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LAND SUITABILITY FOR WHEAT CULTIVATION IN NORTH KUT PROJECT IN IRAQ BY USING ARCGIS

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Abstract

This study was carried out for the purpose of conducting land evaluation of wheat cultivation by using ArcGIS. Land, North Kut Project, Wasit province, Iraq, was evaluated for the cultivation and production of wheat crop using the modified proposals contained in Sys and others 1993. Soil and topographical characteristics as well as climate characteristics were adopted in the study area. The results indicated that the land of the region is classified in varying degrees to very suitable land (S1), medium (S2), limited (S3) and unsuitable (N) for cultivation wheat at present, The main determinant factor was the salinity factor, while the climate was not a specific factor for crop cultivation and the model developed in this study was effective and useful for producing suitable land maps.

***Key words*:** ArcGIS, North Kut, Wasit, Soil, Wheat.

Introduction

Land assessment provides the necessary information and recommendations to determine the appropriate crop varieties to cultivate and identify suitable areas for planting those crops as well as to choose appropriate management alternatives. Pauw (2001) pointed out that the purpose of land assessment is varied according to prior knowledge of potential or future land use and the size and type of study. This process requires the integration of information relevant to both land and climate, so an effective tool or tool should be available to help build a strong, robust and robust database for a reliable reference for many researchers interested in planning land use. One of the most effective, modern and sophisticated tools for building the necessary information base for this process is the use of geospatial systems based on the study of the spatial distribution and spatial analysis of various geographical features to be ready for retrieval and inquiry and map production (ESRI 1991-2009), as well as supporting decision-makers to make their decisions regarding to land use assessment and planning for ops in irrigated areas. The importance of these methods in their ability to deal with digital maps and data tables to be adjustable and update with the possibility of database large agricultural areas and the huge amount of data as well as the possibility of dealing with a lot of calculations and statistical processing and integration of these technologies to a wide range of computer software. Based on the above, the study aimed to determine land suitability to cultivate Wheat in North Kut project according to the proposals of Sys *et al*., (1993).

Materials and methods

Location and area

The project of North Kut was selected in Wasit province due to its geomorphological and physiographical characteristics, as well as its agricultural exploitation and the existence of a previous report of semi-detailed surveys of the study area (Muhammed and Abdullah 2009). The project is between 45^{O} 46' 20'' and 46^{0} 16' 8.56'' in the east and 32^{O} 31' 11.22 and 32^{O} 44' 15 north, with a total area of 49,904 ha. With a total area of 49,904 ha. The project is bordered to the north by Shuwaijah Lake and from the south by the main road between Kut and Alemara city. From the east, it is located in the Wadi Al-Jabbab valley and from the west the main road between Kut and Badra city as shown in the project map of the location (fig. 1).

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The climate

The climatic components that are of primary importance to wheat yield in irrigation areas are the monthly temperature rates as well as the maximum temperatures and the minimum temperatures for one month during the growth period of the wheat crop, as shown in table 1.

Table 1. The temperature prevailing in the study area

	November	December	January	February	March	April
Max C^{O}	23.97	18.19	16.09	19.09	23.81	31.06
Min C^{O}	11.09	6.99	5.27	6.60	10.09	16.02
Average C^{O}	17.53	12.59	10.68	12.85	16.95	23.54

Data preparation

Spatial data input: Data and information available in paper maps were entered into the ArcGIS software using the Scanner and File.tif in the form of images and included soil maps and soil model locations and the UTM WGS84 Datum return in the N38 range.

Quantitative data entry

Tertiary information and data containing the characteristics of spatial information were introduced of the results of the physical and chemical analysis of the soil models using MS Excel and converting them to a database in order to be linked later to the soil units and locations map with the characteristics of the land properties required in the production of the final maps of

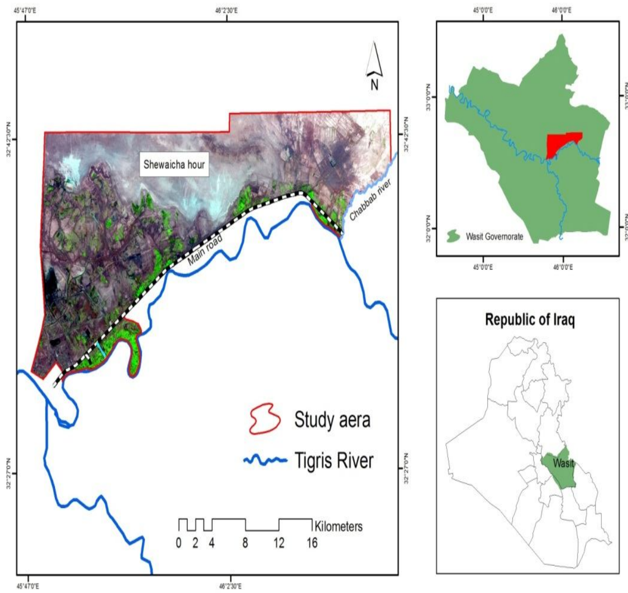

Fig. 1: Location map for the study area

Table 2: Soil, topography and hydrological conditions of irrigated wheat crop.

Land Characteristics		Rating and limitation					
		S1		S2	S3	N1	N2
		0	1	2	3	4	
		100 95	85	60	40	25	0
Topography	(t)						
Slope (%)		0 - 1	1 – 2	2 - 4	4 – 6	-	> 6
Wetness	(w)						
Flooding		F0	-	F1	F2	-	F3+
Drainage		good	Moder.	Imperf.	Poor and aeric	Poor, but drainable	Poor > not drainable
Physical soil characteristics	(s)						
Texture/struct.		C<60s, SiC, Co, Si, SiL, CL	C<60v, SC, C>60s, L	C>60v, SCL	SL, LfS	-	Cm, SiCm, LcS, fS, cS
Coarse fragm (vol%)		0 – 3	3 – 15	15 – 35	35 – 55	-	> 55
Soil depth (cm)		> 90	90 – 50	50 – 20	20 – 10	-	< 10
$CaCo_3$ (%)		3 – 20	20 – 30	30 – 40	40 – 60	-	> 60
Gypsum (%)		0 – 3	3 – 5	5 – 10	10 – 20	-	> 20
Soil fertility characteristics	(f)						
- Apparent CEC (cmole(+)/kg clay)		> 24	24 – 16	< 16 (+)	-	-	-
- Base saturation (%)		> 80	80 – 50	50 – 35	< 35	-	-
- Sum of basic cations (cmole(+)/kg)		> 8	8 - 5	5 – 3.5	3.5 - 2	< 2	-
- pH H_2O		7.0 - 7.6	7.6 - 8.2	8.2 - 8.4	8.4 - 8.5	-	> 8.5
- Organic carbon (%)		> 0.6	0.6 – 0.4	< 0.4	-	-	-
Salinity & Alkalinity	(n)						
- ECe (ds.m^{-1})		0 – 4	4 – 8	8 – 12	12 – 16	16 - 20	20 - 24
- ESP (%)		0 – 15	15 – 20	20 – 35	35 – 45	-	> 45

- Misleading fields represent modified properties according to the conditions of the Iraqi soil., cm: massive clay, C+60, V: very fine clay, vertisol structure, C+60, s: very fine clay, blocky structure, C-60, V: clay, vertisol structure, C-60, S: clay, blocky structure, C0: clay, oxisol structure, FS: fine sand, Cs: coarse sand.

Table 3. Physical and chemical properties of soil (0-50 cm).

Pedon No.	Soil Depth (cm)	Gypsum (%)	Texture	CaCO3 (%)	Drainage	pH	Organic Carbon (%)	ECe ($dS.m^{-1}$)	ESP (%)
P1	105	9.32	SiCL	39.72	MWD	7.69	0.68	80.3	51
P2	120	14.50	SiCL	38.64	PD	7.74	0.57	88.8	58.1
P3	125	6.50	SiC	33.40	PD	7.65	0.81	42.1	37.44
P4	120	6.80	SiC	45.48	PD	7.63	0.64	10.452	14.64
P5	125	5.87	SiL	47.77	MWD	7.76	0.86	12.328	19.55
P6	96	2.73	SiCL	42.39	WD	7.68	0.82	38.38	32.3
P7	150	8.75	SiCL	37.22	PD	7.20	0.92	97	63.56
P8	140	26.30	SiCL	32.24	PD	7.74	0.51	49.8	51.82
P9	130	24.74	SiCL	32.24	IMD	7.64	0.51	16.92	18.2
P10	140	6.52	SiCL	44.71	PD	7.79	0.58	14.22	18.5
P11	110	19.65	SiCL	33.05	MWD	7.42	0.31	107.5	58
P12	150	20.05	SiCL	35.95	PD	7.70	0.32	25	14.05
P13	120	10.88	SiCL	32.30	PD	7.49	0.54	106.4	55.2
P14	130	13.37	SiC	37.68	PD	7.70	0.20	44.66	38
P15	103	15.62	SiCL	37.00	PD	7.67	0.76	29.5	34
P16	140	21.38	SiC	26.18	PD	7.72	0.84	67.48	50.92
P17	120	21.13	SiC	26.23	PD	7.84	0.71	67.93	50.9
P18	130	13.22	SiC	28.89	PD	7.61	1.02	34.46	36.34
P19	120	19.78	SiC	23.99	PD	7.91	0.54	56.7	45.7
P20	140	21.23	SiC	26.71	PD	7.00	0.53	61.06	56.29
P21	120	5.94	SiL	25.37	MWD	7.52	0.47	53.14	55
P22	140	22.25	SiC	27.54	PD	7.35	0.85	64.5	53.3
P23	125	8.10	SiCL	25.15	PD	7.51	0.38	129.62	64.82
P24	150	27.80	SCL	20.81	PD	7.47	0.47	90.12	57.62
P25	120	18.52	SiCL	22.11	IMD	7.60	0.37	74.8	63.13
P26	130	27.50	SCL	27.18	PD	8.13	0.10	64.56	46
P27	125	11.21	SiCL	32.55	PD	7.62	0.64	86.5	51.98
P28	140	11.16	SiCL	31.70	MWD	7.83	0.33	103.2	63.1
P29	125	15.75	SiCL	32.81	PD	7.69	0.50	80.1	56.26
P30	150	24.70	SiCL	30.70	PD	7.57	0.46	99.8	59.4
P31	120	5.88	L	27.62	PD	7.83	0.56	98.42	68.24
P32	140	38.21	SiCL	26.30	PD	7.76	0.84	99.28	62.5
P33	120	8.12	SiC	32.94	PD	7.26	0.59	26.52	41.96
P34	150	25.11	SiCL	46.07	PD	7.80	0.28	62.84	54.4
P35	135	3.14	SiL	28.19	MWD	7.08	0.96	131.3	65.62
P36	150	27.88	SiCL	20.80	PD	7.99	0.60	106.44	59.75
P37	140	1.70	SiC	29.80	PD	7.75	0.64	26.5	23
P38	150	26.84	SiL	26.17	PD	7.90	0.69	83	55.24
P39	120	2.55	SiCL	27.74	PD	7.59	0.68	108.2	55.4
P40	140	21.90	SiC	26.00	PD	7.74	0.59	55.4	48.8
P41	140	5.75	SiCL	25.38	IMD	7.15	0.69	150.14	71.58
P42	140	3.80	SiCL	26.04	MWD	7.71	0.33	123.2	64.8
P43	130	5.76	SiCL	28.52	IMD	7.57	0.57	67.6	51.9
P44	150	6.30	SiL	26.32	IMD	7.44	0.59	114.4	61.12
P45	120	2.44	SiCL	26.68	IMD	7.49	0.63	24.8	35.6
P46	150	6.70	SiCL	24.61	MWD	7.65	0.42	161.72	65.2
P47	140	2.66	SiCL	30.00	PD	7.31	0.56	113.32	44
P48	140	2.66	SiCL	30.00	PD	7.31	0.56	113.32	44

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P49	135	2.75	SiC	26.76	PD	7.42	0.35	88.68	40.6
P50	150	7.20	SiCL	27.14	MWD	7.30	0.30	41.04	46.36
P51	120	6.86	SiC	27.56	PD	7.30	0.30	38.4	38.6
P52	150	1.75	SiCL	29.55	MWD	7.23	0.26	76	53.5
P53	135	9.78	SiCL	27.16	MWD	7.63	0.30	55.64	51.4
P54	150	0.10	SiCL	27.26	MWD	7.60	0.30	49.48	46.84
P55	140	4.30	SiCL	28.42	PD	7.52	0.24	36.32	30
P56	150	24.15	SiCL	22.44	PD	7.20	0.35	99.7	55.4
P57	150	6.70	SiC	26.84	PD	7.24	0.38	102.4	52.8
P58	150	18.04	SiL	27.50	IMD	7.25	0.18	32.92	29.2
P59	140	4.94	SiC	24.43	IMD	7.43	0.23	82.01	36.6
P60	150	2.90	SiL	26.98	MWD	7.42	0.34	137.16	66.3
P61	140	3.75	SiL	27.89	PD	7.92	0.39	58.9	48.3
P62	140	4.53	SiC	24.84	MWD	7.82	0.17	82.18	53
P63	150	0.09	SiL	28.88	WD	7.65	0.51	3.018	6.22
P64	160	36.65	SiCL	18.40	PD	7.25	0.35	103.68	58.75
P65	140	2.29	SiCL	27.25	MWD	8.00	0.20	19.5	35
P66	150	24.84	SiC	24.84	IMD	7.98	0.12	61.4	48.6
P67	150	0.22	SiL	26.52	WD	7.50	0.18	3.804	4.76

Source: Muhammad and Abdullah (2009)

Table 4. Stages of wheat crop growth

Stage	From	To	No. of days
Growing cycle	20-Nov	26-Apr	157
Vegetation stage	20-Nov	8-Mar	108
Flowering stage	8-Mar	24-Mar	16
Ripening stage	24-Mar	26-Apt	33
			157

Table 5: Climate requirements for wheat crop, according to Sys *et al.,* (1993).

Climate Characteristics	Rating an limitation					
	S1		S2	S3	N1	N2
	0	1	2	3	4	
	100 95 85 60 40 25 0					
Mean Temp. of the growing cycle (C°)	18 – 20 18 - 15	20 – 23 15 - 12	23 – 25 12 - 10	25 – 30 10 - 8	- -	> 30 < 8
Mean Temp. of the vegetation stage (C°)	10 – 8 10 - 12	8 – 6 12 - 18	6 – 4 18 - 24	4 – 2 24 - 28	- -	< 2 > 28
Mean Temp. of the flowering stage (C°)	18 – 14 18 - 22	14 – 12 22 - 26	12 – 10 26 - 32	10 – 8 32 - 36	- -	< 8 > 36
Mean Temp. of the Ripening stage (C°)	20 – 16 20 - 24	16 – 14 24 - 30	14 – 12 30 - 36	12 – 10 36 - 42	- -	< 10 > 42
Average daily min. temp. coldest month combined with average daily max. temp. coldest month (C°)	< 8 if < 21	- -	> 8 if - < 21	8 – 19 if - > 21	- - -	- - -

the properties of texture soil, soil interaction, the state of internal drainage, carbonate minerals, stone ratio, cation exchange capacity, sodium ratio, electrical conductivity of saturated soil paste, gypsum ratio, organic matter ratio, soil depth, sodium adsorption ratio and soil gradient.

Numbering of maps

At this stage, unit maps were drawn and soil sample locations and turning them into digital maps (file .shp) to two types of features available in these programs are point features, which represent the soil map and polygon features that represent the map of soils units.

The process of linking geo-tabular data

At this stage, the attribute tables Data is linked, that representing the distribution map of soil units and soil model locations with spatial data, are carried out to obtain integrated geo-maps for soil surveys that are ready for spatial processes to produce land assessment maps.

Land Assessment System

Soil and topographical characteristics: Table 2 shows the general requirements for soil, topography and hydrology suitable for the cultivation of irrigated wheat crop as described by Sys *et al*., (1993).

While table 3 shows the physical and chemical properties of the soil in the study area at a depth of 50 cm.

Climate characteristics

Evaluation of wheat crop climatic characteristics: It was noted that the best date for cultivation the wheat crop in the study area is the second half of November for the germination before the winter to avoid low temperatures of wheat seedling. Also, the length of cold lead to the length of growth, considering that the date of cultivation is November 20 as shown in table 4. The different crop growth periods during the growing season can be determined to assess the climatic requirements of the wheat crop contained in the table of wheat crop climatic requirements as follows:

From the table above, the growth cycle for wheat

Table 6. Ratings of physical and chemical properties of soil (0-50 cm).

Pedon No	Soil Depth	Gypsum	Texture	CaCO3	Drainage	pH	Organic Carbon	ECe	ESP	Rating	Suitability
P1	100	63	100	61	100	91	100	0	24	0	N1
P2	100	51	100	63	60	90	80	0	5	0	N1
P3	100	78	100	77	60	92	100	0	55	0	N1
P4	100	76	100	55	60	92	100	70	95	70	S2
P5	100	81	100	52	100	90	100	58	86	58	S3
P6	100	95	100	58	100	91	100	0	63	0	N1
P7	100	66	100	67	60	100	100	0	0	0	N1
P8	100	31	100	79	60	90	80	0	22	0	N1
P9	100	33	100	79	75	92	80	37	89	33	N1
P10	100	77	100	55	60	89	80	49	88	49	S3
P11	100	41	100	77	100	96	60	0	5	0	N1
P12	100	40	100	70	60	91	60	0	95	0	N1
P13	100	58	100	79	60	95	80	0	13	0	N1
P14	100	53	100	66	60	91	60	0	54	0	N1
P15	100	49	100	68	60	92	100	0	62	0	N1
P16	100	38	100	89	60	91	100	0	24	0	N1
P17	100	38	100	89	60	88	100	0	24	0	N1
P18	100	54	100	86	60	93	100	0	57	0	N1
P19	100	40	100	91	60	87	80	0	38	0	N1
P20	100	38	100	88	60	94	80	0	10	0	N1
P21	100	80	100	90	100	95	80	0	13	0	N1
P22	100	37	100	87	60	97	100	0	18	0	N1
P23	100	70	100	90	60	95	60	0	0	0	N1
P24	100	28	60	94	60	95	80	0	6	0	N1
P25	100	43	100	93	75	93	60	0	0	0	N1
P26	100	29	60	88	60	69	60	0	37	0	N1
P27	100	58	100	79	60	93	100	0	21	0	N1
P28	100	58	100	81	100	88	60	0	0	0	N1
P29	100	49	100	78	60	91	80	0	10	0	N1
P30	100	33	100	83	60	94	80	0	1	0	N1
P31	100	81	80	87	60	88	80	0	0	0	N1
P32	100	22	100	89	60	90	100	0	0	0	N1
P33	100	69	100	78	60	99	80	0	46	0	N1
P34	100	32	100	54	60	89	60	0	15	0	N1
P35	100	94	100	87	100	97	100	0	0	0	N1
P36	100	28	100	94	60	85	80	0	1	0	N1
P37	100	97	100	85	60	90	100	0	80	0	N1
P38	100	30	100	89	60	87	100	0	13	0	N1
P39	100	96	100	87	60	93	100	0	12	0	N1
P40	100	37	100	89	60	90	80	0	30	0	N1
P41	100	81	100	90	75	99	100	0	0	0	N1
P42	100	91	100	89	100	91	60	0	0	0	N1
P43	100	81	100	86	75	94	80	0	22	0	N1
P44	100	79	100	89	75	96	80	0	0	0	N1
P45	100	96	100	88	75	95	100	1	59	1	N1
P46	100	76	100	90	100	92	80	0	0	0	N1
P47	100	96	100	85	60	98	80	0	42	0	N1
P48	100	96	100	85	60	98	80	0	42	0	N1

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P49	100	95	100	88	60	96	60	0	49	0	N1
P50	100	74	100	88	100	98	60	0	36	0	N1
P51	100	76	100	87	60	98	60	0	53	0	N1
P52	100	97	100	85	100	100	60	0	17	0	N1
P53	100	61	100	88	100	92	60	0	23	0	N1
P54	100	100	100	88	100	93	60	0	35	0	N1
P55	100	89	100	87	60	95	60	0	68	0	N1
P56	100	34	100	93	60	100	60	0	12	0	N1
P57	100	77	100	88	60	99	60	0	19	0	N1
P58	100	44	100	88	75	99	60	0	70	0	N1
P59	100	85	100	91	75	96	60	0	57	0	N1
P60	100	95	100	88	100	96	60	0	0	0	N1
P61	100	91	100	87	60	87	60	0	31	0	N1
P62	100	87	100	90	100	89	60	0	18	0	N1
P63	100	100	100	86	100	92	80	93	98	93	S1
P64	100	23	100	95	60	99	60	0	3	0	N1
P65	100	96	100	88	100	85	60	27	60	27	N1
P66	100	33	100	90	75	85	60	0	30	0	N1
P67	100	100	100	88	100	95	60	92	98	92	S1

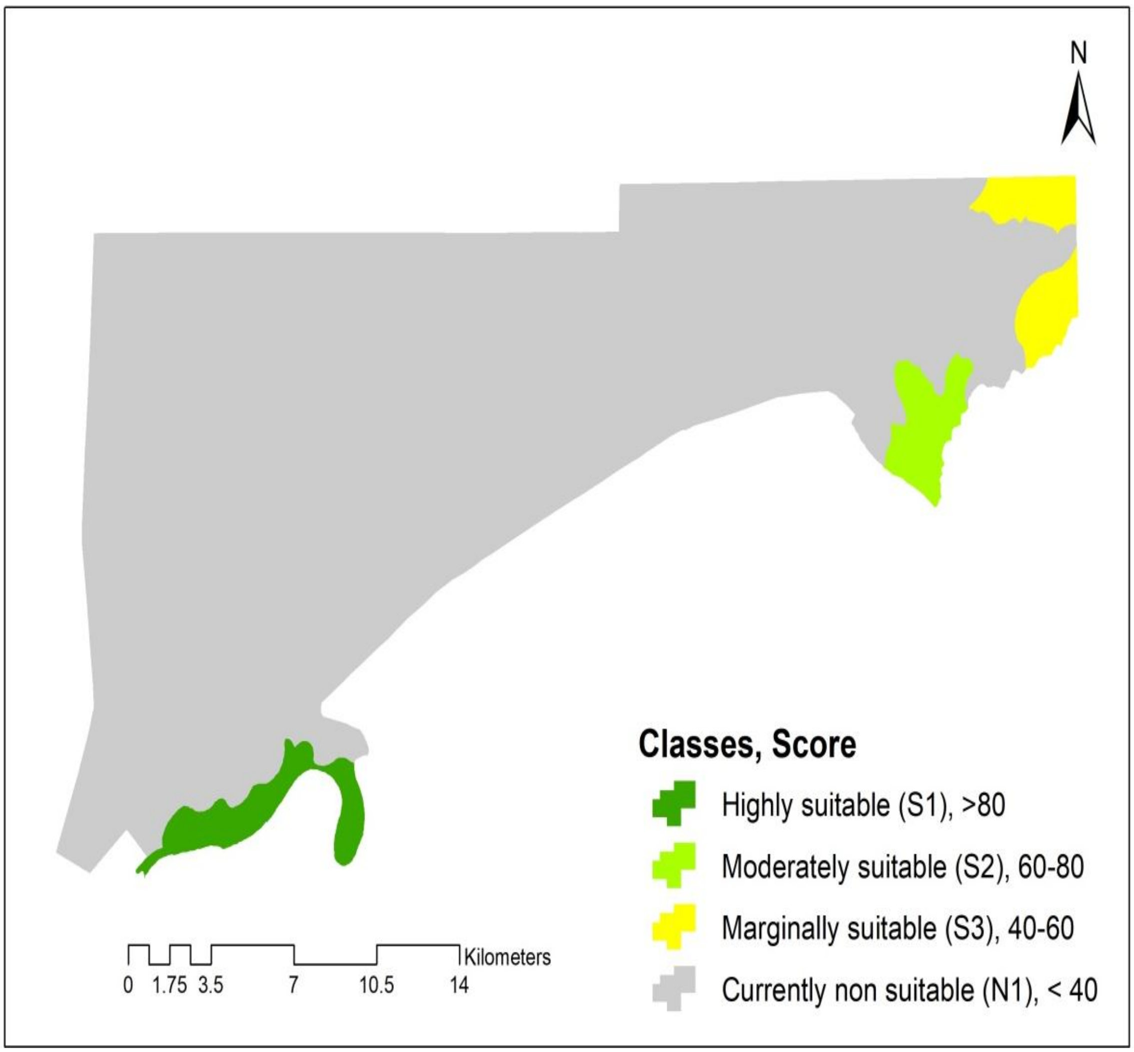

Fig. 2:. Spatial distribution of land suitability varieties for wheat crop cultivation.

crop, which starts from 20/11 to 26/4, is 157 days, and the average temperature for the months of November-April is 17.53, 12.59, 10.68, 12.85, 16.95 and 23.54°C, respectively.

Calculation of climate index for wheat

The Climate Index (CI) was calculated for wheat yield according to the formula suggested by Sys *et al*., (1993).

Climate index (CI) = A1 * A2 * ... * An / $102n^{-2}$

A1, A2 and An are the estimates of the climatic characteristics of the wheat extracted on the basis of their suitability to the wheat growth stages shown in Table 3, after which the final climate estimates are extracted based on the proposal of Sys *et al*., (1993), which was modified by AL Alwani, (2001), table 5.

The results of the final assessment are to classify the land of the region according to its suitability for the irrigation agriculture of wheat. The results of the Li Land index are used to define the grades and varieties of suitability according to the proposals of Sys *et al*., (1993) modified by Pauw in FAO (1976), as follows:

Class S1: Suitable (land index >75)

Class S2: Moderately suitable (land index 50-75)

Class S3: Marginally suitable (land index 25-50)

Class N1: Unsuitable (land index< 25) with severe limitations which can be corrected.

Class N2: Unsuitable (land index< 25) with severe/ or very severe limitations that cannot be corrected.

Results and discussion

Soil assessment and topography:

1. Depth of the soil: The results indicate that the study area was deep and there are no specific layers of depth such as horizons, gypsum, limestone or gravel within the depth of 100 cm, so it is very suitable for the cultivation of wheat crop and gave a rating of 100% and did not constitute a determining factor for relevance.
2. Soil texture: Soil texture is an affecting and important soil characteristic in determining the soil tolerance of water retention and its close relationship to cation exchange capacity and soil permeability according to NCCPI (2008). The field study shows that the predominant texture is SiCL, SiL and SiC. It is not a significant determinant factor of the irrigated agriculture of wheat crop. Evaluation of the texture factor was very appropriate in most study soil units.
3. Content of carbonate minerals: The presence of carbonate minerals in the soil affects both chemical and physical properties. The high concentration of carbonate minerals may impede the growth and cause the yellowing of many plants because of the readiness of some nutrients, especially phosphorus to precipitate. Sys *et al*., (1993) stated that the carbonate content factor is a simple determinant of wheat growth.
4. Gypsum ratio: Gypsum ratio in the project's soil was high, especially in the low areas of Al-Shuweijah Lake. The gypsum materials were deposited in the Lake with the rest of the salts and other soil materials. High exceeded 59%. In the areas near the Tigris River, which are not affected by the water of Al-Shuweijah lake, the ratio of gypsum is low and ranged between less than 0.1% to 3.5%. Gypsum ratios in the soil of the study area are a significant determinant in the above-mentioned areas and are not identified in the vicinity of the Tigris River.
5. Salinity and alkalinity status: Salinity and sodium levels were highly specific to agricultural production, especially wheat cultivation in most parts of the study area.
6. Soil pH: The values of the soil pH were suitable for the growth and cultivation of the wheat crop.
7. Organic carbon ratio: Organic carbon values and their estimates were calculated in the calculation of the land index according to Sys *et al*., (1993) and did not constitute a factor for growing the wheat crop in the region.
8. Drainage degree: The degree of drainage refers to the frequency and duration of wetting periods, which is an important factor in land assessment for different agricultural uses. The degree of drainage varied in the appropriate areas of the study area and estimates were given ranging from 60-100% (table 6).

According to Hamad (2009), the climatic factor of the wheat crop cultivated in the study area and according to the wheat growth stages described above is not a specific factor for planting. Therefore, the climatic factor is very suitable for cultivating the wheat crop in the study area.

Classification of land suitability for the study area for growing wheat crop

The suitability of the land for growing the grain was very high, S1, 1233 ha. (2.47%) Moderately suitable, S2 with an area of 1015 ha. (2%) and marginally suitable, S3 with an area of 1234 ha. (2.47%) and currently not suitable, N1 with an area of 46420 ha. (93%) of the total area of the study area due to high salinity levels due to high levels of groundwater and poor management, as well as the salinity of Al-Shuweijah Lake water which constitutes about 30% of study region (fig. 2).

Conclusions

The determinants of agricultural production in soil models representing the last class varied between high salinity, high percentage of reciprocal sodium and gypsum and low drainage. Geospatial technologies have demonstrated high efficiency and flexibility as well as precision and shortening in time, effort and cost to meet the business requirements on the production of maps and schedules for land assessments.

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