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Research Article

Development of a parametric-based Analytical Hierarchy Process (AHP) utilizing Geographic Information Systems (GIS) for wheat land suitability evaluation

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Abstract
Wheat is considered one of the most essential crops for Egypt. Nevertheless, it is also one of its largest imports. Therefore, it is important to develop an accurate wheat suitability model to define the most suitable areas for its production. This study aimed to develop a parametric-based Analytical Hierarchy Process (AHP) using Geographic Information Systems (GIS) for land suitability evaluation of wheat in a selected area in El-Beheira governorate, Egypt. The climatic and land parameters influencing wheat production in the studied area were selected and rated according to the parametric method. These parameters included slope, texture, calcium carbonate, sum of basic cations, pH, organic matter, salinity, exchangeable sodium percentage and mean temp. of the growing cycle. The rated parameters were processed according to the AHP. The results were compared with Storie and the Square root methods and field observations. When validated using field observations, the developed method had a higher accuracy suitability evaluation for wheat cultivation in the studied area than the other two methods. According to the developed method, almost all of the studied areas could be classified as very suitable (S1) for wheat cultivation. On the other hand, the wheat suitability evaluation according to the other two methods indicated that most of the studied area could be classified as moderately suitable (S2) and marginally suitable (S3), which contradicted the field survey.

Keywords: Analytical Hierarchy Process (AHP), El-Beheira governorate, Geographic information system (GIS), Parametric land suitability evaluation, Wheat land suitability evaluation.

INTRODUCTION

Wheat is a very important component of the daily diet of the Egyptians and constitutes about 50.5% of its total cultivate winter crop area (Siam and Croppenstedt, 2007 and Atta *et al.,* 2022). Despite the current efforts to increase wheat productivity, a large gap exists between production and consumption. The country is overdependent on imports that reach about 12 million tons annually to fulfil its needs (Othman *et al.*, 2014 and USDA, 2023). Moreover, with the vast population increase and climate change impacts, it is vital to increase wheat production further to ensure food security. In this context, selecting the best locations for wheat production is necessary. Land suitability evaluation estimates the suitability of lands for a specific use (Hamzeh *et al.,* 2014) and can significantly impact the profit and loss of investments (Kunda *et al.,* 2013). Therefore, it is considered essential for sustainable land management, land uses planning and food security (Mohammadrezaei *et al.,* 2013). The limitations and potentials of natural resources in a certain area could be identified through land suitability, which could help farming decision-making (Fekadu and Negese, 2020). The land suitability evaluation includes many factors that directly or indirectly influence the potentiality of a certain land use in the area under investigation (Vargahan *et al.,* 2011). Various evaluation methods have been introduced, and parametric methods are widely used for land suitability evaluation (Rabia and Terribile, 2013). In the parametric method, a numerical rating is given to each characteristic for a specific land use. After determining the rating, the overall land suitability classes are assigned accordingly (Hamzeh *et al.,* 2014). Frequently, these methods were integrated with Geographic information systems (GIS). These GIS-based methods are considered a powerful tool for suitability analysis due to their ability to analyze and process the data of spatial layers (Kunda *et al.,* 2013). Integrating this method with GIS for suitability evaluation could support decision-makers in land use planning (Ghabour *et al.,* 2008; Belal and Al-Ashri, 2011; Kumar *et al.,* 2009).

The Analytical Hierarchy Process (AHP) was developed by Saaty (1980) and has been widely used since then in different fields (Al-Barqawi and Zayed, 2008). The AHP is an a multi-criteria decision-making technique that can incorporate different data types and compare each of the two parameters using the pairwise comparison method to convert the human perception of importance into a numerical value (Kumar *et al.,* 2009).The AHP has also been integrated with GIS for land suitability studies. For example, a prototype application utilizing GIS and AHP was developed by *Kunda et al.* (2013). This model can provide the farmers and decision-makers with the information required for agricultural development planning. Similarly, Topuz and Deniz (2023) integrated AHP and GIS to create land use suitability maps and consequently decided which land uses are unsuitable in the research area and suggested alternative land uses and, therefore, contributed to the local and national economy and helped the protection of natural areas.

Various studies compared parametric methods and AHP to decide which approach is more accurate for land suitability evaluation. A comparison between the two approaches revealed that their land suitability evaluation was highly correlated in a selected area in Northeast of Iran (Gholizadeh *et al.,* 2020). On the contrary, various studies revealed that AHP had higher accuracy compared to parametric methods when compared to field observations (Mohammed and Suliman, 2023).The present study aimed to develop and evaluate an accurate land suitability approach for wheat in a selected area in El-Beheira governorate, Egypt, by integrating AHP, parametric methods and GIS.

MATERIALS AND METHODS

Study area

The study area is located El-Beheira governorate, Egypt and covers 175.8 Km^2. The area is outlined by longitudes 29°58'40" and 30°11'20" E and latitudes 30° 41'55" and 30°53'20" N (Fig. 1). Wheat and Egyptian clover were the major crops in the study area in winter 2020-2021 and covered about 67% of the study area. Other crops like citrus, potato, and green beans covered about 21%. The remaining area was covered by strawberries and guava (Makar *et al.,* 2022a). Most of the study area was irrigated using sprinkle irrigation, whether fixed or movable, and drip irrigation. Nevertheless, furrow irrigation was also observed in scattered fields. The land management ranged between mechanization and handwork. The Global elevation model

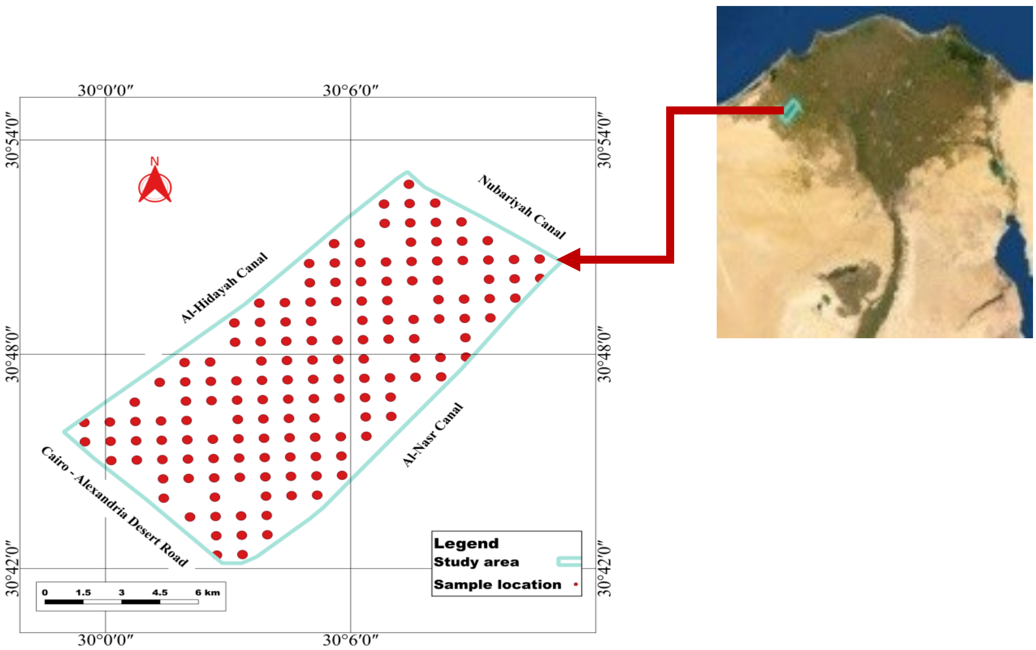

Fig. 1. *Location map of the selected study area in El-Beheira governorate, Egypt*

GMTED2010 was downloaded from Earthexplorer (www.earthexplorer.usgs.gov) (accessed on August 2023). The data was available at 7.5 arc seconds, imported, and subsetted to the study area.The elevation in the study area ranged between 2-30m above sea level and the slope ranged between 0.0 and 3.3%.

The monthly meteorological data from 1991 to 2020 were downloaded from NASA's POWER (Prediction Of Worldwide Energy Resource). The data was available for download from https://power.larc.nasa.gov/data-access-viewer (accessed on May 2022). The data revealed that the mean temperature ranged from 12.9°C in January to 29.6 °C in July, with an average of 21.9° C. There was no rain during August, while the highest was in April, reaching 7.6 mm/month. The total annual rainfall was 39.4 mm (Table 1).

Fieldwork and laboratory analysis

Fieldwork was carried out in the winter season from December 2020 to March 2021. A grid system of 1 observation every 1 Km^2 was used to collect soil samples using an auger. One hundred and forty-nine soil observations were taken for analyses (Fig. 1). For orchards, three soil samples were collected at 120 cm, while for other crops, two samples were collected at 75 cm depth. For each location, the weighted average of each measured soil characteristic was calculated (Morgan et al., 2017). The collected soil samples were air-dried, ground gently, sieved through a 2mm sieve andanalyzed physically and chemically. The particle size distribution was analysed according to (Gee and Bauder, 1986).Calcium carbonate ($CaCO_3$) and organic matter (OM) were determined ollowing the procedure cited inPage et al.(1982). The electrical conductivity (EC) and the soil reaction (pH) were determined according to Jackson(1973). The sum of base saturation (SBC), exchangeable sodium percentage (ESP) and qualitative determination of gypsum were determined (United States Salinity Laboratory staff, 1954).

Land suitability evaluation

A geographic database was designed containing the soil samples location and their chemical and physical properties calculated as averaged weighted within the QGIS software. The inverse distance weighting (IDW) interpolation method was applied to create spatial continuous data. This method is considered relatively fast, easy-to-compute, straightforward and the most frequently used method in spatial interpolation (Lu and Wong, 2008).

The parametric land suitability method described by Sys *et al.* (1991) was used in this study. In this method, a numeral rating is attributed to each characteristic or quality, giving a maximum rating of 100 if the land characteristic is optimal and a lower rating is applied if the characteristic shows a limitation. Rating summary of the climatic, landscape and soil parameters used in this study for wheat according to Sys *et al*. (1993) is shown in Table 2.

The parameters' ratings were then used to calculate the

Table 1. Meteorological data of the studied area from 1991-2020.

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average/ Total
Temperature	12.9	13.8	16.7	20.6	24.9	28.2	29.6	29.7	27.5	24.1	19.3	14.6	21.9
Rain	6.1	5.4	6.9	7.6	0.5	0.5	0.2	0.0	0.2	2.4	6.3	3.3	39.4

Table 2. Climatic, landscape and soil ratings for land suitability of wheat

General criteria	Criteria	Rating			
		S1	S2	S3	N2
		100-85	85-60	60-40	40-0
Climate	Mean temp. of the growing cycle (oC)	18-12	12-10	10-8	<8
Topography	Slope %	0-8	8-16	16-30	>30
Physical soil parameters	Texture*	Si-SiC-SL-CL-SL-L	SCL	SL	SiC
	Depth	->50	50-20	20-10	< 10
	$CaCO_3$ (%)	3-30	30-40	40-60	>60
	Gypsum (%)	0-5	5-10	10-20	>20
Soil fertility parameters	Sum of basic cations (meq/100g)	>5	3.5-5	2-3.5	<2
	pH (H_2O)	7.0-8.2	8.2-8.3	8.3-8.5	>8.5
	OM (%)	>1.72	1.72-0.86	<0.86	--
Salinity & alkalinity	EC (dS/m)	<3	3-5	5-6	>6
	Exchangeable sodium percentage (ESP) (%)	<20	20-35	35-45	>45

*Si= Silt; C= Clay; S= Sand; L= Loam; S1=Very suitable; S2=Moderately suitable; S2=Marginally suitable; N=Not suitable
Source: Sys *et al*. (1993)

overall land evaluation index using the AHP.Utilizing this approach, a pair-wise comparison based on expertise knowledge from long-term observation was applied to the selected climatic, landscape, and soil parameters. Thus, each parameter was assigned a relative importance value ranging from 1 to 9 to createthe AHP matrix, as shown in Table 3 (Saaty, 2008).

After setting up the pair-wise comparison matrix, the values were normalized and the priority vectors for each parameter were determined by dividing the normalized pair-wise values by the sum of their columns (Topuz and Deniz, 2023).To validate the hierarchical structure consistency, the consistency ratio (CR) was determined as described by (Saaty, 2008).

$$CR = \frac{CI}{RI} \quad \text{Eq.1}$$

Where CI is the consistency index and RI is the random index.

The consistency index is calculate as follows

$$CI = \frac{\lambda \max - n}{n - 1} \quad \text{Eq. 2}$$

Where λ max is the principal eigen value and n is the number of parameters.

The λ max is calculated by multiplying the comparison matrices and the priority vectors. Then each element of the weighted total vectors is divided by its priority value and their average is the maximum eigen value (Bozdag *et al*., 2016).On the other hand, the random index values were documented by (Saaty, 2008) as shown in table 4.

CR value less or equal 0.10 indicates that the pair-wise comparison matrix has an acceptable consistency, while a higher value indicates that the hierarchical structure is inconsistent and not suitable for analysis (Bozdag*et al.,* 2016).Thereafter, the suitability classes were determined by the aggregation of the parameter index multiplied by weight.

Two other methods were used to calculate the overall land evaluation index and compared with AHP as well as field observations. These methods included the Storie and the Square root methods as follows (Sys *et al.,* 1991):

Storie method

$$I = A \; x \frac{B}{100} \; x \; \frac{C}{100} \quad \text{Eq. 3}$$

Square root method

$$I = Rmin \; x \sqrt{\frac{A}{100} x \frac{B}{100}} \quad \text{Eq. 4}$$

Where I suitability index, A, B, C are indivisual rating and Rmin: miniumun rating

Unlike the AHP, which assigns importance to each parameter using expert opinion (Rodcha *et al.,* 2019),the Storie method equally allocates importance to all characteristics, while the square root method sets special importance to the characteristic with the minimum rating and equal importance to the remaining parameters. After calculating the overall index, land suitability classes were assigned according to Sys *et al.* (1991) (Table 5). Accordingly,land suitability evaluation can be classified into four classes namely; very suitable, moderately suitable, marginally suitable, and not suitable.

RESULTS AND DISCUSSION

Soil characterization

The results of soil chemical analyses of the samples collected from the study area revealed that soil salinity (EC) ranged from 1.13 to 14.82 dS/m with a mean of 2.63 dS/m. The soil pH varied between 6.98 and 8.29, averaging 7.75. The calcium carbonate ($CaCO3$) content varied between 1.10 % and 16.63 %, with a mean value of 5.80 %. The organic matter (OM) ranged from 0.07 and 3.40 %with a mean of 0.87 %. The sum of basic cations (SBC) ranged from 3.25 to 28.85 meq/100g soil with a mean of 10.15 meq/100g. The exchangeable sodium percentage (ESP) ranged from 5.81 to 42.38% and had a mean value of 15.87% (Table 6). The soil depth of all locations exceeded 100cm and had good drainage conditions; none of the samples contained gypsum

The weighted average values of the soil's physical and chemical analyses were interpolated using IDW within the QGIS software, and spatially continuous maps were produced for each soil characteristic. On the other hand, according to Makar *et al.* (2022b), the studied area had four texture classes: loam, clay loam, sandy

Table 3. Scale for making the pair-wise comparison matrix

Intensity of importance	Definition
1	Equal importance
3	Moderate importance of one over the other
5	Essential or Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values between the two adjacent

Source: Saaty (2008)

Table 4. Random index values used in the AHP method

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.59	1.49	1.51	1.48	1.56	1.57	1.59

Source: Saaty (2008)

Table 5. Index values for the different land suitability classes

Index value	Suitability class
100-75	Very suitable (S1)
75-50	Moderately suitable (S2)
50-25	Marginally suitable (S3)
< 25	Not suitable (N)

Source: Sys *et al.* (1991)

Table 6. Showing soil chemical properties

Parameters	EC dS/m	pH	CaCO3 %	OM %	SBC meq/ 100g	ESP %
Mean	2.63	7.75	5.80	0.87	10.15	15.87
Max	14.82	8.29	16.63	3.40	28.85	42.38
Min	1.13	6.98	1.10	0.07	3.25	5.81

loam and silty loam. The loamy soils represented the major texture class, covering 71.0 % of the studied area, followed by clayey loam soils, which covered 16.5% of the studied area. The silty loam soils covered 6.5% and the sandy soils covered 6% of the studied area.

Land suitability rating

In this study eight land parameters have been considered for land suitability for wheat cultivation including: slope, texture (Tex), $CaCO_3$, SBC, pH, OM, salinity and ESP. These parameters were recommended by Khallouf *et al.* (2019) when evaluating wheat land suitability. A ninth parameter, including the growing cycle's mean temperature (Temp), was considered. The mean temperature of the growing cycle was 15.2 °C and accordingly, the climatic index was 97.74 and the climatic rating was calculated as 98.64 according to (Sys *et al.,* 1991) and; therefore, the rating class for this parameter was S1.

The tables provided by Sys *et al.*(1991) were used to set up the equations for calculating the parametric rating of the various parameters considered in the land suitability evaluation of wheat. Furthermore, the developed equations were used within the raster calculator of the QGIS software to provide rating maps for each parameter. The percentage of total area coverage of each suitability class rating for each parameter group is shown in Fig. 2.

Regarding topography, the slope rating of the studied area ranged from 65.9 to 100. Class S1 represented the majority of the studied area, covering about 97% of its area; the remaining area was classified as S2. Concerning the soil physical parameters, the soil texture rate ranged between 60 and 100, where most of the studied area was classified asS1 and covered 164.5 Km^2 (93.5 % of the studied area), while the class S2 covered the remaining area (Fig. 3A). The calcium carbonate content rate ranged between 95.9 - 100 and the whole studied area was classified as S1. In the case of the soil fertility characteristics, the SBC rated between 40 and 100, where class S1 covered most of the area (99.7 % of the studied area). The organic matter rate ranged between 59.9 and 100, where 55.5 % of the studied area was rated as S3, 40.9% as S2, and the

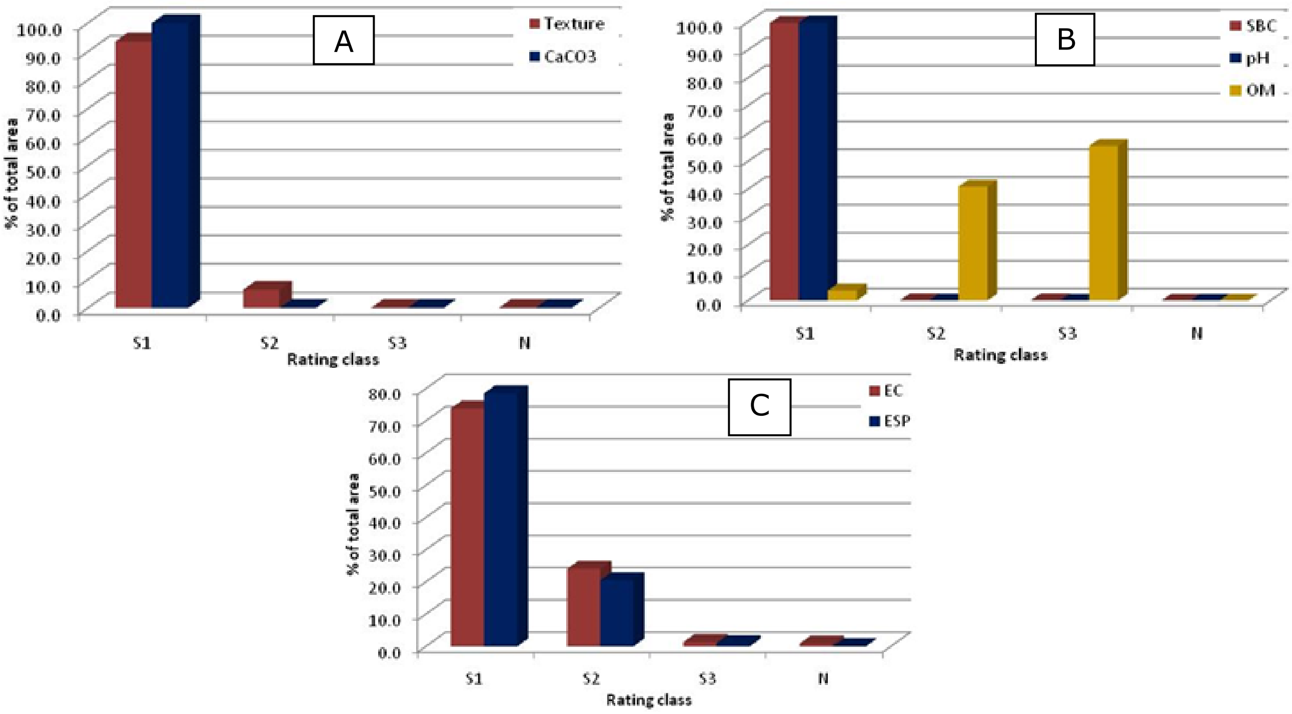

Fig. 2. *Percentage coverage of the parameters rating classes (A: soil physical characteristics, B: soil fertility characteristics and C: salinity and alkalinity).*

remaining area was classified as S1 (Fig. 3B). The soil pH was rated between 60.5 and 99.9 and class S1 represented most of the studied area (99.9%). The soil salinity was rated between 20.3 and 98.3 and class S1 covered 73.8 % of the studied area, while 24% of the studied area was rated S2 and the remaining area was rated as S3 and N classes(Fig. 3C). The soil ESP rating ranged between 25 and 99.9 and 78.5% of the studied area rated as S1, 20.5% rated as S2 while the remaining area was classified as S3 (Fig. 3D).

Analytical Hierarchy Process (AHP)

The first step in developing the AHP after defining the parameters affecting land use suitability for wheat cultivation was to define their weights. This step depends on the study area's condition, suggestions of experts with long-term experience, and literature review. At this step, both soil depth and gypsum contents, which attained a perfect rating of 100 throughout the study area, were excluded. After that, the selected parametersfor evaluation were subjected to pair-wise comparison and based on their relative importance, the AHP matrix was designed (Saaty, 2008; Everest and Gur, 2022; Sathiyamurthi *et al*., 2024). Each factor was given values in this matrix according to their relative importance, ranging from 1 to 9.Thereafter, the weight of each factor is calculated based on the values given to this factor compared to all other factors (Table 7-8). From these tables, the highest weights affecting the overall weight were obtained for soil salinity (27.9%), followed by temperature (18.4%), and then the ESP (13.4%). The lowest weights for slope (2.1 %) and pH (2.0 %) were obtained. On the other hand, texture, calcium carbonate and OM were almost equally important in determining the suitability, with weight ranging from 9.4-9.6%.

Thereafter, the consistency ratio (CR) was calculated to verify the consistency of comparison. The calculated CI was 0.07, and the RI for the nine studied parameters was 1.41. Accordingly, the CR was 0.05, meaning the pair-wise comparison matrix had an acceptable consistency (Taherdoost, 2020; Nungula *et al*., 2024). Finally, the criteria weight was multiplied by the rating index and summed to produce the overall land suitability index and then classified according to(Sys *et al.,*1991). Furthermore, the results of the AHP (Fig. 4A) were compared to the Storie (Fig.4B) and Square root

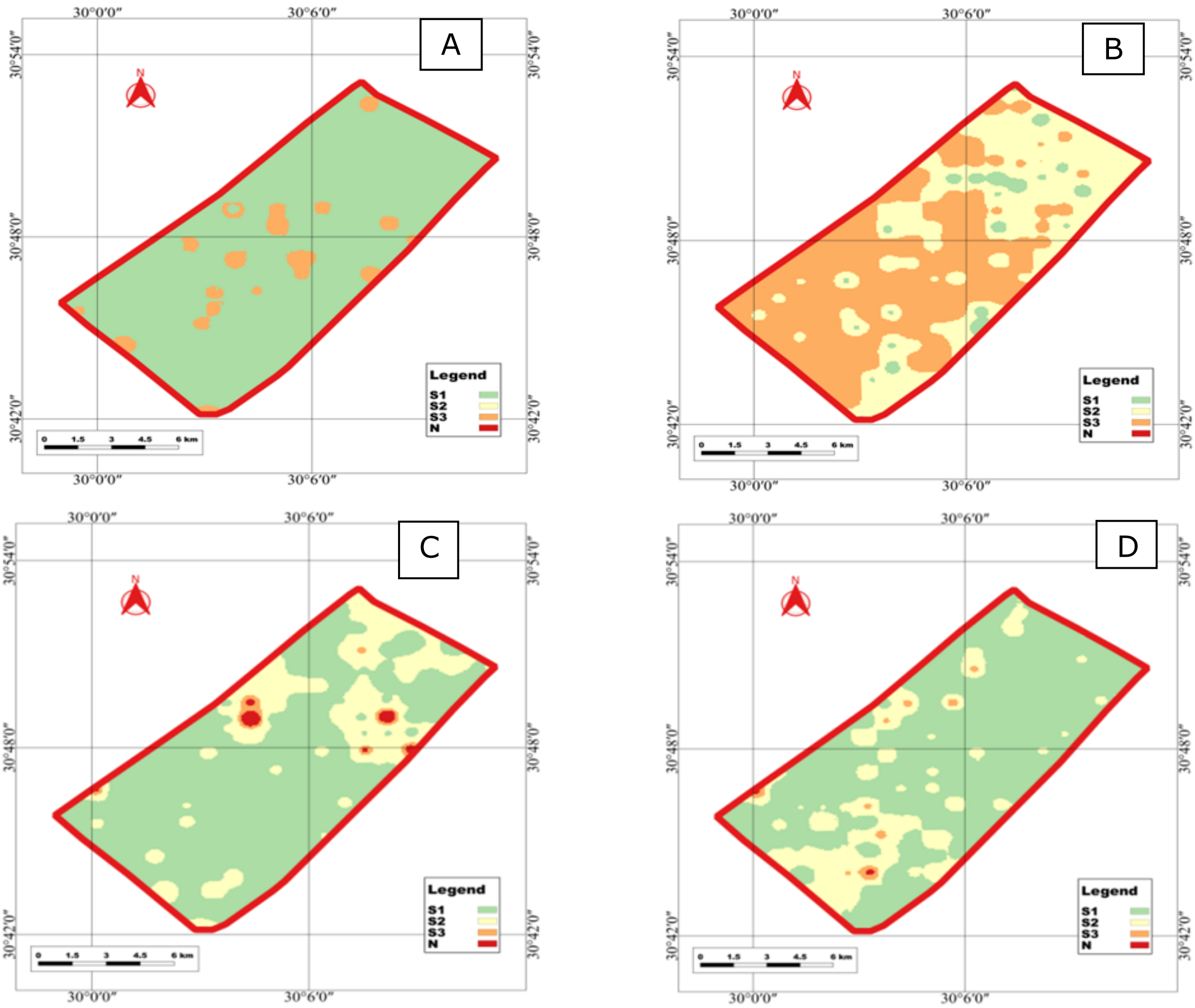

Fig. 3. *Soil parameters suitability classification for wheat cultivation (A: texture; B: OM; C: salinity; D: ESP)*

Table 7. Pair-wise comparison matrix of the Analytical Hierarchy Process (AHP)

Criteria	Temp.	slope	Tex	$CaCO_3$	pH	OM	SBC	EC	ESP
Temp	1.00	8.00	4.00	1.00	7.00	3.00	3.00	0.33	2.00
Slope	0.13	1.00	0.25	0.17	1.00	0.20	0.20	0.13	0.20
Tex	0.25	4.00	1.00	1.00	7.00	1.00	3.00	0.20	0.33
$CaCO_3$	1.00	6.00	1.00	1.00	3.00	1.00	0.50	0.33	1.00
pH	0.14	1.00	0.14	0.33	1.00	0.14	0.14	0.11	0.11
OM	0.33	5.00	1.00	1.00	7.00	1.00	1.00	0.50	0.50
SBC	0.33	5.00	0.33	0.50	7.00	1.00	1.00	0.33	0.50
EC	3.00	8.00	5.00	3.00	9.00	2.00	3.00	1.00	3.00
ESP	0.50	5.00	3.00	1.00	9.00	2.00	2.00	0.33	1.00
Total	5.68	35.00	11.72	8.00	44.00	8.34	10.84	2.93	6.64

Temp= Temperature; Tex = Texture; OM= organic matter; SBC= sum of basic cation; EC= electrical conductivity; ESP= exchangeable sodium percentage

Table 8. Normalized pair-wise comparison matrix of the Analytical Hierarchy Process (AHP)

Criteria	Temp	Slope	Tex	$CaCO_3$	pH	OM	SBC	EC	ESP	Criteria weight
Temp	0.186	0.150	0.101	0.111	0.137	0.265	0.217	0.254	0.231	0.184
Slope	0.023	0.019	0.040	0.019	0.020	0.018	0.014	0.016	0.023	0.021
Tex	0.093	0.037	0.061	0.111	0.137	0.088	0.217	0.064	0.039	0.094
$CaCO_3$	0.140	0.150	0.101	0.111	0.059	0.088	0.036	0.064	0.116	0.096
pH	0.023	0.021	0.034	0.037	0.020	0.012	0.010	0.009	0.013	0.020
OM	0.116	0.049	0.153	0.111	0.137	0.088	0.072	0.064	0.058	0.094
SBC	0.116	0.049	0.101	0.056	0.137	0.088	0.072	0.021	0.058	0.078
EC	0.186	0.449	0.306	0.333	0.176	0.176	0.217	0.318	0.347	0.279
ESP	0.116	0.075	0.102	0.111	0.176	0.176	0.145	0.191	0.116	0.134

Temp= Temperature; Tex = Texture; OM= organic matter; SBC= sum of basic cation; EC= electrical conductivity; ESP= exchangeable sodium percentage

method (Fig.4C). According to the AHP most of the studied area was classified as S1 (99.1 % of the total area), while the Storie method revealed that most of the studied area was classified as S3 and covered 76.3% of the studied area.On the other hand, according to the square root method,57.6 % of the studied area was classified as S2 and 37.6 % as S3.These data revealed a noticeable difference between the three methods (Table 9).

To validate the results of the three methods, the approach recommended by Hamzeh *et al.*(2014) was used. According to this method, the results of the three procedures were compared to field observations, as well as the maximum wheat yield in Egypt (740 tonnes/ km^2)(Ministry of Agriculture and Land Reclamation, 2021).After that, the wheat yield reduction in each observation field was used to estimate the associated land suitability class according to Sys *et al.* (1991) and classification accuracy was evaluated. Initially, random field questionnaire throughout the study area revealed that wheat yield production ranged from 620-740 Tonne/$km^{2,}$ accounting for yield reduction of about 0-16% and indicating class S1 following AHP classification which suggested that most of the studied area could be classified as S1. Furthermore, The comparison with eleven field observations also showed that the developed AHP had higher accuracy than the other two methods, as only one observation was misclassified as S2 instead of S1, with a yield reduction of 24.3% (Table 10).

Table 9. Wheat land suitability class coverage according to the three different methods

Suitability class	Storie		Square root		AHP	
	Km^2	%	Km^2	%	Km^2	%
S1	0.8	0.4	7.1	4.0	174.3	99.1
S2	33.9	19.3	101.2	57.6	1.5	0.9
S3	134.1	76.3	66.0	37.6	0.0	0.0
N	7.0	4.0	1.5	0.9	0.0	0.0
Total	175.8	100.0	175.8	100.0	175.8	100.0

On the other hand, none of the observation fields were correctly classified according to the other two methods. According to these methods, the study area was classified as S2, S3 and N, which should account for more than 25% yield reduction, while the reduction in most of these fields was less than 25%. It was also observed that in most fields, there was a shift in evaluation as the fields that were evaluated as unsuitable in both square root and Storie methods were evaluated asmoderately

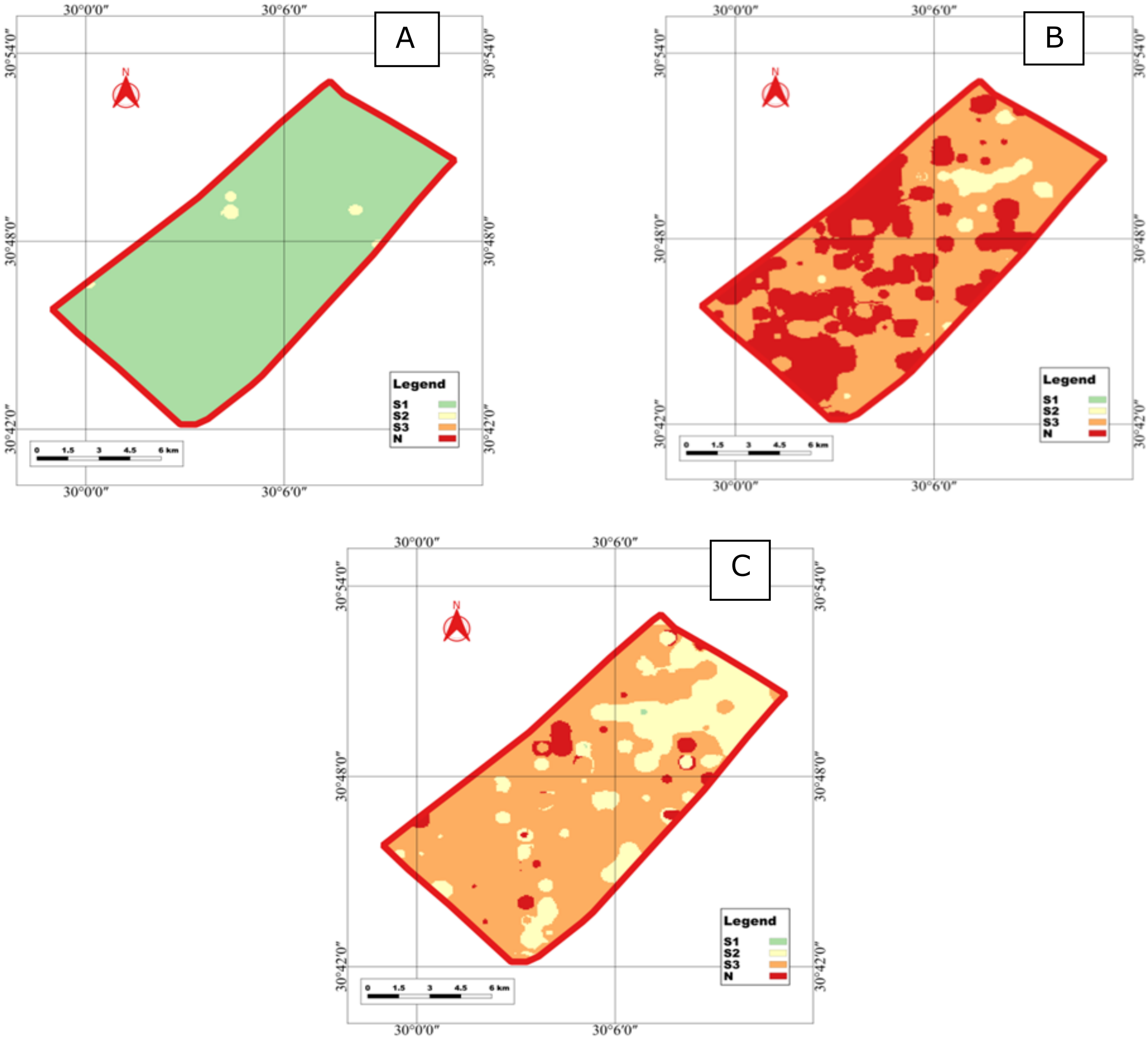

Fig.4. *Wheat land suitability classes according to A: AHP; B:Storie; C: Square root*

Table 10. Comparison of AHP, square root and Storie land suitability evaluation

Field No.	Yield Tonne/Km^2	% of decrease in production	Land evaluation method		
			Storie	Square root	AHP
1	520	29.7	N	N	S2
2	500	32.4	N	N	S2
3	520	29.7	N	N	S2
4	650	12.2	S3	S3	S1
5	650	12.2	S2	S2	S1
6	690	6.7	S3	S2	S1
7	650	12.2	S2	S2	S1
8	650	12.2	S3	S3	S1
9	650	12.2	S2	S3	S1
10	650	12.2	S3	S3	S1
11	560	24.3	N	N	S2

suitable in AHP. While the observation fields were evaluated as moderately and marginally suitable in both square root, Storie methods were evaluated as very suitable in AHP. Similar results were obtained by Rabia and Terribilem (2013), who evaluated wheat land suitability in Valle Telesina, which is located in Southern Italy. They mentioned that both square root and Storie methods underestimate the land suitability, while in the AHP method, the factors impacts are reflected in their highest weight, which eventually impacts the overall land suitability index value. It was also observed that nine of eleven fields had identical land suitability evaluation according to both square root and Storie methods.

Conclusion

There is a large gap between Egypt's production and consumption of wheat every year. This gap resulted in

Egypt being considered one of the largest wheat importers. Therefore, the country is working effortlessly towards increasing its production, raising the importance of developing an accurate land suitability evaluation process for wheat.This study developed an accurate parametric-based AHP method integrated with GIS for the land suitability evaluation of wheat. The developed procedure takes advantage of the well-established parametric method and increases its overall suitability evaluation using AHP. The integration with AHP enables the weighing of each of the parameters influencing wheat production and enhances the land suitability accuracy. The developed procedure has higher accuracy than the square root and Storie methods compared to field observations. Furthermore, the integration with GIS enables an easier and more accurate spatial process of the data. It defines the problematic area that needs attention to increase its productivity or change its land use planning. Based on the results of the developed process, the same method is recommended to be applied further to other land suitability studies.

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Conflict of interests

The authors declare that they have no conflict of interest.

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