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LAND RESOURCES POTENTIALITY OF EL-BAHARIYA OASIS, EGYPT

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ABSTRACT:

The main objective of this work is to identify land capability and suitability in the studied area. To determine the major physiographic units in the area, Software ENVI 5.2 was used to process the "Landsat OlI 8" images and digital elevation model. Morphological descriptions for forty soil profiles were conducted as well as soil samples for physical and chemical analysis.. The current land capability of the area was classified into three classes fair (C3), poor (C4) and very poor (C5) which represent about 93.5, 1.5 and 5.0 % of the total area. The current suitability classes for the selected study crops. These data indicate that 65 % of the study area is classified as marginally suitable (S3) and 35 % is classified as current not suitable for wheat of the study area, 97 % is classified as marginally suitable (S3) and 3 % is classified as current not suitable for barely, 85 % of the study area is classified as marginally suitable (S3) and 15 % is classified as current not suitable for sunflower, 84 % of the study area is classified as marginally suitable (S3) and 16 % is classified as current not suitable for cabbage and 100 % is classified as current not suitable for sorghum, citrus, plum, potato and Alfalfa.

Keywords: Land capability, Land suitability, ASLE program, Soil mapping, El-Baharyia

1. INTRODUCTION

The evaluation of land suitability and capability is a crucial prerequisite for sustainable agriculture, since it establishes the present and prospective potential of any given region

(Tesfay et al., 2017). Land evaluation is the cornerstone of land use planning for agricultural development (Rashed et al., 2019). There are two ways to assess land capability: directly and indirectly. Direct approaches are used in the field or in the lab with some studies conducted under predetermined management and climate settings. On the other hand, models with different levels of complexity are used in indirect evaluations to calculate land productivity (Dengiz and Sağlam, 2012). Farmers can find out through land evaluation how well their property fits specific land use and management strategies in terms of soil limits. To achieve optimal management and utilization of existing land resources for sustainable agricultural crop production, land suitability evaluation study is required (Jimoh et al., 2018). Land suitability valuation is the process of assessing a piece of land's performance in order to predict its potential for crop production. "The fitness of a given type of land for a specified kind of land use, under its present condition (actual suitability) or after improvement (potential suitability)" is the definition of land suitability. (Mousa, 2010). In especially in arid climate zones, land capability assessment is essential to effective planning. The complexity of the soil system restricts the capacity to combine the characteristics of soil to assess its potential. Because multivariate analysis may perform systematic modeling in settings that are ambiguous or hazy, it has been determined to be a suitable method for evaluating soil capability zones (Belal et al., 2015). Numerous research in Egypt have employed RS and GIS for land resource mapping and management (Mohamed et al., 2014). To evaluate the crop adaptability for various soils, RS data and soil survey information can be combined into a GIS (Abdel-Rahman et al., 2016). The aims of study are; (1) produce physiographic map of the studied area using remote sensing and GIS techniques; (2) Evaluate land capability and suitability of the studied area.

2. MATERIAL AND METHODS

2.1. Study area

El-Baharyia Oasis located between longitudes 28° 30′ 0″ and 27° 40′ 0″ N and latitude 28° 30′ 00″ and 29° 10′ 00″ E. It covers an area 1996.84 km2. It includes several sites, including El-Bawiti, El-Harra, Ain-Heiz, El-Ris and Ain-Khoman (Fig.1).

a. Climate

The examined region has a typical desert environment, meaning that dry conditions predominate. According to the Climatologically Normal for Egypt report (2020) from the Egyptian Meteorological Authority. The soils of Bahariya Oasis are typically characterized by a hyper thermic soil temperature regime and a torric soil moisture regime (USDA, 2022).

2.3. Geology and Geomorphology

The location is classified as belonging to the Eocene and Cretaceous era, as evidenced by the presence of limestone, sand dunes, and Tertiary Alkali Olivine Basalt. The geological map of Egypt, created by (CONCO, 1987), contains the geological units of significance at a scale of 1: 500,000. El-Baharyia Oasis is home to three distinct geomorphologic formations, namely depression, plain, and Plateau.

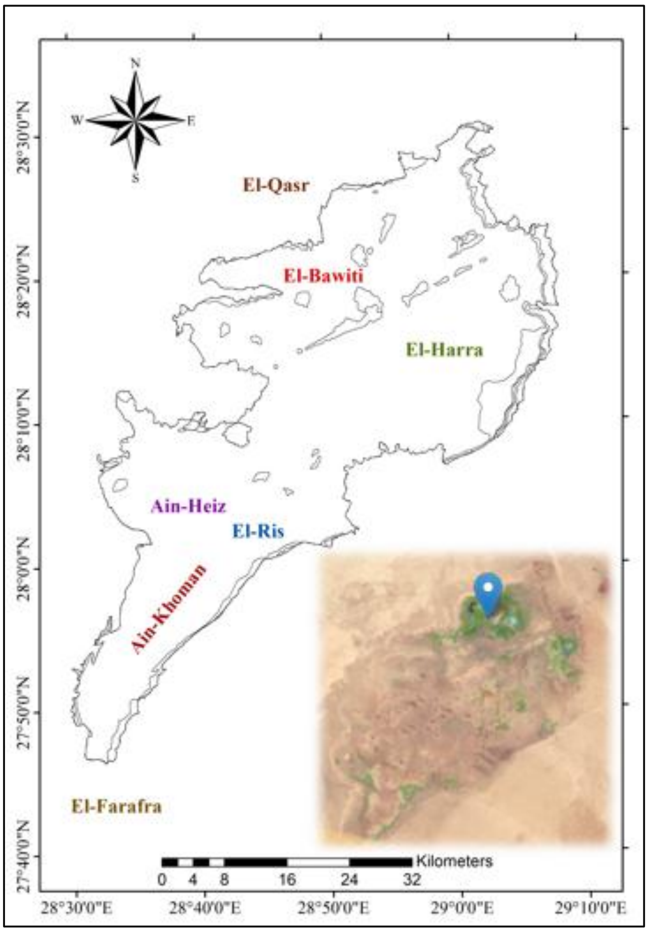

Figure 1: Location of the study area

2.4. Landform mapping

The United States Geological Survey (USGS) Geologic Survey archive provided the two Landsat Operational Land Imager (OLI) satellite images (path 178, row 40) and (path 178, row 41) with a spatial resolution of 30 meters for digital image processing in 2020, as illustrated in (Fig. 2). The image was processed using the ENVI 5.3 software, and a carefully selected combination of bands (7, 3, and 2) was chosen in accordance with Lillesand and Kiefer's (2015) recommendations as shown in (Table 1). The region under investigation's digital elevation model (DEM) (Fig. 3) was taken from the shuttle Radar Topography Mission (SRTM). One of the data sources used for collection is a topographic map (scale 1:100000) of El-Baharyia Oasis, Egypt. The primary GIS platform utilized in this study was ArcGIS 10.8. The research area's soil databases are managed, soil variables are mapped, and modeling is done using a GIS tool. Zink and Valenzuala (1990) established the map legend after physiographic research was used to create a physiographic map of the study area.

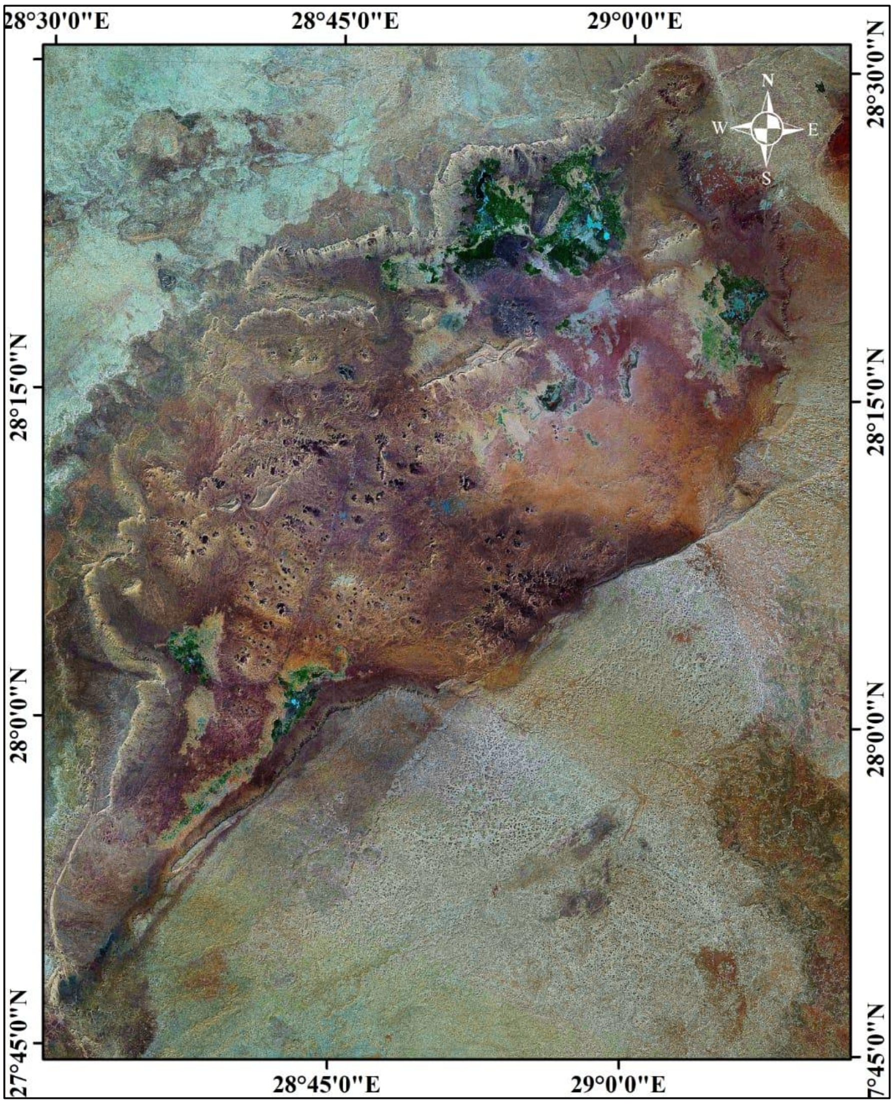

Fig. 2. Enhanced Landsat OLI satellite images.

Table 1. Remote sensing data of the study area.

1. Source	**2. Sensor type**	**3. Identifier**
4. Landsat-8	**5.** OLI / TIRS "Operational Land Imager /Thermal Infrared **6.** Sensor"	LC08_L1TP_178040_20201007_20201018_02_T1 LC08_L1TP_178041_20201007_20201018_02_T1
DEM	SRTM 1 Arc (30x30 meter)	SRTM1N25E028V2

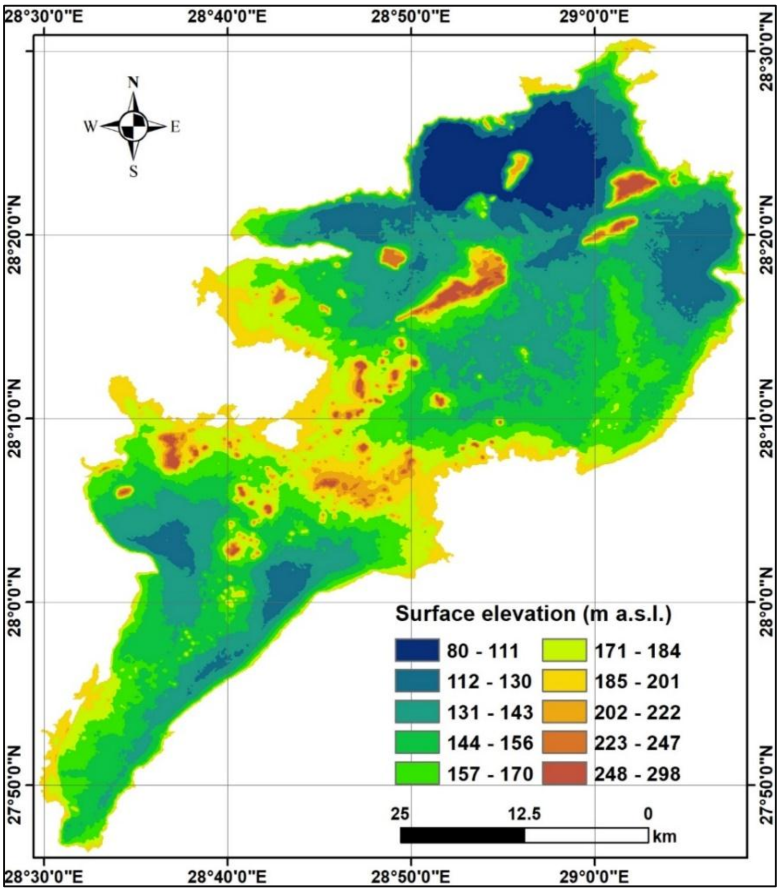

Fig. 3. Digital Elevation Model (DEM) of studied area.

2.5. Field work and laboratory analysis

A thorough soil survey was carried out in the study area, which included excavating forty profiles. The morphological characteristics of the soil were then defined in accordance with the guidelines of the Food and Agriculture Organization (FAO, 2006), and samples were taken for analysis. The dry sieve of the soil was determined in compliance with the regulations of the US Department of Agriculture (USDA, 2004), along with the available N, P, and K nutrients and the cation exchange capacity (CEC), Exchangeable sodium percent (ESP), organic matter (O.M), Calcium carbonates ($CaCO_3$) and Gypsum.

2.6. Land Capability assessment

The land resources were assessed using two systems as follows: Land capability was completed using the method detailed by sys, et al. (1991). It was done based on the land characteristics of the mapping units of the studied area using the tables rating suggested by sys et al, (1991) using the equation:

$$Ci = t/100 \times w/100 \times x/100 \times d/100 \times k/100 \times n/100 \times C/100 \times A/100 \times 100$$

Where: Ci = capability index, t = Slope, w = Drainage, x = Texture, d = Soil depth, k = $CaCO_3$ content, n = Salinity, C= CEC, A= ESP in Table 2.

Range (%)	Land Capability class	Class
>80	Excellent	C1
60 – 80	Good	C2
40 – 60	Fair	C3
20 – 40	Poor	C4
10 – 20	Very poor	C5

< 10	Non agriculture	C6

Table 2. Ranges of land capability classes according to the applied system of land evaluation (ASLE)

2.7. Land suitability assessment

The land suitability for crops will be done by selecting 16 crops to asses there suitability for cultivation in the studied area. The selected crops include the following: Field crops (soybean, barley, sunflower, sorghum and wheat), Vegetables (potato, cabbage, tomato, pea and watermelon), Fodder crops (alfalfa, plum and cowpea) and Fruits (olive, citrus, banana and guava) Soil characteristics of the different mapping units are compared and matched with the requirements of each crop. The matching led to current and potential suitability for each land use using the parametric approach and land index by Sys et al, (1993). Ranges of land suitability classes as shown in Table 3.

Table 3. Ranges of land suitability classes according to the applied system of land evaluation (ASLE)

Range (%)	Land suitability class	Class
>75	Highly suitable	S1
50 – 75	Moderately suitable	S2
25 – 50	Marginally suitable	S3
12.5 – 25	Current not suitable	N1

3. RESULTS AND DISCUSSION

3.1. Physiographic units

In order to identify the landform units, the landscape was analyzed using Digital Elevation Model (DEM) to extract it from satellite imagery. The resulting geomorphology map shows three main landscapes, and Table 4 show the physiographic units over the area under study. (Fig. 4) shows the locations of forty of the studied soil profiles on mapping units.

3.1.1. Soils of plateau

Plateau containing escarpment (PL) and foot slope (FS). No soil profiles were taken in these units.

3.1.2. Soils of plain

Plain with the piedmont plain (PI), desert pavement (DP), Hill land (HL) and sand dunes (SD). The soils in this landform were classified into Typic Torripsamments. The electrical conductivity (EC) values range from 1.34 to 8.76 dS/m, while the $CaCO_3$ content ranges from 1.35% to 21.9%. Gypsum content ranges from 0.3 to 7.3%. Exchangeable sodium percent ranges from 6.4 to 8.5 %.

3.1.3. Soils of depression

Depression including high elevated depression, moderate elevated and low elevated depression (Dh, Dm and DI). The soils in this landform were classified as Typic Calcigypsids, Typic Haplosalids and Typic Aquisalids. The electrical conductivity (EC) values range from 12.6 to 34.7 dS/m, while the $CaCO_3$ content ranges from 32.3% to 93.8%. Gypsum content ranges from 7.3 to 21.2%. Exchangeable sodium percent ranges from 8.5 to 11.1 %.

Table 4. Physiographic legend and areas of the different mapping units.

Physiographic Units	**Land form**	**Mapping unit**	**No. of soil profiles**	**Area Km²**	**%**
Plateau	Escarpment	PL	-	189.02	18.5
	Foot slope	FS	-	63.3	6.2
Plain	Piedmont plain	PI	-	11.02	1.15
	Desert pavement	DP	6	5.28	0.52
	Hill land	HL	-	54.91	5.4
	Sand dunes	SD	-	60.13	5.9
Depression	High elevated depression	Dh	10	124.57	12.2
	Moderate elevated depression	Dm	13	122.71	12.03
	Low elevated depression	Dl	11	101.01	9.9
Total				1996.84	100

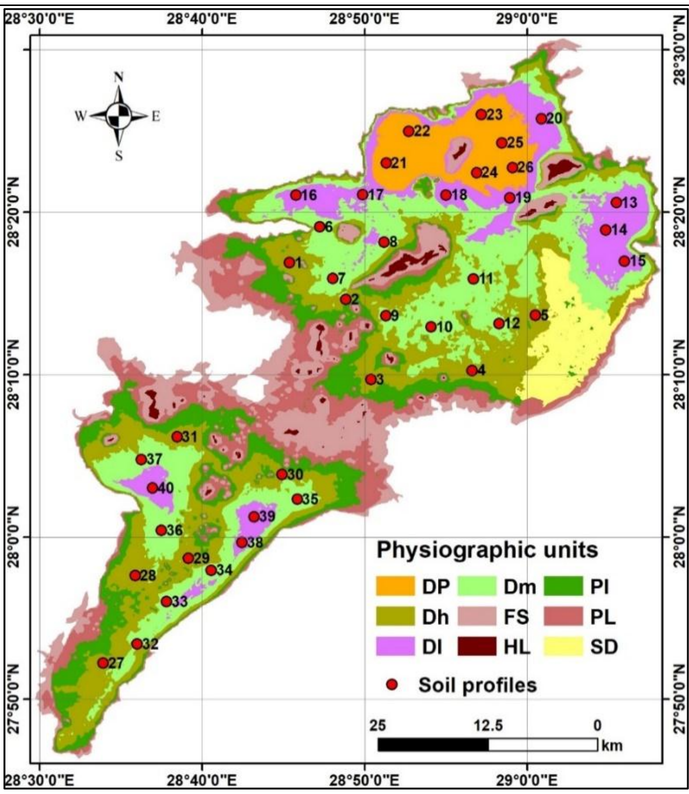

Fig. 4. The main physiographic units and location of soil profiles in the studied area.

3.2. Land capability assessment

Land capability evaluation was carried out using the Agriculture Land Evaluation System for arid and semi-arid regions (ASLE arid). It was done based on the characteristics weighted of the different soil profiles. A land capability model was built using ArcGIS 10.5 software (database) and the resulting tables were imported into ArcGIS to produce the capability map in 2020 (Fig. 5) and (Table 5 and 6). The current land capability of the area was classified into three classes fair (C3), poor (C4) and very poor (C5) which represent about 93.5, 1.5 and 5.0 % of the total area.

3.3. Land suitability assessment

Land suitability for the different crops, i.e., wheat, barley, sunflower, cabbage, Sorghum, Alfalfa, potato, Citrus and plum was tested for the soils using ArcGIS 10.5 software. The results were imported to Arc GIS to display maps. Soil characteristics of the different mapping units were matched with the crop requirements of each crop. The matching led to the current suitability for each crop using the parametric approach and land index as mentioned by Sys et al., (1993). The data in (Table 7 and Fig. 6) show the current suitability classes for the selected study crops. These data indicate that 65 % of the study area is classified as marginally suitable (S3) and 35 % is classified as current not suitable for wheat of the study area, 97 % is classified as marginally suitable (S3) and 3 % is classified as current not suitable for barely, 85 % of the study area is classified as marginally suitable (S3) and 15 % is classified as current not suitable for sunflower, 84 % of the study area is classified as marginally suitable (S3) and 16 % is classified as current not suitable for cabbage and 100 % is classified as current not suitable for sorghum, citrus, plum, potato and Alfalfa.

Table 5. Values of land capability of the study area.

Profile No	Slope	Drainage	Soil_depth	Texture	$CaCO_3$	Salinity	CEC	ESP
1	Undulating	Well	130	Sandy	6.4	8.1	5.2	8.1
2	Undulating	Well	130	Sandy	5.4	9.4	5.7	8.4
3	Undulating	Well	130	Sandy	2.8	5.3	5.4	8.2
4	Undulating	Good	60	Sandy	4.8	14.4	6.3	7.3
5	Undulating	Good	50	Sandy	5.9	13.5	5.9	6.9
6	Undulating	Good	50	Sandy	4.2	19.9	6.8	8.6
7	Undulating	Good	60	Sandy	4.8	22.3	6.0	9.3
8	Undulating	Good	40	Sandy	6.0	25.8	8.5	10.3
9	Undulating	Well	150	Sandy	4.7	11.2	7.2	10.8
10	Undulating	Well	150	Sandy	6.3	19.2	6.9	9.7
11	Undulating	Well	150	Sandy	4.9	19.5	7.0	8.1
12	Undulating	Well	150	Sandy	6.5	14.7	7.8	10.1
13	Undulating	Good	80	Sandy	6.4	23.1	8.5	11.1
14	Undulating	Good	70	Sandy	5.2	24.0	9.0	10.1
15	Undulating	Good	80	Sandy	3.8	34.7	9.2	10.7
16	Undulating	Good	80	Sandy	4.8	21.2	10.2	10.1
17	Undulating	Good	90	Sandy	5.2	23.7	8.8	9.5
18	Undulating	Well	150	Sandy	4.6	7.3	8.6	7.4
19	Undulating	Well	150	Sandy	2.9	7.4	10.9	7.5
20	Undulating	Well	150	Sandy	1.4	2.3	7.9	7.4
21	Undulating	Good	80	Sandy	7.9	2.2	4.9	9.3
22	Undulating	Good	90	Sandy	3.4	3.7	5.4	6.8
23	Undulating	Good	80	Sandy	6.9	1.7	5.1	7.3
24	Undulating	Well	150	Sandy	0.9	1.3	5.4	7.8
25	Undulating	Well	140	Sandy	1.3	1.5	5.8	7.7
26	Undulating	Well	140	Sandy	1.8	2.4	5.4	6.5
27	Undulating	Well	130	Sandy	18.9	15.0	6.2	9.4
28	Undulating	Well	120	Sandy	14.8	16.1	6.4	9.2
29	Undulating	Well	110	Sandy	10.5	10.1	7.3	10.1

30	Undulating	Well	130	Sandy	10.4	11.8	8.5	8.5
31	Undulating	Well	130	Sandy	11.5	11.3	4.9	9.3
32	Undulating	Well	120	Sandy	13.6	7.1	7.4	9.4
33	Undulating	Well	120	Sandy	11.3	8.4	7.2	7.1
34	Undulating	Well	110	Sandy	9.3	5.8	7.2	9.1
35	Undulating	Well	120	Sandy	12.5	8.9	7.4	7.8
36	Undulating	Well	110	Sandy	6.9	23.4	8.8	9.6
37	Undulating	Well	150	Sandy	7.5	4.6	7.5	6.4
38	Undulating	Well	140	Sandy	7.8	6.6	6.5	7.9
39	Undulating	Well	140	Sandy	2.7	4.8	6.5	6.9
40	Undulating	Well	150	Sandy	2.8	2.7	6.4	6.9

Where: Ci= Capability index, t= slope, w= Drainage, x= Texture, d= soil depth, k= $CaCO_3$ content, n= salinity, C= CEC, A=ESP

Table 6. Rating of Land capability of the study area.

Profile No	**t**	**w**	**d**	**x**	**k**	**s**	**C**	**A**	**rate_Ci**	**Ci_class**
1	100	100	100	50	100	70	50	100	17.5	4
2	100	100	100	50	100	70	50	100	17.5	4
3	100	100	100	50	100	80	50	100	20.0	4
4	100	100	70	50	100	70	70	100	17.1	4
5	100	100	70	50	100	70	50	100	12.2	5
6	100	100	70	50	100	50	70	100	12.2	5
7	100	100	70	50	100	50	70	100	12.2	5
8	100	100	60	50	100	50	70	90	9.4	5
9	100	100	100	50	100	70	70	90	22.0	4
10	100	100	100	50	100	50	70	100	17.5	4
11	100	100	100	50	100	50	70	100	17.5	4
12	100	100	100	50	100	70	70	90	22.0	4
13	100	100	80	50	100	50	70	90	12.6	4
14	100	100	70	50	100	50	70	90	11.0	5
15	100	100	80	50	100	50	70	90	12.6	4
16	100	100	80	50	100	50	70	100	14.0	4
17	100	100	80	50	100	50	70	100	14.0	4
18	100	100	100	50	100	80	70	100	28.0	3
19	100	100	100	50	100	80	70	100	28.0	3
20	100	100	100	50	100	90	70	100	31.5	3
21	100	100	80	50	100	90	50	100	18.0	4
22	100	100	80	50	100	90	50	100	18.0	4
23	100	100	80	50	100	100	50	100	20.0	4
24	100	100	100	50	100	100	50	100	25.0	3
25	100	100	100	50	100	100	50	100	25.0	3
26	100	100	100	50	100	90	50	100	22.5	4
27	100	100	100	50	70	70	70	100	17.1	4
28	100	100	100	50	80	50	70	100	14.0	4
29	100	100	80	50	90	70	70	90	15.8	4
30	100	100	100	50	90	70	70	100	22.0	4
31	100	100	100	50	90	70	70	100	22.0	4

32	100	100	100	50	80	80	70	100	22.4	4
33	100	100	100	50	90	70	70	100	22.0	4
34	100	100	80	50	90	80	70	100	20.2	4
35	100	100	100	50	80	70	70	100	19.6	4
36	100	100	80	50	100	50	70	100	14.0	4
37	100	100	100	50	100	80	70	100	28.0	3
38	100	100	100	50	100	80	70	100	28.0	3
39	100	100	100	50	100	80	70	100	28.0	3
40	100	100	100	50	100	90	50	100	22.5	4

Where: Ci= Capability index, t= slope, w= Drainage, x= Texture, d= soil depth, k= $CaCO_3$ content, n= salinity, C= CEC, A=ESP

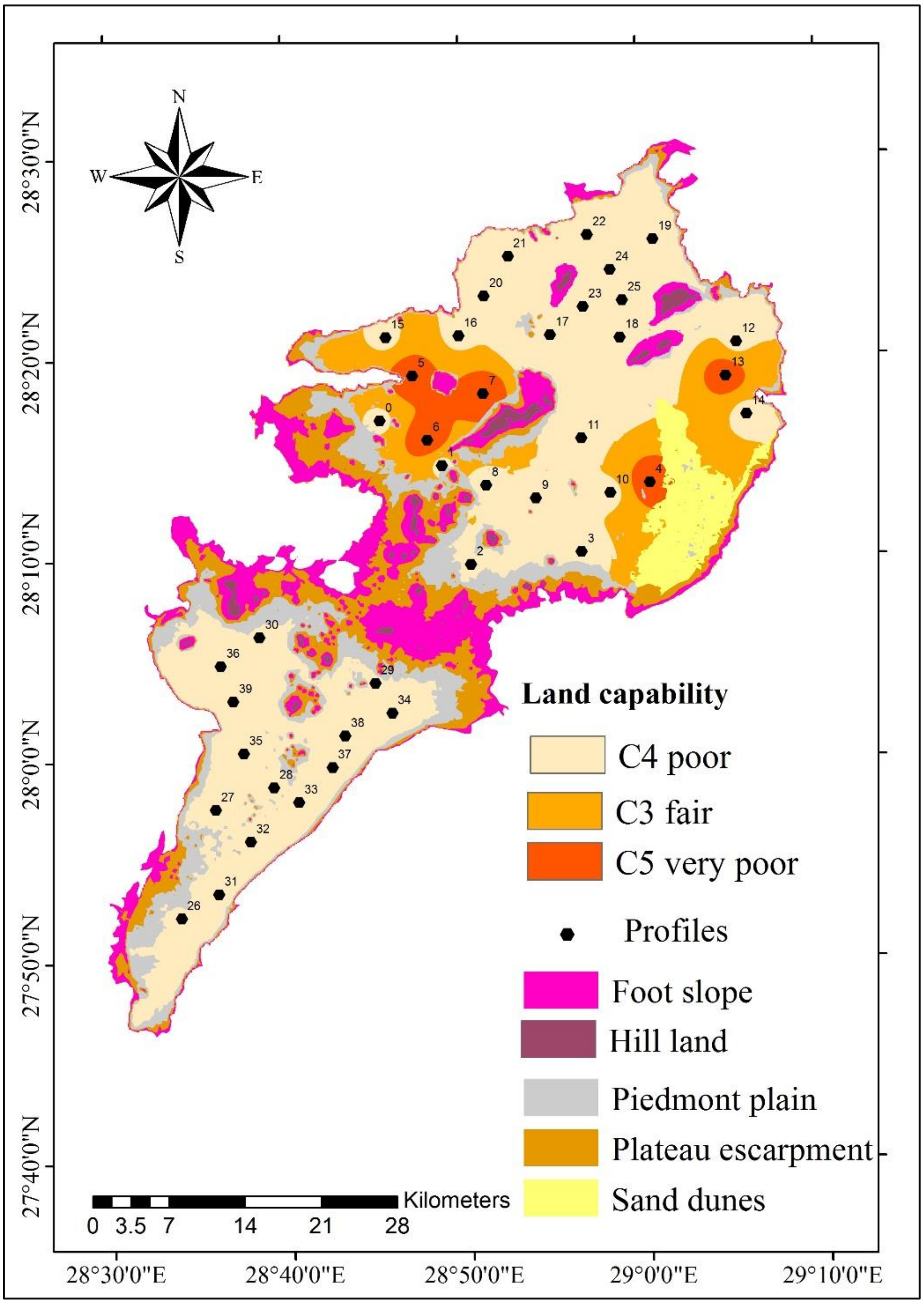

Fig. 5. Land capability map in El-Baharyia Oasis

Table 7. Current land suitability classes of the study area.

No.	wheat	Barley	Sun flower	Cabbage	Sorghum	Alfalfa	Potato	Citrus	Plum
1	N1	S3	S3	S3	N1	N1	N1	N1	N1
2	N1	S3	S3	S3	N1	N1	N1	N1	N1
3	N1	S3	N1	N1	N1	N1	N1	N1	N1
4	N1	S3	N1	N1	N1	N1	N1	N1	N1
5	N1	S3	N1	N1	N1	N1	N1	N1	N1
6	S3	N1	N1	N1	N1	N1	N1	N1	N1
7	S3	N1	N1	N1	N1	N1	N1	N1	N1
8	S3	S3	S3	N1	N1	N1	N1	N1	N1
9	S3	S3	N1	N1	N1	N1	N1	N1	N1
10	S3	S3	N1	N1	N1	N1	N1	N1	N1
11	S3	S3	N1	N1	N1	N1	N1	N1	N1
12	N1	N1	N1	N1	N1	N1	N1	N1	N1
13	N1	N1	N1	N1	N1	N1	N1	N1	N1
14	N1	N1	N1	N1	N1	N1	N1	N1	N1
15	N1	N1	N1	N1	N1	N1	N1	N1	N1
16	N1	N1	N1	N1	N1	N1	N1	N1	N1
17	N1	S3	S3	S3	N1	N1	N1	N1	N1
18	N1	S3	S3	S3	N1	N1	N1	N1	N1
19	S3	S3	S3	S3	N1	N1	N1	N1	N1
20	S3	S3	S3	S3	N1	N1	N1	N1	N1
21	S3	S3	S3	S3	N1	N1	N1	N1	N1
22	S3	S3	S3	S3	N1	N1	N1	N1	N1
23	S3	S3	S3	S3	N1	N1	N1	N1	N1
24	S3	S3	S3	S3	N1	N1	N1	N1	N1
25	S3	S3	S3	S3	N1	N1	N1	N1	N1
26	N1	S3	N1	S3	N1	N1	N1	N1	N1
27	N1	S3	N1	S3	N1	N1	N1	N1	N1
28	N1	S3	S3	S3	N1	N1	N1	N1	N1
29	N1	S3	S3	S3	N1	N1	N1	N1	N1
30	N1	S3	S3	S3	N1	N1	N1	N1	N1
31	N1	S3	S3	S3	N1	N1	N1	N1	N1
32	N1	S3	S3	S3	N1	N1	N1	N1	N1
33	S3	S3	S3	S3	N1	N1	N1	N1	N1
34	N1	S3	S3	S3	N1	N1	N1	N1	N1
35	N1	S3	N1	S3	N1	N1	N1	N1	N1
36	S3	S3	S3	S3	N1	N1	N1	N1	N1
37	N1	S3	S3	S3	N1	N1	N1	N1	N1
38	S3	S3	S3	S3	N1	N1	N1	N1	N1
39	S3	S3	S3	S3	N1	N1	N1	N1	N1
40	S3	S3	S3	S3	N1	N1	N1	N1	N1

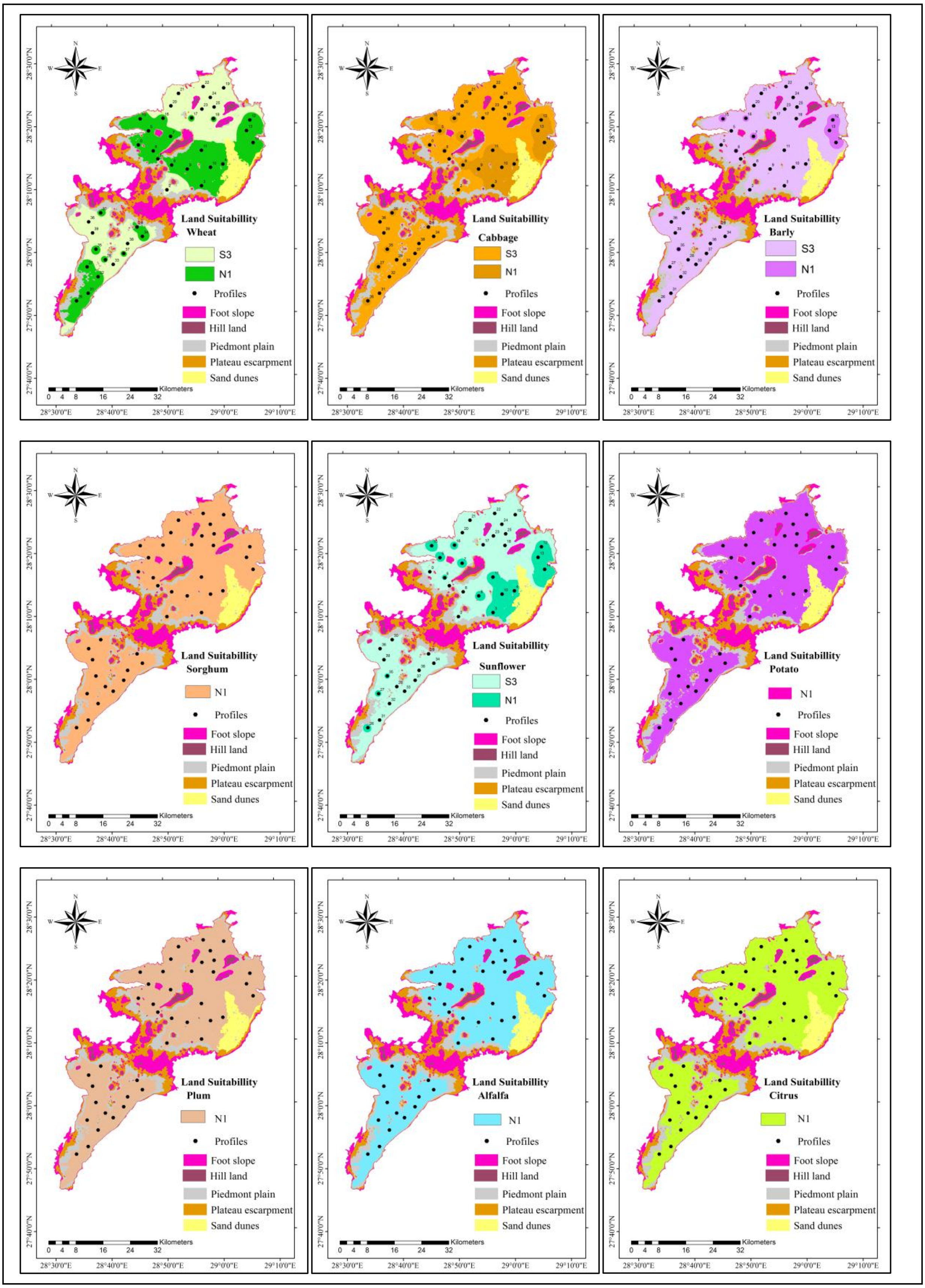

Fig. 6. Land suitability maps of the study area.

4. CONCLUSION

The research findings offer a useful framework for farmers and decision-makers to choose the optimal agricultural management practices and avoid desertification in future land reclamation initiatives in the El-Bahariya oasis.

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