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A DECISION SUPPORT MODEL FOR LAND USE PLANNING AT FARM LEVEL IN EL-DAKHLA OASIS, NEW VALLEY GOVERNORATE, SOUTH EGYPT

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Abstract: This work aimed to create a farm-level decision-support model that would use the properties of the soil, water, and climate measures to aid in decision-making. A detailed soil survey was carried out on the 1750 acres (≈1686.2 Faddans) at the El-Dakhla Oasis, New Valley governorate of Egypt. The study area was located west of the El-Dakhla - East El Owainate road, in close proximity. The primary landforms in the research area were sand dunes and sandy plain. Furthermore, 410 acres with active sand dunes in the southwest of the research region were disregarded from the investigation. On the other hand, the sandy plain (1340 acres) was chosen because of its nearly level terrain, making it perfect for farm design and planning. A total of 303 representative soil samples were taken from 102 soil pedons' various layers and horizons located in the sandy plain. The physical and chemical characteristics of the soils were studied through laboratory and statistical analyses. The only source of water in El-Dakhla Oasis is groundwater. Three groundwater samples were collected from various wells throughout the research region. According to the statistical study, the soils ranged widely from non-calcareous to extremely calcareous, with coarse, moderately coarse, and fine textures. The soils were also nonsaline to moderately saline. Deep soil pedons (125–160 cm) were found in all the study lands. There are hazardous levels of Mn^{2+} and Fe^{2+} in the soils and irrigation groundwater. The soils ranged from being non-gypsiric to rather gypsiric. The current study identified four soil mapping units on 1340 acres by examining the statistical results of dominating soil criteria. Although the collected groundwater includes dangerous levels of iron and manganese, its quality is suitable for agricultural use. The soil and water features were used to determine the potentiality of the lands, which were classified as high (700 acres) and moderate potential lands (640 acres). Depending on the soil, water, and climate, different crops could be grown on the study lands. Recommendations for each soil type included 275 acres for saline agriculture, 345 acres for vegetables, 355 acres for fruit trees, and 365 acres for forages. The 1750-acre study area lands were mapped and planned again, and a decision-support model was proposed based on the prior data. The study area was fragmented into specific farms based on the suggested land utilization types. The right of way was granted to the El-Dakhla - East El Owainate road behind it. A portion of the land with moderate potential class has been taken for non-agricultural activities with structures. The passageways and branches inside the farms were developed to make it easier and faster to access the various farms. Windbreaks and farm fences were placed between the fruit farm and sand dune areas to prevent sand dunes from taking over fruit farms. In addition to implementing strategies to enhance the farm's economic efficiency, it is imperative to incorporate environmental considerations into the farm planning process, potentially necessitating institutional assistance at the farm level. It is advisable to incorporate new environmental initiatives into agricultural policies to address environmental issues, considering the specific attributes of soil, water, and climate. This will enable efficient land use planning and the establishment of sustainable farming practices, thereby mitigating soil degradation, improving irrigation water quality, and addressing climate change concerns. This study's proposed decision model for farm planning may apply to New Valley soils and similar soils worldwide.

Key words: Soil, Water, Iron contamination, Potentiality, Suitability, Farm planning.

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INTRODUCTION

Farm viability is crucial for food security and rural development (McDowell and Kaye-Blake, 2023). Farm succession is crucial for long-term viability, involving retirement planning, managerial skill transfer, and development planning (Selmy *et al.*, 2022). Succession mainly impacts small to medium-sized family farms (McDowell and Kaye-Blake, 2023). Significant agricultural activities, often firms, are treated differently and undergo market transactions like non-agricultural businesses (Burbano-Figueroa *et al.*, 2022). In contrast, small-scale family businesses often transfer assets between generations, maintaining agricultural continuity (Elaalem, 2017). FAO and IFAD (2019) suggest that, succession is a deliberate process, not a sudden transition.

Land use planning (LUP) is essential for strategic land resource management (Ramezani *et al.*, 2023). It encompasses decisions on land acquisition, allocation, use, ownership, and legal principles, including ownership, expropriation rights, and usage requirements (Gwaleba and Chigbu, 2020). Comprehensively addressing social, economic, and environmental concerns makes LUP effective (FAO, 2021). Land and property planning decisions are inherently complex. The LUP system is complex due to the interaction of various actors, resulting in uncertainty (Ramezani *et al.*, 2023).

A farm plan involves integrating several types of information to compare and weigh them against one other (McDowell and Kaye-Blake, 2023). Establishing the necessary information for integration creates a farm plan that can be utilized by several players across jurisdictions. Integration coincides with information changes (Ramezani *et al.*, 2023). Farm plans can serve as a temporary anchor for knowledge and change. Incomplete knowledge can help us progress in this situation. Given the unstable condition of knowledge and policy, consistency, involvement, and responsibility must be addressed (McDowell and Kaye-Blake, 2023). Farm enterprise decision support systems should support tactical and operational planning by analyzing the agricultural system environment and complying with planning and land use concepts (Burbano-Figueroa *et al.*, 2022; McDowell and Kaye-Blake, 2023). A decision-support system enables decision-makers to retrieve data, apply relevant models, formulate plans, visualize results, and assess alternative options (FAO, 2021).

El-Dakhla Oasis is located in Egypt's Western Desert. Set 190 km west of the El-Kharga Oasis, it stretches 155 km from Teneida to Mawhoob, with a suitable agricultural region of 155 km long and 60 km wide (Selmy *et al.*, 2022). The location boasts lush farmland, ample water, and a larger population than El-Kharga Oasis. Groundwater supplies most of El-Dakhla Oasis and Western Desert water for drinking, domestic, and agricultural purposes. El-Dakhla Oasis' agricultural area nearly doubled between 2000 and 2020 due to new boreholes and land reclamation (Selmy *et al.*, 2022). Water is 60–120 m below ground. Salinity is below 1000 ppm. According to Gad *et al.* (2011), 13 deep wells released 30,703 m^3 daily, covering 1397 acres of cultivated area. Continuous groundwater piezometric head reduction has occurred (Selmy *et al.*, 2022). Population growth and agricultural development have led to groundwater drainage exceeding recharging. Groundwater frequently moves north and northeast. Groundwater in the Nubian Sandstone Aquifer has been heavily utilized since 1960. Masoud *et al.* (2018) report a drop in groundwater levels and an increase in salinity.

Finding additional regions with the potential for agricultural use is a high-priority objective for the government as it works to reduce the gap between food production and demand (Selmy *et al.*, 2022). It is widely believed that, the El-Dakhla Oasis is among the ideal locations for expanding agricultural production, as it can contribute to producing food and other essentials of life (Masoud *et al.*, 2018). There is no information on land use planning at the farm level in El-Dakhla Oasis, although the area under investigation is a potentially fruitful location for agricultural expansion. Therefore, the purpose of the current research is to characterize, assess, and map the soil and irrigation water spatial variability of soil physicochemical properties using GIS techniques and, consequently, to propose a decision tool for land use planning at the farm level in the El-Dakhla Oasis, to serve as a reference decision model for management and planning the soils in the New Valley region.

MATERIALS AND METHODS

Study Area

The 1750-acre research area is located on the southern side of El-Dakhla Oasis, New Valley governorate (Fig., 1). The area under investigation can be found to the west of the El-Dakhla - East El Owainate route and to the south of the Oasis of El-Dakhla (Fig., 1). The El-Dakhla - East El Owainate road runs parallel to the research area. The study area was selected for agricultural planning on the almost flat topography terrain of the Oasis. El-Dakhla Oasis is a natural depression in Egypt's Middle Western Desert. Groundwater was the main irrigation supply in the El-Dakhla Oasis (Fig., 2). This source is found in the Nubian sandstone strata, expanding from south to north (Hammad, 1986). Additionally, most of El-Dakhla Oasis's 520 springs and ponds have dried up, leaving those dependent on electric pumps for water (Sefelnasr *et al.*, 2014).

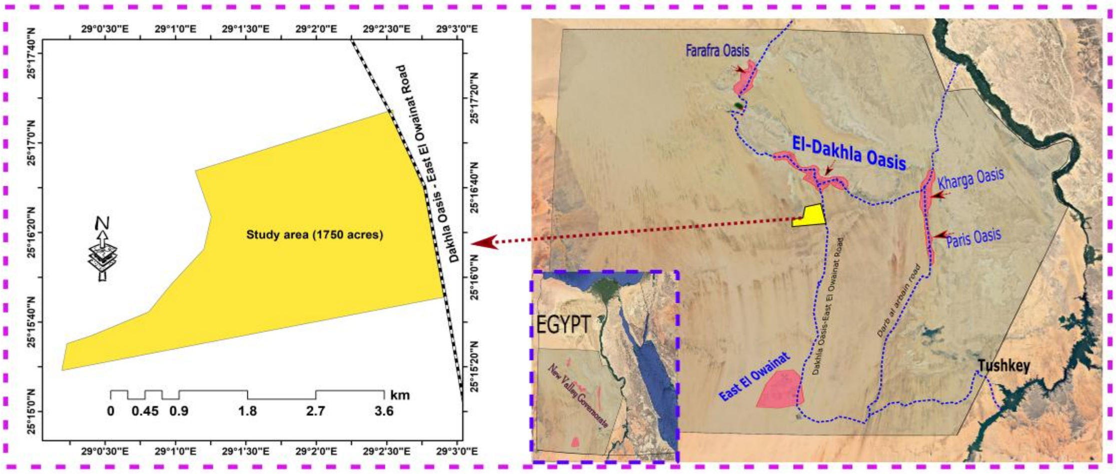

Fig. (1): Location of the study area. It is situated west of the El-Dakhla - East El Owainate route

Fig. (2): The primary source of groundwater affected by iron used in irrigation in the studied lands

El-Dakhla Oasis has the following geomorphological units: a northern high plateau, escarpment, footslope, gravely plains, terraces, sand dunes, sand sheet, sandy plain, pavement plain, depression, inselbergs, and playa (Masoud *et al.*, 2018; Fig. 3A). The sandy plain and sand dunes that make up the study area are shown in Fig., 3A. The examination took place on a sandy dune and plain. According to Selmy *et al.* (2022), the El-Dakhla valley marks the northern edge of the high plateau. This plateau features a broad, rough bed and a steep rise to the north. The Oasis depression lowlands, including remnant hills, alluvial terraces, and piedmont plains, are heavily influenced by erosion and sedimentation. The structural plain was created by integrating the El-Dakhla depression into a large, northward-sloping raised plain. The El-Dakhla depression has exposed minerals from the Late Cretaceous and Quaternary periods (Masoud *et al.*, 2018; Fig. 3B).

The foundation is covered by Nubia sandstone, a combination of sandstone and claystone from the Upper Jurassic Campanian period. The formation consists of geological units with increasing ages: Six Hills, Abu Ballas, Sabaya, and Maghrabi. Taref is the newest formation (Fig., 3). The Mut Formation, made up of shale, siltstone, and claystone, covered the El-Dakhla depression during the Campanian invasion. This condition happened over time. Ebraheem *et al.* (2004) discovered that, the depression's bottom primarily comprises Quaternary deposits. These deposits include alluvial, playa, sand dunes, and inland sabkha. The Nubian sandstone aquifer system's water-bearing rocks and limiting strata are interconnected. Fertile aquifers emanate from Taref, Sabaya, and Six Hills sandstone formations. According to Kato *et al.* (2014), unmanaged groundwater extraction can dry out shallow wells, deepen the groundwater table, and change hydraulic head patterns and flow directions, making collection economically problematic. The Taref sandstone aquifer has 28% effective porosity near the surface but decreases with depth due to lower sand content and increased cementation by Fe^{2+} and Mg^{2+} cations. In the El-Dakhla depression, the eastern section has a forecast transmissivity of 400 m^2/day, whereas the western part, with more sand, has 550 m^2/day. At its maximum thickness of 110.45 meters, the Taref aquifer has an average hydraulic conductivity of 6.76 m per day.

According to Ebraheem *et al.* (2004), the Six Hills aquifer has a thickness of over 1000 m and grows in thickness west and south. The average Sabaya aquifer thickness is 275 m. The increase in thickness is due mainly to fault expansion in these directions. In the Teneida and Mut regions, Gad *et al.* (2011) found piezometric surface data for the Taref, Sabaya, and Six Hills aquifers at 118, 111, and 135 m above mean sea level, respectively.

Recent groundwater and soil quality degradation has hampered agricultural operations in the El-Dakhla Oasis (Masoud *et al.*, 2018). Salinization and high Fe^{2+} and Mn^{2+} levels have reduced sustainable resource utilization, causing mass palm tree death (Fig., 4a). Seasonal irrigation water evaporation in the southern area of El-Dakhla Oasis has increased salt content in recently reclaimed lands (Fig., 4b), resulting in thick salt crusts around the center depression (Fig., 4c). Drainage of water in depressions results in the creation of manufactured canals. The salinization that results may be seen around the edges of the ponds (Figs., 4d and 4e). The irrigation by groundwater can result in the precipitation of the trace elements manganese and iron. They have produced soils high in iron and manganese (Fig., 4f), and oxidation has taken place in the dry pond containing iron-rich groundwater used to irrigate the reclaimed fields (Fig., 4g).

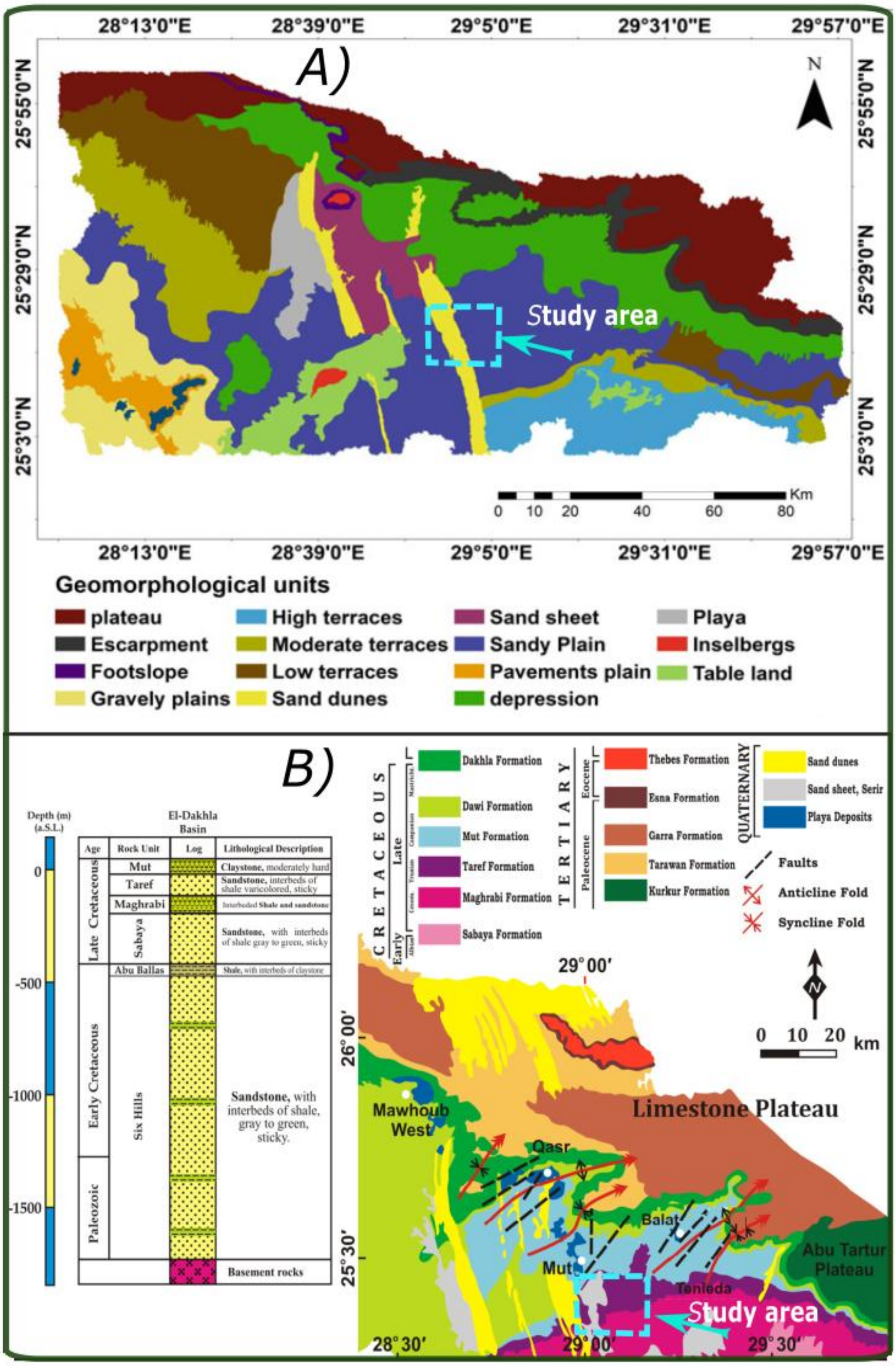

Fig. (3): El-Dakhla Oasis geomorphology and geology. A) The geomorphological units across the Oasis; B) The geological formations, structure, stratigraphy, and lithofacies (Masoud *et al.*, 2018). A dotted square denotes the research area in Fig. (1)

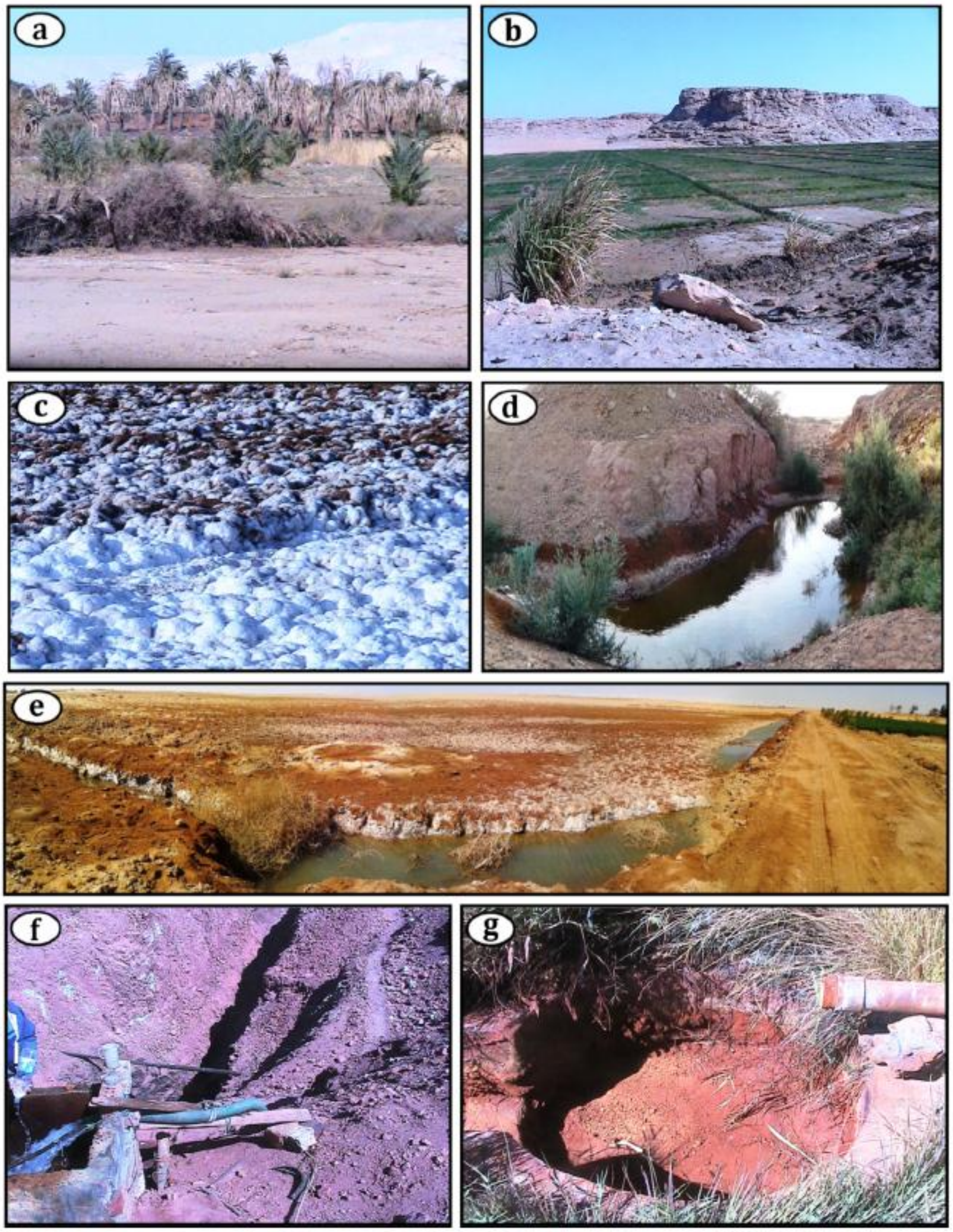

Fig. (4): Salinization and Fe-rich soil formation in El-Dakhla depression: a) palm tree death from salinity, b) high salt content in newly reclaimed sandy land in the south from irrigation water evaporation, c) salt crusts in the middle depression, d) and e) drainage water seepages in the lowest depression region, resulting in salinization and iron oxide abundance (Masoud *et al.*, 2018)

Climate of the El-Dakhla Oasis

The climatic analysis included data from two meteorological stations: El-Dakhla (25.5°N, 28.967°E, 117 m) and El-Kharga (25.45°N, 30.533°E, 73 m). The environment at El-Dakhla Oasis is hot and dry, with low annual rainfall, rapid evaporation, and high sun exposure (Ismael, 2015). The region is classified as hyper-arid (UNEP, 1997). At the El-Kharga station in 2011, the Egyptian Meteorological Authority reported an average of 87% relative sunlight duration, ranging from 82% in January to 90% in June-August. The southern desert of Egypt receives the most sunlight worldwide. The average annual ET_p was 1781 mm, with monthly totals above 200 mm from May to August (Fig. 5A) (Kimura *et al.*, 2020). El-Dakhla had average annual, maximum, and minimum temperatures of 24.4, 32.9, and 15.9 °C from 2010 to 2020 (Fig., 5B). Daily high and low temperatures were 42.5 and 4.4 °C, respectively. The average diurnal temperature amplitude was 16.9 °C, with a high at 21.2 °C and a low at 12.4 °C. Seasonal temperature variation is minor from June to August but significant from March to May due to the Khamsin wind. According to the Egyptian Meteorological Authority (2011), temperatures never drop below 0 °C.

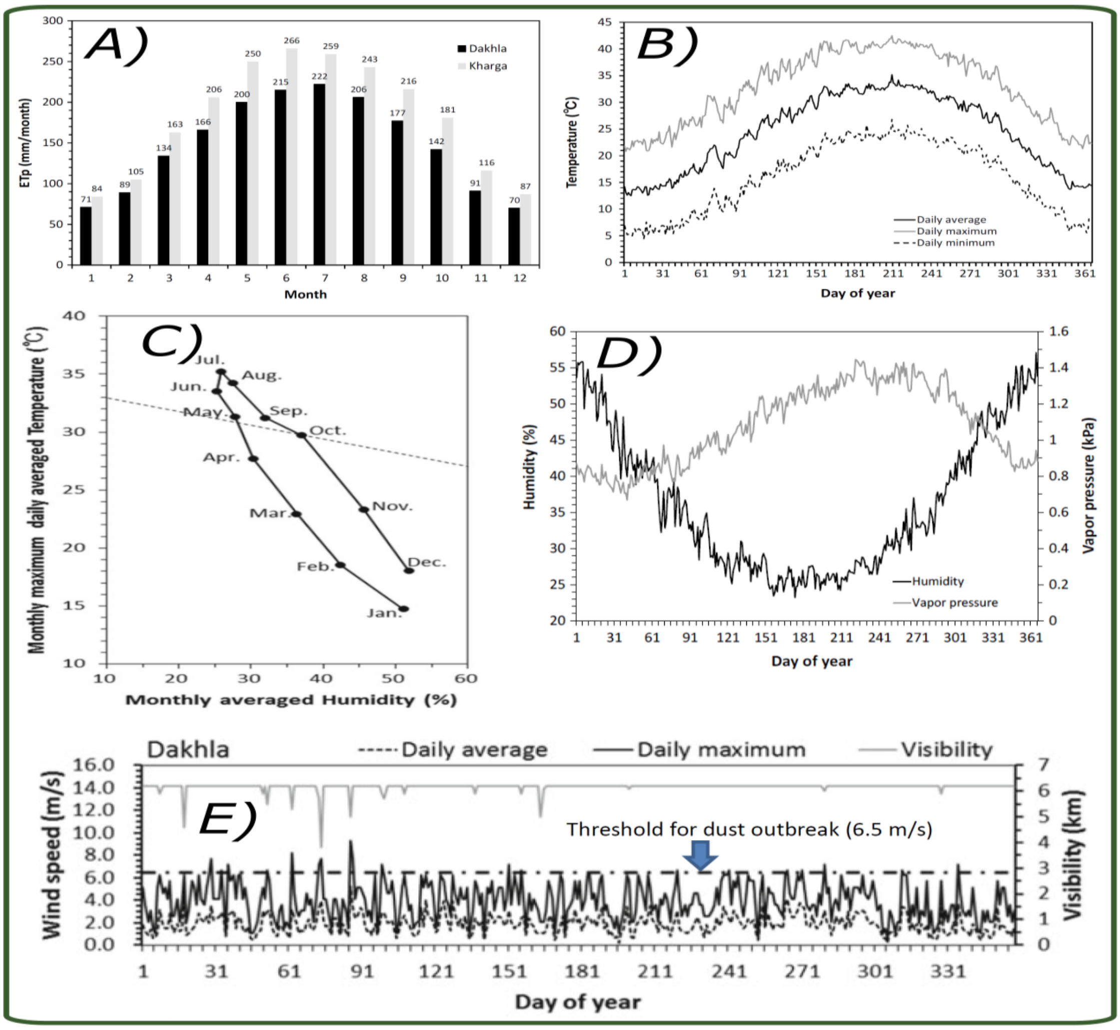

Fig. (5): Climate conditions of the El-Dakhla Oasis, including the study area. A) Evapotranspiration; B) Daily temperature; C) Monthly temperature and humidity; D) Daily humidity and vapor pressure; and E) Wind speed

Although El-Dakhla has desert-like temperatures and huge diurnal amplitude, it is not too harsh for human activity (Ismael, 2015). A discomfort score based on monthly maximum daily averaged temperature and humidity (Figs., 5C and 5D) indicates a relatively long comfortable season for human activities, from October to April. Since summer ET_p demands are high in agriculture (Fig., 5A), winter cultivation is beneficial for water conservation (Kimura *et al.*, 2020). Interestingly, the most comfortable time for humans coincides with winter agricultural production. Due to sufficient warmth for agriculture, cultivation in El-Dakhla Oasis, especially during summer, relies on groundwater availability due to little rainfall. Wet rice cultivation occurs every few years (Kimura *et al.*, 2020). High pressure causes calm wind speeds in El-Dakhla, with an annual average of 1.9 m/s and a maximum of 3.9 m/s (Kimura *et al.*, 2020). However, on certain days, the highest wind speed exceeds the threshold for dust outbreak (Fig., 5D). Dust emissions may occur year-round, particularly during Khamsin, if the threshold wind speed is 6.5 m/s. Additionally, winds over 6.5 m/s typically reduce vision. Strong winds may result from a desert-specific mixing layer during spring and Khamsin (Ismael, 2015).

According to the standards established by the Soil Survey Staff (2022), the temperature and moisture regimes of the soil were categorized as *Hyperthermic* and *Torric*, respectively. The Mediterranean and the Western Desert are swept by winds from the northwest and the north as they move southward. Wind speed and direction have the most significant role in erosion and deposition at the site that was investigated.

Soil Sampling

To achieve research aims, a detailed soil survey was done in the researched area (Fig., 6). The study area (1750 acres) had two identified landforms. These consist of a sandy plain (1340 acres) and sand dunes (410 acres) (Fig., 3). After considering soil morphology and the soil grid, 126 pedons were distributed on the selected landforms to accomplish the desired survey scale (Fig., 6). Of these pedons, twenty-four were found on active sand dunes in the southeast of the field's study area and were left out of the research. The sampling site distribution was adapted to match the geomorphological trends of the research area. In the field, soil profile sites were recorded using Garmin GPS and mapped (Fig., 6). Unless blocked by bedrock or water tables, soil profiles were dug to 1.5 m depth based on their nature. The soil profiles were morphologically analyzed using soil description criteria (FAO, 2006; Soil Science Division Staff, 2017). Based on soil morphological variance on the sandy plain, thirty-three (303) representative soil samples were taken from various layers and horizons of the 102 soil pedons that were studied. Air-dried samples were pulverized, sieved using a 2 mm sieve, and stored in polyethylene containers for laboratory tests.

Soil and Water Analyses

The pipette method was used for soil texture determination, and dry sieving was used for sand fractionation following the standards of Gavlak *et al.* (2005). Soil paste pH, Soil salinity (EC_e) organic matter (OM), $CaCO_3$, gypsum, cation exchange capacity (CEC), and ESP (exchangeable sodium percentage) were measured as per the standards procedures (Nelson, 1982; Houba *et al.*, 1995; Hesse, 1998; Bashour and Sayegh, 2007; Alvarenga *et al.*, 2012). A shallow aquifer (40-100m) representing all soil types in the research area was sampled using three wells during field study and sampling (Fig., 6). The groundwater wells were pumped to remove sluggish or filthy water before collecting samples in polyethylene bottles. Samples were stored at four °C until lab analysis. Portable meters were used to measure chemical properties like TDS and pH. A Hach Direct Reading/2000 Spectrophotometer detected Fe^{2+} (mg/l) as a trace component. Hach (1990) established analytical methods for quantifying main soluble cations (K^+, Na^+, Ca^{2+}, Mg^{2+}), soluble anions (SO_4^{2-}, HCO_3^-, Cl^-), and trace element Mn^{2+} in a lab within days of sampling. Table (1) shows chemical analysis results of the groundwater samples.

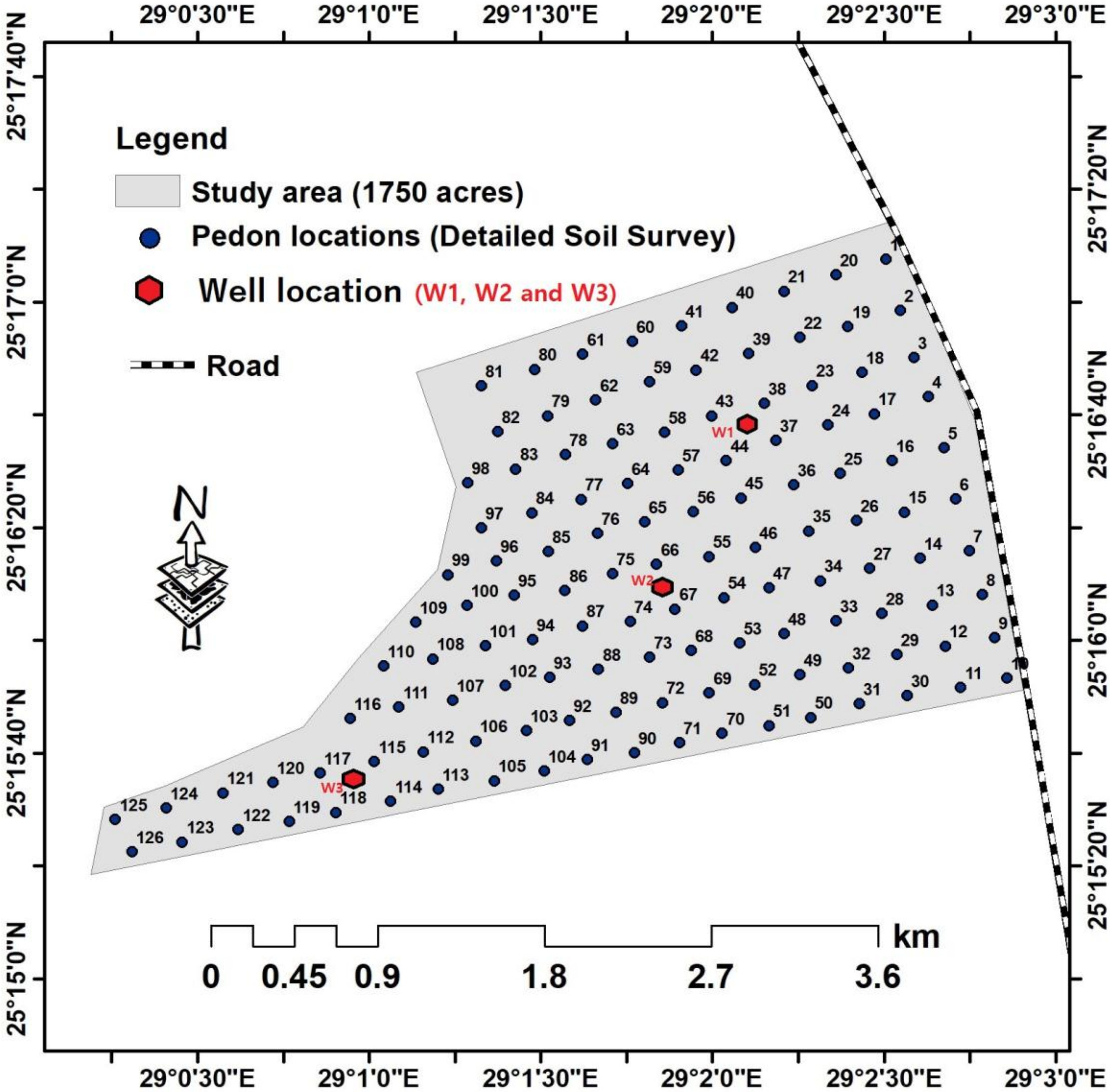

Fig. (6): Pedons (Soil) and wells (groundwater) locations grid achieving the detailed soil survey in the study area

Statistics and Geostatistics Processing

To produce summary statistics and identify patterns in source datasets, SPSS 17.0 was utilized. Descriptive statistics of minimum, maximum, range, mean, standard deviation, skewness, kurtosis, and coefficient of variation were performed for the soil characteristics of the entire study area. Pearson correlation coefficient (r) was utilized when analyzing each dataset. According to Wilding (1985), the coefficient of variation (CV) of soil properties might be low (less than 15%), moderate (between 15 and 35%), or extremely variable (more than 35). The application of geostatistics allowed for the investigation of spatially varying patterns of soil parameters within the study region. The ArcGIS program is used to build maps that define the soil's spatial variability by linking soil datasets known as attributes to sampling locations known as spatial. ArcMap software was used to build soil and potentiality maps, and point data was incorporated into both processes. The geostatistical analysis was carried out in ArcGIS by employing the geostatistical analyst from ESRI (2014).

This study employs the qualitative desert land potentiality evaluation (Q_LDLPE) approach for land potentiality assessment and the qualitative desert land aptness for crops (Q_LDLAC) method for land suitability and aptness (Elwan, 2013; 2019).

RESULTS AND DISCUSSION

This study introduces the Farmland Use Plan (FUP) to provide irrigation water and soil resources characteristics in the El-Dakhla Oasis study area. These tools enable farmers to create and implement a sustainable plan for using farmland resources, promoting environmental conservation, and increasing productivity and profits.

Irrigation Groundwater Characteristics in the Study Area

The chemical parameters in groundwater samples are TDS, pH, soluble cations and anions, Fe^{2+}, and Mn^{2+}. Table (1) displays the chemical analysis results for the sampled wells. Groundwater contamination was high with naturally occurring Fe^{2+} and Mn^{2+} trace elements (Ismael, 2015). Iron and manganese are predominantly found in anaerobic groundwater, resulting from natural water-rock processes rather than land use activities. In 2011, the World Health Organization (WHO) established health-based limits for Fe^{2+} (>0.3 mg/l) and Mn^{2+} (>0.1 mg/l), although the concentrations above these limits (23.06-55.95 mg/l for Fe^{2+} and 0.98-6.15 mg/l for Mn^{2+} (see Table 1). Groundwater samples are unsafe for drinking due to high Fe^{2+} (>0.3 mg/l) and Mn^{2+} (>0.1 mg/l) values. All groundwater samples meet WHO (2011) requirements for livestock and irrigation, with salt concentrations below 500 mg/l. The irrigation water quality considerably affects agricultural productivity in the examined area. Elevated salt levels in El-Dakhla Oasis can impact soil structure, permeability, and aeration, impacting plant growth (Masoud *et al.*, 2018).

Soil Characterization and Units

Soils of the study area were categorized into four units (Fig., 7), namely SMU1: deep, coarse textured, nonsaline, extremely calcareous (Fig., 8); SMU2: deep, coarse textured, moderately saline, moderately calcareous (Fig., 9); SMU3: deep, moderately coarse textured, slightly saline, slightly calcareous (Fig., 10); SMU4: deep, coarse over fine textured, moderately saline, non-calcareous (Fig., 11). The major physicochemical characteristics of the studied soils are presented in Table (2).

All the soils were quite deep (more than 100 centimeters), with the soils of SMU1 and SMU2 having a total depth of 160 centimeters and the pedon depth of SMU. 3 ranging from 125 to 150 centimeters. The lower depth of SMU. 3 was caused by a buried compacted clay layer (2Ab), as shown in Fig. 10. 155 centimeters was the depth of SMU4. The texture of the soil ranged from coarse sand to clay. The presence of buried layers with clay texture (2Ab in P47b of SMU3; Fig., 10 and Ab in P23 of SMU4; Fig., 11) influenced the soils. These horizons produced salt accumulation within soil pedons with limited permeability.

Table (1): Chemical characters of groundwater samples

Well No.	T.D.S. (mg/l)	pH	Soluble Cations (meq/l)				Soluble Anions (meq/l)			Fe^{2+} (mg/l)	Mn^{2+} (mg/l)
			Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3	SO_4^{-2}	Cl^-		
1	295	7.42	13.65	11.41	20.98	3.07	16.05	14.05	17.32	43.65	2.06
2	137	6.95	5.36	10.45	7.36	1.25	7.32	6.35	11.85	55.95	6.15
3	197	6.84	9.32	9.02	10.25	2.89	8.05	9.75	13.53	23.06	0.98

Table (2): Soil properties for only the five representative soil pedons (18 soil samples) to be the most typical examples of each soil mapping unit.

S.M.U.	Horizon name and depth, cm	pH	EC_e d S/m	ESP (%)	$CaCO_3$ (%)	Gypsum (%)	CEC $Cmol(+)kg^{-1}$	OM (%)	Mn^{2+} (mg/kg)	Fe^{2+} (mg/kg)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Texture class
SMU1 (P94)	**Ap:** 0-35	7.98	1.92	7.25	23.15	0.98	6.36	0.12	965	12321	3.65	89.05	7.62	3.33	FS
	BC: 35-85	8.02	0.76	6.34	27.16	1.07	8.26	0.24	476	7586	4.06	82.74	7.03	10.23	LFS
	C1: 85-125	7.46	1.34	4.78	33.42	0.78	7.05	0.06	832	3417	1.69	82.86	10.30	6.84	LS
	C2: 125-160	8.84	1.43	8.35	29.52	0.65	5.03	0.04	715	1935	2.95	90.62	3.65	5.73	COS
SMU2 (P41)	**A:** 0-33	8.36	8.16	9.52	6.35	2.54	6.45	0.12	163	5932	11.02	90.11	5.05	4.84	Sand
	Ck: 33-100	8.58	13.45	11.35	9.35	4.06	7.04	0.14	142	4136	7.36	87.30	7.03	5.67	LCOS
	2C: 100-160	9.41	15.32	15.34	3.35	4.32	9.12	0.17	162	3547	9.32	83.94	4.32	11.74	LFS
SMU3 (P47a)	**A:** 0-25	8.14	2.48	6.35	1.02	0.01	8.45	0.18	74.15	496	4.36	80.82	7.62	11.56	COSL
	C1: 25-83	8.69	4.32	7.09	1.62	0.95	11.25	0.14	49.32	423	3.16	78.74	8.65	12.61	FSL
	C2: 83-150	7.88	6.78	4.32	0.95	1.24	10.91	0.04	94.36	162	1.05	80.99	6.65	12.36	SL
SMU3 (P47b)	**A:** 0-27	7.83	3.36	9.65	0.32	1.41	10.98	0.36	100.25	195	7.62	78.72	9.32	11.96	FSL
	C1: 27-52	8.41	2.8	6.78	0.12	0.98	9.35	0.18	49.32	596	5.32	80.02	8.36	11.62	SL
	C2: 52-105	8.65	4.36	8.09	0.93	0.04	8.36	0.14	30.25	473	1.36	76.42	7.03	16.55	COSL
	2Ab: 105-125	9.05	7.65	10.42	1.78	2.65	26.35	0.27	83.62	452	2.65	56.03	6.95	37.02	SC
SMU4 (P23)	**Ap:**0-20	8.36	4.78	11.05	0.11	2.87	7.01	0.14	10.36	513	11.36	93.51	3.65	2.84	Sand
	Bt:20-70	8.05	9.05	7.23	0.0	0.14	30.2	0.37	19.32	198	2.65	50.07	4.61	45.32	SC
	C:70-105	8.17	6.34	5.35	0.0	0.75	14.36	0.23	55.46	265	26.32	80.15	5.45	14.40	SL
	Ab:105-155	9.05	13.76	14.05	0.08	4.02	41.02	0.29	13.06	485	5.36	23.36	34.61	42.03	C

Explanations: Soil Survey Staff (2022) determined master and suffix designations to the horizons of soil pedons. Soil texture class was given based on the fractionation of sand content; COS (coarse sand); LCOS (loamy coarse sand); COSL (Coarse sandy loam); SL (Sandy loam); FSL (Fine sandy loam); LFS (loamy fine sand); FS (fine sand); SC (sandy clay); C (Clay).

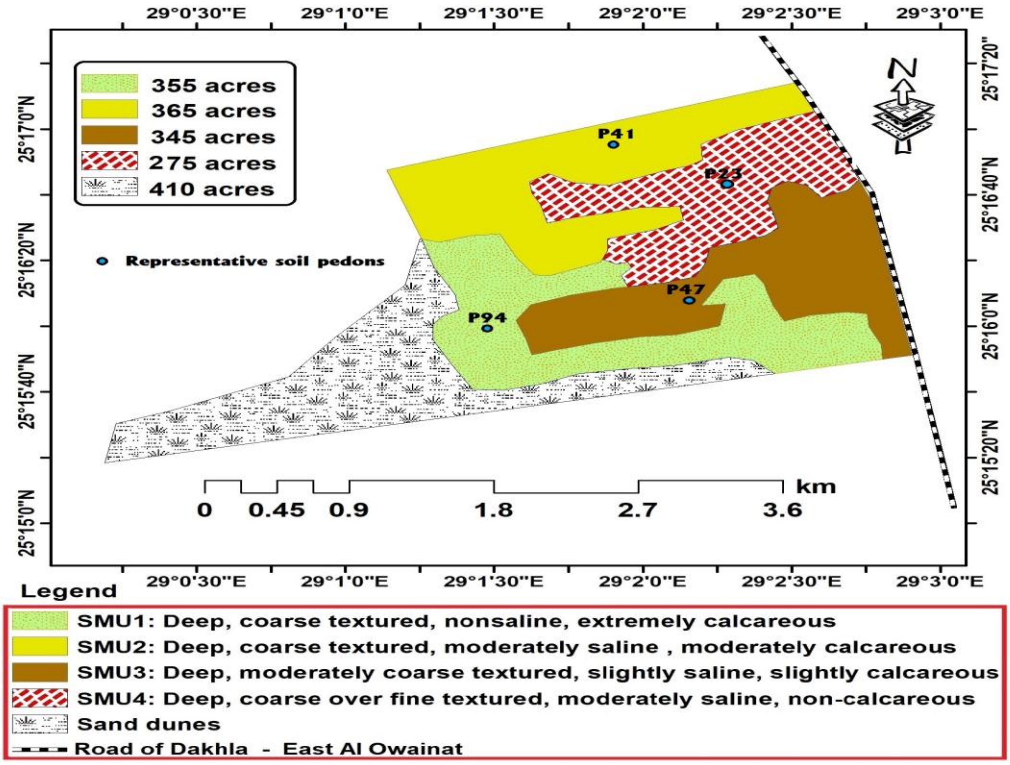

Fig. (7): Soil mapping units in the study area

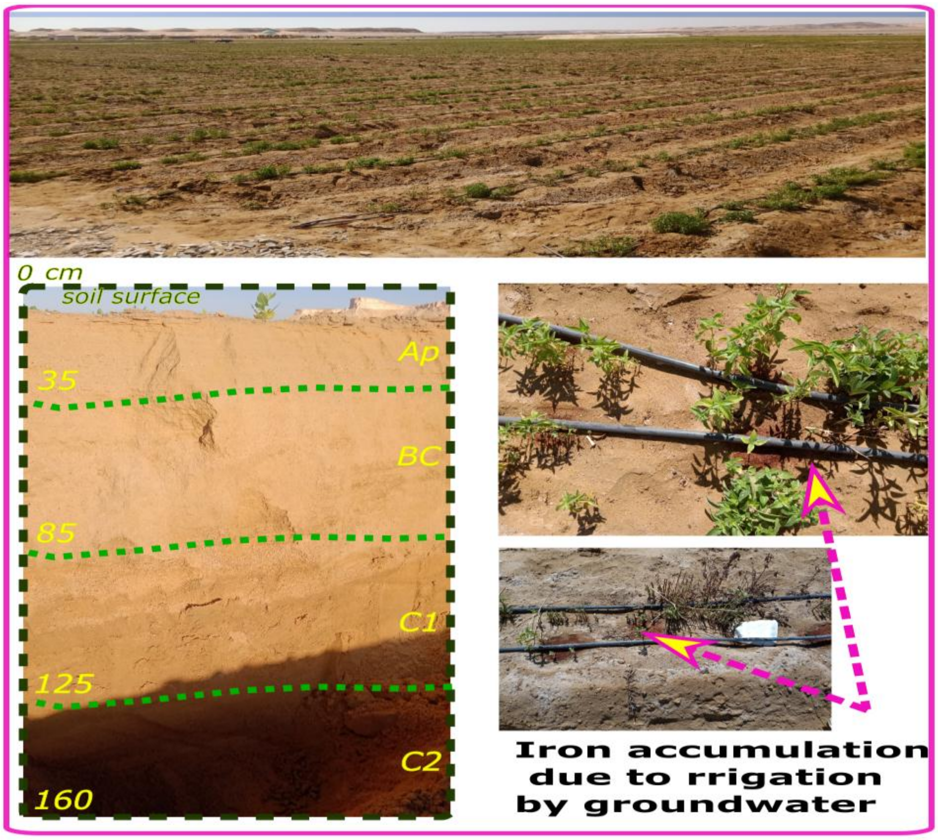

Fig. (8): Groundwater irrigation impacted SMU1 soils, and the plants wilted owing to Fe toxicity

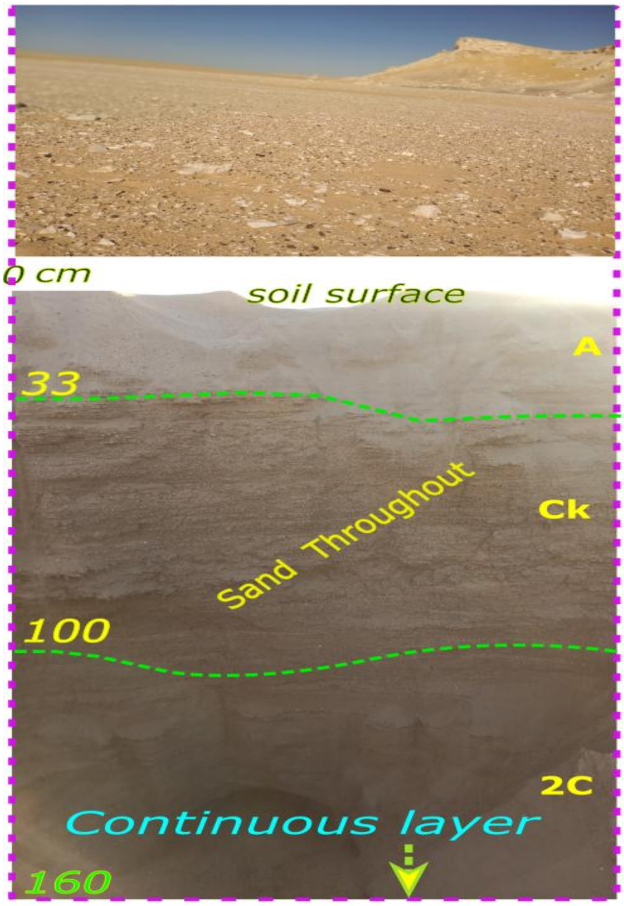

Fig. (9): SMU2 soils feature coarse texture across the soil pedon and coarse fragments on the land surface

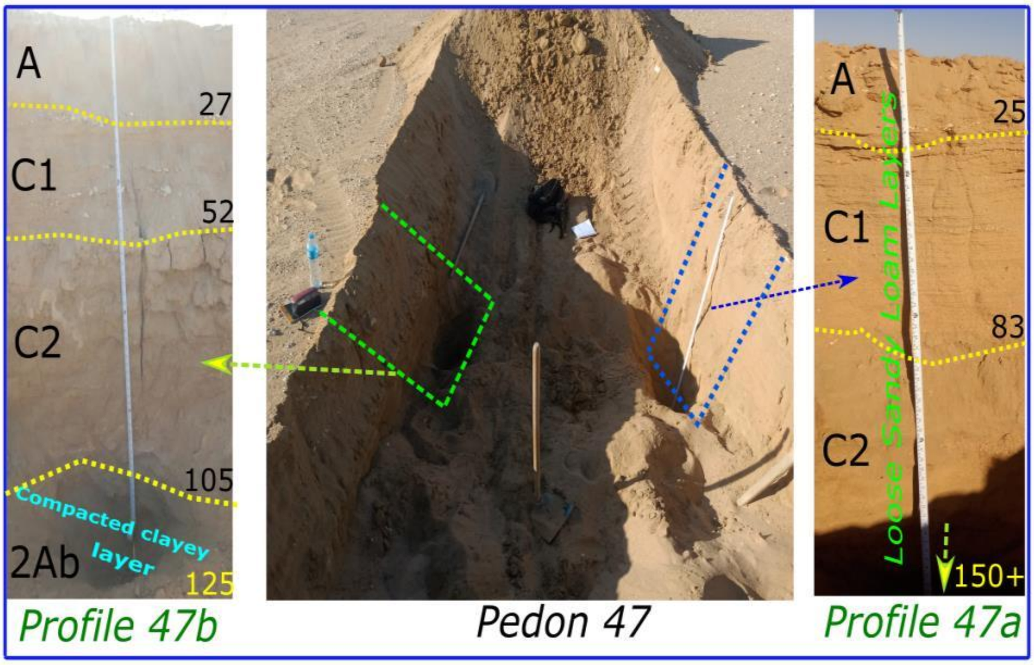

Fig. (10): Soils of SMU3 showing two different soil profiles in the same soil pedon pit

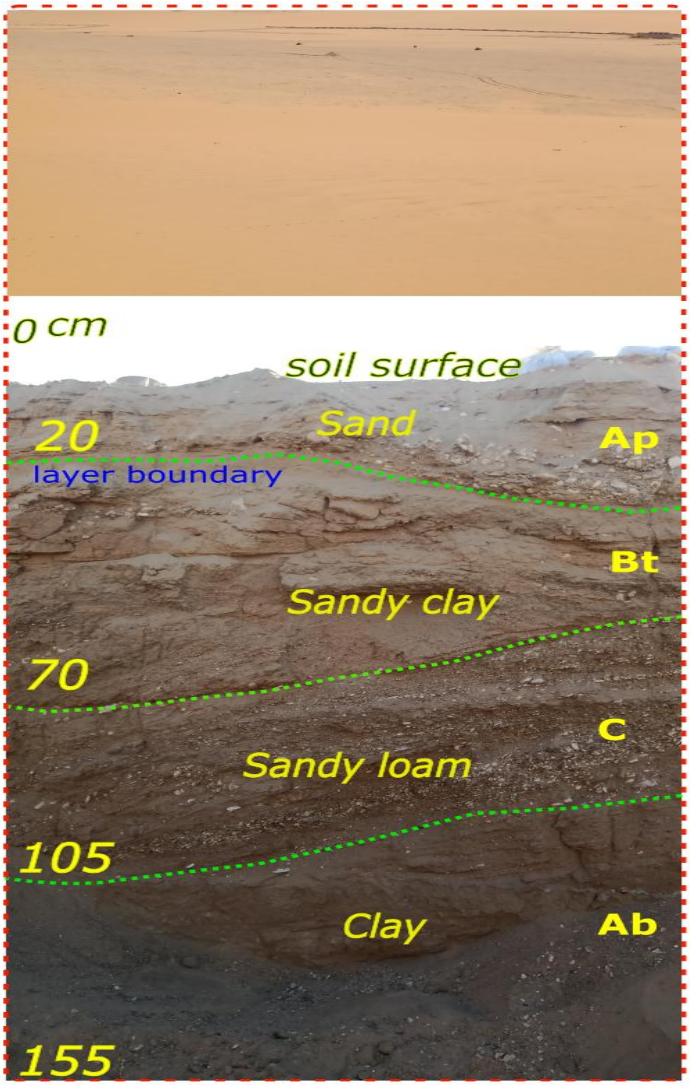

Fig. (11): Soils of SMU4, including soil surface and deep soil profile with buried horizon (Ab)

The pH of the soil varies from 7.46 to 8.84 in SMU1 (P94), 8.36 to 9.41 in SNU2 (P41), 7.83 to 9.05 in SMU3, and 8.05 to 9.05 in SMU4. According to Schoeneberger *et al.* (2012), all soil mapping units are classified as slightly to very strongly alkaline. This pH is not likely to promote nutrient immobilization or plant nutrient shortage in the research area. However, locations with soil pH levels above 8.5 will experience a significant loss in fertility when carbonate is added.

The gravel content ranged from <2% to more than 25%. In SMU1 soils, the largest value of gravel content was found in layer C (Fig. 11). SMU1 irrigated soils with Fe-rich groundwater exhibit higher surface layer Fe^{2+} (12321 mg/kg) and Mn^{2+} (965 mg/kg) values. These amounts were toxic to cultivated plants in SMU1, causing them to die. The soils of the research region were classified as nonsaline (2 dS/m), slightly saline (4-8 dS/m), and moderately saline (8-16 dS/m) based on salinity (EC_e) and FAO (2006). Based on the lime content, the soils were classed as non-calcareous, slightly calcareous (<2%), moderately calcareous (2-10%), and extremely calcareous (>25%). According to the gypsum content, the studied soils are characterized as non-gypsiric to slightly gypsiric.

Descriptive Statistics of Soil Properties

Summary results reveal significant variation in soil parameters among the entire studied soil pedons. Table (3) shows that, soil properties had variable descriptive statistic values. The tested soil characteristics ranged from 0.33 to 12159, suggesting significant variation in properties like Fe^{2+}, Mn^{2+}, EC_e, and sand content between soil pedons. In contrast, the pH, gypsum, and OM range measurements showed close minimum and maximum values. The average values of examined parameters ranged from 0.19 to 6249.49 for soil pedons. Fe^{2+}, Mn^{2+}, depth, CEC, sand, and clay exhibited high mean values, while other variables had low values. The SD of the examined variables ranged from 0.06 to 28.36. In this study, a low SD indicates data points near the average, such as gypsum, OM, and gravel, whereas a high SD indicates data points distributed across a wide range, such as Fe^{2+}, Mn^{2+}, pedon depth, and sand content.

According to the findings, the soil was quite deep, with a depth that ranged from 125 to 160 cm and a mean of 142.9 cm. Previous research indicated that the soil profile's depth in the El-Dakhla Oasis ranged from 70 to 150 centimeters (Hamed and Khalafallh, 2017). These findings are partially compatible with previous research. On average, the pH was 8.88, and there was only a slight range of variation in the pH values. The saturated soil extract had an electrical conductivity that ranged from 0.76 to 15.32 dSm^{-1}, with a mean of 8.74 dSm^{-1}. According to the Soil Science Division Staff (2017) findings, the soils ranged from nonsaline to moderately salty and from slightly alkaline to extremely alkaline. Based on earlier research findings, the soils subjected to this investigation were classified as being neutral to slightly and moderately alkaline, with pH values ranging from 7.08 to 8.9. The exchangeable sodium percentage (ESP) was found to have a range from 4.32 to 15.34%, with a mean of 10.36%, as shown in Table (3). According to the ESP values, there is no danger of sodicity at all, although there is a significant risk of it (FAO, 1988). According to Jafari *et al.* (2018), salinization and alkalinization are commonplace in desert settings because of the absence of rainfall, high temperatures, and high evaporation rates, all of which contribute to salt accumulation. The distribution of the particle sizes showed a wide range of variation, with the percentage of sand varying from 23.36 to 93.5%, with a mean of 57.44%; the percentage of silt varying from 3.65 to 34.61%, with a mean of 20.13%; and the percentage of clay varying from 2.84 to 45.32%, with a mean of 24.18% (Table, 3). According to the USDA soil texture triangle categorization, the analyzed soils were separated into three distinct categories depending on their texture: coarse textured, moderately coarse textured, and fine textured. These groups are depicted in Fig., 7. Tantawy (2016) came to similar conclusions consistent with these findings.

In Table (3), the soil had a gypsum level of less than 5%, ranging from 0.01 to 4.32%, with an average of 2.77%. Low soil gypsum content in the studied area may be due to insufficient application and inadequate pedogenic gypsum production processes (FAO, 1990; Hashemi *et al.*, 2011). Table (3) displays a wide range of $CaCO_3$ levels in soils, from 0.0 to 33.42%. The considerable variance in $CaCO_3$ is due to soil types, notably sand fraction content. Hazelton and Murphy (2016) found that, the cation exchange capacity ranged from 7.6 to 56.8 cmol (+) kg^{-1}, indicating a modest to high range (Table, 3). Clay content and mineral kinds may cause a wide range of CEC due to insufficient organic matter. Selmy (2005) identified kaolinite, smectite, illite, and mixed phases as the main clay minerals in the soils studied. Soils with high surface area clay minerals (Smectite) showed higher cation exchange capacity values, while kaolinite had the opposite effect. Furthermore, it was linked to fine particles, notably clay and silt fractions. Hazelton and Murphy (2016) found that, soil organic matter levels ranged from 0.04 to 0.37%, averaging 0.19% (Table 3). Limited foliage cover, high temperatures, and organic fertilizer deficiencies in the research area may contribute to this (Jafari *et al.*, 2018).

Table (3): Descriptive statistics of soil characteristics of 102 pedons in all mapping units in the study region (n = 303).

Soil Property	Range	Minimum	Maximum	Mean	SD	CV (%)	Kurtosis	Skewness
Depth (cm)	35.0	125.0	160.0	142.90	19.51	14.26	0.410	0.785
pH	2.05	7.36	9.41	8.88	0.98	3.04	0.359	0.962
EC_e (dSm^{-1})	14.56	0.76	15.32	8.74	1.36	97.32	5.321	3.624
ESP (%)	11.02	4.32	15.34	10.36	3.65	57.36	0.924	0.569
$CaCO_3$ (%)	33.42	0.0	33.42	17.71	2.69	66.49	2.382	1.756
Gypsum (%)	4.31	0.01	4.32	2.77	0.84	34.02	-0.429	0.637
CEC cmol(+)kg^{-1})	35.99	5.03	41.02	22.03	3.54	49.67	-0.719	0.963
OM (g kg^{-1})	0.33	0.04	0.37	0.19	0.06	81.2	0.539	1.596
Mn (mg/kg)	954.64	10.36	965	488.68	25.32	56.39	6.325	2.065
Fe (mg/kg)	12159	162	12321	6249.49	28.36	43.14	9.025	1.458
Gravel (%)	25.27	1.05	26.32	13.08	1.05	1.65	-4.023	3.065
Sand (%)	70.15	23.36	93.51	57.44	8.32	27.33	-1.952	-0.429
Silt (%)	30.96	3.65	34.61	20.13	3.04	33.68	-0.862	0.169
Clay (%)	42.48	2.84	45.32	24.18	4.03	54.36	-1.179	0.265

SD (Standard Deviation), CV (Coefficient of Variation).

According to Wilding (1985), the coefficient of variation (CV) of soil parameters can be broken down into three distinct groups: low (less than 15%), moderate (15–35%), and high (more than 35%). The coefficient of variation (CV) was found to differ from one variable to the next and ranged anywhere from 1.65% to 97.32% across all of the soil properties. According to the results of the CV analysis, the variability was found to be low for the soil pH (CV = 3.04%) and gravel (CV = 1.65%), moderate for sand (CV = 27.33%), and high to extremely high for the majority of the soil parameters (Table, 3). According to Lepcha and Devi (2020), the high and extremely high variance in soil characteristics may be caused by a combination of human and environmental variables such as agricultural management techniques, the nature of the soil, and the circumstances of the climate. (Soropa *et al.*, 2021) found that soil salinity showed the largest fluctuation among the qualities of soil that were evaluated. Agricultural management methods and climate conditions may easily alter soil salinity. Although the pH of the soil showed the least amount of change, it is also less affected by situations like these due to the buffering ability of the soil pH.

Skewness values indicate skewed data in all soil characteristics datasets except depth, gypsum, sand, and silt (Webster and Oliver, 2007). The skewness of the majority of the soil parameters was positive. Positive skewness was seen across various soil parameters, ranging from 0.169 to 3.624. On the other hand, the skewness values for the sand content are both negative (-0.429), Table (3). According to Cooksey (2020), skewness can be caused by extreme values in soil properties, either positively or negatively. According to Cooksey (2020), these findings imply that, the data regarding soil properties did not follow a normal distribution. A log transformation was used to collect data on the soil characteristics (Webster and Oliver, 2007). According to Cooksey (2020), the term "kurtosis" refers to a measure of the form of probability distributions that is comparable to "skewness." The different soil qualities are represented by Kurtosis values in Table (3) that range from -4.023 to 9.025.

Soil Properties Correlation

Table (4) displays correlation coefficients for soil parameters evaluated. Both sand fraction and $CaCO_3$ showed a substantial negative connection with CEC, OM, silt, and clay. Conversely, CEC showed a substantial positive relationship with OM, silt, clay, ESP, SAR, EC_e, and sand/$CaCO_3$ (Table 4).

The positive link between sand and $CaCO_3$ in soils may be due to carbonate sands (calcium carbonates in sand size), Soropa *et al.,* (2021). The relationship between the three fractions of soil particles is inversely proportional because their sum equals 100%. It explains why sand has a negative connection with silt and clay. A rise in one is balanced by a fall in the other, and vice versa. The lack of electrical charges in sand hinders its ability to exchange cations, leading to a negative connection with CEC (Cooksey, 2020). The association between clay and CEC was also strong (r = 0.99). Clay is known for its ability to absorb and transport cations through adsorption. The presence of negatively charged sites on clay particles, particularly smectite minerals, in the research area, may explain this association (Lepcha and Devi, 2020).

Clay has a positive link with CEC due to expansive clays (2:1), such as smectites, which have a large surface area and high moisture absorption (Lepcha and Devi, 2020). The significant negative association between silt fraction and $CaCO_3$ may be because $CaCO_3$ is linked to sand in the study location, which has an inverse relationship with silt. The CEC showed a substantial positive connection with silt and clay fractions and a negative correlation with sand fractions. Because tiny particles have a more significant surface area and capillary holes than sand, soil can hold more water. Sand fraction has a smaller surface area (0.001–0.01 m^2 g^{-1}) and lower chemical and physical activity than clay fraction (5-750 m^2 g^{-1}) based on mineral type (Soropa *et al.,* 2021). Arid soils in the research location have high sodium ion (Na^+) soluble salt content. The EC_e showed a substantial positive connection with both ESP and SAR. The link between CEC and OM is positive since OM raises CEC.

Land Potentiality in the Studied Area

According to the water characteristics in Table (1) and the soil properties and their correlations in Tables (2, 3, and 4), the Q_LDLPE approach classified the lands under study into two categories (Fig., 12). High potential land (700 acres) and moderate potential land (640 acres) are shown in Fig. (12). The potentiality of the lands in SMU1 and SMU3 is classified as high. On the other hand, high-potential lands have larger concentrations of iron and manganese, yet the soil salinity is still within acceptable levels. In contrast, the potentiality of the lands in SMU2 and SMU3 is classified as moderate (Figs., 7 and 12). The main limitations in moderate potential lands were soil salinity and compacted layers within the soil pedons.

Suggested Crop and Trees

Based on the irrigation groundwater quality (Table, 1), climate criteria (Fig., 5), soil types (Fig., 7), land potentiality (Fig., 12), the Q_LDLAC method optimized the examined farmlands for various crops and trees (Fig. 13). In the study area, fruit trees were recommended for 355 acres, forages for 365 acres, vegetables for 345 acres, and saline agriculture (including salt-tolerant crops) for 275 acres due to salinity limitations (Fig., 13).

Developed Decision Support Model for Study Area at El-Dakhla Oasis

Farmland use planning (FUP) is based on group advancement, as depicted in Fig. (14) for both group and individual farms. The research area's climate, soil quality, and irrigation water characteristics were used to suggest the ideal land use plan (Fig., 15).

Table (4): The correlation coefficient matrix of the studied soil properties.

Property	Pedon depth	pH	$CaCO_3$	Gypsum	CEC	ESP	EC_e	Fe^{2+}	Mn^{2+}	OM	Sand	Silt	Clay
Pedon depth	1												
pH	0.17^{NS}	1											
$CaCO_3$	-0.22^{NS}	0.78^{**}	1										
Gypsum	-0.41^{*}	0.14^{NS}	-0.16^{NS}	1									
CEC	0.36^{*}	-0.35^{*}	-0.66**	0.23^{NS}	1								
E.S.P.	-0.38^{*}	0.04^{NS}	-0.68**	-0.19^{NS}	-0.19^{NS}	1							
EC_e	0.23^{NS}	0.08^{NS}	0.01*	0.69^{*}	0.43*	0.60^{**}	1						
Fe^{2+}	-0.28^{NS}	-0.87^{*}	-0.76*	-0.52^{**}	-0.18^{NS}	0.52^{**}	-0.71^{*}	1					
Mn^{2+}	0.19^{NS}	-0.78^{**}	-0.59*	0.10^{NS}	0.79^{*}	-0.64^{*}	-0.54^{*}	0.55	1				
OM.	-0.47*	-0.21^{NS}	-0.52**	0.66*	0.81^{**}	-0.72^{*}	-0.49^{*}	-0.22^{NS}	0.82^{**}	1			
Sand	-0.19^{NS}	0.23^{NS}	0.51*	-0.22^{NS}	-0.88^{**}	0.17^{NS}	0.17^{NS}	0.21^{NS}	-0.12^{NS}	-0.75^{**}	1		
Silt	0.11^{NS}	-0.16^{NS}	-0.20^{NS}	0.35*	0.71^{**}	0.38^{*}	-0.11^{NS}	-0.17^{NS}	0.69^{**}	0.52^{**}	-0.91^{*}	1	
Clay	0.62*	-0.61^{*}	-0.58**	0.19^{NS}	0.69^{**}	-0.12^{NS}	-0.19^{NS}	-0.2^{NS}	0.94^{**}	0.86^{*}	-0.89^{**}	0.63*	1

* Significant at P = 0.05 level (2-tailed).
** Significant at P = 0.01level (2-tailed).
NS Non-significant.

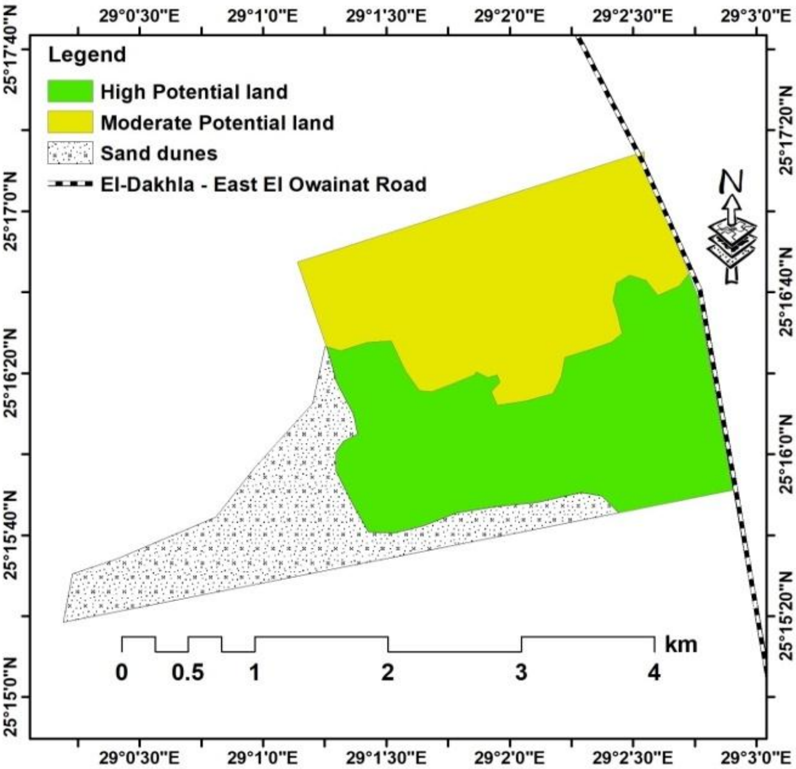

Fig. (12): Land potentiality of the study area

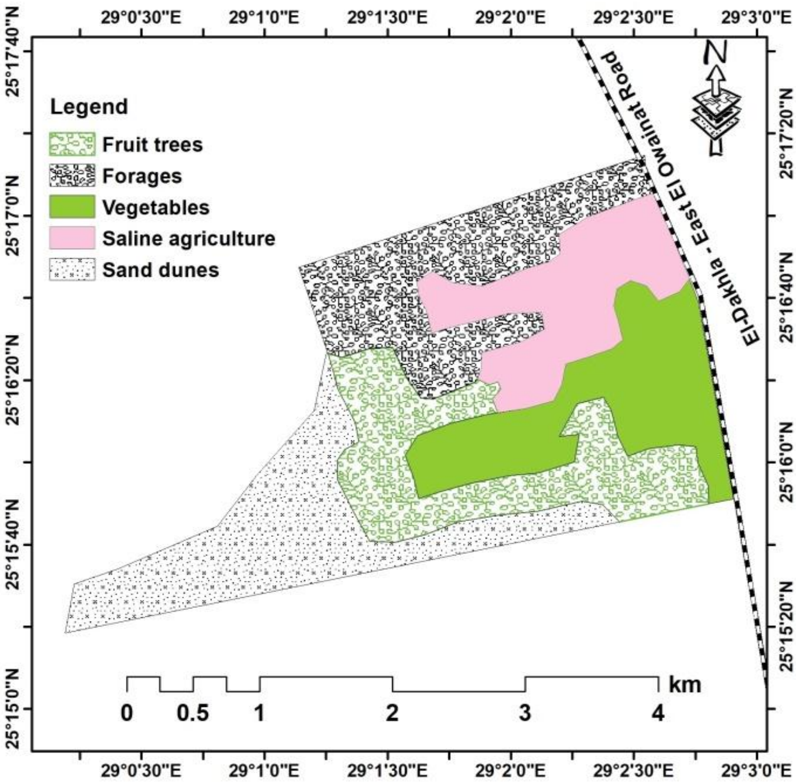

Fig. (13): Suggested crops in the lands of study area

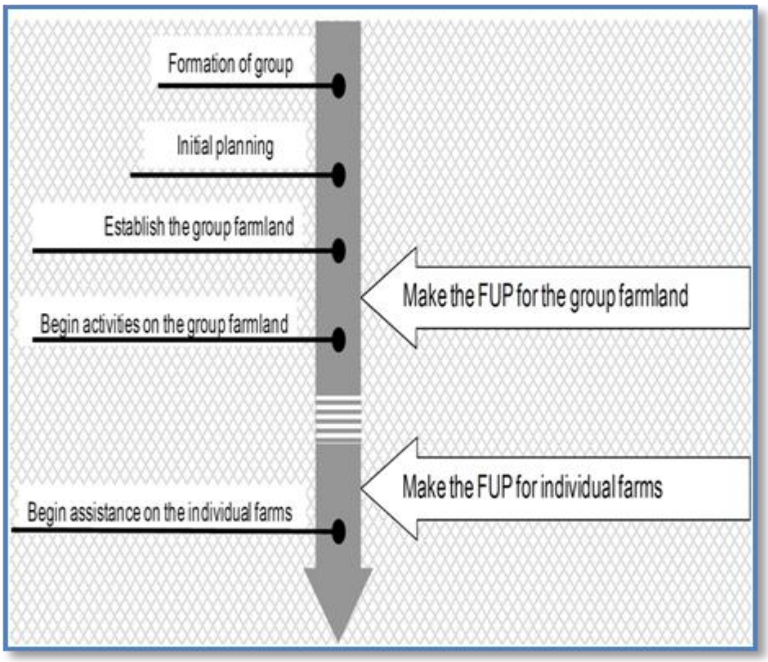

Fig. (14): Outline of making farmland use plan (FUP) in the study area at El-Dakhla Oasis

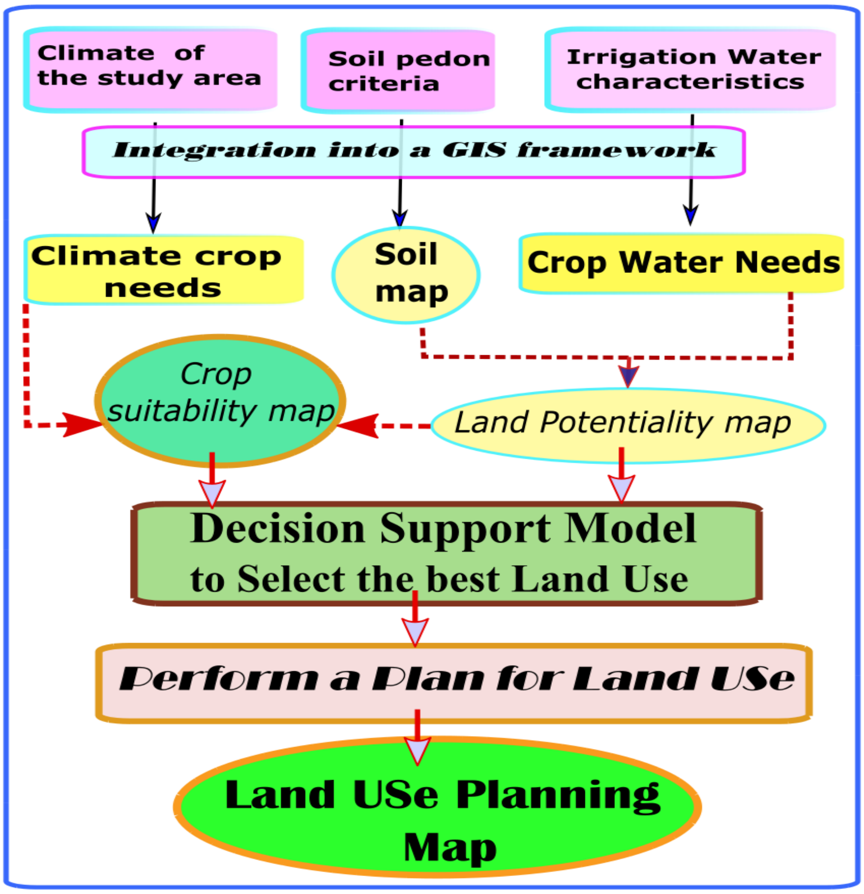

Fig. (15): Proposed decision support model for land use planning at the farm level

After confirming the initial activity plan and establishing the group farmland, convey the FUP concept to the farmers for their participation in its creation. The FUP must be completed promptly before the group begins planting or conservation efforts. After achieving maturity and meeting conditions, a FUP must be created for each farm to get assistance in the second phase. Land use planning was done at the farm level (Fig., 15). Various processes can make an FUP for a specific farm.

First, chatting with beneficiaries, gathering general information, and touring the farm are the initial steps for land use planning. Second, measuring and mapping soil units (Fig., 7) and land potentiality (Fig., 12) using irrigation water and soil parameters are the specific steps for farm management. Third, a crop suitability map was created based on each soil type, and climate condition in the El-Dakhla Oasis (Fig., 13). Fourth, a decision support model for land use planning at the farm level in the El-Dakhla Oasis may be implemented as shown in Fig. (15). Fifth, the study area lands may be divided into fragmented farms (Fig., 16) and land utilization types were used to create a future land use map (Fig., 17). Finally, estimate inputs, create a work schedule, and confirm the FUP should be considered in the future. A "farm" is typically a manufacturing unit, but its formation might vary. A beneficiary (farmer) may work on multiple pieces of land simultaneously and treat them as one farming unit "plot" (Fig., 17).

Farmland can be used for agriculture, livestock, tourism, or a combination of these (agricultural and animal farming). The farm includes the farmer's house, an adjacent yard, and fallow pastures. A farm has secondary crops, forages, and tree fields that develop after clearing previously farmed land, as long as the owner or user intends to cultivate them shortly. When land is abandoned, it is no longer considered part of the farm. The land use map of the farm should accurately show its shape, acreage, terrain, crops, water bodies, roads, trees, structures, and GPS coordinates. The land use planning map should include a bar scale, north arrow, and coordinates (Fig., 17). Farm property is divided into plots based on current land use, slope, and soil parameters in the soil map (Fig., 16). Two types of sites are created when planning a farm: buildings for non-agricultural uses and potential farmed land.

Land division is typically more detailed on agricultural farms than on cattle farms. The proposed plan for conservation and eco-friendly strategies differ significantly between crop farming and fruit trees. For the FUP to be effective, land division (segmentation) should be neither too detailed nor too simple (Fig., 16). Applying production use criteria for potential farming areas helps pick acceptable crops and incorporate conservation practices in each soil mapping plot. A second tour of the farmland with the beneficiary, reviewing the map on location, and discussing future uses is recommended.

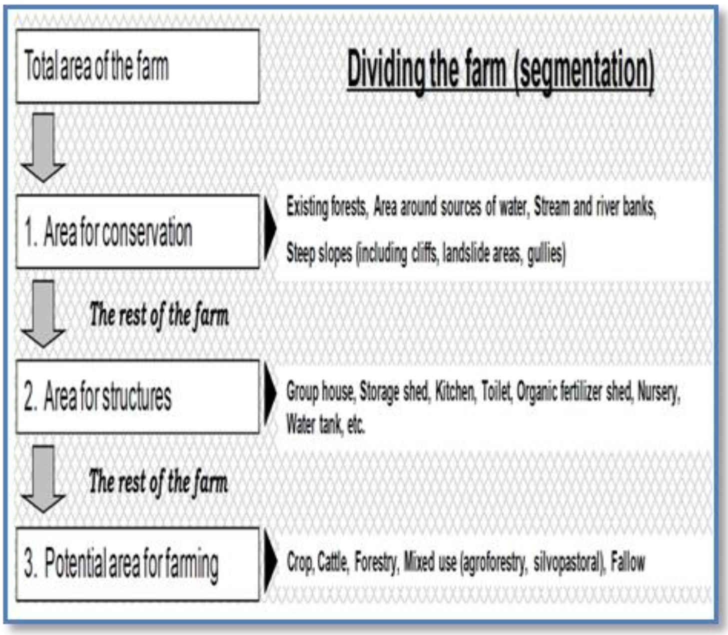

Fig. (16): Dividing the farm (segmentation)

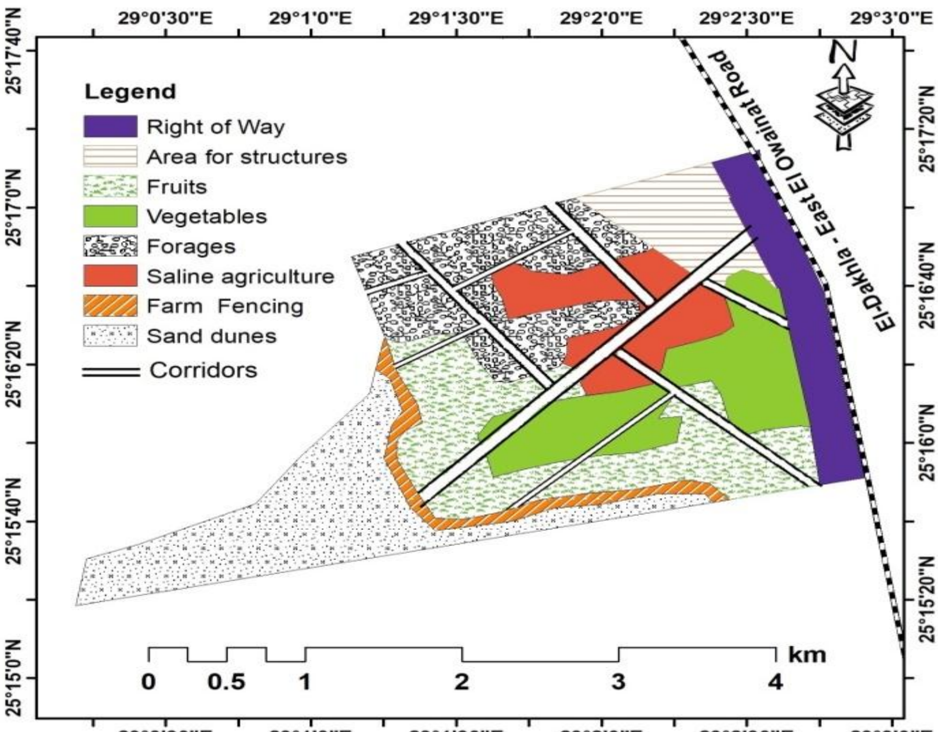

Fig. (17): Proposed land use planning at farm level in the El-Dakhla Oasis, New Valley governorate

When planning the study area again, 1,750 acres of study area were partitioned into several farmsteads (Fig., 17). The road of El-Dakhla - East El Owainate was given the right of way behind it. The site with moderate potential has a portion of it developed with structures, such as a community center, a storage shed, a kitchen, and a restroom, among other things. The different farms can be reached more quickly and readily by establishing key corridors and branches inside the farms themselves. Farm fencing, windbreaks, and barriers were installed between the fruit and sand dune areas to protect fruit farms from being overrun by sand dunes (Table, 17).

After applying the proposed farm planning model (Figs., 15 and 17), the study area was divided again into various farms based on soil, water, and climate factors to select crop and fruit tree varieties. In the study region, 136 acres of moderately productive lands for saline agriculture and forages were chosen for construction and structures. Some lands in the area are less productive than others. Approximately 300 meters width of buffer zone has been established for the entrance road east of Al-Owainat-El-Dakhla, spanning the entire research area. This 165-acre zone has been detached from surrounding farmlands, independent of soil productivity. Protection fences and windbreaks were created to protect the fruit farm from nearby active sand dunes. Main and subinterval paths were planned to provide easy access to all farms in the research area. All farm areas in the research region were adjusted after removing the road reserve and construction zone.

When combined with soil analysis data, land use potentiality can guide crop and technique selection. The beneficiary's intentions determine the crops to be introduced in the plots. The project's technical staff should provide proposals to improve environmental and farmer economic outcomes. The FUP classifies crops as annuals, perennials, tubers, and trees. These can be referred to as "various vegetables", "fruit trees", or "3-year rotations" since details will be determined annually. Aggressive planning can lead to a task beyond the beneficiary's capacity. To prevent issues, project staff and heirs should have accurate knowledge of crops, including planting and harvest seasons, crop management techniques, yields, labor requirements, and material requirements. A frequently updated database of unit costs and suppliers for various commodities is necessary.

Digitalizing and integrating agricultural information into the GIS is necessary for integrated planning of the study area. These benefits include georeferencing the farm's location on the base map, enabling geometric analysis and attribute depictions, creating clear thematic images for users, and providing a scientific foundation for watershed management parties.

CONCLUSION

This work established a land use planning system in El-Dakhla Oasis, which uses detailed soil survey, groundwater characterization, and climate criteria to aid decision-makers in evaluating different land-use planning options. The system meets the concept of planning land use planning and supports farm-level planning. The decision-maker can analyze the planning environment, quantify expectations, possibilities, and restrictions, create plans, and assess their feasibility during the process. Computerized analysis is used in each phase, allowing decision-makers to actively participate and influence the process when necessary. Accordingly, a soil map, a potentiality map, a crop map, and a farm planning map were generated for the study area to land use planning at the farm level. These maps enable the individual to prioritize various aims. Many of the fundamental concepts of primary processes in agricultural production systems are articulated in complementary models. The integrated models integrate data from several sources and disciplines into management choices. They also offer a reasonable framework for data collecting, focusing on elements significantly impacting system behavior.

GIS concepts organize and analyze geographical data alongside thematic data and display conclusions in a controllable, contagious, and intelligible fashion. GIS technology is used to solve complex problems with many objectives that were previously difficult to handle.

After the study area was subjected to the proposed model for farm planning, it was divided into multiple farms based on the soil, water, and climate measures for recommending crop and fruit tree types. Within the study area, 136 acres of moderately potential lands designated for saline agriculture and fodder have been taken for structures and construction areas. These lands are considered less productive than the other lands in the area. A buffer zone, stretching the entire length of the study area and spanning at least 300 meters, has been set aside for the entrance road east of Al-Owainat-El-Dakhla. This zone spans 165 acres and has been removed from the nearby farmlands, regardless of whether they are situated on highly or moderately productive soils. In addition, protective fences and windbreaks have been built along the fruit farm to shield it from neighboring active sand dunes, and main and subinterval pathways have been planned to facilitate easy access to all farms within the research area. All of the study area's current farm areas have been altered after the areas designated for the road reserve and construction zone were subtracted.

Improving economic efficiency should go hand in hand with safeguarding the ecology of the intended farm, which may require aid from institutions on the farm level. This condition should occur simultaneously. Concerning the environmental problems, it is recommended to incorporate new ecological program protections from the agricultural policy into appropriate land use planning. These plans should include safeguards for the environment, the ground, and the water. It is feasible that the choice model presented in this study can be used for the soils in New Valley and other locations of the world that are comparable to New Valley soils in this regard.

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نموذج لدعم القرار من أجل تخطيط إستخدام الأراضي على مستوى المزرعة في واحة الداخلة، محافظة الوادي الجديد، جنوب مصر

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الملخص العربى

تهدف هذه الدراسة إلى إنشاء نموذج دعم القرار على مستوى المزرعة بإستخدام خصائص التربة ومياه الري والخصائص المُناخية للمساعدة في إتخاذ القرارات السليمة للتنمية المُستدامة بنطاق واحة الداخلة، محافظة الوادي الجديد بالصحراء الغربية، مصر. تقع منطقة الدراسة غرب محور الداخلة – شرق العوينات ، جنوب واحة الداخلة. تم إجراء حصر تصنيفي تفصيلي Detailed soil survey لمساحة 1750 إيكر acre (≈ 1686,2 فداناً) جنوب واحة الداخلة. تم تمييز عدد اثنين فقط من الأشكال الأرضية الأساسية بمنطقة الدراسة، وهما الكثبان الرملية Sand dunes ، والسهل الرملي Sandy plain. وعلاوة على ذلك، تم إستبعاد 410 إيكر والتي تحتوي على كثبان رملية والتي توجد في جنوب غرب منطقة الدراسة. ومن ناحية أخرى، تم اختيار السهل الرملي لإجراء الدراسة والذي يغطي مساحة تصل إلى 1340 إيكر حيث يتميز بسطح شبه مستوي، مما يجعله مكان مثالي لتصميم وتخطيط المزارع. تم تجميع حوالي 303 عينة تربة ممثلة من طبقات وآفاق مختلفة لـ 102 قطاع تربة متوزعة على هيئة شبكة soil grid في السهل الرملي، تحقيقاً للحصر التصنيفي التفصيلي. تم دراسة الخصائص الفيزيائية والكيميائية للتربة بإستخدام التحليل الإحصائي. مع العلم بأن المصدر الوحيد لمياه الري في واحة الداخلة هو المياه الجوفية. تم أخذ ثلاثة عينات من مياه الآبار عبر منطقة الدراسة. وفقًا للدراسة الإحصائية لبيانات التربة، تباينت التربة بشكل كبير كونها غير جيرية إلى شديدة الجيرية ، مع تفاوت قوام التربة ما بين الخشن والمتوسط والناعم. كما أوضحت الدراسة بأن التربة غير ملحية إلى متوسطة الملوحة. حيث اتسمت كافة قطاعات التربة المدروسة بأنها عميقة (125-160 سم). تم إكتشاف مستويات تصل إلى حد السمية من الحديد Fe^{2+} والمنجنيز Mn^{2+} سواء في عينات التربة والتي تؤدي في بعض الاحيان الى موت البادرات، أو في عينات المياه والتي يصعب معها الشرب سواء للانسان او للحيوان. وبناءً على نسبة الجبس ، تعتبر التربة تحت الدراسة غير جبسية او خفيفة التأثر بالجبس. كما تم تحديد أربع أنواع تربة Soil mapping units على مساحة 1340 إيكر لمنطقة الدراسة بناءً على نتائج خصائص التربة، بالإضافة إلى انه تم إكتشاف الكثبان الرملية التي تغطي مساحة 410 إيكر في الجزء الجنوب الغربي لمنطقة الدراسة في حالة نشطة. أوضحت نتائج الدراسة، على الرغم من أن عينات المياه الجوفية تحتوي على مستويات عالية من الحديد والمنجنيز ، إلا أن جودتها مناسبة للاستخدام الزراعي ولكن تحت إدارة مُستدامة. تم استخدام خصائص التربة والماء لتحديد درجة إنتاجية الأراضي تحت الدراسة Land Potentiality ، حيث تم تصنيفها على أنها عالية الإنتاجية High potential (700 إيكر) ، ومتوسطة الانتاجية Moderate potential (640 إيكر). وبإستخدام نموذج تقييم الأراضي للمحاصيل المختلفة، يمكن زراعة محاصيل مختلفة اعتمادًا على بيانات التربة والماء والمناخ. وطبقاً لكل نوع من التربة، فقد أوصت الدراسة بالتراكيب متحملة الملوحة تحت نظام الزراعة الملحية على مساحة 275 إيكر، والخضروات (345 إيكر) ، وأشجار الفاكهة (355 إيكر) ، والعلف (365 إيكر). تم إبتكار في هذه الدراسة آداة لاتخاذ القرار من أجل التخطيط المناسب لأراضي منطقة الدراسة على مستوى المزرعة، والتي يمكن أن يتم تطبيق هذا النموذج لكافة أراضي واحة الداخلة. وبتطبيق النموذج المقترح على منطقة الدراسة؛ فقد تم إعادة تقسيم منطقة الدراسة إلى عدة مزارع طبقاً لنوع المحصول أو اشجار الفاكهة المُقترحة ، مع تخصيص جزء من الأراضي الاقل إنتاجية كالمتوسطة الإنتاجية بمنطقة الدراسة للانشاءات والمباني الملحقة للمزارع على مساحة تصل 136 إيكر والتي تم إستقطاعها من الأراضي متوسطة الإنتاجية والمخصصة للزراعة الملحية والاعلاف، مع ترك حرم لطريق الداخلة – شرق العوينات بعرض لا يقل عن 300 متر بطول منطقة الدراسة على مساحة 165 إيكر والتي تم إستقطاعها من مساحات المزارع الملاصقة سواء المقامة على الاراضي متوسطة أو عالية الإنتاجية، علاوة على أنه تم تصميم ممرات داخلية

رئيسية وأخرى فرعية للوصول إلى كافة مزارع منطقة الدراسة بسهولة، بالاضافة إلى إنشاء سياج حماية ومصدات للرياح على طول مزرعة الفاكهة لحمايتها من الكثبان الرملية النشطة المجاورة. بجانب ذلك، فلابد من اتخاذ خطوات لجعل إقتصاد المزرعة أكثر كفاءة، حيث لابد من إتخاذ الإجراءات البيئية في الاعتبار اثناء تخطيط المزرعة، والتي قد تتطلب الدعم المؤسسي على مستوى المزرعة. أما بالنسبة للمشاكل البيئية، فسيكون الأفضل دمج برامج بيئية جديدة من السياسة الزراعية مع خصائص التربة والمياه والمناخ من أجل تخطيط جيد لاستخدام الأراضي وتقسيمها إلى مزارع تحت إدارة مُستدامة للتغلب على مشكلات التربة، جودة مياه الري، التغير المناخي. يمكن تطبيق نموذج القرار المقترح في هذه الدراسة من أجل تخطيط المزرعة على باقي أراضي الوادي الجديد والأراضي المماثلة حول العالم.