LAND SUITABILITY ASSESSMENT USING AHP (ANALYTICAL HIERARCHY PROCESS) AND SYS,1993 METHODS IN ARID AND SEMI-ARID REGIONS FOR RICE FARMING

R. J. Mohammed[1,2] A. A. Suliman[2]
Lecturer Prof.
[1]Dept. Soil Science and Water Resources , Coll. of Agri, Al-Qasim Green University
[2]Dept. Soil Science and Water Resources, Coll. of Agri Engin Sci University of Baghdad
rafalalshukiri@agre.uoqasim.edu.iq abdulhalim.a@coagri.uobaghdad.iq

ABSTRACT

This study was aimed to investigate the extent the land to productive due to the fact that climatic changes and the increase in population growth are reasons that led to an increase in the demand for food, especially in developing countries. Therefore, a scientific way must assess the suitability of lands for growing crops. This research aims to provide an integrated approach to the process of analyzing the suitability of agricultural lands for crop growth. Rice in the Al-Mishkhab region of Al-Najaf Governorate using the analytical hierarchy model AHP and compared with the method of (Sys, 1993) and the actual production in the field, 12 soil parameters were determined (electrical conductivity, soil interaction, cation exchange capacity, exchangeable sodium ratio, texture soil, lime, gypsum, organic carbon, drainage, soil depth, slope, flooding) and three criteria were added in the AHP method due to their importance in Iraqi soils, which are (total nitrogen, available phosphorus, crop class). The results were extracted and showed that all the results of the study Using the method (Sys, 1993) within the unsuitable range for cultivation N2, either using the analytical hierarchy method and giving varying importance to the above soil criteria, it was found that 12% Very suitable for S1, 60% suitable for agriculture S2, and 28% moderately suitable for S3. Identical to actual crop production in the study area.

Keywords: land evolution; soil salinity; rice; soil productivity.

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تقييم ملاءمة الاراضي باستخدام طرق التحليل الهرمي و طريقة SYS,1993 في المناطق الجافة وشبه الجافة لزراعة محصول الرز

رفل جاسم محمد[1] عبدالحليم علي سليمان[2]
مدرس استاذ
[1] جامعة القاسم الخضراء/ كلية الزراعة [2] جامعة بغداد/ كلية علوم الهندسة الزراعية

المستخلص

نفذت هذه الدراسة لبيان مدى قابلية الارض الانتاجية كون ان التغايرات المناخية وزيادة النمو السكاني اسباب ادت الى زيادة الطلب على الغذاء خصوصا في الدول النامية لذا من الضروري بطريقة علمية تقييم ملائمة الاراضي لزراعة المحاصيل ويهدف هذا البحث الى تقديم نهج متكامل لعملية تحليل ملائمة الاراضي الزراعية لنمو محصول الرز في منطقة المشخاب التابعة لمحافظة النجف الاشرف بأستخدام نموذج التسلسل الهرمي التحليلي AHP ومقارنته بطريقة (Sys, 1993) والحاصل الفعلي في الحقل اذ تم تحديد اثنا عشر معيار من معايير التربة (التوصيل الكهربائي، تفاعل التربة، السعة التبادلية للايونات الموجبة، نسبة الصوديوم المتبادل، نسجة التربة، الكلس، الجبس، المادة العضوية، درجة الصرف، عمق التربة، الانحدار، الفيضان) واضيف ثلاث معايير في طريقة AHP وذلك لاهميتها في الترب العراقية وهي (النتروجين الكلي، الفسفور الجاهز، صنف المحصول المزروع) تم استخراج النتائج واظهرت ان جميع نتائج الدراسة بأستخدام طريقة (Sys, 1993) ضمن المدى غير الملائم للزراعة N2 اما بأستخدام طريقة التسلسل الهرمي التحليلي واعطاء اهميات متفاوتة لمعايير التربة اعلاه وجد ان 12% ملائمة جدا S1 و60% ملائمة للزراعة S2 و28% متوسطة الملائمة S3 وقد كانت هذه النتائج مماثلة للانتاج الفعلي لمنطقة الدراسة.

الكلمات المفتاحية: تقييم الاراضي، ملوحة التربة، الرز، انتاجية التربة.

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INTRODUCTION

Land evaluation is defined as the process of determining the suitability of lands for various uses, such as crop production in general, forest production, grazing, rain-fed agriculture, or the establishment of tourist facilities and others (3). The evaluation process includes, in a simple way, a comparison of the different uses of the land and the relationship of that to the amount of effort exerted to use the land in each case (47). Land suitability evaluation predicts land performance based on various land use types (36). Land suitability at the field scale changes in each part of a local area because of variations in its topo-positions and soil properties. Hence, this is necessary to evaluate, classify, and manage land units to improve land productivity based on local potentials and limitations (Food and Agriculture Organization (19). As a result, the analytical hierarchy process (AHP) integrates multi-criteria elements that offer scores for land suitability assessments in several dimensions (15,17). Saaty (43) recommended AHP approach is one of the best techniques for managing diverse components and showing the connections between agroecological and environmental factors in a hierarchical structure (1980). Additionally, a novel method for assessing the suitability of a piece of land is presented by integrating the AHP method with a geographic information system (GIS) (8,35,38). AHP is widely used and recognized as one of the most effective ways of determining the weights of factors as an MCDA strategy. (29). An essential step in determining the suitability of a piece of land is weighing the pelements that determine its features. Future complications will arise from varying levels of land features influencing the appraisal of the property's suitability. (18,31,34,44,49) developed an analytical hierarchy procedure (AHP). GIS has been used as the optimum strategy for controlling many heterogeneous agents. (9). Dengiz et al., (16) explained in a study he conducted to develop a spatial model to assess the suitability of lands for rice cultivation using GIS. Through his results, he found that 55.5% of the study area is suitable to a high or medium degree for rice cultivation, while 34% of the study area is unsuitable for rice cultivation. Because of soil or topography, the results were validated by a field study and division of the suitability of the study area, as it was found that most of them are S1, S2, and S3 as a class of suitability. A study was conducted in India by (25) using AHP and GIS, and several criteria were selected, including rain, temperature, texture, soil density, drainage, pH, O.C., EC, and slope. The results showed that 6% of the study area is very suitable for S1 and 71% is suitable for S2 and 23% is medium suitability S3 for the rice crop, while the rice was 28% is S2 and 72% is S3 while 28% is S1 and 71% is S2 and 1% is S3 for the maize crop as was 85% is S2 and 15% is S3 for millet crop. This study was aimed to used AHP and SYS methods, AHP had excellent results for managing the weights of land attributes and determining the land suitability value. Therefore, AHP approaches could be a powerful way to improve the accuracy of determining if a piece of land is suitable for growing a particular crop.

MATERIALS AND METHODS

Study area: This study was conducted in central Iraq in Najaf province in Al-Mashkhab district Figure (1). rice crop is grown in some parts of the study area. based on a classification method, Entisols and Inceptisols (51) were found, and the average monthly temperature varies From 12 to 37.81 degrees Celsius. The lowest and highest temperatures occur in January and July, respectively.

Soil sampling and analysis: Thirty soil samples were collected from depths between 0 and 30 cm, air-dried, and passed through a 2 mm opening sieve. The Latin.

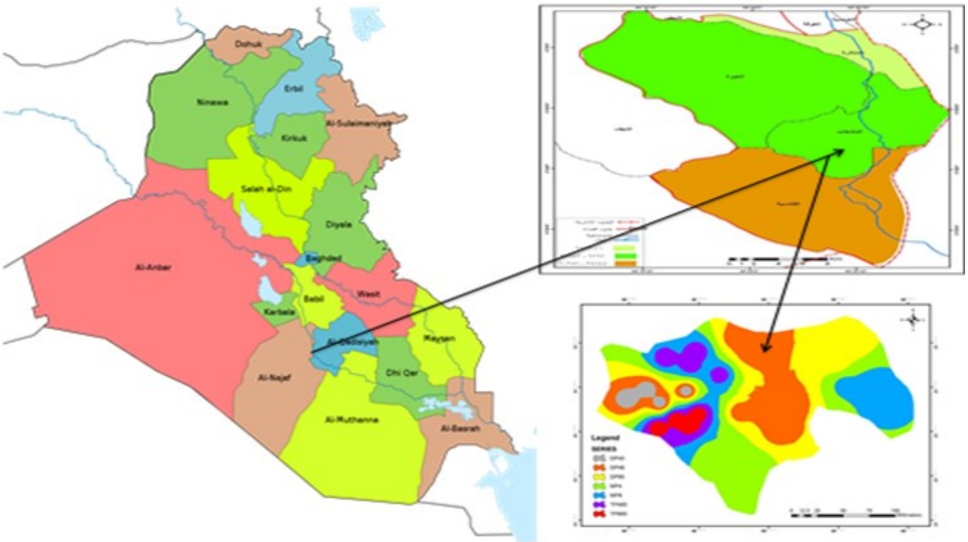

Figure 1. Map of the study area

Data chemical and physical of soil used

The coefficients that were calculated evaluate the suitability of land for crop production are (pH), electrical conductivity (ECe), organic carbon (OC), soil texture, internal drainage, lime, gypsum, cation exchange capacity, exchangeable sodium ratio, total nitrogen, and available phosphorus, slope, soil depth, flooding, and crop class (Table 1, 2) based on a relevant literature review.

Table 1. Soil chemical properties for Al-Najaf site

Surface Sample	Ec dSm^{-1}	Ph.	ESP	CEC $Cmol_ckg^{-1}$ Soil	O.M gm kg^{-1}	Total N. $mg.kg^{-1}$	AV. P. $mg.kg^{-1}$	$CaCo_3$ gm kg^{-1}	$CaSo_4$ gm kg^{-1}
1	1.83	7.63	1.93	24.1	9.7	573	13.9	24.3	12.48
2	1.58	7.65	2.23	20.3	9.8	562	14.2	23.9	12.75
3	1.72	7.58	1.72	20.5	9.1	560	13.6	24	11.1
4	7.31	7.1	7.53	20.19	9.7	496	8.5	33.8	9.8
5	6.5	6.9	7.26	19.42	11.2	510	8.2	33.1	12.15
6	6.16	7.18	6.38	20.45	10.7	507	7.8	34.4	11.65
7	10.95	7.1	9.6	13.08	3.6	208	4.3	32.1	11.32
8	12.89	7.14	10.55	12.06	3.7	219	4.8	32.2	11.7
9	12.52	7.21	10.02	13.68	3.7	220	4.1	34	11.55
10	3.11	7.69	3.29	16.73	10.1	490	12.6	30	11.93
11	4.8	7.58	3.4	19.13	9.9	479	11.8	28.9	10.8
12	3.18	7.73	3.86	20.11	10.2	482	12.2	30.2	10.29
13	3.35	7.1	3.01	18.46	9.3	312	13.1	26.3	10.98
14	3.89	6.85	3.26	14.04	9.8	315	12.9	27.8	9.62
15	2.63	7.02	2.97	18.08	9.2	331	13.6	26.9	9.3
16	6.23	7.42	8.62	24.1	9.8	723	10.9	20.9	9.64
17	8.11	7.51	9.73	18.12	11.7	752	11.2	21.6	9.2
18	9.13	7.48	9.91	16.1	10.8	718	11.5	22.3	10.18
19	2.88	7.42	3.45	14.62	10	477	13.3	17.9	12.9
20	2.71	7.52	2.33	18.46	10.7	482	13.1	17.3	12.63
21	2.9	7.41	3.48	17.95	10.2	469	13.6	18.1	12.13
22	10.58	7.48	7.79	9.58	7.7	139	3.9	20.6	11.96
23	10.96	7.58	8.11	10.41	7.5	162	3.2	19.3	11.92
24	10.62	7.53	10.91	10.16	7.4	130	3.1	18.2	11.74
25	12.01	7.52	12.73	9.53	7.8	123	3.5	20.1	11.72

Table 2. Soil Physical properties for Al-Najaf site

Surface Sample	N	E	Drainage	Clay gm kg^{-1}	Silt gm kg^{-1}	Sand gm kg^{-1}	Texture
1	31°53'16"	44°29'34"	Poorly	240	390	370	Loam
2	31°52'48"	44°29'32"	Poorly	280	410	310	Clay loam
3	31°53'00"	44°29'42"	Poorly	190	430	380	Loam
4	31°49'00"	44°30'30"	Poorly	320	500	180	Silty clay loam
5	31°48'12"	44°30'45"	Poorly	300	440	260	Clay loam
6	31°48'26"	44°31'37"	Poorly	260	360	380	Loam
7	31°50'53"	44°32'40"	Poorly	240	530	230	Silty loam
8	31°50'20"	44°33'19"	Poorly	200	460	340	Loam
9	31°50'56"	44°33'16"	Poorly	180	530	290	Silty loam
10	31°49'19"	44°32'59"	Poorly	290	440	270	Silty loam
11	31°49'50"	44°31'36"	Poorly	310	430	260	Clay loam
12	31°50'05"	44°32'30"	Poorly	390	460	150	Silty clay loam
13	31°51'43"	44°29'26"	Poorly	290	180	530	Sandy clay loam
14	31°51'46"	44°28'04"	Poorly	180	340	480	Loam
15	31°51'23"	44°28'37"	Poorly	150	300	550	Sandy loam
16	31°50'55"	44°29'56"	Poorly	270	410	320	Loam
17	31°50'10"	44°29'37"	Poorly	230	450	320	Loam
18	31°50'47"	44°28'47"	Poorly	220	480	300	Loam
19	31°49'41"	44°29'22"	Poorly	310	400	290	Clay loam
20	31°49'46"	44°28'15"	Poorly	280	380	340	Clay loam
21	31°49'02"	44°28'07"	Poorly	260	500	240	Silty loam
22	31°48'30"	44°27'52"	Poorly	260	280	460	Sandy clay loam
23	31°48'35"	44°28'37"	Poorly	250	290	460	Loam
24	31°47'34"	44°28'16"	Poorly	220	230	550	Sandy clay loam
25	31°48'01"	44°27'27"	Poorly	250	210	540	Sandy clay loam

Land evaluation according to the AHP system: The AHP analytical hierarchy process is used as one of the multi-criteria decision-making tools (Multi-Criteria Decision Making - MCDM) or Multi Criteria Evaluation - MCE. At this stage, the hierarchical structure of the study is formed according to several levels. The main criteria are represented, while the third level of the pyramid represents the secondary criteria, as the principle of the method is based on double comparisons between the studied criteria matrices to determine the weight of each factor that controls the suitability analysis, through a binary comparison of the criteria matrices then values (weights) are given for each studied criterion According to its relative importance and impact on the appropriation process, and the values (weights) range from 1 to 9, as the number y1 means that the two criteria studied (I, j) have the same effect and 9 reveals that one of the criteria is of high importance in the process of appropriation and evaluation as shown in Table 3. (20, 43,44).

Weight determination using the AHP method from MCDA: The AHP method is considered among the best available approaches of MCDA, which was used for assessing and analyzing land-use suitability for different crops (28,36). The pairwise comparison matrix was created based on the relative importance of one criterion over another for determining the parameter weights, as per the AHP preference scale (Table 4).

$$\boldsymbol{A} = [\boldsymbol{a11}\ \boldsymbol{a12}\ \boldsymbol{a1n}\ \boldsymbol{a21}\ \boldsymbol{a22}\ \boldsymbol{a2n}\ \boldsymbol{an1}\ \boldsymbol{an2}\ \boldsymbol{ann}] \quad \textbf{.......(1)}$$

In the pairwise matrix, the sum of each column was represented as follows:

$$\boldsymbol{aij} = \sum_{i=1}^{n} \boldsymbol{aij} \qquad \textbf{.........(2)}$$

Table 3. Pairwise comparison scale

Relative Importance	Definition	Description
1	Equally important	Two factors contributing uniformly to the predefined goal.
3	Moderately important	Experience and judgment are negligibly in favor of one as compared to the another
5	Strongly important	Experience and judgement strongly in favor of one in comparison to the other
7	Very strong import	Experience and judgments very strongly favor one over the another. Its necessity is revealed in practice.
9	Extremely important	The sign favoring one as compared to the other parameter is of the maximum possible validity
2, 4, 6, 8	Intermediate	When compromise is needed
Reciprocals	Less importance	
	← 1/9 1/7 1/5 1/3 1 3 5 7 9 →	
	Less Importance more	

Then, each value in the matrix was divided by the respective column sum to create a standardized pairwise matrix:

$$bij = \frac{aij}{\sum_{i=1}^{n} aij} = [b11\ b12\ b1n\ b21\ b22\ b2n\ bn1\ bn2\ bnn\ ] \quad \text{.......(3)}$$

Lastly, considered (n) to create the weighted matrix of the priority criteria:

$$wij = \frac{\sum_{i=1}^{n} bij}{n} = [w11\ w12\ w1n\ ] \quad \text{........(4)}$$

The original consistency vectors were obtained by multiplication of the pairwise matrix by the weight vectors:

$$[a11\ a12\ a1n\ a21\ a22\ a2n\ an1\ an2\ ann\ ]X[w11\ w12\ w1n\ ] = [a11w11\ a12w12\ a1nw1n\ a21w21\ a22w22\ a2nw1n\ an1wn1\ an2wn2\ annw1n\ ] = [v11\ v12\ v1n\ ] \text{.........(5)}$$

Furthermore, the principal eigenvector (λmax) was computed by averaging the elements of the consistency vector:

Table 4. the principal eigenvector

	Pairwise	weighted sum value	AVERAGE	Max
OM	5	0.954605	0.0635427	15.02305
PH	6	1.168254	0.0776009	15.05465
EC	9	1.756187	0.1166505	15.05511
CaCO3	3	0.572155	0.0380843	15.02337
CEC	5	0.958079	0.0637699	15.02401
ESP	5	0.958079	0.0637699	15.02401
SLOPE	1	0.189947	0.0126434	15.02343
Texture	9	1.756187	0.1166505	15.05511
Derange	5	0.954605	0.0635427	15.02305
soil Depth	1	0.189947	0.0126434	15.02343
Avlp. P	7	1.337818	0.0890525	15.0228
Tot. N	7	1.337818	0.0890525	15.0228
CaSo4	3	0.572155	0.0380843	15.02337
Flooding	3	0.574848	0.0382619	15.02 401
Crop Class	9	1.756187	0.1166505	15.05511
Average				15.03182

$$= \sum_{i=1}^{n} avij = 15.03182$$

Eigenvalues were computed by averaging the respective rows of each matrix, these values were also mentioned as relative weights

Table 5. Pairwise comp arison matrix

	OM	PH	EC	CaCO3	CEC	ESP	SLOPE	Texture	Drainage	Depth	P	N	CaSo4	Flooding	Crop Class
OM	5/5	5/6	5/9	5/3	5/5	5/5	5/1	5/9	5/5	5/1	5/7	5/7	5/3	5/3	5/9
PH	6/5	6/6	6/7	6/3	6/5	6/5	6/1	6/7	6/5	6/1	6/7	6/7	6/3	6/3	6/7
EC	9/5	9/6	9/7	9/3	9/5	9/5	9/1	9/7	9/5	9/1	9/7	9/7	9/3	9/3	9/7
CaCO3	3/5	3/6	3/9	3/3	3/5	3/5	3/1	3/9	3/5	3/1	3/7	3/7	3/3	3/3	3/9
CEC	5/5	5/6	5/9	5/3	5/5	5/5	5/1	5/9	5/5	5/1	5/7	5/7	5/3	5/3	5/9
ESP	5/5	5/6	5/9	5/3	5/5	5/5	5/1	5/9	5/5	5/1	5/7	5/7	5/3	5/3	5/9
SLOPE	1/5	1/6	1/9	1/3	1/5	1/5	1/1	1/9	1/5	1/1	1/7	1/7	1/3	1/3	1/9
Texture	9/5	9/6	9/9	9/3	9/5	9/5	9/1	9/9	9/5	9/1	9/7	9/7	9/3	9/3	9/9
Drange	5/5	5/6	5/9	5/3	5/5	5/5	5/1	5/9	5/5	5/1	5/7	5/7	5/3	5/3	5/9
soil Depth	1/5	1/6	1/9	1/3	1/5	1/5	1/1	1/9	1/5	1/1	1/7	1/7	1/3	1/3	1/9
Avlp. P	7/5	7/6	7/9	7/3	7/5	7/5	7/1	7/9	7/5	7/1	7/7	7/7	7/3	7/3	7/9
Tot. N	7/5	7/6	7/9	7/3	7/5	7/5	7/1	7/9	7/5	7/1	7/7	7/7	7/3	7/3	7/9
CaSo4	3/5	3/6	3/9	3/3	3/5	3/5	3/1	3/9	3/5	3/1	3/7	3/7	3/3	3/3	3/9
Flooding	3/5	3/6	3/9	3/3	3/5	3/5	3/1	3/9	3/5	3/1	3/7	3/7	3/3	3/3	3/9
Crop Class	9/5	9/6	9/9	9/3	9/5	9/5	9/1	9/9	9/5	9/1	9/7	9/7	9/3	9/3	9/9

Table 6. Calculation of weights for each soil parameters

	OM	PH	EC	CaCO3	CEC	ESP	SLOPE	Texture	Drange	Depth	. P	N	CaSo4	Flooding	Crop Class	AVERAGE
OM	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
PH	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
EC	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
CaCO3	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
CEC	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
ESP	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
SLOPE	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Texture	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Drange	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
soil Depth	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Avlp. P	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Tot. N	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
CaSo4	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Flooding	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Crop Class	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

In the AHP method, while executing the pairwise comparisons of criteria, a certain level of variation may follow. To tackle this problem, consistency ratio (CR) was used for preventing bias through criteria weighting. As a solution, eigenvectors and the largest eigenvalue of the respective matrix were computed, and the consistency index (CI) was examined using the following equation:

$$CI = \frac{\lambda_{max} - n}{n - 1} = 0.002273$$

Here, λmax represents the maximum eigenvalue of the pairwise comparison matrix and n is the number of criteria in each PWCM. Finally, the uniformity of the PWCM was examined using the random consistency index (RI) value, as shown in Table 9. CR was computed by using the method given below.

$$CR = \frac{CI}{RI} = 0.001439$$

To be valid, its consistency ratio should be ≤0.10. If the acquired value is larger than 0.10, it is essential to develop the PWCM. Aggregation of the weight and standardized rated criterion map Weighted overlay method was used to aggregate standardized rated criteria and weighted criteria to map the suitable land based on the equation below. These maps were reclassified based on a parametric model of a land index to generate FAO land classes which convert suitability values into classes to produce the final map (Table 4).

$$LS = \sum_{i=0}^{n} Wi\, Xi$$

where LS is the Land suitability, Wi is the weight of factor, and Xi is the criterion score of factor i.

RESULTS AND DISCUSSION

1. Land suitability using Sys, 1993 methods

The results in Table (7) show to the soil properties Al-Mishkhab area in Al-Najaf Governorate, and the standard multiplication method proposed by Sys et.al., 1993 was adopted for the purpose of indicating the land suitability for the productivity of rice crop. The results shown in Table (8) revead to evaluate soil properties for the cultivation of rice in the study area, as follows: Soil texture It is one of the important and influential soil property in determining the soil's ability to retain water and its close relationship to the cation exchange capacity and soil permeability according to (37). for pedons, and between (12.5-72.5) for surface samples in the Mishkhab area (16,37,39).

Carbonate minerals: Carbonate is a determining factor for the growth of the rice crop, as the estimated values for the rice crop ranged (12.5-54) in the pedon sites and for surface samples (12.5-55.40) (16,17,21,24,37).

• Gypsum percentage: According to Table (8), The gypsum content factor was given an estimate ranging between (93.55-95.4) for surface samples (16)

Salinity: Soil salinity values ranged (1.58-12.89) dSm^{-1}.the values of suitable salinity estimates were between (12.5-90) in the sites between (12.5-89.2) for the rice crop. Salinity is a severe determinant of rice yield (23,24 ,37,50)

Table 7. Weight of factor for each parameter soil by using sys et al.,1993

	PH	EC	ESP	TEX	DEPTH	GYPS	CaCo3	OC	CEC	SLOPE	FLOODING	DRANGE	sutibi	Class
L1	89.75	86.7	99.04	12.5	100	93.76	41.4	64.25	100	90	100	72.5	1.57	N2
L2	89.58	89.2	98.89	72.5	100	93.63	42.2	64.5	90.38	90	100	72.5	8.61	N2
L3	90.17	87.8	99.14	12.5	100	94.45	42	62.75	90.63	90	100	72.5	1.44	N2
L4	94.17	36.73	96.24	72.5	100	95.1	12.5	64.25	90.24	90	100	72.5	1.09	N2
L5	96	38.75	96.37	72.5	100	93.93	12.5	68	89.28	90	100	72.5	1.21	N2
L6	93.5	39.6	96.81	12.5	100	94.18	12.5	66.75	90.56	90	100	72.5	0.21	N2
L7	94.17	27.63	95.2	50	100	94.34	12.5	49	80.44	90	100	72.5	0.38	N2
L8	93.83	12.5	94.45	12.5	100	94.15	12.5	49.25	78.84	90	100	72.5	0.04	N2
L9	93.25	12.5	94.98	50	100	94.23	12.5	49.25	81.38	90	100	72.5	0.17	N2
L10	88.1	71.13	98.36	50	100	94.04	12.5	65.25	85.91	90	100	72.5	1.32	N2
L11	89.2	52	98.3	72.5	100	94.6	12.5	64.75	88.91	90	100	72.5	1.47	N2
L12	87.7	70.25	98.07	72.5	100	94.86	12.5	65.5	90.14	90	100	72.5	2	N2
L13	94.17	68.13	98.5	12.5	100	94.51	12.5	63.25	88.08	90	100	72.5	0.34	N2
L14	96.5	61.38	98.37	12.5	100	95.19	12.5	64.5	81.94	90	100	72.5	0.3	N2
L15	94.83	77.13	98.52	12.5	100	95.35	12.5	63	87.6	90	100	72.5	0.39	N2
L16	91.5	39.43	95.69	12.5	100	95.18	48.2	64.5	100	90	100	72.5	0.83	N2
L17	90.75	34.73	95.14	12.5	100	95.4	46.8	69.25	87.65	90	100	72.5	0.66	N2
L18	91	32.18	95.05	12.5	100	94.91	45.4	67	85.13	90	100	72.5	0.56	N2
L19	91.5	74	98.28	72.5	100	93.55	54.2	65	82.84	90	100	72.5	8.59	N2
L20	89.8	76.13	98.84	72.5	100	93.69	55.4	66.75	88.08	90	100	72.5	9.75	N2
L21	91.58	73.75	98.26	50	100	93.94	53.8	65.5	87.44	90	100	72.5	6.27	N2
L22	90.2	28.55	96.11	12.5	100	94.02	48.8	59.25	74.97	90	100	72.5	0.41	N2
L23	90.17	27.6	95.95	12.5	100	94.04	51.4	58.75	76.27	90	100	72.5	0.42	N2
L24	90.58	28.45	94.09	12.5	100	94.13	53.6	58.5	75.88	90	100	72.5	0.44	N2
L25	90.67	12.5	92.27	12.5	100	94.14	49.8	59.5	74.89	90	100	72.5	0.18	N2

Soil reaction pH: Soil reaction values ranged between (6.85-7.69) and these values are considered suitability values for rice crops ranged between (87.7-96.5) for samples in the study area (10).

• ESP: Exchangeable sodium percentage values ranged between (1.72-12.73) for the study sites,. The values of The suitability for rice crop ranges between (92.27-99.04) and it is noted that the low ESP values less than 15% were due to the high divalent carbons (Ca^{+2}, Mg^{+2}) at the expense of sodium (5,47)

• Cation exchangable capacity: CEC: The values of the cation exchangable capacity in the pedons of the study area ranged between (9.53-24.1) Cmolckg $^{-1}$ Soil, and these values are good.

• Organic carbon: the suitability values ranged between (49-69.25) for the study sites with respect to the rice crop (1,4,14,16,42).

• Internal drainage: according to the morphological description, study area, and an estimate was given for this factor (44), and it was a determining factor in all the soils of the study area for the rice crop(7).===It is clear from the results above, which described the contribution of 12 factors to the suitability of the land for productivity. They were distributed between very specific, medium and simple determination, and that the most important and determinant of these factors for productivity are (soil texture, content of carbonate minerals, soil salinity and the percentage of organic carbon).

The final results of evaluating the dominant soil units in the study area, which are shown in Table (8) Figure (2), indicated that there is a decrease in the suitability classes of soils for cultivating the rice crop, as it is noted that 100%,. The reason for this decrease is related to many reasons starting from the low values of some reasons included in the equation (48), as there were specific reasons, non-specific reasons, and moderately determined reasons, as it is noted that the reasons of pH, ESP, soil depth, gypsum content, and CEC, slope and flood were non-specific reasons, while the reasons of soil salinity, texture, CaCO3 and organic carbon were specific reasons and as a result of adopting multiplication method, as one characteristic is sufficient to reduce productivity values to very low levels

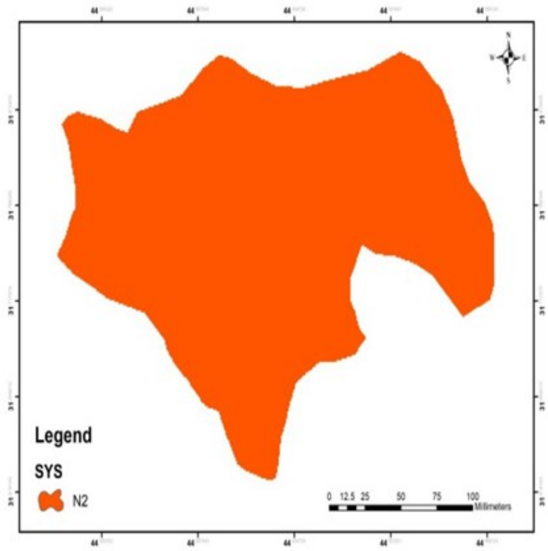

Fig 2. land suitability by using sys methods

Land suitability using AHP methods

The results in Table (9) show general property of the lands of Al-Mishkhab region in the province of Al-Najaf, and the AHP method was adopted to indicate the suitability of the lands for the productivity of the rice crop.= Soil texture: The results in Table (9) indicat that the soil texture is a very important property and had a clear impact on land suitability for agriculture and therefore the productive capacity, as it was given an importance of 9/9 with a weight of 11.66%, and this value changes according to the type of soil texture depending on the weights obtained. From the rice crop requirements table according to Sys et.al., 1993, it amounted to 1.458% L25, reached 8.457% for the class Clay loam, which is equivalent to 72.5 in the table of rice crop requirements according to Sys et.al., 1993 for each of L20, L19, L12, L11, L5, L4, L2(20,30,32,45). Calcium carbonate: it was given the importance of 3/9 with a weight of 3.808%. With a weight of 12.5- 55.40 when using the equation of Sys et.al., 1993, and this ratio is considered an influential and determining factor, despite the coexistence of most Iraqi soils with these ratios and giving them good productivity, and therefore their weight value was reduced when using the AHP method, as the highest weight value reached is 3.808%, and thus we note that its value ranged between 0.476% for each of P5, P4, P3, P2 L15, L14, L13, L12, L11, L10, L9, L8, L7, L6, L4 and 1.607% for each of L3, L2 and 1.729% for sample L18 and 1.782% for sample L17 and 1.836% for sample L16 and 1.859% for sample L22 and 1.897% for sample L25 and 1.958% for sample L23 and 2.041 for sample 2.L049 and 2.049% for sample L21 and 2.064% for sample L19, (12). Gypsum: (gypsum) in the soil, which was given importance by 3/9 and with a weight of 3.808%. (11). Soil salinity: It was given importance 9/9 with a weight of 11.66%. value between 12.5 - 89.20 when using the Sys et.al., 1993 equation. When using the AHP method, it is given the utmost importance. Therefore, we note that the highest weight value reached by salinity is 11.66%, and thus its values ranged between 1.458% and 1.458%. 10.41%.for soil sample (2,8,13,22,28). Soil reaction: its importance was 6/9 with a weight of 7.76%. to 7.424% for, soil. Cations Exchangeable capacity: It was given an importance of 5/9 with a weight of 6.376%, and the weights ranged between 5.028%. 6.377 for surface samples, and to a very appropriate degree, as it was given weights that ranged between 78.84-100 when using the Sys et.al., 1993 equation(41). Total nitrogen: The results shown in Table (8) show that the study sites contained varying proportions of nitrogen between the low and the high. It was given an importance of 9/7 with a weight of 8.905%. Its weight value ranged between 4.798% for the L25 sample to 8.467% for the L17 sample when using AHP methods (40,45,49,46) Available Phosphorus: The results in Table (8) show that the study sites contained varying percentages of Available phosphorous between low and high. It was given importance 9/7 with a weight of 8.905%. Its weight value ranged between 3.055% for L24 to 7.213% for L2. This factor was introduced as a new measure to calculate land suitability when using AHP method, because this element is of great importance in the fertility aspect of the soil (6,26) Crop class: The genetic difference between cultivars is one of the most important factors determining the growth and productivity of most crops. The crop cultivar had an important role in this productivity. It was given importance by 9/9 with a weight of 11.66%.As for surface samples, the value reached 11.66% for each.

Table 8. Weight of factor for each parameter soil by using AHP methods

	PH	EC	ESP	TEX	DEPTH	GYPS	CaCo3	OC	CEC	SLOPE	FLOO	DRANGE	Total N.	AV. P.	Crop class	SUTABI	CLASS
L1	6.9647	10.114	6.3155	1.4581	1.2643	3.5708	1.5767	4.0826	6.377	1.1379	3.8262	4.6068	7.8295	7.0797	11.665	77.868	S2
L2	6.9517	10.405	6.3059	8.4572	1.2643	3.5656	1.6072	4.0985	5.7632	1.1379	3.8262	4.6068	7.7903	7.2133	11.665	84.658	S1
L3	6.997	10.242	6.3221	1.4581	1.2643	3.5971	1.5995	3.9873	5.7791	1.1379	3.8262	4.6068	7.7832	6.9461	11.665	77.212	S2
L4	7.3074	4.284	6.1369	8.4572	1.2643	3.6218	0.4761	4.0826	5.7544	1.1379	3.8262	4.6068	7.5338	4.8088	8.7488	72.047	S2
L5	7.4497	4.5202	6.1455	8.4572	1.2643	3.5771	0.4761	4.3209	5.6931	1.1379	3.8262	4.6068	7.6051	4.702	8.7488	72.531	S2
L6	7.2557	4.6194	6.1736	1.4581	1.2643	3.5866	0.4761	4.2415	5.7752	1.1379	3.8262	4.6068	7.5944	4.5595	8.7488	65.324	S2
L7	7.3074	3.2225	6.0709	5.8325	1.2643	3.5929	0.4761	3.1136	5.1295	1.1379	3.8262	4.6068	4.7821	3.3751	2.9163	56.654	S3
L8	7.2815	1.4581	6.0231	1.4581	1.2643	3.5856	0.4761	3.1295	5.0279	1.1379	3.8262	4.6068	4.9095	3.5087	2.9163	50.61	S3
L9	7.2363	1.4581	6.0569	5.8325	1.2643	3.5885	0.4761	3.1295	5.1893	1.1379	3.8262	4.6068	4.921	3.3217	2.9163	54.961	S3
L10	6.8366	8.2968	6.2721	5.8325	1.2643	3.5813	0.4761	4.1462	5.4786	1.1379	3.8262	4.6068	7.4804	6.5008	8.7488	74.485	S2
L11	6.922	6.0658	6.2686	8.4572	1.2643	3.6028	0.4761	4.1144	5.6699	1.1379	3.8262	4.6068	7.3825	6.1446	8.7488	74.688	S2
L12	6.8056	8.1947	6.2539	8.4572	1.2643	3.6125	0.4761	4.162	5.7481	1.1379	3.8262	4.6068	7.4092	6.3227	8.7488	77.026	S2
L13	7.3074	7.9468	6.281	1.4581	1.2643	3.5993	0.4761	4.0191	5.6165	1.1379	3.8262	4.6068	5.8953	6.7235	5.8325	65.991	S2
L14	7.4885	7.1594	6.273	1.4581	1.2643	3.6252	0.4761	4.0985	5.2251	1.1379	3.8262	4.6068	5.922	6.6344	5.8325	65.028	S2
L15	7.3591	8.9967	6.2823	1.4581	1.2643	3.6313	0.4761	4.0032	5.5862	1.1379	3.8262	4.6068	6.0645	6.9461	5.8325	67.471	S2
L16	7.1005	4.5989	6.1021	1.4581	1.2643	3.6249	1.8357	4.0985	6.377	1.1379	3.8262	4.6068	8.3638	5.7439	11.665	71.804	S2
L17	7.0423	4.0507	6.0667	1.4581	1.2643	3.6332	1.7823	4.4003	5.5894	1.1379	3.8262	4.6068	8.4671	5.8775	11.665	70.868	S2
L18	7.0617	3.7532	6.061	1.4581	1.2643	3.6146	1.729	4.2574	5.4284	1.1379	3.8262	4.6068	8.346	6.011	11.665	70.221	S2
L19	7.1005	8.6321	6.267	8.4572	1.2643	3.5628	2.0642	4.1303	5.2829	1.1379	3.8262	4.6068	7.3646	6.8125	11.665	82.174	S1
L20	6.9686	8.88	6.3027	8.4572	1.2643	3.5679	2.1099	4.2415	5.6165	1.1379	3.8262	4.6068	7.4092	6.7235	11.665	82.777	S1
L21	7.1069	8.603	6.266	5.8325	1.2643	3.5774	2.0489	4.162	5.5759	1.1379	3.8262	4.6068	7.2934	6.9461	11.665	79.913	S2
L22	6.9996	3.3304	6.1286	1.4581	1.2643	3.5807	1.8585	3.7649	4.7807	1.1379	3.8262	4.6068	3.9833	3.2682	2.9163	52.905	S3
L23	6.997	3.2196	6.1184	1.4581	1.2643	3.5814	1.9575	3.7331	4.8634	1.1379	3.8262	4.6068	4.2496	3.0812	2.9163	53.011	S3
L24	7.0293	3.3187	6.0001	1.4581	1.2643	3.5849	2.0413	3.7172	4.8385	1.1379	3.8262	4.6068	3.8791	3.0545	2.9163	52.673	S3
L25	7.0358	1.4581	5.884	1.4581	1.2643	3.5853	1.8966	3.7808	4.7758	1.1379	3.8262	4.6068	3.7981	3.1614	2.9163	50.586	S3

and 5.833% for samples L15, L14, L13, and 2.916% for samples L25, L24. , L23, L22, L9, L8, L7, and thus we note that the crop variety had a clear effect in determining the productive capacity of the soil, as the more the crop is resistant to environmental conditions And some of the poor characteristics of the soil, such as the higher the salinity, the better productivity it gives, and that this productivity benefits the soil productivity (25,33). The results in Table (9) and Figure (3) show the evaluation of land suitability for the rice crop

Class S1:The lands belonging to this class were characterized as being suitable lands for the cultivation of rice crop and this class constitutes an area of 4187.84 hectares, they were L2, L19, L20 within S1 means within the limits of this category.

Class S2:The lands belonging to this cultivar were characterized as medium suitable for the cultivation of rice crop due to the presence of some severe and very severe determinants, especially soil salinity and the carbonate minerals factor, respectively, reached 20939.39 hectares and by 60.60% of the lands of the study area. As for surface samples, they wereL21, L18, L17, L16, L15, L14, L13, L12, L11, L10, L6, L5, L4, L3, L1 within S2.

Class S3:The lands belonging to this cultivar were characterized as being suitable to a limited degree for the cultivation of rice crop due to the presence of some very severe determinants, including organic carbon, salinity, calcium carbonate, and the crop variety, phosphorus, and soil texture.This class constituted an area of 9422.72 hectares, or 27.27% of the land of the study area. As for surface samples, they were L25, L24, L23, L22, L9, L8, L7 within S3, i.e. within the limits of this class

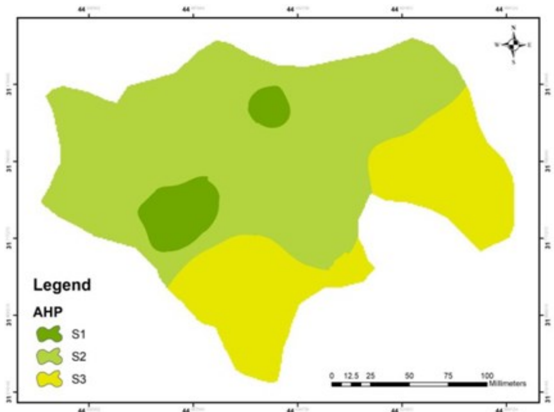

Fig 3. Land evaluation by AHP methods

Conclusion

It is clear from this study that the (Sys, 1993) land evaluation equation is not feasible to be used for Iraqi soils, especially for the rice crop, because it gives the same importance for all criteria, especially since some criteria are constant for Iraqi soils and some have the highest values such as flooding and soil depth, so it was found necessary to vary the importance of these characteristics Using the AHP method and giving weight to each criterion and adding three criteria (total nitrogen, phosphorus, and cultivated crop variety) to obtain values that are very close to the actual land productivity.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

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