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Modeling land cover map according to the environmental susceptibility indicators of Nineveh governorate using remote sensing and GIS

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Abstract:

Construction a model of land cover and land uses map with indicators of environmental susceptibility for governorate of Nineveh by applying digital environmental standards adopting physical medium variables and prevailing land uses in an attempt to design a mathematical model of sensitivity of land susceptibility and factors that may contribute to the degree of sensitivity، so the digital data of the American satellite LANDSAT OLI 2019 and the data of the digital elevation for sensor srtm30 as well as data of the digital climatic space stations, a preference weights adopted for each index according to maximum probabilities ،supervised classification with specified accuracy of standard classification with field survey، prevailing land uses in the governorate. The results were reinforced in the mapping of environmental susceptibility regions on 5 classes (very high susceptibility, high susceptibility، medium susceptibility، weak susceptibility، and untenable) according to 3 levels (natural strategic level، vital natural human dynamic level، capable level of investment).

Keywords: *Modeling, land cover map, environmental susceptibility indicators,remote sensing and GIS.*

I. Introduction

The environmental classification is one of the area classifications of land use and land cover related to the use of data derived from remote sensing data, model is a simplified representation of reality that helps to describe, understand and predict how things work in the real world, and models represent the

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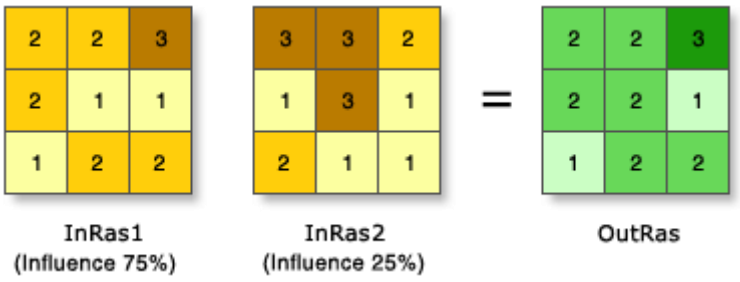
point of view of theirdesigners due to interactions and complexity in this world. (Mohammed, 2008:51), it's one of the means of understanding what's happening on earth and spatial relationships can be understood through model, processing and simulation (Sharaf, 2010,37), geographer uses geographic-modeling with the aid of modern digital technology of Remote sensing and GIS to achieve three aims, first assessment of geographical phenomena, second, estimation to measure geographical phenomena, their elements, environmental impacts and estimates, and third, to predict changes that occur with geographical phenomena over time (Dawood, 2014:171).

GIS software provides the possibility of extracting information and data from remote sensing data and linking them spatially to standard values in digital and descriptive terms, and tabulating them in the form of tables and matrix with specific dimensions that represent a graphic model that reflects the gradations of values either chromatic or digitally to achieve balance in arranging, order and coinciding of the data with the same geographical reference, projection and multiple variables are the data of the study required, as well as achieving the possibility of weight coinciding within spatial analyses and be automated modeled, including weighted overlay layers figure (1) and assembly of weighted sum.



Source: https://www.esri.com/en-us/arcgis/products/spatial-analytics-data-science/capabilities/spatial-analysis

Figure (1) spatial process in layers

II. Material and method

2.1 Study area Nineveh governorateis the third largest administrative unit in terms of population and the first in the agriculture in Iraq located in northwestern Iraq, bordered to the north by Dohukgovernorate and to the east erbil and Kirkuk governorate, while salah al-Din and Anbar governorates are located to the south and to the west the international border with the state of Syria, and astronomically it lies between longitudinal 41° 30' _44° 30' east and latitude 35° 00' -37° 00', north, occupy an area (37597.53) $km^2$from total area of Iraq Figure (2).

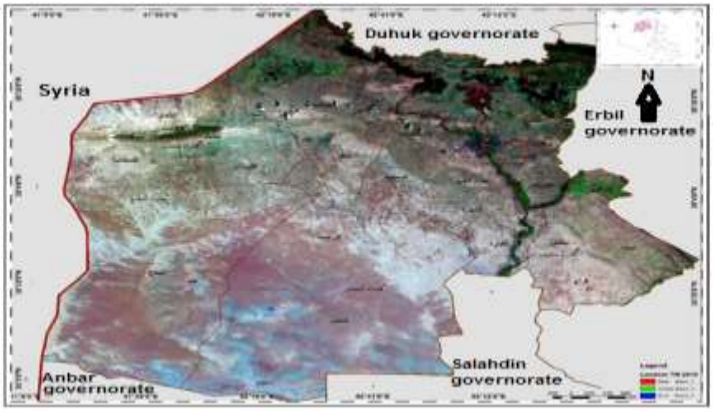


Figure (2) Nineveh governorate location within Iraq

2.2 Data acquisition& programs

2.2.1 digital and paper data:1- Iraqi topographic maps with a scale of 1/100,000 produced by the Ministry of Water Resources and Public Survey Authority for the year 1990.
2. Landsat OLI8 2014 satellite images https://libra.developmentseed.org/
3. Digital elevation model Data: DEM 30 Shuttle Radar Topography Mission 1 Arc-Second Global

2.2.2 Programs:1- ERDAS Imagine: The most important processes used in this program was engineering, radiometric correction, supervised controlled classification and uncontrolled classification (Classification Unsupervised).
2-Program ARC GIS 10.7 Desktop Softwarein data mapping, management and various analysis processes.
3. Global Mapper: building digital DTM models, producing 3D holograms and producing a digital spatial database.
4- Spss: A mathematical computer analysis program that processes digital tables and extracts mathematical relationships between them.
5- Excel: Within the Microsoft office software group it is used in the processing of digital matrix and mathematical relationships in graphic form.

2.3Environmental susceptibility ofphysical and human characteristics:

Criteria were used in the construction of the final map to identify types of land susceptibility according to the physical and human characteristics in Nineveh governorate, aspecific input were adopted as follows:

2.3.1- Physical properties included:

2.3.1.1 - Geology and tectonics:this criteria defined within the time when the province was formed during the geological ages and gave the first weights forQuaternary (Daghestani, 2012: 19) (Industry and Minerals, 2000) being responsible for the formation of sediments covering the region in general, followed by the tertiary period and so on as shown in table (1)Figure 3a

Table (1) Preference weights, percentage and area of geological formations and tectonicaccording tolithiology

Formation age	Weights	Area /km^2	Percentage/ %
Quaternary 1	5	3941.9	10.16
Quaternary 2	4	9865.45	25.44
Quaternary 3	3	14064.18	36.22
Tertiary	2	10724.04	27.66
Cretaceous	1	168.61	0.42

2.3.1.2- slope have a great importance in determining the usability of the earth and the criteria are adopted here on the basis of the prevailing landform and the degree of slope (zuidam&zuidam, 1979) and are defined by five main categories, as shown in table 2 and Figure 3b.

Table (2)Preference weights of slope, Percentage and area

Slope/ degree	Class	Weights	Area/ km^2	Percentage/ %
0-1.9	Plain	5	32885.34	85
2-7.9	Gently slope	4	4869.02	12.58
8-15.9	Moderately steep	3	637.03	1.646
16-29.9	Steep	2	265.19	0.68
more than 30	Very steep	1	31.46	0.08

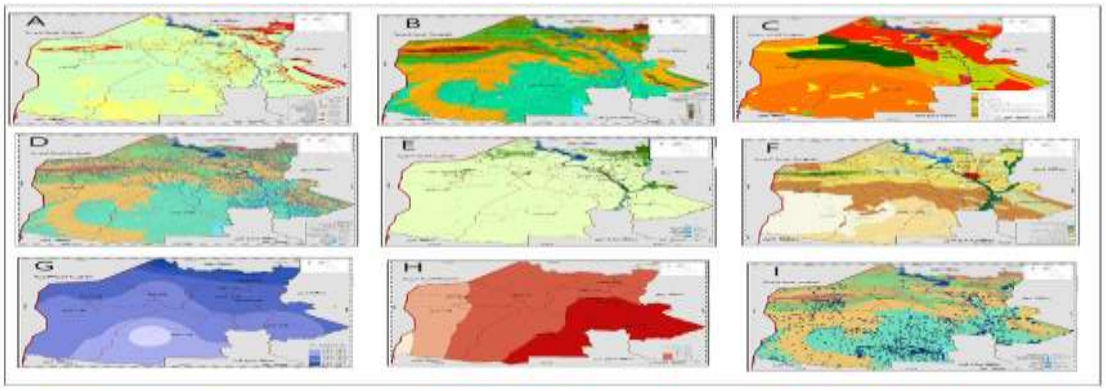
2.3.1.3- Soil : The divisions that al-Taie came up with were based on the soil classification of Iraq and as detailed during the report of the first phase (Buring, 1960) (AL-Daghstani, 2011, and given weights according to the general characteristics and as shown in table (3) and figure (3c) .

Table (3) Preference weights of slope, Percentage and area

Soil type	Weights	Area/ km^2	Percentage/ %
Brown deep layer	5	7303.57	18.87

Brown moderate and shallow layer covering deep eroded bakhtiari gravels	4	12182	31.48
Lithosol with sandstone and gypsum	3	1076.6	2.78
Stony desert lands	2	1146.5	2.96
Valleys bed	1	16988.32	43.9

Figure (3) Physical characteristics of Nineveh Province



2.3.1.4- Surface water Including Lake Mosul Dam, the Tigris and Zab rivers, as well as toQaa- Flat Floored Bottom(seasonal floods depressions) scattered throughout the province, and preferringweights have been placed according to the abundance of water and the possibility of use (Al-Taie, 2002: 161) and as shown in table (4) and Figure 3d

Table (4)Preferring weights of surface water, Percentage and area

Surface water	Weights	Area/ km^2	Percentage/ %
Mousl dam lake	5	309.77	0.8
Tigris river	4	938.7	2.426
Upper zab river	3	392.15	1.013
Seasonal valleys	2	558.41	1.44
Qaa- Flat Floored Bottom	1	555.86	1.436

2.3.1.5- Vegetation : plants were classified into five dominant types in the region and according to the area and density in the province, and relied on satellite data with accuracy (5 m) in

derivation and classification of the plant and its conformity with the official data, so weights were given according to relative importance and as shown in table (5) and figure (3e) .

Table (5) Preferring weights of vegetation, Percentage and area

vegetation	Weights	Area/ km^2	Percentage/ %
Farmed land (agricultural uses)	5	1544.08	73.46
Steppe and forest	4	212.32	10.1
Seasonal plants and seasonal valley	3	23.66	1.17
thorny plant	2	6.23	0.29
Rivers plants (reeds, papyrus and Tamarix)	1	315.4	15.08

2.3.1.6-deteriorate Landunits:These including a degraded land by the environmental imbalance of existing geomorphic processes for each landform unit are defined as and as shown in table (6) and figure 3f (Buday,1980).

Table (6) Preferring weights of deteriorate Landunits,Percentage and area

Deteriorate land units	Weights	Area/ km^2	Percentage/ %
Badland and intermittent streams	5	9062.12	23.4
Lands exposed to desertification a moving sands accumulation	4	2688.38	6.94
Seasonal plants and seasonal valley	3	4167.26	10.77
Active water erosion areas on hills and mountains	2	6810.5	17.6
Sabkha depression	1	15959.6	41.25

2.3.1.7- 7- rain : It's have a great importance for the region, whether being physical or human, through what is mentioned in the first report of the impact of humidity and rain on activities so was determine the amounts of rain according to the isohyets and humidity http://chrsdata.eng.uci.edu , As shown in Table (7) and Figure 3g.

Table (7) Preferring weights of Rain amounts,Percentage and area

Rain amount / mm	Weights	Area/ km^2	Percentage/ %
> 650	5	724.775	1.87
650 - 550	4	2600.05	6.7
550 - 450	3	9882.75	25.5
450 - 350	2	16958.7	43.79
350 - 250	1	8557.15	22.09

2.3.1.8 -Temperature: high temperatures negatively affect environmental life and prevalent physical characteristics in the province(http://chrsdata.eng.uci.edu), weights were given to temperature rates according to the impact they have on all other characteristics and as shown in table (8) and Figure 3h .

Table (8) Preferring weights of Temperature average, Percentage and area

Temperatureaverage/ c°	Weights	Area/ km^2	Percentage/ %
< 12	5	9066.31	23.42
16 – 12	4	6862.55	17.7
20 - 16	3	8012.01	20.69
24 - 20	2	5613.11	14.49
24>	1	9157.57	23.6

2.3.1.9 -Groundwater:

Through chemical and physical elements for groundwater analysis so found weights for the possibility of use in general, weights were identified as by the following and as shown in Table 9 and Figure 3i

Table (9) Preferring weights of Groundwater Suitability, Percentage and area

Groundwater Suitability	Weights	Area/ km^2	Percentage/ %

Suitable for human and animal use	5	5581.6	14.4
Suitable for growing plants, fruits and vegetables	4	9140.3	23.6
Suitable for certain types of vegetables	3	6459.9	16.68
Unsuitable and used in industry	2	12227.36	31.58
It is not suitable for any use except extractive and oil industries	1	5307.078	13.70

2.3.2- Human properties included:

2.3.2. 1- Human settlements

2.3.2. 2- Transport routes

2.3.2. 3- Airports

2.3.2. 4- Extractive industries (e.g. oil and gas refineries)

2.3.2. 5- Water, gas and oil pipelines

2.3.2. 6- Irrigated projects

2.3.2. 7- Agricultural land

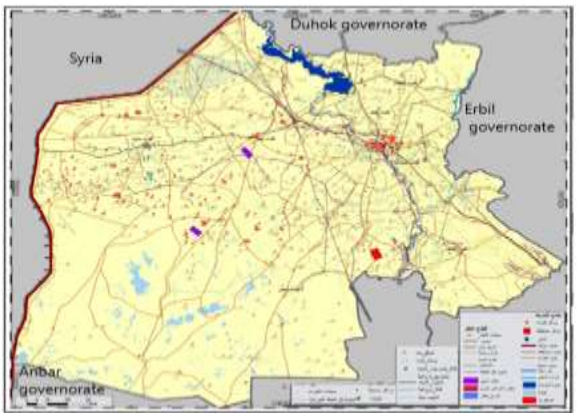
As shown in Table (10) and Figure 4a

Table (10) Preferring weightsfor Land uses, Percentage and area

Land uses	Weights	Area/ km^2	Percentage/ %
Human settlements - Transport routes	5	912.84	2.35
Agricultural land	4	35775.23	92.22
Airports	3	204.76	0.52
Extractive industries (e.g. oil and gas refineries	2	39.49	0.1

and mine			
Water, gas and oil pipelines Irrigated projects	1	1858.57	4.791

Figure (4) Anthropogenic uses prevailing in Nineveh province



2.4 - Environmental susceptibility according to Preferring weights:

Through all of the above, criteria were derived and defined for the setting up of a 10km^2 areal relationship matrix, (Kraak&normaling ,1995:104) for each of these physical and human characteristics and digitally processed), the results showed five categories of classification by weight value of each of these characteristics, as shown in table 11 and Figure 5 .

Table (11) Spatial relationship matrix for variables by classification categories

Classes	Class I high-capability	Class 2 good-capability	Class 3 moderate-capability	Class 4 poor-capability	Class 5scarce-capability
Soil	Valleys bed	Stony desert lands	Lithosol with sandstone and gypsum	Brown moderate and shallow layer covering deep eroded bakhtiari gravels	Brown deep layer
Geology	Quaternary 1	Quaternary 2	Quaternary 3	Tertiary	Cretaceous
Slope	Plain 0-1.9	Gently slope	Moderatel	Steep 16-29.9	Very steep

		2-7.9	y steep 8-15.9		>30
Surface water	Mousl dam lake	Tigris river	Upper zab river	Seasonal valleys	Qaa- Flat Floored Bottom
vegetation	Farmed land (agricultural uses)	Steppe and forest	Seasonal plants and seasonal valley	thorny plant	Rivers plants (reeds, papyrus and Tamarix)
Deteriorate land units	Badland and intermittent streams	Lands exposed to desertification a moving sands accumulation	Seasonal plants and seasonal valley	Active water erosion areas on hills and mountains	Sabkha depression
Rain	> 650	650 - 550	550 - 450	450 - 350	350 - 250
Temperature	<12	16– 12	20 - 16	24 - 20	24>
Groundwater	Suitable for human and animal use	Suitable for growing plants, fruits and vegetables	Suitable for certain types of vegetables	Unsuitable and used in industry	It is not suitable for any use except extractive and oil industries
Land uses	Human settlements - Transport routes	Agricultural land	Airports	Extractive industries (e.g. oil and gas refineries and mine	Water, gas and oil pipelines Irrigated projects
Area	5766.06	7727.06	10672.7	8721.48	4710.23
Ratio	15.33	20.55	28.38	23.19	12.5

Multiple correlation relationships are a guide in detecting the appropriateness of the prevailing geographical characteristics and from table (12) appear the following:

-A strong relationship between geological formations, lithology and tectonics as a uniform - layer and classification of soil, surface water, plant and the prevailing landforms (environmental cover) and rain, but the weak relationship was with the surface and slope, temperatures and land uses, back to table (11) the objective causes of this can be identified for that.

-The degree of regression has a strong positive relationship with the heat and weak with the rest of the indicators.

-Surface water has a strong positive relationship other than temperature; its relationship is weak with surface water because it reflects a different negative impact

- plant has a strong relationship with the characteristics largely positive except the negative inverse relationship with land uses and high temperature

Environmental cover (landforms) different relation to characteristics in general, so that it is strong and positive except heat and land uses.

- rain and heat have inverse relations, higher temperature, the lower rain, the relationship with the land uses is moderate positive for the rain, but the higher temperature been negativerelation.

Figure (5) classification of land cover according to the environmental suitability of Nineveh governorate

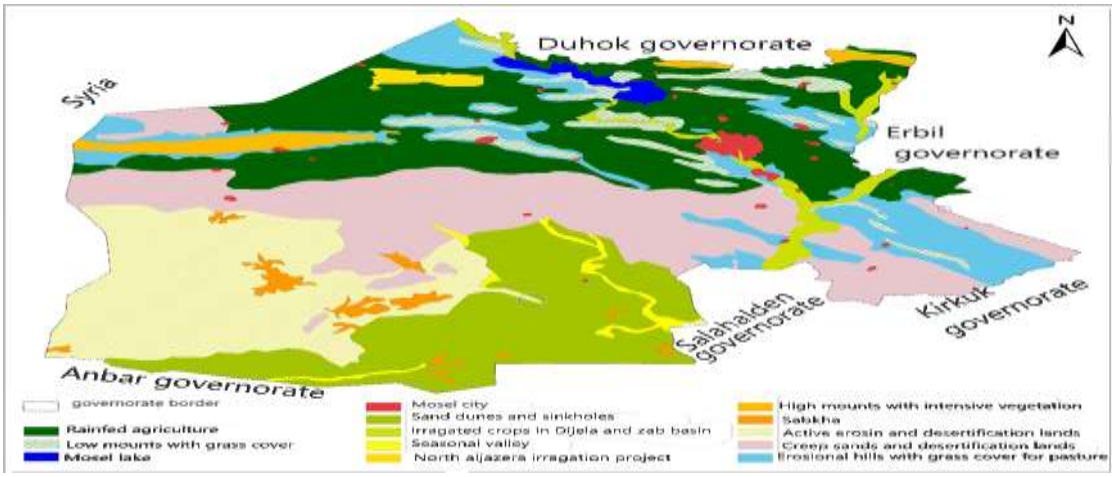


Table (12) Correlation between environmental variables

Environmental Character	Soil	Geology	Slope	Surface water	Plant	Landform	Rain	Temperature	Ground water	Land use

s										
Soil	1									
Geology	1	1								
Slope	-1	-1	1							
Surface water	0.949	0.949	0.9-49	1						
Plant	0.959	0.959	0.9-59	0.843	1					
Landform	0.971	0.971	-0.971	0.877	0.946	1				
Rain	0.849	0.849	-0.849	0.767	0.801	0.774	1			
Temperature	-1	-1	1	-0.949	-0.959	-0.971	-0.849	1		
Groundwater	1	1	-1	0.949	0.959	0.971	0.849	-1	1	
Landuse	0	0	0	0	-0.040	-0.157	0.504	0	0	1

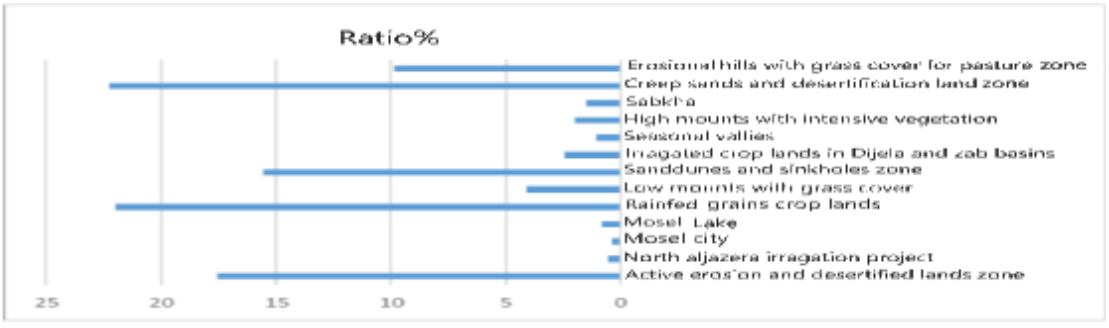
Weight matching using ArcMap10.7 and Spatial Analyses through Wight Overly show that the results are as in Table (13) Figure 6

Table (13) Classification of geographical patterns and regions of the land cover in Nineveh governorate

Num	Land cover class	Area /km^2	Ratio /%

1	Range of deserted land and active erosion	6786.08	17.525
2	North Island Irrigation Project	224.18	0.579
3	Mosul city	142	0.367
4	Mosul lake	313.14	0.809
5	Rain fed grain crops (wheat and barley)	8512.21	21.983
6	Low-mountain areas with grass-covered terrain	1591.73	4.111
7	Areas of sand dunes and sinkhole	6018.07	15.542
8	Land of the crops of green vegetables in Tigris and zab basin	941.24	2.431
9	Seasonal valley streams	404.64	1.045
10	High-terrain mountain areas with dense vegetation cover	782.31	2.020
11	Sabkha depressions	574.51	1.484
12	The range of land exposed to desertification and the accumulation of creeping sand	8609.12	22.233
13	The range of erosional hills with grass cover used for grazing	3823.24	9.873

Figure (6) classification of geographical patterns and regions of the land cover in Nineveh governorate



III. Conclusion

- possibility of classifying patterns and regions using physical and human variables in the detection of natural resources and the relationship between all variables mathematically and descriptively.

-The largest area is suitable for investment, especially in the fields of agriculture and with a proportion(%75).

-As a result of negligence and lack of planning, desertified areas occupied a proportion (54%) of the total areas and it is within the region suitable for investment.

-The current investment and planning of the province's potential in all economic fields is not commensurate with what observe in table (13) for theunused covertypes.

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