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RESEARCH ARTICLE

Identifying the Best Suitable Places for Urban Agriculture in Baghdad City: "Abu Ghraib District," as a Case Study

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ABSTRACT

Urban agriculture plays an important role in planning sustainable cities through maintaining environmental, economic, and social balance within cities. This is achieved by employing geographic information systems (GIS) in determining the selection of the best agricultural area and the most suitable for urban agriculture in cities, as well as determining the decline of agricultural areas and green lands that have a negative impact on the urban environment, biodiversity, and natural life within cities. Because urban agriculture is one of the most important elements that limit the deterioration of agricultural lands resulting from climate change, the human factor (salinity problem, land erosion, poor management of soil and natural resources of the land). The research aims to choose the best agricultural areas that are most suitable for urban agriculture in Baghdad city according to its requirements related to climate change, soil characteristics, and human resources through using geographical information systems (GIS).

The general research methodology used the descriptive and analytical approach of the data of soil surveys approved by the Ministry of Water Resources and the National Center for Research and Development (Soil Department). The research employs GIS after obtaining satellite visualizations and soil samples of the study area, then evaluating the lands and extracting maps of their suitability for some crops and horticultural plants, in addition to relying on the inductive descriptive approach to data (natural resources, crop requirements, and climate data) using GIS and the remote sensing program to determine spatial suitability for urban agriculture.

تحديد افضل الاماكن المناسبة لزراعة الحضرية لمدينة بغداد " قضاء ابو غريب" منطقة الدراسة

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يعد دور الزراعة الحضرية مهماً في تخطيط المدن المستدامة من خلال تحقيق التوازن البيئي والاقتصادي والاجتماعي داخل المدن عن طريق توظيف نظم

المعلومات الجغرافية في تحديد اختيار افضل مساحة زراعية واكثر ملائمة للزراعة الحضرية للمدن وكذلك تحديد انحسار المساحات الزراعية والمناطق الخضراء التي تكون انعكاس سلبي على البيئية الحضرية وعلى التنوع الحيائي والحياة الطبيعية داخل المدن , ولكون الزراعة الحضرية تعد احد من اهم العناصر التي تحد من تدهور الاراضي الزراعية الناتجة من سوء المناخ والعامل البشري (مشكلة الملوحة ,تجريف الارض , سو ءادارة التربة , يهدف البحث الى اختيار افضل المساحات والموارد الطبيعية للارض الزراعية التي تكون اكثر ملائمة للزراعة الحضرية لمدينة بغداد "قضاء ابو غريب " منطقة الدراسة وحسب متطلباتها المتعلقة بالمتغيرات المناخ وخصائص التربة والموارد البشرية باستعمال نظم المعلومات الجغرافية. بالاعتماد على المنهج الوصفي والتحليلي للبيانات الخاصة بمسوحات التربة المعتمدة من وزارة الموارد المائية والمركز الوطني للبحوث والتطوير / قسم وذلك باستخدام برنامج نظم معلومات جغرافية بعد الحصول على التربة) المرئيات الفضائية والعينات التربة الخاصة بمنطقة الدراسة ومن ثم تقييم للاراضي واستخراج خرائط ملائمتها لبعض المحاصيل والنباتات البستنية (الموارد وفضلاً عن ذلك الاعتماد على المنهج الوصفي الاستقرائي للبيانات الطبيعية ومتطلبات المحصول والبيانات المناخية) باستعمال نظم المعلومات الجغرافية وبرنامج التحسس النائي لتحديد الملائمة المكانية للزراعة الحضرية.

INTRODUCTION

The concept of urban agriculture began to emerge with the rapid urban expansion witnessed by most cities around the world and the increase in population growth and consumption of natural resources (1), especially agricultural lands and their decline, which led to an increase in interest in urban agriculture by urban residents, policy makers and planners (2).

Urban agriculture is considered important in the development of contemporary cities and has gained great importance recently because of its effective role in improving residents' conditions (3). It has begun to disappear in the cities for many reasons, including excessive urbanization, and the fact that many cities suffer from the decrease of green areas due to the pressures of different human activities (4).

Urban agriculture plays a vital role in most urban cities of the world in terms of achieving sustainability, food security, and self-sufficiency for those cities by meeting the needs of the population to provide goods and services directly or indirectly. In many cases(5), political and economic crises have stimulated both personal and urban food production, in addition to the possibility of overcoming the problems that arise from climate change and confronting them by increasing green areas within urban cities (6). It is worth noting that urban areas have potential for agricultural activities in terms of growing vegetables and fruits and raising poultry, although the concept of agricultural is still related to rural areas only (7).

THE CONCEPT OF URBAN AGRICULTURE

It is defined as an "industry" that does not only include the production of food and other products, whether growing plants or raising animals, but also includes their processing and distribution. In addition(8), it contributes to various services, such as the management of transportation and marketing services, non-agricultural services such as water storage(9), agricultural tourism, urban greening, and landscape management (10). Therefore, the concept of urban agriculture is much more complex to be given a basic definition.

There are different opinions concerning the spatial dimension of urban agriculture represented by the distinction between urban agriculture and peri-urban agriculture that surrounds the city (11).

The distinction between urban and rural areas is difficult and it depends on the local characteristics of each city; therefore, some countries have designed their spatial scope for urban agriculture according to national and local laws and characteristics (12). Urban agriculture has several forms, including those related to applied production, for example horticulture, including greenhouses, container planting, hydroponics, modern aeroponics, aquaculture, animal husbandry, and agroforestry (13).

Each location of agricultural activity can be managed differently depending on the model of organization, property rights, and active parties involved in the production process (14). Urban agriculture is the transformation of food production within urban cities that helps reduce pressure on existing agricultural land and increases the accessibility and availability of healthy foods, as well as it contributes to the urban landscape (15) In addition, it could provide a great contribution to both urban food security and urban employment and increase gross domestic production, as urban agriculture has made important contributions to feeding city residents while creating job opportunities for increasing numbers of the poor, and thus it can be a strategic tool to alleviate poverty in those areas (16).

Agricultural areas can be integrated with the urban structure to provide a variety of services, including infrastructure services, such as wastewater recycling and urban waste recycling (17), as well as reducing local air temperatures, improving air quality, treating soil, sequestering carbon, and enhancing biodiversity(18). In addition to its advantages in the social aspect that include creating an interactive space for urban residents to reconnect with their food diet, natural bodies, personal health improvement, relaxation feelings and well-being, and providing areas for community engagement and education (19).

The role of remote sensing and geographic information systems in classifying and evaluating lands suitable for urban agriculture. Urban agriculture plays an important role in sustainable development and the sustainability of natural resources. This study attempts to determine urban agriculture sites in terms of their suitability using geographic information systems and remote sensing (20). One of the most important characteristics and advantages of remote sensing is the detection of features and patterns of spatial relationships that are difficult to obtain directly from the surface of the Earth (21). The role of remote sensing is to monitor the Earth's surface via satellites without direct contact with the Earth's surface, in order to obtain information regarding the appearance of the Earth's surface and human activities, in addition to the possibility of following up on temporal variables and other field

It is worth mentioning that the applications of remote sensing have received great attention in geomorphological studies due to the fact that satellite images have high spatial resolutions, comprehensiveness, a wide range of spectrum, and temporal-frequencies' availability. They play a vital role in studying and scanning the Earth's surface, especially the geomorphological phenomena such as soil, vegetation cover, sand dunes, and other phenomena, in addition to studying human activities, such as urban areas and agricultural lands (cultivated and plowed) that can be monitored through remote sensing techniques (22).

It is worth mentioning that these phenomena have different spectral reflections, as they interact with the electromagnetic rays that are emitted from the sun, as these phenomena are characterized by specific spectral characteristics that can be distinguished by analysis and classification. Remote sensing technologies are of prominent importance in the field of collecting information on the Earth's natural and human resources on a comprehensive and regular bases due to their ability to discriminate the various types of land use and land cover Normalized Differences Vegetation Index (NDVI) and their ability to monitor the changes that occur in them while calculating their areas, in addition to other operations (. As for geographic information systems (GIS) programs, they are considered among the techniques that have proven their importance in (preserving, processing, analyzing, and updating) data and benefiting from it by integrating with other information and thus producing completely different results (outputs) that are useful for decision makers in making appropriate solutions Normalized Differences Vegetation Index (NDVI): The values of Normalized Differences Vegetation Index (NDVI) are calculated by using Arc GIS 10.3 program for satellite visuals, through the mathematical model [NDVI=band5-band4/ band5+band4] (23). The illustrative colors of the regions were adopted in the research, according to the table below.

MATERIALS AND WORK METHODS:

The evaluation process was conducted for urban agriculture lands in the study area, which are located in the central part of Iraq in Baghdad Governorate, Abu Ghraib District. Models were used within the (MS Excel) program and the Geographic Information Systems program (ArcGIS), in accordance with the methodology used by the (IAO), which was originally derived from the methodology of the Food and Agriculture Organization (FAO), which relies on the results of the analysis of environmental requirements and agricultural land management.

The results have indicated the process of evaluation of the suitability of lands for urban agriculture in the study are. It was found that they were suitable for producing a group of strategic crops selected by the researcher and according to the requirements of the research**.**

An assessment of the suitability of the selected crops was carried out based on matching the requirements of the selected crops with their requirements for land characteristics, where the climatic conditions were considered homogeneous and did not represent a determining factor for suitability. The assessment was conducted according to the methodology used by the (IAO), originally derived from the methodology of the Food and Agriculture Organization (FAO), which is based on the results of the analysis of environmental requirements and land management. In other words, assessing land suitability helps predict productivity according to land value.

The suitability of urban agriculture lands was classified numerically (Score) and descriptively into three categories: S1 class includes lands that are very suitable with the expectation of highest production. S2 class is moderately suitable because of some determinants, S3 class is marginally suitable due to the increase in previous determinants, N1 class is not suitable because there are current limitations that prevent the use of that land, where the lowest production is expected. N2 class is not suitable now and in the future due to the presence of critical limitations that cannot be overcome or repaired, such as the presence of stones, inappropriate textures in soils containing very high percentages of gypsum, as well as the main limiting factor in urban agriculture of the targeted crops is the soil salinity of the study area **.**

GEOGRAPHIC CHARACTERISTICS OF THE STUDY AREA

The location and climate of the study area**:**

•The study area is located in the central part of Iraq, Baghdad Governorate and its surrounding areas, and extends geographically within the following coordinates: (E°44.80 N°33.00 and E°44.00 N°33.75)**.**

•The irrigation system used in the study area is perfusion**.**

•The climate of the study area is dry and cold in winter and very hot in summer**.**

RESULT AND DISCUSSION

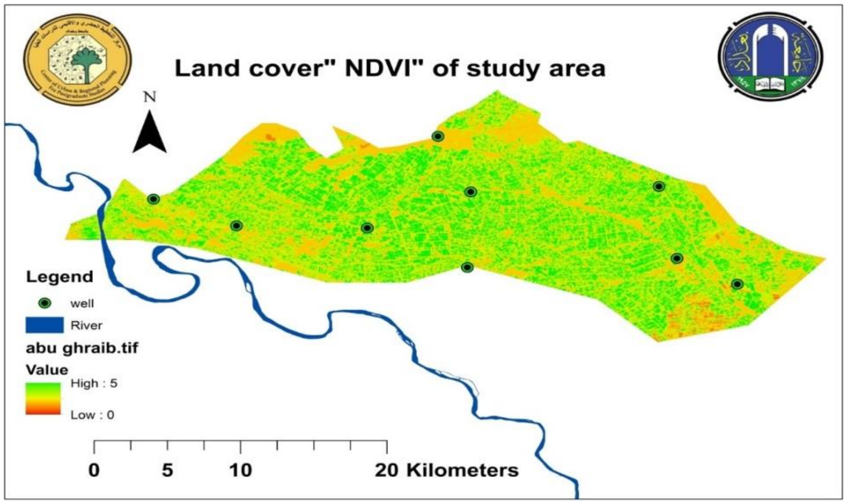

Figure 1: Shows the vegetation index of the study area using satellite images for the year 2020. Source (the researcher)

Suitability assessment of the strategic crop (tomato) in the study area:

Conducting a climate assessment of the study area:

The results of the climate assessment for the tomato crop production, according to the main growth stages, indicated that the final rating value was 85% at Baghdad station. The climatic factors used in the assessment were: the mean maximum and minimum temperatures during the crop's growth stages.

Table 1: Shows the climate assessment of tomato crop for urban agriculture of the study area. Source (Ministry of Agriculture/Meteorology Department)

Mean Temperature (Growing cycle)				**Class, degree of limitation and rating scale**						**Rating**			
ºC	0	40	60	85	95	100	95	85	60	40	0	0	99.65
	10	13	16	18	20	22	24	26	30	35	40	80	
22.14	0	0	0	0	0	99.65	0	0	0	0	0	0	
Mean Temperature (Germination)				Class, degree of limitation and rating scale						Rating			
ºC	0	40	60	85	95	100	95	85	60	40	0	0	92.9
	8	10	12	16	18	22	26	30	32	35	38	80	
17.58	0	0	0	92.9	0	0	0	0	0	0	0	0	
Mean Temperature (Yield Formation)				Class, degree of limitation and rating scale						Rating			

ºC	0	40	60	85	95	100	95	85	60	40	0	0	
	10	12	14	16	18	19	20	22	27	32	37	80	65.5
25.9	0	0	0	0	0	0	0	65.5	0	0	0	0	

Relative Humidity (Growing Cycle)			Class, degree of limitation and rating scale							Rating				
%	40	40	40	60	85	95	100	95	85	60	40	40	40	
	0	10	16	20	24	30	45	60	80	90	100	100	100	99.27
47.19	0	0	0	0	0	0	99.27	0	0	0	0	0	0	

Conducting the process of evaluating the suitability of the soil for the tomato crop:

The soil evaluation was based on eleven factors that were studied through chemical and physical analyses, in addition to a description of the study area, the main determining factor was identified as salinity, as well as adding calcium carbonate and the percentage of saturated bases. The dominant classes were N2 (Not permanently suitable) and S1 (the highly suitable), as shown in Chart (1) and map (2) below:

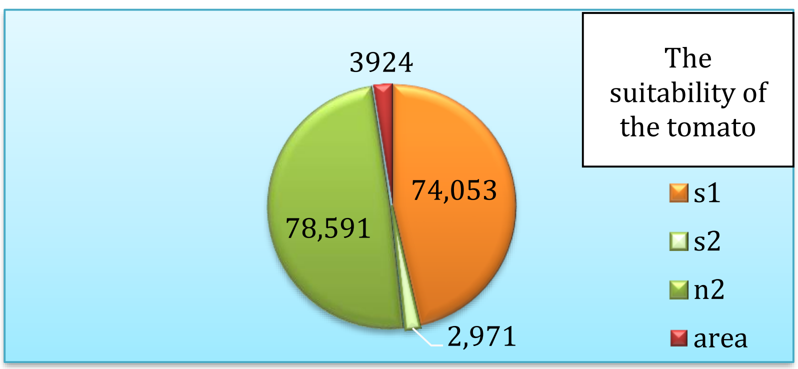

Chart 1: Shows the areas in hectares for the spatial suitability of the tomato crop

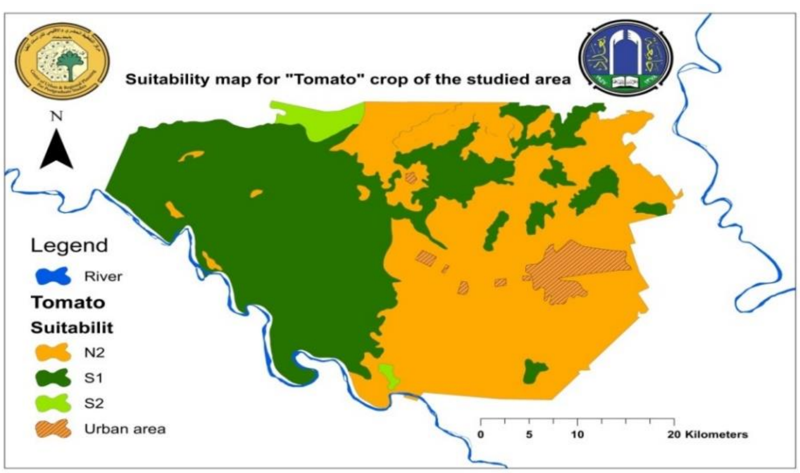

Figure 2: Shows the classification of the spatial suitability for the tomato crop. Source (the researcher).

Suitability assessment of the strategic (potato) crop in the study area:

Conducting a climate assessment of the study area:

The results of the climate evaluation for the potato crop production, according to the main growth stages, indicated that the final rating value was 98% at Baghdad station. The climatic factors used in the assessment were: the mean maximum and minimum temperatures during the crop's growth stages, as shown in Table (2) below.

Table 2: Shows the climate assessment of potato crop for urban agriculture of the study area. Source (Ministry of (Agriculture/Meteorology Department).

Mean Temperature				Class, degree of limitation and rating scale									Rating
ºC	0	40	60	85	95	100	95	85	60	40	0	0	
	6	8	10	13	16	18	20	24	27	30	33	80	
18.51	0	0	0	0	0	98.625	0	0	0	0	0	0	98.625

Conducting the process of evaluating the suitability of the soil for the study area:

The soil evaluation was based on eleven factors that were studied through chemical and physical analyses, in addition to a description of the study area, the main determining factor was identified as salinity, as well as calcium carbonate and the percentage of saturated bases. The dominant classes were N2 (Not permanently suitable) and (the moderately suitable) class (S2), as shown in Chart (2) and map (3) below:

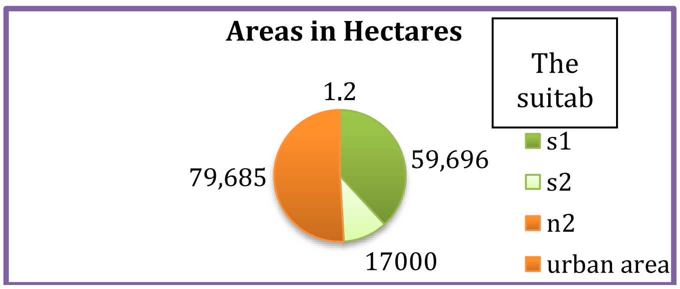

Chart 2: Shows the areas and the spatial suitability of the potato crop

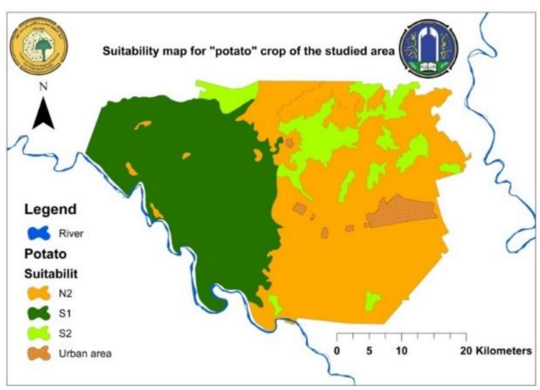

Figure 3: Shows the classification of the spatial suitability for the potato crop. Source (the researcher)

Suitability assessment of the strategic (onion) crop in the study area:

Conducting a climate assessment of the study area:

The results of the climate evaluation for the onion crop production, according to the main growth stages, indicated that the final rating value was 74% at Baghdad station. The climatic factors used in the assessment were: the mean maximum and minimum temperatures during the crop's growth stages, as shown in Table (3) below.

Table 3: Shows the climate assessment of onion crop for urban agriculture of the study area. Source (Ministry of Agriculture/Meteorology Department).

Mean Temperature (Growing cycle)					**Class, degree of limitation and rating scale**								**Rating**
ºC	0	40	60	85	95	100	95	85	60	40	0	0	98.55
	7	10	13	16	18	19	20	22	23	25	27	80	
Mean Temperature (Germination)					Class, degree of limitation and rating scale								Rating
ºC	0	40	60	85	95	100	95	85	60	40	0	0	50.06
	-1	2	5	10	15	18	20	25	30	35	40	80	
32.48	0	0	0	0	0	0	0	0	50.06	0	0	0	

Conducting the process of evaluating the suitability of the soil for the study area:

The soil evaluation was based on eleven factors that were studied through chemical and physical analyses, in addition to a description of the study area, the main determining factor was identified as salinity, as well as calcium carbonate and the percentage of saturated bases. The dominant classes were N2 (Not permanently suitable) and (the marginally suitable) class (S3), as shown in Chart (3) and maps (4) below:

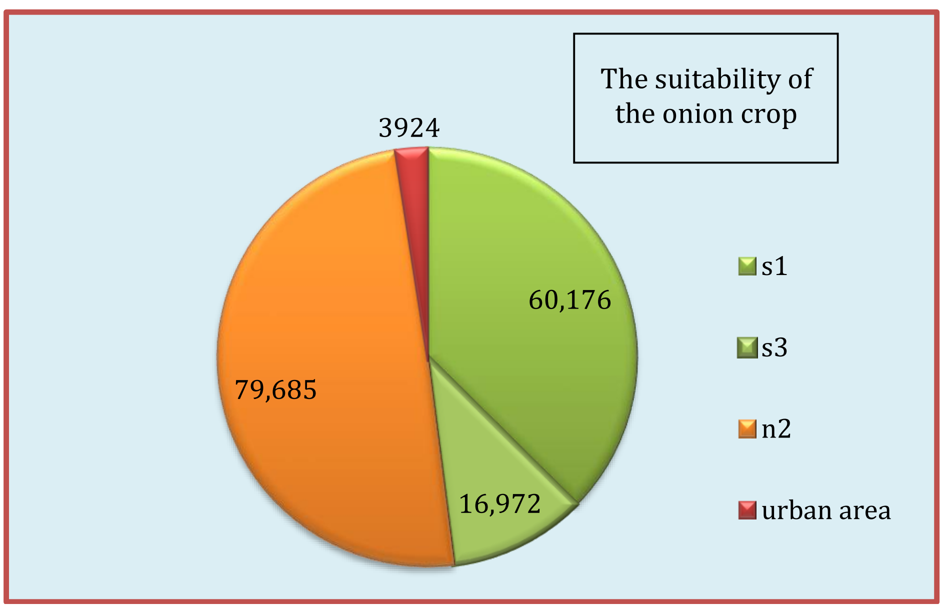

Chart 3: Shows the areas and the spatial suitability in hectares. Source (the researcher).

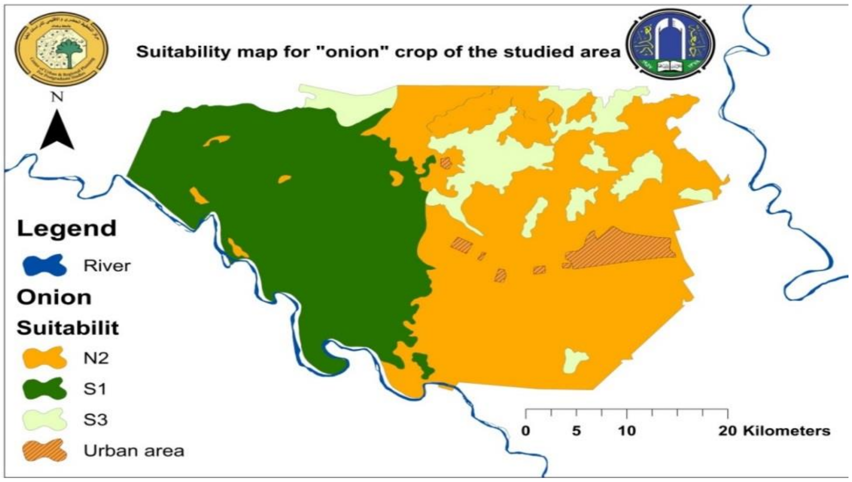

Figure 4: Shows the classification of the spatial suitability for the onion crop. Source (the researcher).

Suitability assessment of the strategic (maize) crop in the study area:

Conducting a climate assessment of the study area:

The results of the climate evaluation for the maize crop production, according to the main growth stages, indicated that the final rating value was 66% at Baghdad station. The climatic factors used in the assessment were: the mean maximum and minimum temperatures and relative humidity during the crop's growth stages, as shown in Table 4 below.

Table 4: Shows the climate assessment of the maize crop for urban agriculture of the study area. Source (Ministry of Agriculture/Meteorology Department).

MEAN Teamrature_Growingycle				**Class, degree of limitation and rating scale**						**Rating**			
ºC	0	40	60	85	95	100	95	85	60	40	0	0	75.55
	0	10	15	20	24	25	26	28	32	40	45	60	
18.11	0	0	75.55	0	0	0	0	0	0	0	0	0	
Relative humidity growing cycle (%)				Class, degree of limitation and rating scale						Rating			
%	40	60	85	95	100	95	85	60	40	0	0	0	95
	0	20	24	30	40	50	75	90	100	0	0	0	
50	0	0	0	0	0	95	0	0	0	0	0	0	

Conducting the process of evaluating the suitability of the soil for maize crop in the study area:

The soil evaluation was based on eleven factors that were studied through chemical and physical analyses, in addition to a description of the study area, the main determining factor was identified as salinity, as well as calcium carbonate and the percentage of saturated bases in some areas. The dominant classes were S3 (the marginally suitable class), N2 (not permanently suitable), S1 (highly suitable), in addition to S2 (moderately suitable), as shown in Chart 4 and map 5 below:

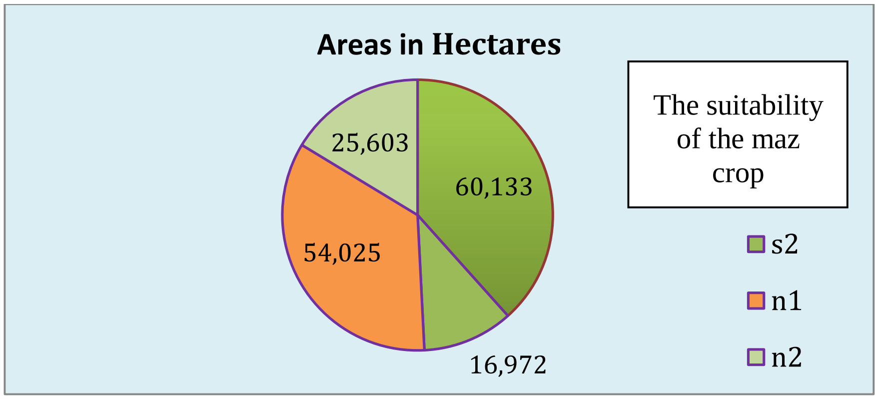

Chart 4: Shows the areas and the spatial suitability in hectares. Source (the researcher).

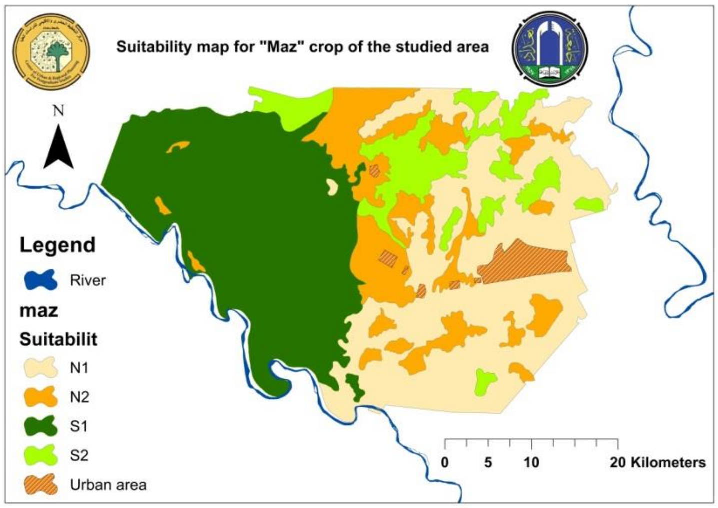

Figure 5: Shows the classification of the spatial suitability for maize crop. Source (the researcher)

CONCLUSIONS

The results indicated that the lands of study areas were suitable for producing a group of strategic crops, to varying degrees, to very suitable lands (S1), moderately suitable lands (S2), marginally suitable lands (S3), unsuitable lands that can be treated, and unsuitable lands that cannot be treated. Moreover, vegetation cover was used to determine the areas of agricultural land and growing crops areas and compare them with the crop suitability of the study area, where the determining factor in growing most of the targeted crops was the soil salinity of the study area. The role of the used models was effective and efficient in reducing effort and time, as well as the high accuracy in drawing maps and dealing with data from its various sources.

THE STUDY RECOMMENDED THE FOLLOWING:

1. Adopting advanced computer methods and systems in land evaluation processes and monitoring continuous environmental changes through modern satellite images, the use of spatial data, and the necessity of updating data obtained from old soil surveys for the purpose of obtaining accurate results that simulate reality and support the process of sustainable development of natural resources.

2. The importance of digital spatial data lies in its ability to deal with digital maps and their tabular data, in order to be modified and updated, with the possibility of building a database with horizontal

trends represented by the wide agricultural areas and vertical trends expressed by the large and enormous amount that this data can accommodate.

3. Activating and identifying agricultural lands, green fields, and urban agriculture vacant areas, in order to be a coherent means of stimulating participation in managing urban growth for a better sustainability in environmental, social, and economic aspects.
4. Sustainability indicators for the study area were evaluated through the application of urban and semi-urban agriculture according to environmental, economic, and ecological indicators.
5. One of the objectives of the research was contributing to effective strategic planning for urban agriculture and making appropriate planning decisions by decision-makers regarding the use of suitable lands for urban agriculture of important strategic crops in the study area .

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