NTU Journal of Agricultural and Veterinary Sciences (2024) 4 (3) : 168-6175
DOI: https://doi.org/10.56286/ntujavs.v2i2

IRAQI Academic Scientific Journals

JAVS NTU

P-ISSN: 2788-9890 E-ISSN: 2788-9904
NTU Journal of Agricultural and Veterinary Sciences
Available online at: https://journals.ntu.edu.iq/index.php/NTU-JAVS/index

Mapping of agricultural ecological zones (AEZ) for Nineveh Governorate

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Article Informations

Received: 16-06- 2024,
Accepted: 13-08-2024,
Published online: 28-09-2024

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Key Words:
Agricultural environmental map, hydrology map, land use, remote sensing.

A B S T R A C T

The research aims to develop a map of the agricultural environmental areas of Nineveh Governorate using remote sensing (RS) and the Geographic Information System (GIS) techniques. The study area located between longitudes 25 41 and 15 44 east and latitudes 15 34 and 3 37 north with an area of 37,323 km^2.

The map of agricultural ecological zones was derived by projecting five landform classes combined with seven soil mapping units, 9 types of land uses, 4 agro-climatic zones and hydrological map resulting in nine classes of an agricultural environmental map that included mountainous lands , urban areas, rugged areas with irrigated lands, irrigated lands, solid lands and residential areas, rainfed lands\1, natural pastures, rainfed lands\2, irrigated lands, irrigated and rainfed lands, with ratios reaching at rates of (2.28, 8.14, 10.49, 9.95, 15.05, 30.16, 19.01, 2.03, 2.88) % for each, respectively.

Introduction

Agroecological zone is an area with the same agricultural productive potential due to the homogeneity of its climate and the similarity of its specific conditions [1] also defined it as a land area with balanced potential [2] Relatively to crop productivity, it is known as the process of natural description of the characteristics (soil, physiography, climate, land use/land cover, productivity) of a specific site of land that has homogeneous and similar areas in climate, soil characteristics, and land shape to know the expected productivity at this site and the factors determining production capacity. for this site [3].

Agroecological zone (AEZ) maps are considered the cornerstone of developing agricultural planning, as the success or failure of any farm system is closely linked to the process of assessing the climate-environmental resources of this system [3].

The distribution of agricultural ecological zones is affected by climatic changes (precipitation, temperature), which are the two determining factors for most crops, as the difference in rainfall between mountains and plains and the difference in height above sea level leads to a difference in the intensity of rain and a difference in the level of humidity, which results in the appearance or absence of specific crops. In a particular climate, as well as the forms of surface runoff and groundwater reserves and the forms of agricultural practices applied, which contribute to enhancing the ability of the soil to retain moisture by increasing agricultural and tree cover in areas exposed to wind and rain erosion, which in turn is reflected in the diversity and distribution of future agricultural environmental areas, [4].

Agroecological zone maps are considered an essential tool for agricultural planning as a result of the integration and interrelation of the main factors defining agroecological zones and accurately showing the wide diversity of agricultural environments. The production of these maps requires a great effort to prepare them to be a working guide in the hands of agricultural decision-makers to help them understand the comprehensive interconnectedness between the units of eco-zones. Agriculture is moving away from traditional methods. The availability of modern technologies such as Geographic Information Systems (GIS) and Remote Sensing (RS) also contributes to achieving the comprehensiveness of this vision through the process of spatial linking of agricultural environmental zone units.

[5] divided the Central and Western Asia and North Africa (CWANA) region into 677 agroecological zones based on several factors, which included climate, land use, land cover, topography, and soil. This process used a methodology developed by [6], which included measuring the climatic similarity of ecological regions and using climate parameters in ecological sites for comparison with other sites.

Materials and methods

The stage of mapping of agricultural ecological zones AEZ:
A map of AEZ was derived by deducing five maps includes, landform map, soil map, hydrology map, land use map, and agro-climatic zones ACZ map. To achieve this, climate data (precipitation and temperature) covering a period of 41 years (1981-2022) was collected, the data was digitized and retrieved, and was accompanied by field and laboratory work

Landform:

It was deduced according to [7] from projecting maps of topographic features, including settlement lines, elevation, slope, direction, land shape (Figure 1), using the Spatial Analyst-Raster Calculator extension from the Arc GIS program, where it was deduced the map of the study area, and then the area was divided into (low, medium, extreme, very severe, steep, moderate, and mild slopes).

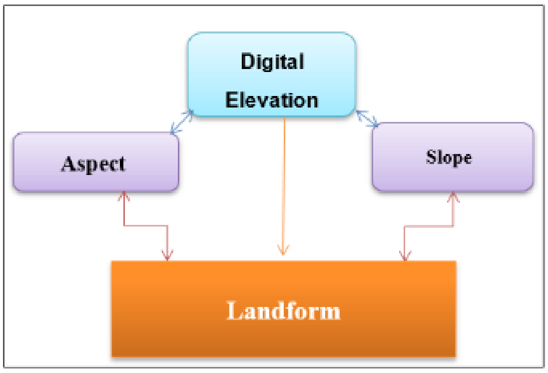


Figure (1) A method for inferring a map of the Earth's shape

Hydrological map:

The hydrological map was developed according to the following methodology

1. Identify sub-water basins (watersheds).
2. Determine the water network and the main and subsidiary waterways.

Agro-climatic map:

The process of mapping of agro-climatic zones (ACZ) is based on data on monthly and annual average values of climate indicators (temperature, precipitation, evaporation-transpiration) [8], and the recorded climate data was processed within the climate station, where station data were used the climatic conditions located within the governorate and the virtual climatic stations obtained from the NASA website. This included the following steps:

1. Collect geographical data, which includes (station name, latitude, and longitude, and height above sea level) with the help of a GPS device.
2. Processing data for recorded climate indicators (temperature, precipitation, evaporation, transpiration, minimum temperatures, maximum temperatures) within the station, verifying them, and excluding abnormal values to avoid their impact on the logical results.
3. Preparing the geographic and climate database using (ArcGIS10.4.1)
4. Conducting spatial analysis operations using the Spline method [9], and creating digital surfaces to smooth the surfaces using the climate database that includes monthly averages and represents the total (precipitation, minimum and maximum temperatures, and evapotranspiration (ETP) according to [10] for the main climate stations.
5. Cartographic output of the following climate maps:

A. Rainfall map: prepared by calculating average of total annual rainfall (mm).

B. Drought Index Map: Prepared by using thorn wait equation:

AI=P\T+10

Where AI is aridity index, P is annual precipitation mm, and T is average temperature.

Temperature maps: including,

-Average monthly temperatures for the hottest month (July) o C.

-Average monthly temperatures for the coldest month (January) o C.

Agricultural climate map:

After collecting the data, databases were prepared and underwent analysis, interpretation, and processing, and finally, the final product was obtained, a map of agro climate zones (ACZ) according to [11] as shown in figure (2).

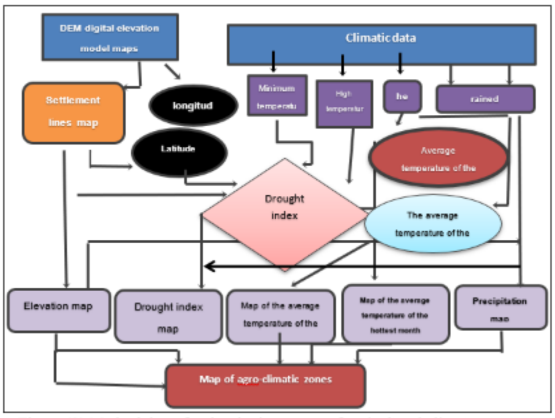


Figure (2) Methodology for developing a map of agricultural climate zones according to (De Pauw et al, 2004)

Agricultural environmental map:

The map of agricultural ecological zones AEZ was derived by deducing five maps: (land shape map, soil map, hydrological map, land use map, and agricultural climate zone map). To achieve this, six satellite images, topographical maps, and climatic data covering 41 years were collected, these data were digitized and retrieved, accompanied by field and laboratory work. After collecting the data, databases were prepared and subjected to analysis, interpretation, processing operations, and finally, a map of agricultural environmental zones (Figure 3).

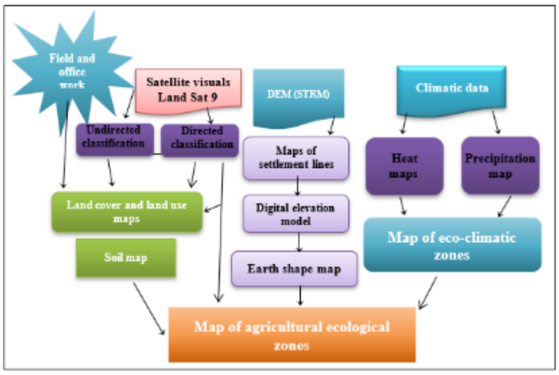


Figure (3): The methodological chart for developing a map of agricultural ecological areas according to (Saha and Pande, 1996)

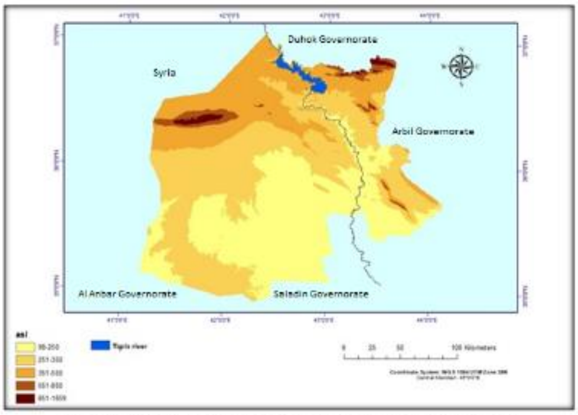
Results and conclusions:

Topographical features:

The land surface in Nineveh Governorate and general in Iraq varies greatly and includes a variety of terrains and slopes.

1. Height above sea level:

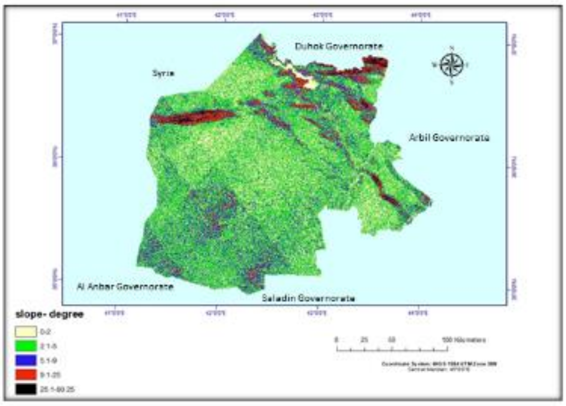
The map of elevation above sea level (map: 1), shows that there are large differences in elevation between the studied areas, as the highest elevation values were in the north and northeast of Nineveh Governorate and decreased towards the south. Due to the large area of Nineveh Governorate, the elevation degrees were divided into five classes, the highest elevation ranged (851-1659m asl), it is located in the far north-east of the governorate, where it contains highlands and mountains. It is part of the mountain range extending in Dohuk Governorate, represented by the mountains Pakerman and Akre, which occupied an area of 14858.5 km^2 (38%). The lowest elevation was (98–250 m) in the southern parts, it is called the plateau region, which is represented by the Jazira Plateau, and extends from the south of the highlands (Makhul, Adi, and Sinjar in the north) to the western desert and the alluvial plain in the south, with an area of (366.2 km2). Its surface consists of flat land interspersed with plateaus, hills, and dunes of varying heights.



Map (1) elevation above sea level asl for Nineveh Governorate

2. Slopes:

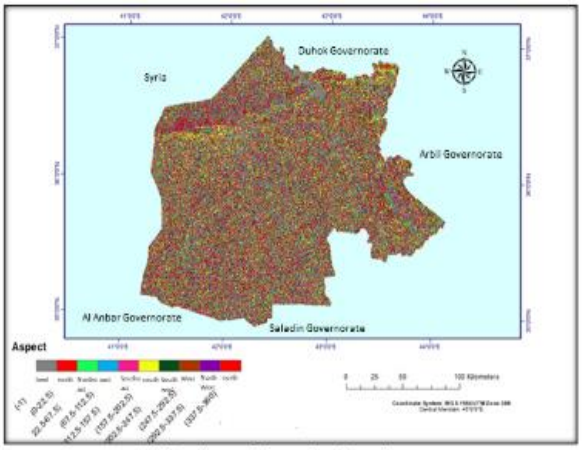
Most of the very steep slopes were concentrated in the mountains adjacent to Dohuk Governorate in the northern part of Nineveh Governorate. The slopes degree was divided into three classes, includes high slopes (25.1-80.25%) and its area reached (17,552 km^2), at a rate of (45.3%) of the area of Nineveh Governorate. As for the moderate slopes, they are observed in the central part of the governorate, it ranged between (5.1-25%), with an area of (18,261 km^2) and a percentage of (47.2%), while low and gentle slopes ranged between (0-5%), with an area of (2,900 km^2) and a percentage of (7.5%), in the plains.



Map (2) of slopes degrees of the land in Nineveh Governorate

3. slopes Direction:

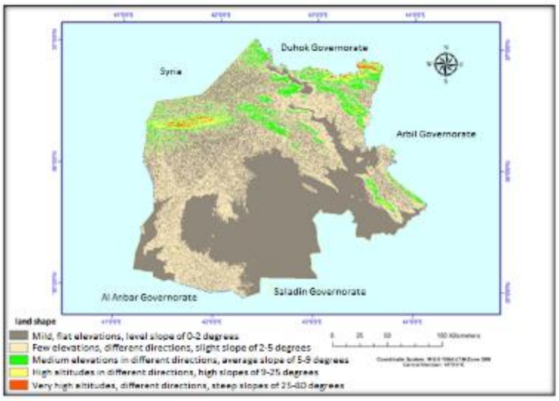
It is not possible to determine a specific direction for the slopes in the governorate in general because they vary from one region to another.



Map (3) directions of slopes in Nineveh Governorate

4. Landform:

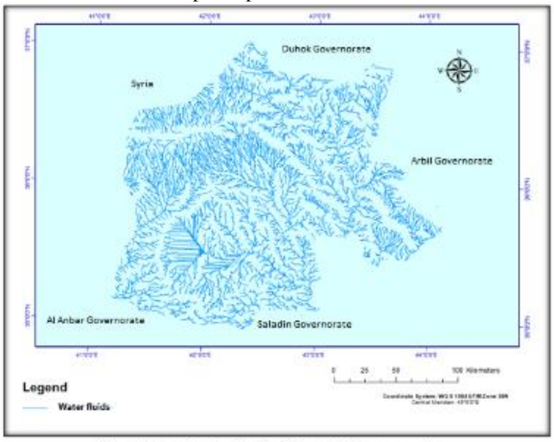
Each of the following topographic indicators: height, slope, and direction contribute to determining the landform of the study area. The landform map shows that the topography is complex and takes various forms. In general, its complexity and ruggedness decrease from north to south, where flat and slightly sloping lands are concentrated for more than (55%) and directionless in the central and southern parts of Nineveh Governorate, which constitute an area of (21,413 km^2), while the lightly undulating land has slight southern elevations with a slight slope of (36%) and an area of (14,103 km^2), while plateaus with mountains of medium, western elevations With a moderate slope, covering an area of (2403 km^2) at a rate of (6%), and steep and steep plateaus and mountains with northerly and northwestern directions, with a greater slope (9%), concentrated in the northern and eastern part of the governorate, its area reached (793 km^2) at a rate of (3%) combined as shown in map (4).



Map (4): landform in Nineveh Governorate

5. Hydrological characteristics:

Digital hydrological maps in Nineveh Governorate showed that there is a network of permanent and seasonal valleys and streams, varying in numerical density (map 5), which covers all the topographic features in the governorate (valleys, plains, mountain plateaus), forming secondary basins in the governorate with an area of (33,073 km^2). (85%), which was formed as a result of the overlapping effects of the topography of the land, the type of soil, the prevailing climate, and the amount of annual precipitation.



Map (5): water bodies in Nineveh Governorate

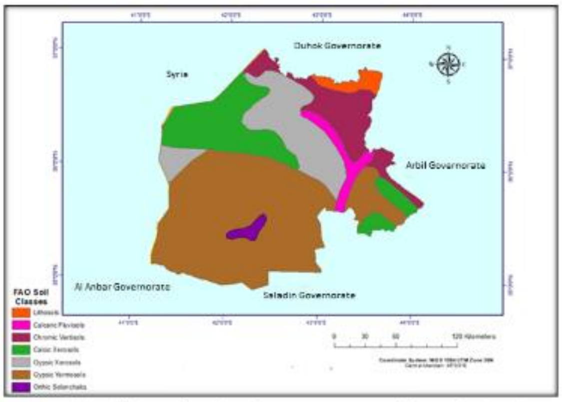
There are also shared basins with the surrounding areas of Nineveh Governorate, which constitute an area of (5639 km^2) and a percentage of(%14.75) .

The hydrological basins in the governorate are concentrated in the central plains (map 6).

Map (6): Water basins in Nineveh Governorate

6. (FAO) classification of soils in Nineveh Governorate:

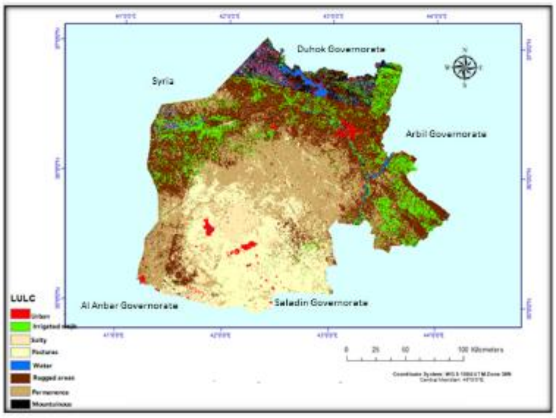
Through the map (7), we notice the varying distribution of soil types in Nineveh Governorate, as it is clear that in the northern regions, lithosol soils are widespread, and these soils are spread in the mountainous areas, where they occupy an area of 815.2 km^2 (2%). Then (Chromic Vertosols), which are calcareous soil with a heavy clay texture, are characterized by the presence of cracks within the first 100 cm of the soil surface. It occupies an area of 4182 km^2 (11%) of the area of Nineveh Governorate. By examining these types (Chromic Vertosols), it is noted that they are characterized by a lack of accumulated salts due to their permeability and the nature of water sources that are low in salt, rain, and snow. As for the central region, in which multiple types appear, represented by gypsic (Calcic With a percentage of (18%), (Gypsic Yermosols), are desert soils containing a gypsic horizon, within (125 cm) of the soil surface, they occupy the largest area of Nineveh Governorate (19,051.4 km^2), with a percentage of (49%) of its total area, and in the middle are (Orthic Solonchaks), they are water deposits, with high salinity, and devoid of diagnostic horizons, except for the pale Ochric horizon. These soils are usually spread in flat areas in the arid and semi-arid regions, while in Nineveh Governorate, they occupy the smallest area (429 km^2) and at a rate of (1%), as (Calcaric Fluvisols) and they belong to the Fluvial class, which are sediments of running water, that do not contain diagnostic horizons.



Map (7) soil classes in Nineveh Governorate according to the (FAO) classification.

7. Land use map:

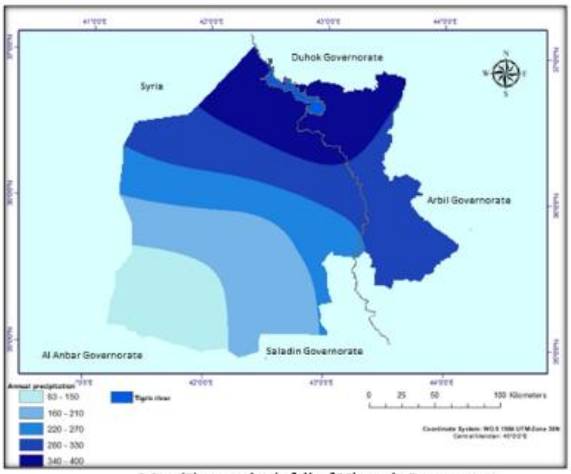
The selected targets (urban places, mixed forests, irrigated lands, pristine lands, fruit trees, pastures, water bodies, rocky outcroppings, and marginal lands) were separated using the controlled classification Maxillopod maximum likelihood method using the points that were projected on the map by a GPS device, which were distributed As follows: urban areas (120,501.27 km^2), agricultural lands irrigated by wells (428,813.91 km^2), saline lands (146,726.73 km^2), pastures (856,505.25 km^2), bodies of water (100,687.14 km^2), rugged areas (1,138,738.95 km^2), desiccated lands (100,687.14 km^2). 991,903.86 km^2), mountainous lands (98,013.69 km^2), The urban areas were concentrated along the course of the Tigris River and the lowland areas formed by river terraces, which are considered among the most fertile lands, in addition to the location of the major cities. The urban areas constituted (3.1%), while lands irrigated with wells spread (11%) of the area of Nineveh Governorate. As for the saline lands, it was concentrated in the southern regions, at a rate of (3.8%). Likewise, as for pastures, it was distributed in the southern parts of the governorate, at a rate of (22.1%). As for the water bodies, they were represented by the Tigris River and its tributaries, in addition to the Mosul Dam Lake, at a rate of 2.6%. The rugged areas constituted the largest percentage of Nineveh Governorate, where it reached 29.3%, as it extended from the northeast to the northwest in a crescent shape, followed by the demesne lands with a percentage of 25.6%, and the least of them were the mountainous areas, which formed a percentage of 2.5% in the map (8).



Map (8) of land uses and land cover for Nineveh Governorate

8. Average annual rainfall:

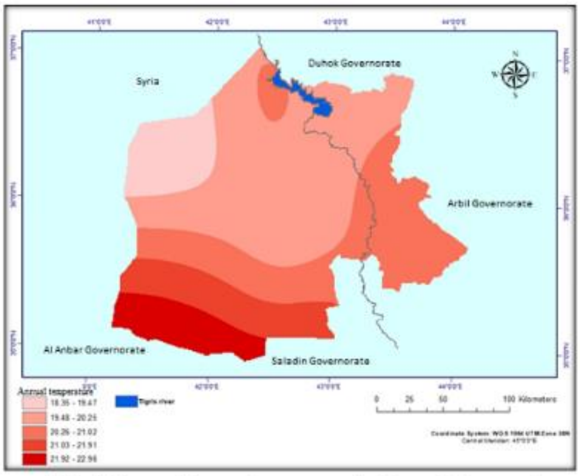
The annual fluctuation of rainfall is a prominent feature of rainfall in Nineveh Governorate, as rainfall amounts vary in terms of the annual total according to the measuring stations spread in the study area, where the highest percentage of rainfall was at the stations (Al-Shaykhan, Mosul, and Rabia), where it ranged between (340-400 mm) and covered an area of 10885.4727 km^2 (28.08%), while it began to decrease in the stations (Al-Hamdaniyah, Tal Afar, Sinjar), where it was (280-330 mm), as these rains covered an area of 8627.511693 km^2 (22.37%), while it continued to decrease in the southwestern direction of the governorate at (Tal Abta) station and reached (160-270 mm) with an area of 13740.443464 km^2 (35.44%), but the lowest percentage of precipitation was reached in my station (Hatra and Al-Baaj) and it was between (83-150 mm) and with an area of 5470.532862 km^2 (14.11%) of the total area(map 9).



Map (9) annual rainfall of Nineveh Governorate
Source: (General Authority for Meteorology and Seismic Monitoring, Iraq).

9. Annual temperature:

Annual temperature averages in Nineveh Governorate vary greatly depending on the season and time.



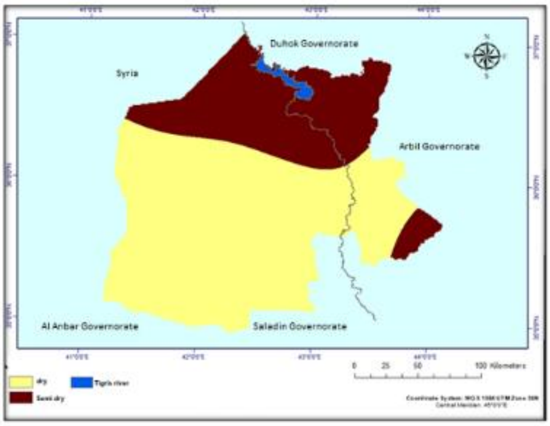
Map (10): annual temperature averages for Nineveh Governorate
Source: (General Authority for Meteorology and Seismic Monitoring, Iraq).

10. Drought index:

This map was deduced through the following relationship:

$$AI= \frac{P}{T+10}$$

Any result of dividing the annual precipitation map by (annual heat map +10)
AI = aridity index
P = annual precipitation map
T = annual heat map
The study showed, as shown in the map (11), that the governorate is divided into two regions, dry areas located in the southern part of the governorate, which occupied a large area amounting to (26,246.18 km^2) of the governorate and was concentrated in the stations (Tal Abta Makhmour, Baaj, Al-Hadar), and semi-arid. In the stations (in the northeastern part of the governorate, with an area of (12522.78 km^2), which shows the distribution of the percentages of the drought index from the governorate's area, is as follows: (68%) for the dry and (32%) for the semi-arid.



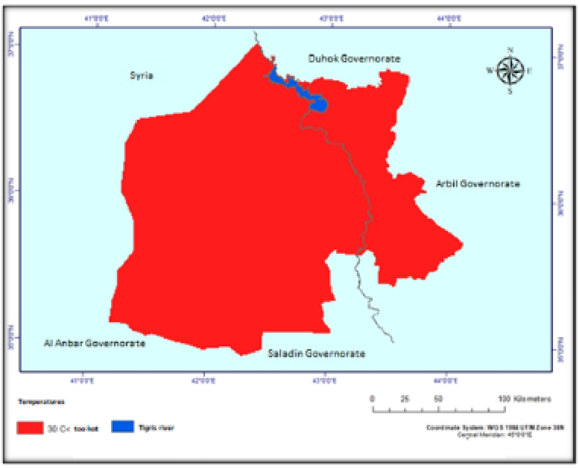
Map (11): drought index for Nineveh Governorate

- Average annual temperatures for the hottest month:

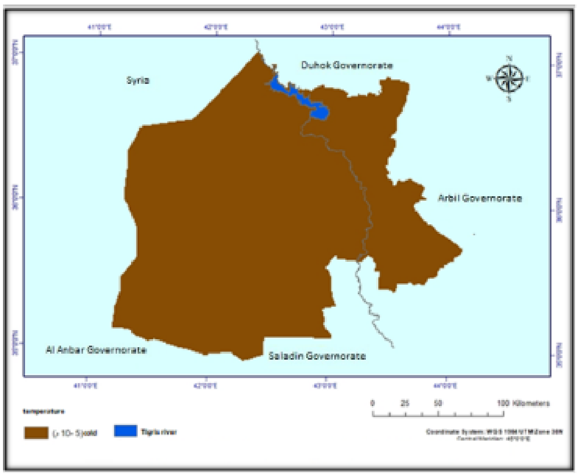
The map of the average annual temperatures for the hottest month showed that the lowest temperature was (30°C), which spread throughout all parts of the governorate, and that the highest temperatures ranged between (more than 30°C) and were also observed in all parts of Nineveh Governorate (map 12).

- Average annual temperatures for the coldest month:

The map of average temperatures for the coldest month showed that the lowest value was (5 °C) in all parts of the governorate, while the highest value was (10 °C) in all parts of Nineveh Governorate, as shown in the map (13) The coldest month in Nineveh Governorate in general and in Iraq is January. During this month.



Map (12) Average annual temperatures for the hottest months in Nineveh Governorate



Map (13) Average annual temperatures for the coldest months in Nineveh Governorate

11. Agricultural climate map:

The agricultural map was derived from projecting both the drought index map with an average temperature map for the hottest months and an average temperature map for the coldest months.

The map of the agricultural climatic zones of Nineveh Governorate showed that the governorate includes two agricultural climatic zones: the first zone, which is characterized by climatic characteristics (dry, cold in winter, very hot in summer) and is located in the southeastern part of the governorate, which is represented in the areas of (Al-Hamdaniya, Makhmour, Tal Abta, Al-Baaj and Al-Hatra) with an area of (26,246.18 km^2), with a percentage of 67.6%, while the second region is characterized by climatic characteristics (semi-arid, cold in winter, very hot in summer) and is located in the central part and the northern part, which is (Al-Shaykhan, Al-Hamdaniya, Mosul, Tal Afar, Sinjar, and Rabia). With an area of (12522.77 km^2) and a percentage of (32.3%), (map14).

Map (14): agricultural climatic zones of Nineveh Governorate

12. Agricultural ecological zones map:

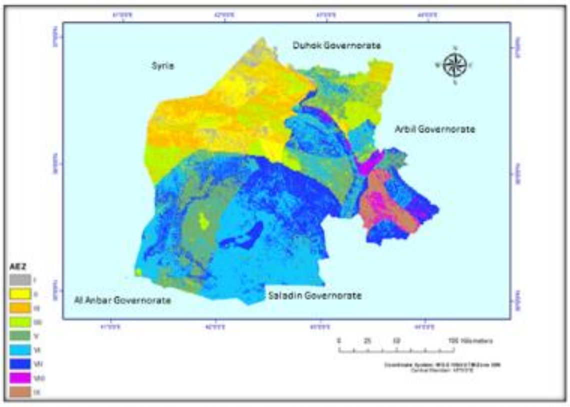
The map of agricultural environmental regions was deduced by projecting the following maps, (Landform map, Soil unit map, Hydrology map, Land use map, and Agro-climatic map within the same spatial and geographic extension as shown in the map (15) within the GIS environment, and using spatial analysis resulted in map units for the distribution of agricultural environmental zones in Nineveh Governorate, where five landform classes were combined with seven soil map units, nine land use classes, and four agro-climatic zones with the hydrological map (resulting in nine rows or Agro-environmental map units, and the distribution of the zone units was Agro-environmental climate zones are as follows:

1. Mountainous lands and urban areas:

   Xeric Hoplogypsids, Lithic Xerorthents, medium elevations, different directions, moderate slope (5-9 degrees), semi-arid, cold in winter, very hot in summer, water sources are limited.
2. Rugged areas with irrigated lands, light to low elevations, flat to different directions, level (0-2) degrees to slight slope (2-5) degrees, semi-arid, cold in winter, very hot in summer, availability of water sources.
3. Irrigated lands, Xeric Hoplocalaids, slight elevations, flat to different directions, level (0-2)

degrees to a slight slope (2-5) degrees, semi-arid, cold in winter, very hot in summer, availability of water sources.

4. Rocky lands and residential areas, high to very high altitudes, different directions, high slope (9-25) degrees to very steep (25-80) degrees, semi-arid, cold in winter, very hot in summer, availability of water sources.
5. fedrain lands, Typic Calcigypsids, light elevations, different directions, slight slope (2-5) degrees, dry and cold in winter, very hot in summer, availability of water sources dependent on rain.
6. Natural pastures,Tyric Galcigypsids,low elevations, flat, level slope (0-2) degrees, dry and cold in winter, very hot in summer, scarcity of water sources.
7. Typic calcigysids, light, flat elevations, level slope (0-2) degrees, dry and cold in winter, very hot in summer, availability of rain-based water sources.
8. Typic Torrifluvets, irrigated lands, light to low elevations, flat to different directions, flat slope (0-2) degrees to slight slope (2-5) degrees, dry, cold in winter, very hot in summer, availability of water sources.
9. fedrain and irrigated lands, Typic Calcigypsids, Light to low elevations, flat to different directions, flat slope (0-2) degrees to slight slope (2-5) degrees, dry, cold in winter, very hot in summer,the availability of water sources depends on rain and wells.



Map (15) of the agricultural ecological zones of Nineveh Governorate

Conclusions

A deep understanding of the distribution of agricultural environmental zones will, in turn, determine the climatic and fertility environments for crops and fruit trees according to actual reality and will give a clear vision of the development of new agricultural strategies by agricultural decision-makers in formulating future agricultural policies to allocate specific crops and specific varieties to specific agricultural environmental zones. Or what is known as the agricultural environmental identity for each crop according to the actual reality and the geographical area, and this ultimately contributes to improving the environmental, agricultural, and service reality and the economic returns of crops, and the ultimate goal of all of this is to preserve natural resources, especially non-fertile, renewable ones that serve sustainable development.

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