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## Optimizing Agricultural Land Evaluation of Some Areas in the New Delta Region, Al-Dabaa Corridor, Egypt

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THE CONTINUOUSLY rising demand for food production has emphasized the importance of efficient land evaluation systems in agriculture. This research study aimed to estimate crop suitability and land capability of some new reclamation areas along El-Dabaa axis in the north-western desert of Egypt, which will participate in the planning of prospective projects aimed at reclaiming desert land in the area. In order to represent different geomorphic units in the area under investigation, 115 soil profiles were dug. Subsequent laboratory analyses were conducted to determine the physicochemical parameters of the examined soils. Using ALESarid-GIS software, land capability evaluation was accomplished and land suitability was performed for 12 crops. The results revealed that the high capability class C3 (Fair) occupied 45.84% of the investigated area, while the moderate capability C4 (Poor) occupied approximately 34.2%. The results of the land suitability analysis illustrated that 16.7% and 8.98% of the studied area were categorized as S1 (highly suitable) for wheat and olive, respectively. It was detected that 63% of the examined area was S2 (moderately suitable) for wheat, more than 50% for olive, bear, and alfalfa, more than 26% for barley, sugar beet, tomato, and onion. Furthermore, the examined area was S3 (marginally suitable) for onion (53.44%), sugar beet (47.23%), soybean and barley (42%), tomato and sorghum (38%), maize, potato, pear, and alfalfa (more than 28%). However, it was observed that sand texture, shortage of available water, high soil permeability, and lack of available nutrients were the key limiting parameters for land capability and crop cultivation. Hence, soil suitability modelling for various crops and mapping of land capability can help decision-makers plan for potential agricultural development and outcome desert land reclamation projects in Egypt.

**Keywords**: Land capability; Crop suitability; ALESarid-GIS; Egypt.

### 1. Introduction

The requirement for efficient systems to assess land suitability for agriculture has emerged due to the growing population and higher food production demands. Land evaluation involves gauging if the land is appropriate for different agricultural tasks, considering its physical, biological, and socio-economic attributes. This evaluation is indispensable for sustainable agriculture, land-use planning, and environmental conservation. Agricultural land evaluation is crucial for adept land management, particularly in farming, as it helps determine the best practices and land uses for a specific area. Nonetheless, conventional evaluation techniques are slow, costly, and frequently lack scientific precision. The development of a new agricultural region via desert reclamation requires determining the most advantageous agricultural use for the newly acquired land, based on the principle of land evaluation (Dent and Young 1981). It provides a basis for sustainable land use planning and a tool for strategic decision-making. During the process of land evaluation, the land use planner conducts a comprehensive assessment of the land's features and then compares them to the prerequisites of the desired land utilization. The degree of compatibility between the land mapping unit and the requirements of the land use is described by land suitability in a more practical context(FAO 1976). While land suitability is an essential requirement for sustainable management and agricultural output, numerous land evaluation models have been created with the aim of offering a measurable approach to linking a land mapping unit with different suggested soil purposes, including; the LECS "Land Evaluation Computer System" (Wood and Dent 1983), LEV-CET "Land

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Evaluation procedure for middle of Ethiopia" (Yizengaw and Verheye 1995), MicroLEIS System (De la Rosa, Moreno et al. 1992), ALES "the Automated Land Evaluation System" (Rossiter 1990; Rossiter and Van Wambeke 1997), LEIGIS "The Land Evaluation Using an Intelligent GIS" (Kalogirou 2002), LUSET "land use suitability evaluation tool", a computer-based program (Yen, Pheng et al. 2006). However, it must be noted that the lack of a universally accepted and standardized land evaluation model that can be automatically applied to all circumstances, because the biophysical conditions exhibit variations across different geographical regions globally (Rossiter 1996; Rossiter 2003). The land use planner is required to ensure that there is congruence between the framework of the model and the region under investigation. Therefore, it is crucial to note that each of the aforementioned systems presents its unique limitations with regard to evaluating land suitability. For example, LECS is constrained by its simplicity and its specific development for Sumatra, Indonesia. On the other hand, LEIGIS lacks climatic factors and is restricted to just five crops (Nwer 2006). MicroLEIS, however, exhibits a limitation in that it has been specifically designed for the Mediterranean region's lands alone. Consequently, it is imperative to employ it exclusively inside its original calibration zone, as the extrapolation to other scenarios lacks calibration (De la Rosa, Moreno et al. 1992; Aldabaa, Zhang et al. 2010; Wahab, El-Semary et al. 2013; Yousif 2019). The Land Use Suitability Evaluation Tool (LUSET) is a utility for assessing land suitability for many crops using specific crop requirements, including climate, land, and water conditions, consequently many research studies have utilized the (LUSET) model to determine crop suitability in arid and semiarid regions such as (Aldabaa and Khralifa 2016; Yousif 2017; Yousif 2018; Yousif and Ahmed 2019; Yousif, Hassanein et al. 2020). While the ALES system grants land evaluators the ability to construct customized expert systems, its predictions for land suitability are confined to principal crops within tropical areas exclusively (Rossiter 1990; Rossiter and Van Wambeke 1997). The scope of ALESarid-GIS is restricted exclusively to provinces characterized by arid and semi-arid conditions (Abd EL-Kawy, Ismail et al. 2010). Ismail et al., (Ismail, Bahnassy et al. 2005) created ALES-arid to estimate land suitability for agricultural use in arid and semi-arid zones. ALES-arid is directly connected to its associative database and indirectly associated with a GIS using the dual approach. ALESarid-GIS is the upgraded edition of ALES-Arid, designed to evaluate agricultural crop suitability and land capability within the context of a GIS environment (Abd EL-Kawy, Ismail et al. 2010). Through this methodology, ArcGIS v.9.3 and ALES-arid are utilized in a familiar GIS user interface and ALES-arid code is inserted in the GIS. The ALESarid-GIS version was adapted in order to compute the indices for land capability and crop suitability such as (field crops, forage crops, vegetables, and fruit trees). The evaluation is relies on crop suitability influenced by the soil physical, chemical, and fertility properties, quality of irrigation water, and meteorological conditions. The latter environmental factors are used for assessing the inherent soil-based qualities of land in terms of their correlation with agricultural suitability. ALESarid-GIS model offers a practical solution that effectively balances precision, ease of implementation, and a moderate data requirement. As a result, it has been favored for assessing land capability and soil suitability for particular crop cultivation in various investigations, for example (Wahab, El-Semary et al. 2013; Darwish and Kawy 2014; Abd EL-Kawy, Osama et al. 2019; Alharbi and Aggag 2020; Amira, Shalaby et al. 2020; El-Hassanin, Abd El Hady et al. 2020; Mahmoud, Binmiskeen et al. 2020; Elnashar, Abbas et al. 2021; Rashed 2021; Alnaimy, Shahin et al. 2022; Nada, Bahnassy et al. 2022; Salama 2023). The primary objectives of this study encompass: 1) Establishing a spatial soil database for one of the new reclamation areas along El-Dabaa axis in the northwestern desert of Egypt. 2) Evaluating its potential for reclamation through an assessment of the crop suitability for cultivating various crops and land capability, which will contribute to the planning of prospective projects aimed at reclaiming desert land in this area

## 2. Materials and Methods

Study area: The area under investigation is situated in the northwestern part of Egypt, Matrouh region between latitudes 29° 45′ to 30° 10′ N and longitudes 29° 50′ to 29° 59′ E (Figure 1). The investigated area covers an area of 35695.18 hectares (356.95 $km^2$). An arid and semi-arid is distinguished climate in the investigated area, where the mean temperature fluctuated between 12.58 °C in January and 28.14 °C in August. The annual rainfall fluctuates between 1.78 mm in April and 28.46 mm in December. The maximum and minimum values of relative humidity were recorded in December (64.84 %) and May (39.72 %). While, the wind speed ranges between 2.18 $ms^{-1}$ in November and 4.06 $ms^{-1}$

in January and March. Moreover, evapotranspiration (Eto) fluctuates between 10.56 mm $day^{-1}$ in December and 25.95 $day^{-1}$ in July.

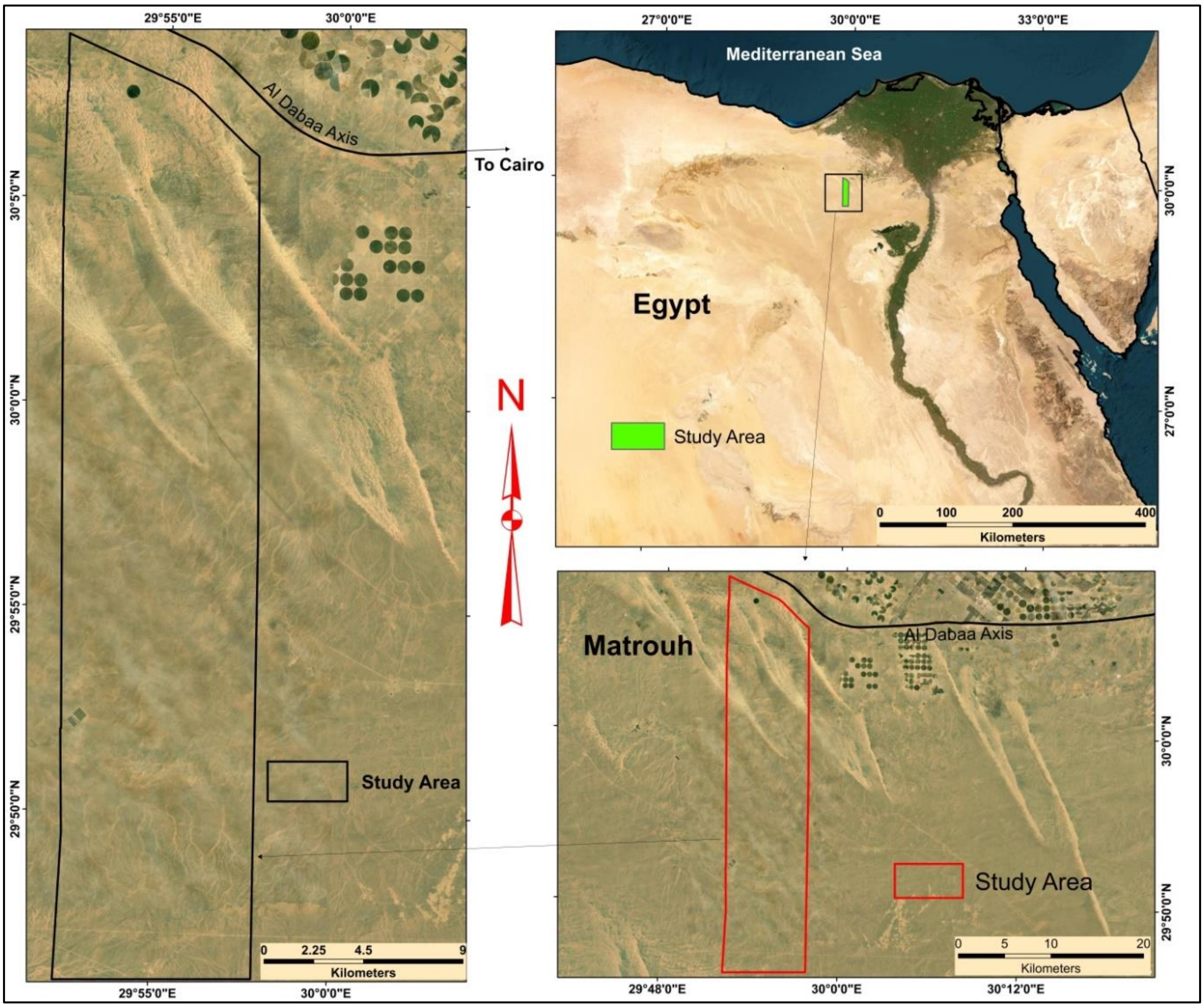


**Fig. 1. The geographical location of the area under investigation .**

Topographical analysis (Figure 2) illustrated that the elevation of the investigated area ranged between 49 and 282 m ASL (Figure 2-A). The northern portion of the study region is distinguished by a moderate to steep slope, whereas the southern portion is characterized by a gentle slope (Figure 2-B, 2-C and 2-D). The northern portion of the investigated area is traversed by sand dunes (Figure 1).

**Remote Sensing work:** Remote sensing data were utilized to establish a connection between the extracted geomorphological units and the soil capability of the examined area. Simultaneously, the Sentinel 2 image, with a spatial resolution of 10 m for the visible bands (blue, green, red) and the near-infrared band (20 m) was procured on 1 January 2020. Sentinel 2 image, DEM with 30 meter resolution, and field surveys were incorporated to improve the visibility of the geomorphological map generated using the approach produced by (Dobos, Norman et al. 2002). This was dependent on the utilization of topographical details, including the slope, curvature, aspect, and relief intensity of the investigated area, which were generated from the DEM data using SAGA GIS software (Olaya and Conrad 2009). As a result, 11 distinct geomorphological units were derived to represent the different landforms. Each of these landforms was confirmed through field GPS surveys. Subsequently, the resulting landform map used as a base map, where every geomorphic unit displayed homogeneous inherent characteristics. This map was subsequently employed for spatial analyses of soil characteristics, as discussed in (Sys, Van Ranst et al. 1991).

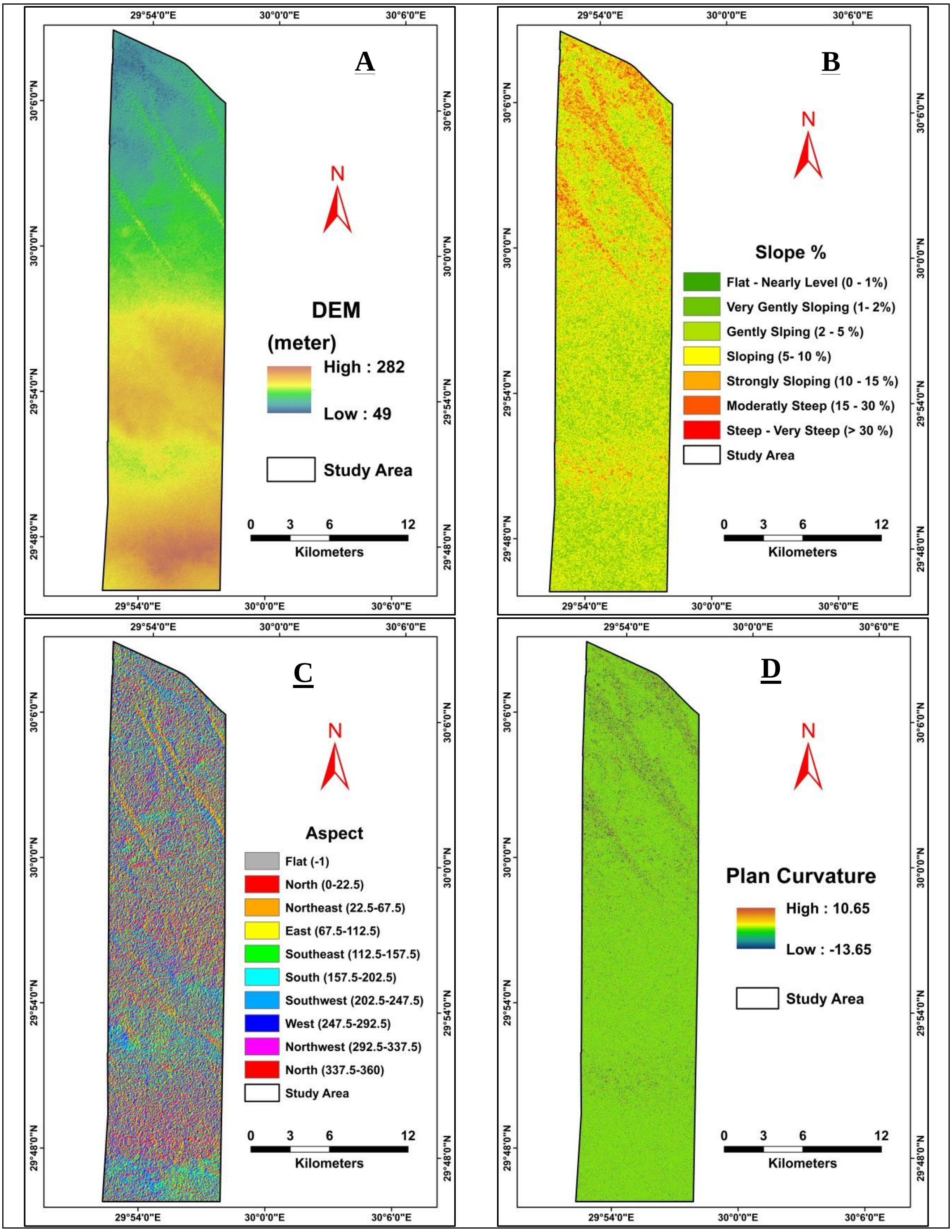


**Fig. 2. Topographical analysis of the studied area, digital elevation model (A), slope gradient (B), aspect (C) and plan curvature (D).**

**Field and Laboratory work:** 115 soil profiles were excavated to accurately represent geomorphic units of the examined area (Figure 1). Morphological soil profile description were performed in the field (FAO 2006). In total, 344 soil samples were collected to represent all the soil profiles layers and prepared for laboratory work. Then, the physiochemical properties of soil were analyzed according to with USDA protocols (USDA 2022). Soils of the investigated area were classified according to the key to soil taxonomy approach (Staff 2022).

**Crop Suitability Assessment and Land Capability:** In this study, land capability evaluation and crop suitability were executed by employing the ASLEarid-GIS model (Abd EL-Kawy, Ismail et al. 2010). This system was incorporated within the Arc-GIS software package to determine the crop suitability and land capability indices for some crops and provide suitability maps. Tables 1 and 2 demonstrate the ratings employed by ALESarid-GIS for crop suitability evaluation and land capability classes, respectively (Abd EL-Kawy, Ismail et al. 2010). The interpolation GIS method, known as inverse distance weight, was utilized to generate land suitability maps for various crops. Figure 3 illustrates the flowchart of the research methodology that was performed to evaluate the lands in the investigated area.

**Table 1. ALESarid-GIS ratings for land suitability.**

| Definition | Class | Range (%) |
|---|---|---|
| Highly suitable | S1 | 100-80 |
| Moderately suitable | S2 | 80-60 |
| Marginally suitable | S3 | 60-40 |
| Conditionally suitable | S4 | 40-20 |
| Potentially suitable | NS1 | 20-10 |
| Actually unsuitable | NS2 | < 10 |

**Table 2. ALESarid-GIS ratings for land capability.**

| Definition | Class | Rating (%) |
|---|---|---|
| Excellent | C1 | 100-80 |
| Good | C2 | 80-60 |
| Fair | C3 | 60-40 |
| Poor | C4 | 40-20 |
| Very poor | C5 | 20-10 |
| Non-agriculture | C6 | < 10 |

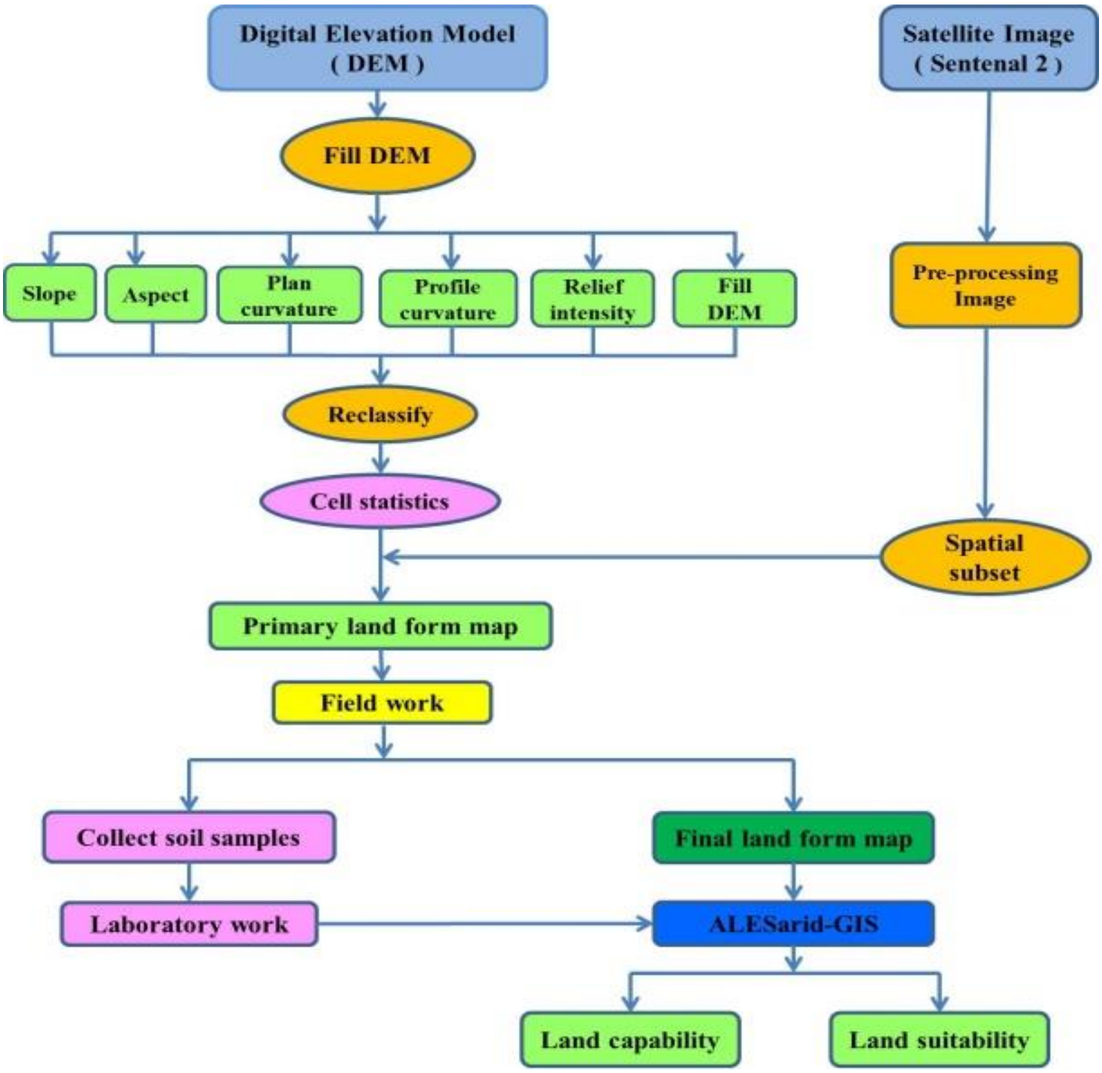


**Fig. 3. Flowchart of the research methodology of the investigated area.**

### 3. Result

Soils of geomorphological units: Eleven distinct geomorphological units were identified within the investigated area and subsequently manipulated through the incorporation of DEM, sentenal2 images, and accurate field data. Figure 4 and Table 3 show the 11 geomorphic units that characterize variabilities in the study area. The investigated area exhibited a topography that can be described as almost flat to gently undulating surface, whereas the presence of sand dunes was observed in the northern portion and some hills were observed in the central and southern parts of the investigated area. Hills, petroleum areas, and sand dunes are recognized as excluded areas, representing 18.76 % of the investigated area.

The subsequent lines discuss the prevailing geomorphic units in the study area.

**Basin:** This unit occupies an area of 3840.16 hectare (10.46 %) and is represented by 14 soil profiles. As shown in Table 4 and Figure 5, the soil depth of this unit was classified as deep soil (120-150 cm). Salinity of soils fluctuates between non-saline and slightly saline soil (0.22 – 2.27 $dSm^{-1}$). The $CaCO_3$ content varies from slightly to moderately calcareous, reaching 2.85%. Soil pH fluctuates from moderately alkaline to alkaline soils (8.17-8.93). The exchangeable sodium percentage (ESP) ranged between 9.34 and 10.32%.

**Table 3. Areas in hectare and $km^2$ of geomorphological units.**

| Landform | No. of soil profiles | Area hectare | Area $km^2$ | % |
|---|---|---|---|---|
| Basin | 14 | 3840.16 | 38.40 | 10.76 |
| Dry wadi | 8 | 763.06 | 7.63 | 2.14 |
| High old river terraces | 18 | 4588.72 | 45.89 | 12.86 |
| Low old river terraces | 13 | 3403.78 | 34.04 | 9.54 |
| Moderate old river terraces | 17 | 4242.28 | 42.42 | 11.88 |
| Pediment | 15 | 3000.94 | 30.01 | 8.41 |
| Pediplain | 15 | 2015.78 | 20.16 | 5.65 |
| Plain | 5 | 3077.46 | 30.77 | 8.62 |
| Sand sheet | 10 | 4066.55 | 40.67 | 11.39 |
| Hills | -- | 1601.74 | 16.02 | 4.49 |
| Petroleum area | -- | 787.89 | 7.88 | 2.21 |
| Sand Dunes | -- | 4306.82 | 43.07 | 12.07 |
| **Total area** | | 35695.18 | 356.95 | 100.00 |

**Dry wadi:** This unit occupies an area of 763.06 hectare (2.14 %), and is represented by 8 soil profiles. The soil depth of this unit was classified as deep soil (130-150 cm). Soil EC varies between non-saline and slightly saline soil (0.54 – 1.92 dSm1). The content of $CaCO_3$ varies from slightly to moderately calcareous where it reached 2.85%. Soil pH fluctuates from moderately alkaline to alkaline soils (8.53-8.77). The ESP ranged between 9.50 and 10.16 %, as presented in Table 4 and Figure 5.

**High old river terraces:** This unit occupies an area of 4588.72 hectare (12.86 %) and is represented by 18 soil profiles. The oil depth of this unit was classified as deep soil (120-150 cm). Soil EC fluctuates between non-saline and slightly saline soil (0.35 – 3.59 $dSm^{-1}$). The content of $CaCO_3$ varies from slightly to moderately calcareous where it reached 2.95 %. Soil pH fluctuates from very weakly alkaline to alkaline soils (7.46-8.94). The ESP ranged between 9.41 and 10.96 %, as illustrated in Table 4 and Figure 4.

**Low old river terraces:** This unit is represented by 13 soil profiles and occupies an area of 3403.78 (9.54 %). The soil depth of this unit was classified as deep soil (120-150 cm). Soil EC fluctuates between non-saline and slightly saline soil (0.15 – 2.97 $dSm^{-1}$). The content of $CaCO_3$ varies from slightly to moderately calcareous where it reached 4.54 %. Soil pH fluctuates from moderately alkaline to alkaline soils (8.41-8.81). The ESP ranged between 9.31 and 10.66 % (Table 4 and Figure 5).

**Moderate old river terraces:** This unit is represented by 17 soil profiles and occupies an area of 4242.28 (11.88 %). The soil depth of this unit was classified as deep soil (120-150 cm). Soil EC fluctuates between non-saline and moderately saline soils (0.17 – 4.26 $dSm^{-1}$). The content of $CaCO_3$ varies from slightly to moderately calcareous where it reached 3.95 %. Soil pH fluctuates from very weakly alkaline to alkaline soils (7.22-8.93). The ESP ranged between 9.32 and 11.28 %, as shown in Table 4 and Figure 5.

**Pediment**: This unit is represented by 15 soil profiles and occupies an area of 3000.94 (8.81 %). The soil depth of this unit was classified as deep soil (120-150 cm), as illustrated in Table 4 and Figure 5. Salinity of soils fluctuates between non-saline and slightly saline soils (0.20 – 3.68 $dSm^{-1}$). The content of CaCO3 varies from slightly to moderately calcareous where it reached 4.59 %. Soil pH fluctuates from weakly alkaline to alkaline soils (7.93-8.87). ESP ranged between 9.34 and 11 %.

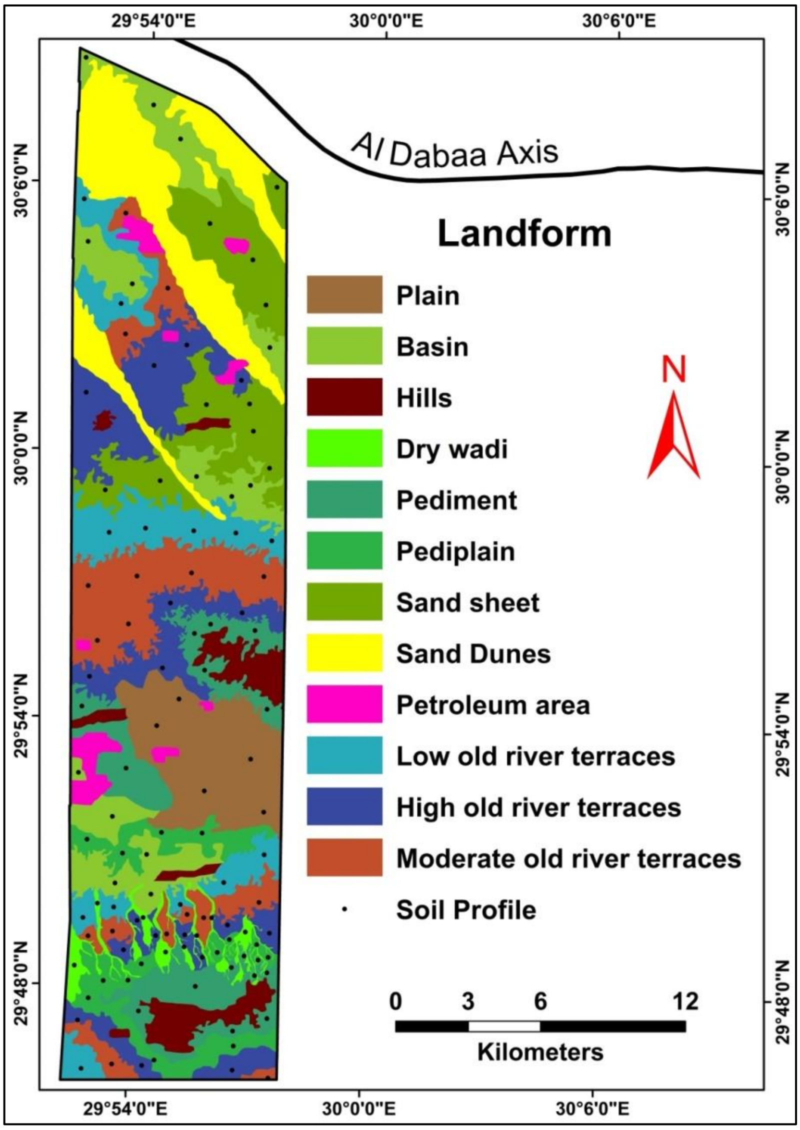


**Fig. 4. Geomorphological map of the investigated area.**

**Pediplain**: This unit is represented by 15 soil profiles and occupies an area of 2015.78 (5.65 %). The soil depth of this unit was classified as deep soil (120-150 cm). Soil salinity fluctuates from non-saline soil to strongly saline soil (0.20 – 8.10 $dSm^{-1}$). The content of CaCO3 varies from slightly to moderately calcareous where it reached 4.05 %. Soil pH fluctuates from weakly alkaline to alkaline soils (7.83-8.93). ESP ranged between 9.24 and 23.41%, as presented in Table 4 and Figure 5.

Plain: This unit occupies an area of 3077.46 (8.62 %) and is represented by five soil profiles. The soil depth of this unit was classified as deep soil (120-150 cm). Soil salinity fluctuates between non-saline and moderately saline soils (0.92 – 5.64 $dSm^{-1}$). The content of CaCO3 varies from non to slightly calcareous where it reached 1.75 %, as explained in Table 4 and Figure 5. Soil pH fluctuates from moderately alkaline to alkaline soils (8.41-8.71). ESP ranged between 9.68 and 11.93 %.

**Sand sheet:** This unit occupies an area of 4066.55 (11.39 %) and is represented by ten soil profiles. Soil depth of this unit is moderately deep and deep which varies between 90 and 150 cm. Soil salinity varies from non-saline soil to moderately saline soil (0.13 – 7.30 $dSm^{-1}$). The content of CaCO3 varies from slightly to moderately calcareous where it reached 3.36 %. Soil pH fluctuates from weakly alkaline to alkaline soils (7.92 - 8.91). ESP ranged between 9.30 and 23.58 % (Table 4 and Figure 5).

**Table 4. Descriptive statistics of some soil properties in Sand sheet unit.**

| Unit | Statistic | Depth cm | EC dSm-1 | pH | CaCO3 % | SAR % | ESP % | Texture VCS % | CS % | MS % | FS % | VFS % | Si&C % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| basin | Min. | 120 | 0.22 | 8.17 | 0 | 7.18 | 9.34 | 5.79 | 9.29 | 21.03 | 1.37 | 0.34 | 0.18 |
| | Max. | 150 | 2.27 | 8.93 | 2.85 | 8.13 | 10.32 | 30.16 | 37.28 | 62.87 | 41.22 | 11.69 | 3.87 |
| | Mean | 143.93 | 0.85 | 8.62 | 0.75 | 7.47 | 9.64 | 13.32 | 18.91 | 46.51 | 15.42 | 4.65 | 1.2 |
| | S. D. | 10.77 | 0.63 | 0.17 | 0.85 | 0.29 | 0.3 | 7.33 | 8.14 | 13.83 | 9.57 | 3.59 | 1.17 |
| | Var. | 116.07 | 0.4 | 0.03 | 0.72 | 0.09 | 0.09 | 53.75 | 66.19 | 191.24 | 91.59 | 12.91 | 1.36 |
| | CV | 7.49 | 74.44 | 1.94 | 113.1 | 3.92 | 3.12 | 55.06 | 43.03 | 29.74 | 62.07 | 77.29 | 97.01 |
| Dry wadi | Min. | 130 | 0.54 | 8.53 | 1.95 | 7.33 | 9.5 | 0.35 | 6.98 | 9.02 | 2.35 | 1.15 | 0.23 |
| | Max. | 150 | 1.92 | 8.77 | 4.73 | 7.97 | 10.16 | 23.38 | 41.83 | 83.33 | 31.46 | 17.89 | 3.27 |
| | Mean | 147.5 | 1.15 | 8.59 | 2.48 | 7.61 | 9.79 | 14.06 | 20.08 | 44.19 | 15.9 | 4.88 | 0.9 |
| | S. D. | 7.07 | 0.66 | 0.1 | 0.97 | 0.31 | 0.32 | 8.93 | 10.89 | 23.71 | 10.72 | 5.64 | 1.03 |
| | Var. | 50 | 0.44 | 0.01 | 0.94 | 0.09 | 0.1 | 79.7 | 118.69 | 562.07 | 114.94 | 31.84 | 1.07 |
| | CV | 4.79 | 57.38 | 1.11 | 39.21 | 4.03 | 3.23 | 63.49 | 54.27 | 53.65 | 67.44 | 115.63 | 115.3 |
| High old river terraces | Min. | 120 | 0.35 | 7.46 | 0 | 7.24 | 9.41 | 0.35 | 3.43 | 0.89 | 3.86 | 0.7 | 0 |
| | Max. | 150 | 3.59 | 8.94 | 2.95 | 8.74 | 10.96 | 25.59 | 41.83 | 71.47 | 65.36 | 37 | 3.27 |
| | Mean | 135.56 | 1.9 | 8.5 | 1.34 | 7.96 | 10.15 | 13.86 | 20.32 | 39.98 | 19.46 | 5.55 | 0.83 |
| | S. D. | 15.04 | 0.79 | 0.31 | 1.01 | 0.37 | 0.38 | 6.72 | 10.59 | 18.5 | 17.03 | 8.34 | 0.91 |
| | Var. | 226.14 | 0.63 | 0.1 | 1.02 | 0.13 | 0.14 | 45.16 | 112.23 | 342.25 | 290.18 | 69.49 | 0.83 |
| | CV | 11.09 | 41.68 | 3.63 | 75.08 | 4.61 | 3.72 | 48.47 | 52.14 | 46.27 | 87.53 | 150.11 | 110.72 |
| Low old river terraces | Min. | 120 | 0.15 | 8.41 | 0 | 7.15 | 9.31 | 3.21 | 9.54 | 21.92 | 5.84 | 0.93 | 0.02 |
| | Max. | 150 | 2.97 | 8.81 | 4.54 | 8.45 | 10.66 | 26.7 | 30.21 | 57.62 | 27.24 | 13.76 | 3.66 |
| | Mean | 147.69 | 1.15 | 8.64 | 1.25 | 7.61 | 9.79 | 15.85 | 20.91 | 43.28 | 13.98 | 5.27 | 0.72 |
| | S. D. | 8.32 | 0.91 | 0.11 | 1.27 | 0.42 | 0.43 | 7.73 | 6.36 | 10.31 | 5.61 | 4.6 | 0.99 |
| | Var. | 69.23 | 0.82 | 0.01 | 1.62 | 0.18 | 0.19 | 59.71 | 40.4 | 106.31 | 31.48 | 21.19 | 0.97 |
| | CV | 5.63 | 79.04 | 1.26 | 101.94 | 5.54 | 4.43 | 48.76 | 30.4 | 23.82 | 40.15 | 87.34 | 137.77 |
| Moderate old River terraces | Min. | 120 | 0.17 | 7.22 | 0 | 7.16 | 9.32 | 1.35 | 7.58 | 23.59 | 0.01 | 0.25 | 0 |
| | Max. | 150 | 4.26 | 8.94 | 3.95 | 9.06 | 11.28 | 24.81 | 41.84 | 66.2 | 30.6 | 16.92 | 4.68 |
| | Mean | 134.71 | 1.39 | 8.55 | 1.1 | 7.72 | 9.9 | 14.44 | 19.26 | 44.52 | 15.46 | 5.29 | 1.02 |
| | S. D. | 15.05 | 1.15 | 0.37 | 1.27 | 0.54 | 0.55 | 6.21 | 8.09 | 11.67 | 9.23 | 4.93 | 1.13 |
| | Var. | 226.47 | 1.33 | 0.14 | 1.6 | 0.29 | 0.3 | 38.59 | 65.37 | 136.24 | 85.11 | 24.32 | 1.28 |
| | CV | 11.17 | 83.26 | 4.38 | 115.53 | 6.93 | 5.57 | 43.01 | 41.98 | 26.22 | 59.69 | 93.18 | 110.26 |
| Pediment | Min. | 120 | 0.2 | 7.93 | 0.13 | 7.17 | 9.34 | 2.06 | 1.63 | 12 | 2.19 | 0.61 | 0.09 |
| | Max. | 150 | 3.68 | 8.87 | 4.73 | 8.79 | 11 | 43.35 | 60.7 | 84.99 | 19.25 | 11.95 | 2.98 |
| | Mean | 144 | 1.8 | 8.55 | 1.28 | 7.91 | 10.1 | 17.22 | 27.24 | 38.57 | 11.56 | 4.63 | 0.78 |
| | S. D. | 12.42 | 1.17 | 0.25 | 1.49 | 0.54 | 0.56 | 10.89 | 15.38 | 20.03 | 5.61 | 3.36 | 0.91 |
| | Var. | 154.29 | 1.36 | 0.06 | 2.21 | 0.29 | 0.31 | 118.61 | 236.66 | 401.22 | 31.51 | 11.26 | 0.82 |
| | CV | 8.63 | 64.98 | 2.89 | 115.97 | 6.85 | 5.52 | 63.26 | 56.48 | 51.93 | 48.55 | 72.42 | 116.69 |
| Pediplain | Min. | 120 | 0.2 | 7.83 | 0 | 7.17 | 9.24 | 5.61 | 10.45 | 7.52 | 3.51 | 0.94 | 0.14 |
| | Max. | 150 | 8.1 | 8.93 | 4.05 | 20.84 | 23.41 | 26.56 | 40.83 | 61.21 | 31.82 | 23.08 | 5.16 |
| | Mean | 139.67 | 2.04 | 8.5 | 1.36 | 8.66 | 10.86 | 13.56 | 19.13 | 41.19 | 17.78 | 7.19 | 1.15 |
| | S. D. | 13.43 | 1.93 | 0.31 | 1.11 | 3.4 | 3.51 | 5.37 | 7.48 | 15.13 | 7.46 | 6.27 | 1.4 |
| | Var. | 180.24 | 3.73 | 0.1 | 1.23 | 11.57 | 12.31 | 28.79 | 55.97 | 228.84 | 55.59 | 39.37 | 1.95 |
| | CV | 9.61 | 94.83 | 3.67 | 81.24 | 39.3 | 32.31 | 39.57 | 39.1 | 36.73 | 41.94 | 87.26 | 121.61 |
| Plain | Min. | 120 | 0.92 | 8.41 | 0 | 7.5 | 9.68 | 10.71 | 14.76 | 1.76 | 8.02 | 0.51 | 0.09 |
| | Max. | 150 | 5.64 | 8.71 | 1.75 | 9.69 | 11.93 | 20.28 | 32.91 | 49.39 | 65.19 | 9.44 | 1.69 |
| | Mean | 133 | 2.71 | 8.58 | 0.58 | 8.33 | 10.53 | 14.9 | 22.14 | 33.2 | 24.68 | 4.28 | 0.8 |
| | S. D. | 15.65 | 1.75 | 0.13 | 0.74 | 0.81 | 0.84 | 4.48 | 7.11 | 18.62 | 24.03 | 3.47 | 0.66 |
| | Var. | 245 | 3.07 | 0.02 | 0.54 | 0.66 | 0.7 | 20.03 | 50.53 | 346.73 | 577.21 | 12.01 | 0.44 |
| | CV | 11.77 | 64.72 | 1.55 | 126.16 | 9.76 | 7.95 | 30.04 | 32.11 | 56.08 | 97.34 | 80.92 | 83.18 |
| Sand sheet | Min. | 90 | 0.13 | 7.92 | 0 | 7.14 | 9.3 | 2.35 | 10.04 | 30.1 | 7.49 | 0.72 | 0.12 |
| | Max. | 150 | 7.3 | 8.91 | 3.36 | 21 | 23.58 | 27.01 | 33.16 | 65.99 | 19.6 | 9.94 | 4.23 |
| | Mean | 141 | 1.07 | 8.58 | 0.51 | 8.63 | 10.83 | 12.38 | 19.06 | 50.55 | 12.99 | 3.58 | 1.44 |
| | S. D. | 20.25 | 2.2 | 0.29 | 1.02 | 4.35 | 4.48 | 6.75 | 8.08 | 11.11 | 4.16 | 2.91 | 1.54 |
| | Var. | 410 | 4.84 | 0.08 | 1.04 | 18.91 | 20.06 | 45.56 | 65.25 | 123.34 | 17.29 | 8.47 | 2.38 |
| | CV | 14.36 | 206.47 | 3.33 | 200.9 | 50.41 | 41.34 | 54.52 | 42.38 | 21.97 | 32.02 | 81.37 | 106.94 |

Min.: Minimum; Max.: Maximum; S. D.: Standard Deviation; Var.: variance; Skew. Skewness; Kurt.: Kurtosis; CV: Coefficient of Variance; SAR: Sodium Adsorption Ratio; ESP: Exchangeable Sodium Percent; VCS: Very Coarse Sand; CS: Coarse Sand; MS: Medium Sand; FS: Fine Sand; VFS: Very Fine Sand; Si : Silt; C: Clay.

**Soil Characterization and Mapping**

According to the geographical distribution pattern of soil salinity (Figure 5-A), "non to slightly saline soils" (EC<4 dS/m$^{-1}$) are present in approximately 98% of the research area. As illustrated in Figure 5-C, about 84 % of the investigated soils are strongly alkaline (pH > 8.5), while 16 % are slightly alkaline soils (pH < 8.5). The spatial distribution of soil calcium carbonate (Figure 5-D) revealed that 91% of the investigated soils are slightly calcareous (CaCO3 < 2), while 9 % are moderately calcareous soils (CaCO3 > 2). As demonstrated in Figure 5-E, about 99 % of the studied soils are deep soils (effective soil depth > 100 cm).

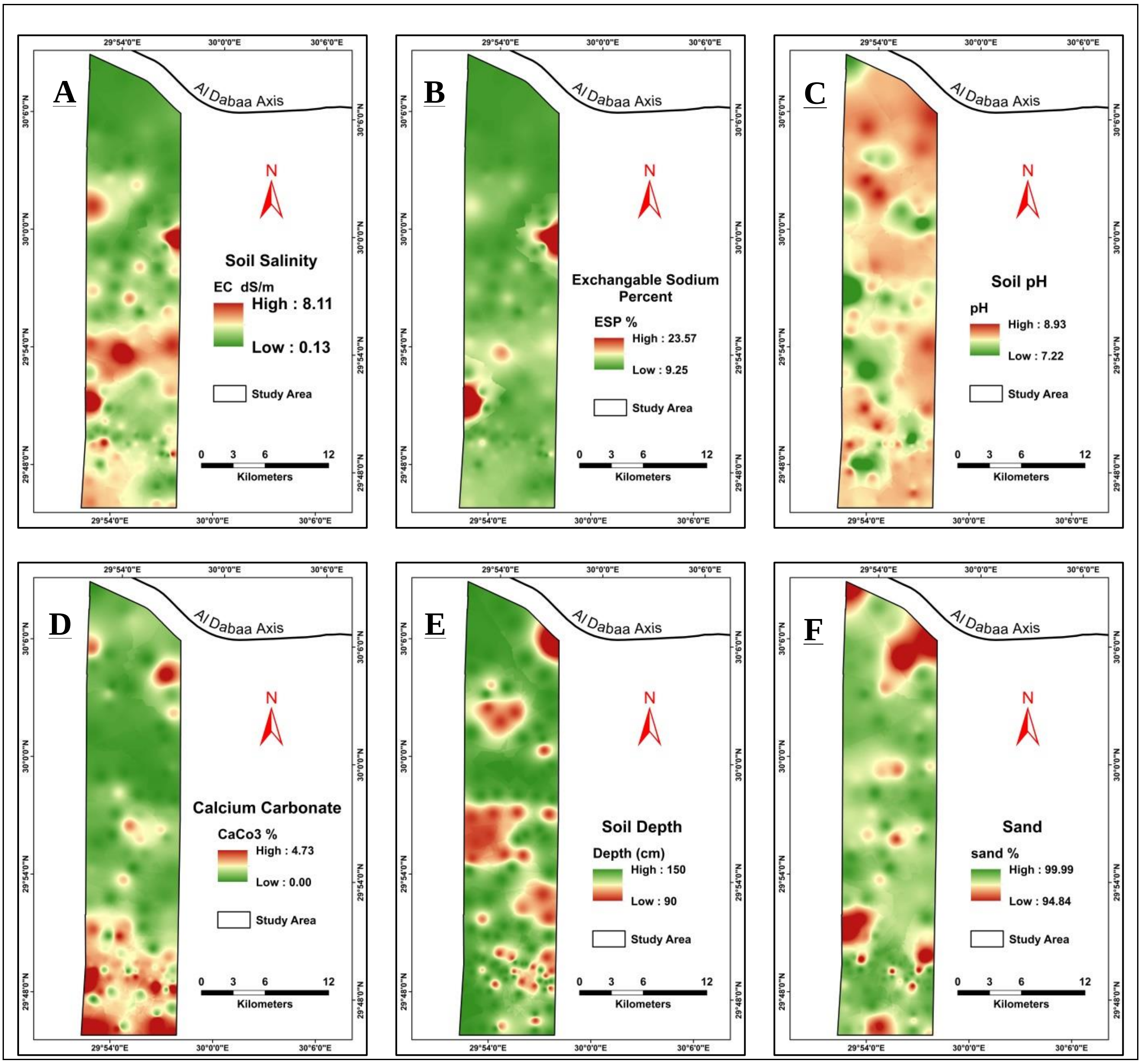


**Fig. 5. Spatial distribution maps of soil salinity (A), exchangable sodium percent (B) , pH (C), calcium carbonate (D), soil depth (E), and sand content (F).**

## 4. Discussion

The dominant soil texture in the investigated area is sand and soils were classified as Typic Torripsamments which is consistent with (Ali, Ageeb et al. 2007; Abd El-Aziz 2018; Yousif 2018; Yousif 2019; Yousif, Hassanein et al. 2020) .

**Land capability**

The land capability map that has been generated reveals that a majority of the studied area (16361.27 ha) belongs to class 3 (C3, Fair) and is mostly distributed around the whole study area as illustrated in Figure 6 and Table 5. While, 34.29 % (12238.25 ha) of the total area is Poor (C4) and 1.12 % (399.21 ha) is Very Poor (C5). The primary land capability constraints include sandy soil texture, insufficient available water, high soil permeability, limited organic matter content, and deficiency of available nutrients, which is consistent with (Yousif 2018; Belal, Mohamed et al. 2019; Mohamed, Belal et al. 2019; Yousif 2019).

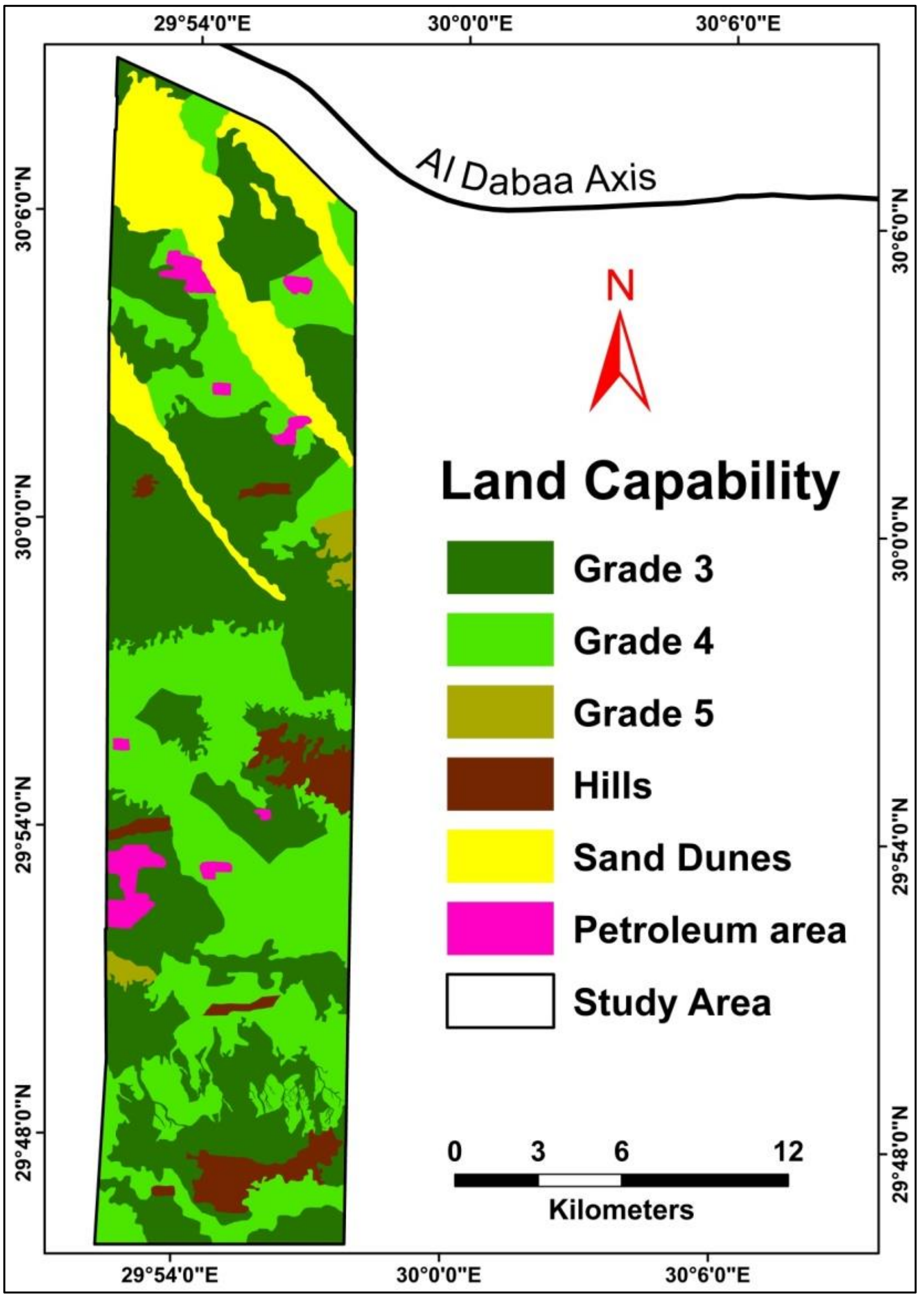


**Fig. 6. Spatial distribution of land capability classes.**

**Table 5. Distribution of land capability grades over geomorphological units.**

| Units | C 3 (Fair) | C 4 (Poor) | C 5 (Very Poor) | Total |
|---|---|---|---|---|
| Basin | 2704.44 | 1135.71 | 0.00 | 3840.16 |
| Dry wadi | 388.81 | 369.63 | 0.00 | 758.44 |
| High old river terraces | 2369.91 | 2218.81 | 0.00 | 4588.72 |
| Low old river terraces | 2853.34 | 550.44 | 0.00 | 3403.78 |
| Moderate old river terraces | 1441.83 | 2800.46 | 0.00 | 4242.28 |
| Pediment | 2407.36 | 598.20 | 0.00 | 3005.56 |
| Pediplain | 873.36 | 1005.53 | 136.89 | 2015.78 |
| Plain | 666.28 | 2411.18 | 0.00 | 3077.46 |
| Sand sheet | 2655.94 | 1148.30 | 262.31 | 4066.55 |
| Total area (hectare) | **16361.27** | **12238.25** | **399.21** | **28998.73** |
| % of the total area | **45.84** | **34.29** | **1.12** | **81.24** |

**Crop suitability**

Based on the soil attributes and climatic conditions in the examination area, agricultural land suitability was conducted for 12 crops, including field crops (wheat, barley, sugar beet, maize, soybean, sorghum, and alfalfa), vegetable crops (onion, potato, and tomato), and fruit crops (olive and pear). Table 6 and Figure 7 present the geographical distribution of land suitability classifications for each crop. The assessment findings indicated that the examined crop suitability ranged from S1 to S4 with different constraining factors in every category based on the geomorphological unit. The geomorphic units such as the hills, sand dunes, and petroleum areas were not take into account in the suitability evaluation, which represents 18.76 % of the investigated area. The findings illustrate that 16.67 % (5951.29 ha) of the entire area was S1 (highly suitable) for wheat and 8.98 % (3205.90 ha) was highly suitable for olive trees. Furthermore, 63.02 % (22494.04 ha) of the area was S2 (moderately suitable) for wheat and more than 50 % of the whole investigated area was S2 for growing alfalfa, olive, and pear. This is agreed with (Yousif 2018; Shalaby, Khedr et al. 2023). While more than 30 % of the entire area was S2 for barley, and sugar beet. Moreover, land suitability results indicate that 53.44 % (19077.04 ha) was S3 (marginally suitable) for onion and more than 40 % of the study area was S3 for barley, sugar beet, soybean, and tomato. This is consistent with the findings of Shalaby (Shalaby, Khedr et al. 2023) who is observed that alfalfa and tomato are suitable crops to cultivate in the studied region. While more than 33 % of the total area was S3 for maize, sorghum, and potato. Approximately 28 % of the entire area was S3 for alfalfa and pear. Finally, 41.14 % (14686.09 ha) of the examined area was conditionally suitable (S4) for maize, while 37.56 % (13406.92 ha) of the investigated area was S4 for sorghum, which is consistent with (Shoman, Yacoub et al. 2013; Elbasyoni 2018). More than 25 % of the studied area was S4 for potato and soybean. Generally, the study area possesses considerable prospects for cultivating various crops such as field, vegetable, and fruit crops, with the aim of reaching sustainable agricultural development.

**Table 6. Crop suitability areas for the investigated crops.**

| Crop | S1 | | S2 | | S3 | | S4 | |
|---|---|---|---|---|---|---|---|---|
| | Hectare | % | Hectare | % | Hectare | % | Hectare | % |
| **Wheat** | 5951.29 | 16.67 | 22494.04 | 63.02 | 0.00 | 0.00 | 553.40 | 1.55 |
| **Barley** | 288.64 | 0.81 | 13276.30 | 37.19 | 14880.40 | 41.69 | 553.40 | 1.55 |
| **Sugar beet** | 0.00 | 0.00 | 11587.03 | 32.46 | 16858.31 | 47.23 | 553.40 | 1.55 |
| **Maize** | 0.00 | 0.00 | 1394.33 | 3.91 | 12918.31 | 36.19 | 14686.09 | 41.14 |
| **Soybean** | 0.00 | 0.00 | 4945.29 | 13.85 | 15052.61 | 42.17 | 9000.83 | 25.22 |
| **Sorghum** | 0.00 | 0.00 | 1941.48 | 5.44 | 13650.34 | 38.24 | 13406.92 | 37.56 |
| **Onion** | 0.00 | 0.00 | 9368.29 | 26.25 | 19077.04 | 53.44 | 553.40 | 1.55 |
| **Potato** | 0.00 | 0.00 | 6861.88 | 19.22 | 11894.70 | 33.32 | 10242.15 | 28.69 |
| **Tomato** | 0.00 | 0.00 | 9806.50 | 27.47 | 14455.15 | 40.50 | 4737.08 | 13.27 |
| **Alfalfa** | 288.64 | 0.81 | 18375.47 | 51.48 | 10033.13 | 28.11 | 301.50 | 0.84 |
| **Olive** | 3205.90 | 8.98 | 21252.57 | 59.54 | 4540.26 | 12.72 | 0.00 | 0.00 |
| **Pear** | 0.00 | 0.00 | 18676.55 | 52.32 | 10322.18 | 28.92 | 0.00 | 0.00 |

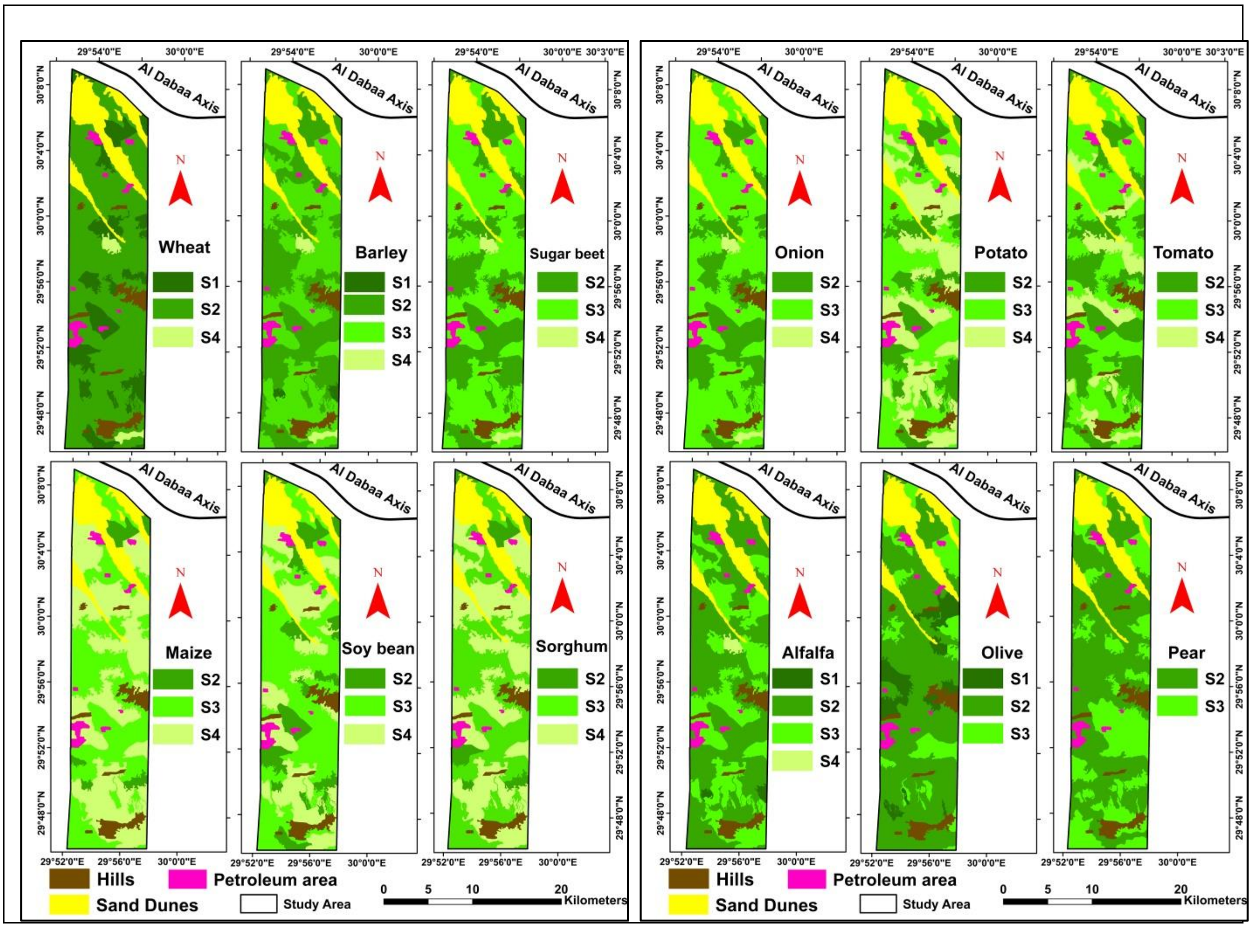


**Fig. 7. Crop suitability maps for the investigated crops.**

## 5. Conclusions

The primary objectives of land use planning revolve around the assessment of land capability, which is contingent upon the ecological potentialities and limitations. Additionally, land use planning seeks to anticipate the inherent soil suitability for supporting a specific crop over an extended duration. In Egypt, the arid and semi-arid regions exhibited a scarcity of land and water resources. The coastal area of Egypt has emerged as the primary location for a wide range of economic activities. Therefore, this research was conducted to investigate the crop suitability of some crops and land capability using ALESarid-GIS. The analysis of land capability for the investigated soils indicated that two grades are dominant in the investigated area C3 (Fair) and C4 (Poor) representing 45.84% and 34.29% out of the total investigated area, respectively. Results of ALISarid-GIS revealed that twelve crops are exhibit the most suitable to cultivate in the study area. Highly suitable class (S1) was predicted for wheat and olive, encompassing 16.7% and 8.98% of the examined area, respectively. Approximately 63%, 59%, 52%, 51%, 37%, 32%, 27%, 26%, 19%, and 13%, of the study area, is considered moderately suitable (S2) for wheat, olive, pear, alfalfa, barley, sugar beet, tomato, onion, potato, and soybean**,** respectively. On the other hand, marginally suitable (S3) class was founded for crop cultivation such as onion, sugar beet, soybean, barley, tomato, sorghum, maize, potato, pear, and alfalfa with an area about 53.44%, 47.23%, 42.17%, 41.69 %, 40.50% 38.24% 36.19%, 33.32%, 28.92%, and 28.11% of the study area, respectively. Sand texture, shortage of available water, high soil permeability, and lack of available nutrients are the key limiting parameters for land capability and crop cultivation. Finally, this study demonstrated that the analysis of soil properties to determine the land capability and crop suitability is an influential tool that can be used to support decision-making, especially in huge agricultural expansion projects. Likewise, remote sensing data and GIS techniques were regarded as main tools to conduct the soil capability and crop suitability in order to accomplish the ideal land use planning in these recently reclaimed areas.

**Conflicts of interest**

“There are no conflicts to declare”.

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