope, and elevation to analyze changes in land uses brought on by fast urbanization. As it outlines the causes and trends of urban growth, its output can be utilized to enhance land use management and city planning. To determine the function of other urban agents and investigate the non-quantitative and non-spatial controlling mechanisms of land-use changes, more research is required.

REFERENCES


