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Full length article

Utilizing Geographic Information Systems (Gis) In Designing Irrigation Networks

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ABSTRACT

The objective of this research is to use ArcGIS software to identify suitable irrigation systems and crop selections. This will be accomplished by developing soil maps, contour maps, farm planning strategies, and calculating of primary flow rates for a newly established agricultural site located in the reclamation areas in Sadat City. This study covers an area of 98.6 feddan, divided into 61 land profiles to assess prevailing issues. Key soil characteristics examined include depth, electrical conductivity (EC), pH, calcium carbonate content, sodium adsorption ratio (SAR), and soil texture. After the analysis, maps were generated using ArcMap 10.4.1. Results indicate that 99% of the area is suitable for agriculture, while one% is unsuitable due to soil salinity and sodium absorption. Additionally, 98% of the arable land is deemed suitable for all irrigation systems, while 2% is more appropriate for sprinkler and drip irrigation systems. Given the reliance on groundwater and the sandy soil composition, sprinkler and drip systems are preferred over surface irrigation. Key limitations on irrigation system usage include soil type, calcium carbonate content, soil tendencies, and salinity, which also restrict certain crop choices. In conclusion, Geographic information System (GIS) tools are essential for determining optimal irrigation systems, suitable crops, and for establishing a database to support smart irrigation practices.

1. Introduction

Water resources are limited globally, and much of the economically feasible development has already been done. Population growth and recurring droughts further strain these resources, creating an imbalance between supply and rising demand. Effective planning and management rely on accurate data on water usage, irrigation techniques, and large-scale irrigation system characteristics. Prompt monitoring and exploration of new water sources are essential, requiring modern techniques like GIS. GIS is a valuable tool for managing irrigation water, allowing managers to visualize different management plans and improve water management strategies (Mohammadi, 2019).

In arid regions, irrigated agriculture is affected by multiple factors including water scarcity, urbanization, soil salinization, and degradation, in addition to population growth and climate change (Dimov et al., 2016). The Middle East and North Africa region has been experiencing rising temperatures and declining precipitation, in recent years. (Lelieveld et al., 2016; Almazroui et al., 2017).

A Geographic Information System (GIS) is a computer-based system used for storing, managing, analysing, and retrieving spatial data (Massei et al., 2014). The

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benefits of GIS include providing users or decision makers with an easy way to formulate policies related to spatial aspects. With GIS technology, mapping water irrigation networks become more efficient and accessible. Geographic Information Systems (GIS) and databases provide essential tools and flexibility, allowing the management of land resources for various functions and uses. Hence, GIS and associated databases are widely used in agricultural development, natural resource management, environmental science and land use planning and development (Jolly et al., 2001; Gustafson et al., 2001; Brown et al., 1998; Yeh and Li, 1998). Soil surveys utilize computer systems to store, process, interpret and retrieve vast amounts of data generated from the survey that can be manipulated and displayed within the GIS. The volume of information generated in soil surveys is typically large, and this information is complex and interrelated. It includes data and the identification related to the identification and description of the soils, their location, and interpretation of their suitability for irrigated agriculture and other land uses. All points and data are geographically related and displayed on maps to provide information on the location and extent of the soils and their properties.

The growing dependence on irrigated agriculture coincides with intensified competition for water and increased awareness of unintended negative consequences of poor design and management. Irrigation systems are selected, designed and operated to meet the specific irrigation requirements of each crop field on the farm while controlling deep percolation, runoff, evaporation and operational losses to establish a sustainable production process. Two-thirds of the world's water is used in irrigation, and 40% of total agricultural production is obtained from irrigated areas. Unsustainable and insufficient management of irrigation projects leads to poor performance. Additionally, shortcomings in design, construction, operation, and maintenance contribute to the inefficiency of irrigation systems (Gundogdu et al., 2002). Information that assists system managers must be easily accessible for effective irrigation management. Most data related to irrigation is geographically characterized. The use of GIS software is crucial for establishing databases for irrigation systems to ensure readily accessible and relevant data. Data must be collected, recorded and interrelated systematically. For this reason, it is very important to organize the database, which serves as the foundation of the information system (Gundogdu et al., 2002).

The aim of this study is to theoretically present the importance of applying GIS tools in irrigation project management to facilitate mapping, database integration, planning/management and modeling. The study is applied to a private farm in Sadat City, Menoufia Governorate. First this study aims to determine the most essential data for irrigation project management. After identifying the necessary data, classification and standardization of the data were conducted.

2. Materials and methods

2.1. . Location

The study area encompasses approximately 98.6 feddans in Sadat City, located in El-Menoufia governorate, which lies in the northwestern portion of Egypt. It is Coordinates are as follows: (N30°19'53.00", E030°33'36.66") (N30°19'58.91", E030°33'23.47") (N30°20'28.21", E030°33'42.14") (N30°20'22.91", E030°33'55.79"). Fig. 1.

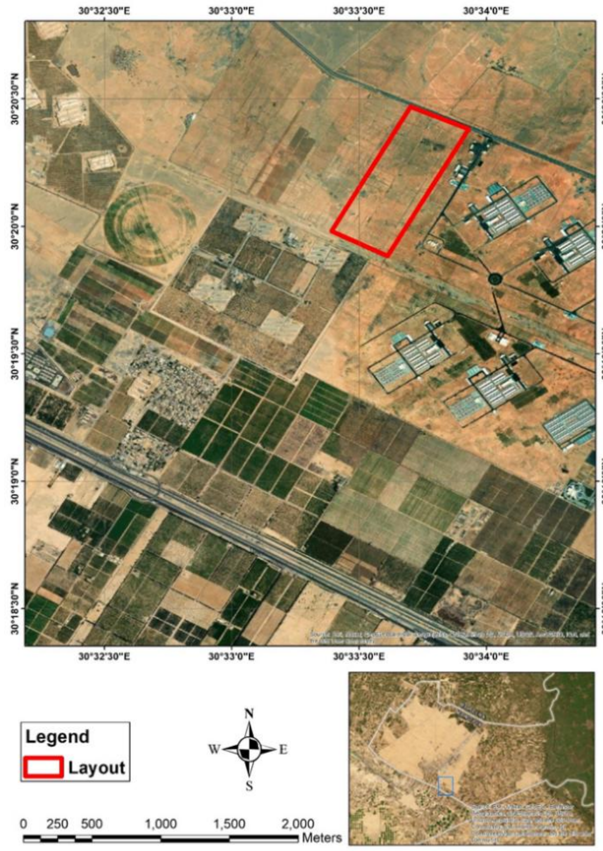

Fig. 1. Location map of the study area in Sadat City, El-Menoufia governorate.

2.2. Climate

The climate of the area is characterized by extreme aridity, a long, rainless summer, and short, cold winter with rare rainfall. The mean monthly maximum temperature ranges from 20.0 to 34.8C° while the mean minimum temperature ranges from 7.2 to 20.5C°. Rainfall ranges from 53.7 to 65.8 mm per year, and precipitation is strictly confined to the winter season.

2.3. Field work

The study area extends over approximately 98.6 feddans and was surveyed using 61 soil profiles chosen to represent different points and degraded portions of the study area Fig. 2. Representative profiles were morphologically described according to FAO (2007) and sampled for further laboratory analyses.

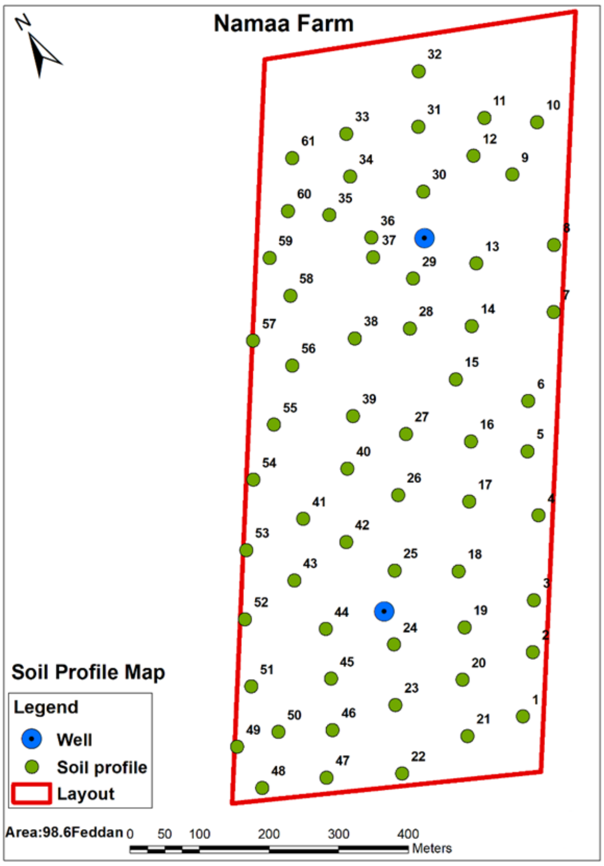

Fig. 2. Locations of soil profiles in the study area of Sadat City, El-Menoufia governorate.

2.4. Soil analyses

Collected soil samples were analyzed to determine (1) physical properties, including soil texture **(Page et al., 1982)** and (2) chemical properties such as electrical conductivity (EC), soluble cations and anions, soil reaction (pH), and total calcium carbonate (Zhang et al., 2005).

2.5. Land evaluation

Land suitability classes for irrigation systems, cultivation, and various field, forage, vegetables and fruit crops were identified for each soil unit according to (Burt, 1995; Sys, 1979; Ayers and Westcot 1985; and Scianna 2002) considering soil properties and climate conditions.

2.6. GPS and GIS processing

Soil profiles coordinates and elevations were determined using GPS. The ArcGIS Spatial Analyst 10.4.1 extension provides tools for spatial data analysis like buffering, masking, and interpolation, which apply statistical theory and techniques to the modelling of spatially referenced data.

2.7. Methodology development

The use of GIS to design and plan irrigation systems requires a procedure for adequate analysis as shown in the flow chart (Fig. 3). The methodology developed and applied in this study consists of the following steps in Fig. 3.

3. Results and discussions

3.1. Data collection and inputting

The Arc GIS software, specifically ArcMap 10.4.1 from Esri Company, was utilized in this study to leverage its tools for constructing a database of the study area. This process involved inputting data related to land elevations, coordinates of soil profiles, and chemical analysis results of soil samples. The data was then organized, analyzed, and used to create contour maps and soil maps.

3.1.1. Spatial data

The points file, which includes the data on the boundaries of the study area, elevation levels and the coordinates of the soil profiles surveyed by the GPS device, was imported using the GPX to Features tool from ArcToolbox, as shown in Fig. 4.

3.1.2. Soil analysis

Table 1 shows the Chemical analysis of soil sectors of the study area. The results in Table 1 were entered into the program's database and linked to the coordinates of each soil profile as shown in Fig. 5.

3.2. Analyzing data

After preparing the database, the ArcMap 10.4.1software tools are used to analyze spatial and descriptive data, and to create contour maps, slope, and soil maps. These maps enable the identification of areas suitable for cultivation versus those that are not, as well as determining the appropriate crop types and irrigation systems based on soil type and land slope.

3.2.1. Create Contour map

A digital elevation model (DEM) is created using ArcMap 10.4.1software through the DEM tool, based on values from points entered the ArcMAP database. DEM is then used to create contour maps that illustrate variations in land elevation. These maps are essential for dividing the farmyard into plots and for calculating pressure differences in the main and submain irrigation lines caused by elevation changes.

After applying the above methods to the study area, it was found that elevations gradually ranged between > 54.8 m above sea level (A.S.L) and <61m A.S.L as shown in Fig. 6 . The highest elevation recorded between 59.1and 61m A.S.L, accounted for about

16.75% of the study area, while the lowest elevation, recorded between 54.8 and 57 m A.S.L, covered approximately 15.25%. Additionally , the elevation range between 57.9 and 59 m A.S.L made up about 68% of the study area.

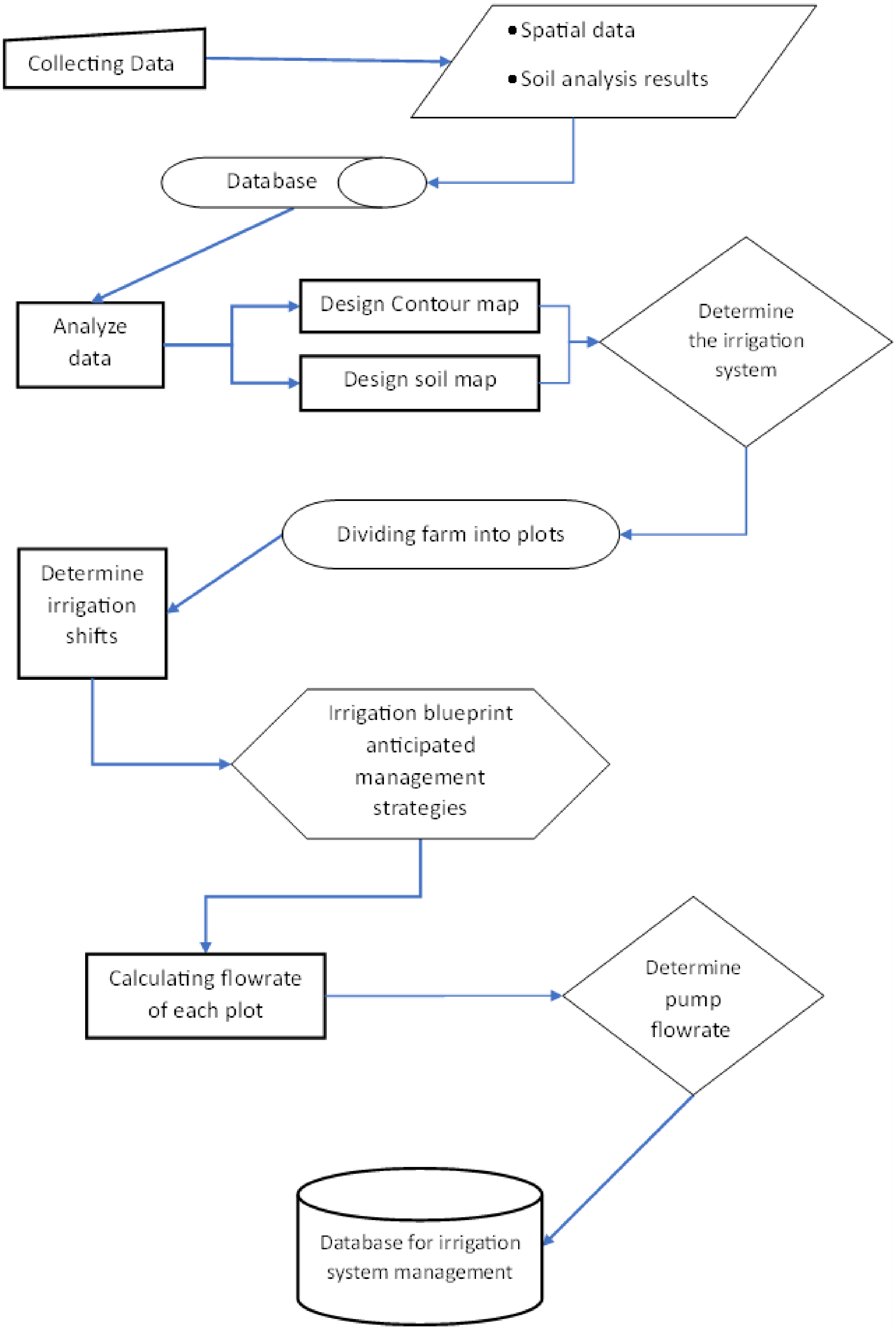

Fig. 3. The methodology developed and applied of this study.

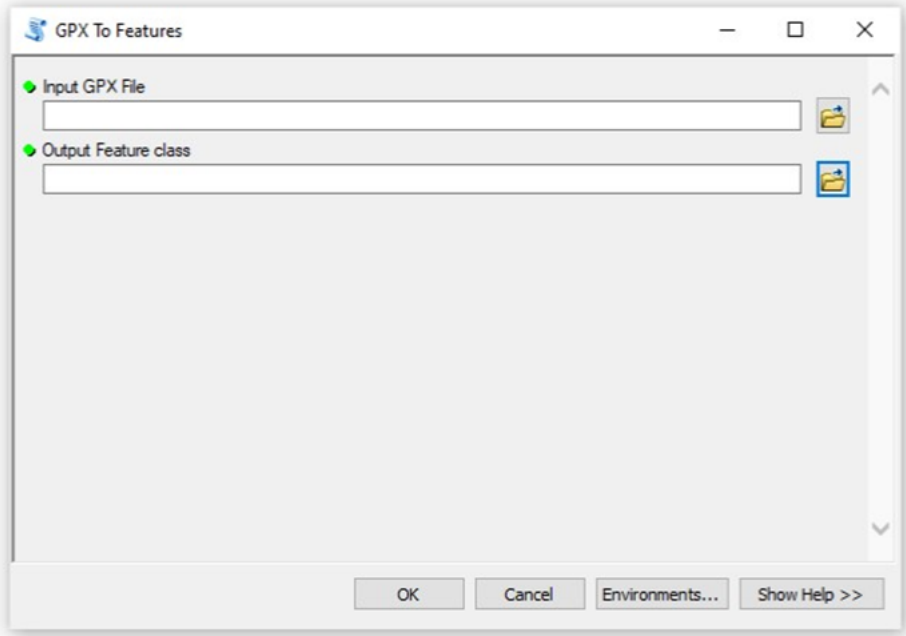

Fig. 4. Entering GPS coordinates into ArcMap.

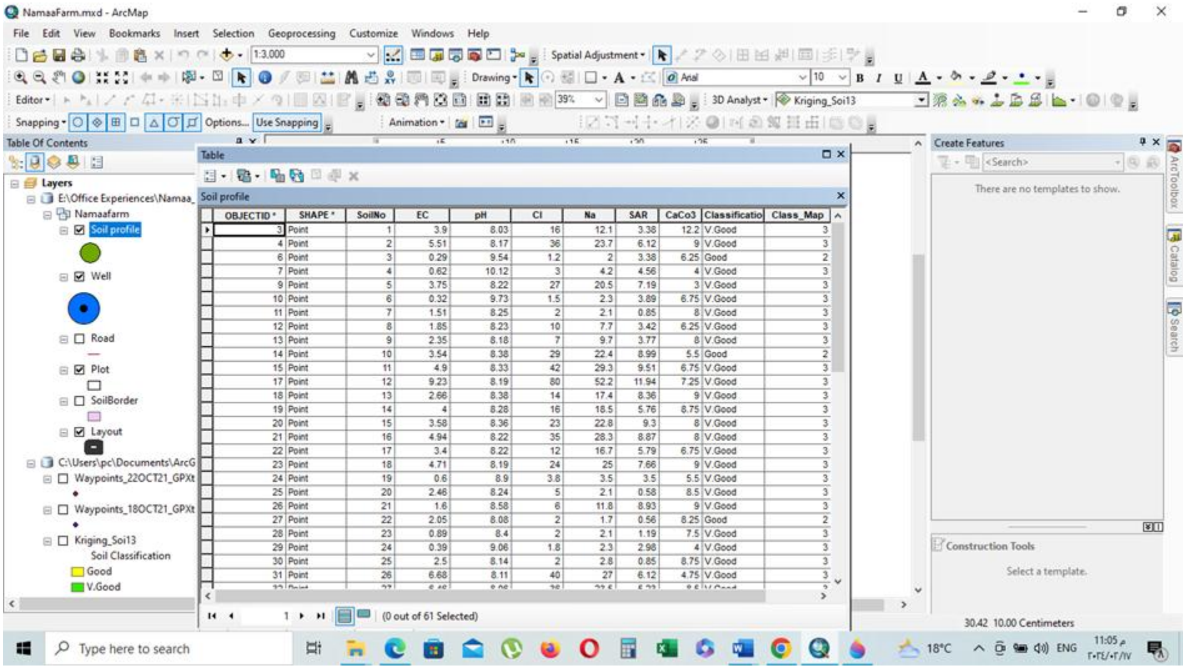

Fig. 5. The database after inserting the results of the analysis.

3.3. Analyzing data

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Table 1
Chemical analysis of soil sectors of the study area

Sample No	pH	EC (ms/cm)	CO3	HCO_3	Cl	So_4	Ca	Mg	Na	K	SAR	$CaCo_3$ (%)
1	8.03	3.90	0	2.0	16	21.0	15.3	10.2	12.1	1.4	3.38	12.20
2	8.17	5.51	0	2.0	36	17.1	18.0	12.0	23.7	1.4	6.12	9.00
3	9.54	0.29	0	1.6	1.2	0.1	0.5	0.2	2.0	0.2	3.38	6.25
4	10.12	0.62	0.4	2.6	3	0.2	1.0	0.7	4.2	0.3	4.56	4.00
5	8.22	3.75	0	1.2	27	9.3	9.8	6.5	20.5	0.7	7.19	3.00
6	9.73	0.32	0	1.5	1.5	0.2	0.5	0.2	2.3	0.2	3.89	6.75
7	8.25	1.51	0	1.0	2	12.1	7.0	5.2	2.1	0.8	0.85	8.00
8	8.23	1.85	0	1.0	10	7.5	7.5	2.7	7.7	0.6	3.42	6.25
9	8.18	2.35	0	1.0	7	15.5	10.0	3.3	9.7	0.5	3.77	8.00
10	8.38	3.54	0	2.0	29	4.4	9.0	3.4	22.4	0.6	8.99	5.50
11	8.33	4.90	0	2.0	42	5.0	14	5.0	29.3	0.7	9.51	6.75
12	8.19	9.23	0	2.0	80	10.3	30.0	8.3	52.2	1.8	11.94	7.25
13	8.38	2.66	0	2.0	14	10.6	6.0	2.7	17.4	0.5	8.36	9.00
14	8.28	4.00	0	2.0	16	22.0	14.5	6.2	18.5	0.8	5.76	8.75
15	8.36	3.58	0	1.0	23	11.8	8.5	3.6	22.8	0.9	9.30	8.00
16	8.22	4.94	0	1.0	35	13.4	14.2	6.2	28.3	0.7	8.87	8.00
17	8.22	3.40	0	1.0	12	21.0	11.7	5.0	16.7	0.6	5.79	6.75
18	8.19	4.71	0	1.0	24	22.1	15.0	6.3	25.0	0.8	7.66	9.00
19	8.90	0.60	0	2.0	3.8	0.2	1.4	0.6	3.5	0.5	3.50	5.50
20	8.24	2.46	0	1.4	5	18.2	17.5	4.5	2.1	0.5	0.58	8.50
21	8.58	1.60	0	1.0	6	9.0	2.2	1.3	11.8	0.7	8.93	9.00
22	8.08	2.05	0	1.0	2	17.5	13.5	4.4	1.7	0.9	0.56	8.25
23	8.40	0.89	0	1.0	2	5.9	4.6	1.6	2.1	0.6	1.19	7.50
24	9.06	0.39	0	1.8	1.8	0.3	0.8	0.4	2.3	0.4	2.98	4.00
25	8.14	2.50	0	1.0	2	22.0	16.0	5.5	2.8	0.7	0.85	8.75
26	8.11	6.68	0	1.0	40	25.8	29.0	10.0	27.0	0.8	6.12	4.75
27	8.06	6.46	0	1.0	36	27.6	30.0	10.4	23.5	0.7	5.23	8.50
28	8.06	7.17	0	1.0	42	28.7	31.0	10.4	29.2	1.1	6.41	8.50
29	8.15	6.17	0	1.2	40	20.5	26.0	8.8	26.0	0.9	6.23	11.00
30	8.12	3.54	0	1.0	12	22.4	17.5	6.8	10.4	0.7	2.98	7.50
31	8.18	2.96	0	1.0	11	17.6	12.0	4.2	12.7	0.7	4.47	5.50
32	8.14	3.06	0	1.0	8	21.6	17.6	7.5	4.7	0.8	1.32	8.50
33	8.57	1.08	0	1.0	6	3.8	3.2	2.5	4.3	0.8	2.55	6.50
34	8.26	2.80	0	1.0	17	10.0	11.8	2.6	12.9	0.7	4.81	7.00
35	8.81	0.63	0	1.0	4	1.3	1.6	1.0	3.30	0.4	2.89	7.50
36	8.32	2.51	0	1.4	14	9.7	8.4	2.8	13.2	0.7	5.59	6.75
37	8.13	6.23	0	1.4	35	25.9	20.3	12.0	29.0	1.0	7.23	8.75
38	8.10	6.08	0	1.2	34	25.6	22.6	12.5	24.9	0.8	5.93	6.00
39	8.17	2.77	0	1.4	6	20.3	12.8	6.2	8.0	0.7	2.59	5.50
40	8.24	2.02	0	1.0	8	11.2	7.0	4.0	8.2	1.0	3.50	6.75
41	8.14	4.73	0	1.0	22	24.3	17.2	10.5	18.4	1.2	4.94	6.25
42	8.08	5.70	0	1.0	34	22.0	20.0	12.4	23.7	0.9	5.89	5.25
43	8.22	2.40	0	1.0	4	19.0	13.0	6.7	3.50	0.8	1.11	6.00
44	8.24	4.63	0	1.2	32	13.1	13.8	7.3	24.0	1.2	7.40	7.25
45	8.08	8.89	0	1.0	55	32.9	32.0	16.2	39.7	1.0	8.10	9.75
46	8.08	7.55	0	1.4	46	28.1	30.0	10.5	34.0	1.0	7.55	8.10
47	8.20	5.04	0	1.0	28	21.4	16.5	10.0	22.6	1.3	6.20	5.75
48	8.65	1.26	0	1.2	5	6.4	2.4	1	8.4	0.8	6.46	5

Continue Table 1

Sample No	pH	EC (ms/cm)	CO3	HCO_3	Cl	So_4	Ca	Mg	Na	K	SAR	$CaCo_3$ (%)
49	8.13	5.62	0	1.4	40	14.8	16	11	28.2	1	7.68	4.5
50	8.15	11.88	0	2	88	28.8	40	12.6	58.4	7.8	11.4	8.25
51	8.56	2.17	0	2	16	3.7	3	1.2	16.5	1	11.45	6.5
52	8.22	3.32	0	2	12	19.2	14	5	13.7	0.5	4.44	4
53	9.45	0.2	0	0.9	0.9	0.2	0.4	0.2	1	0.4	1.85	6.25
54	9.01	0.58	0	1.6	4	0.2	1	0.4	4	0.4	4.82	3.5
55	8.25	3.25	0	2	8	22.5	14.8	5	12	0.7	3.82	8.5
56	8.19	1.84	0	2	2	14.4	12	4	1.8	0.6	0.64	2.5
57	8.11	2.95	0	2	7	20.5	16	5.4	7	1.1	2.14	7.5
58	8.13	2.64	0	2	7	17.4	13.5	4.6	7.7	0.6	2.57	7
59	8.54	1.41	0	2	8	4.1	3.5	1.2	8.7	0.7	5.68	8.5
60	8.59	1.45	0	2	8	4.5	2.8	1	10	0.7	7.3	8.25
61	8.25	2.78	0	2	5	20.8	16	4	7.2	0.6	2.27	6.75

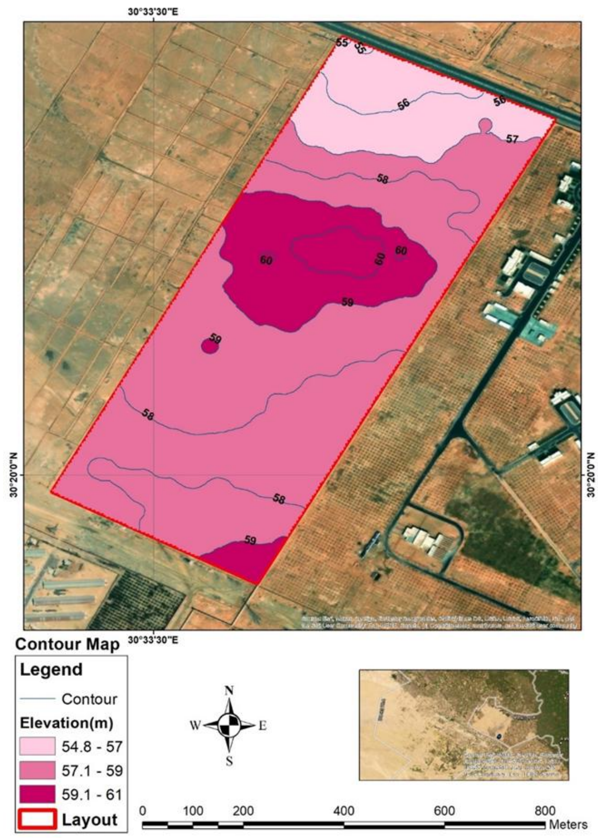

Fig. 6. Elevations of the study area at Sadat City, El-Menoufia governorate.

The digital elevation model also facilitates the creation of a slope map, which is useful for selecting the appropriate irrigation system for the land. Slopes are typically calculated in percent (%) or degrees (°). The Classification of slope in the study area follows (Burt, 1995). The slope analysis, as shown in Fig. 7 reveals that study area is predominantly characterized by the slope in the 0.00-3% range, 98%% of the area. The remaining 2% falls within the 3.1-5% slope class. When considering slope criteria for settlements, the area with 98% of the land at a 0.00-3% slope is more suitable for all types of irrigation systems. However, the 2% of the area with a slope of 3.1-5.00% is better suited for sprinkler and drip irrigation systems. To calculate the percentage and area of each section in the ArcMap program, follow these steps: Arc Toolbox > Spatial Analyst Tools > Reclass > Reclassify, as shown in Fig. 8. From Fig. 8, it can be observed that study area is predominantly characterized by slopes in the 0-3% class, covering 98% of the area. The remaining 2% falls within the slope class of 3.1-5%.

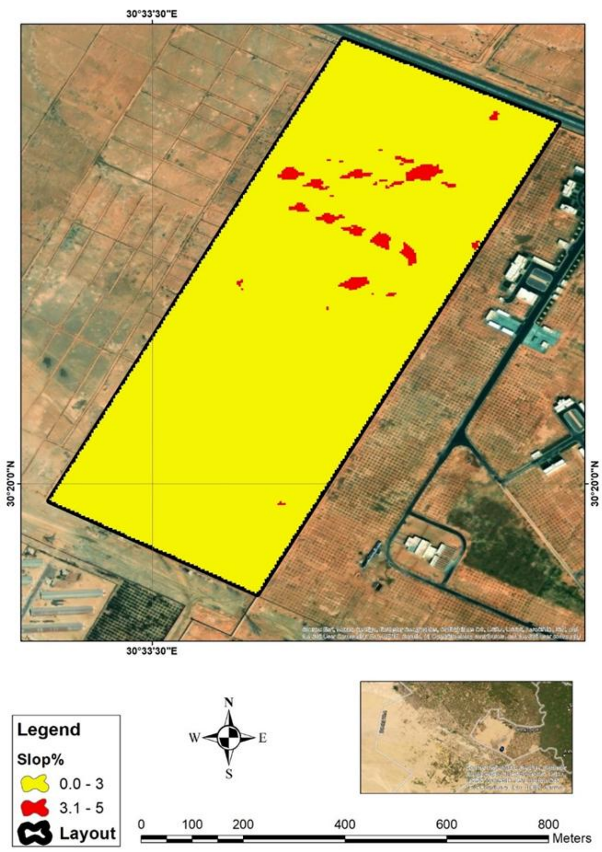

Fig. 7. Slope of the study area at Sadat City, El-Menoufia governorate.

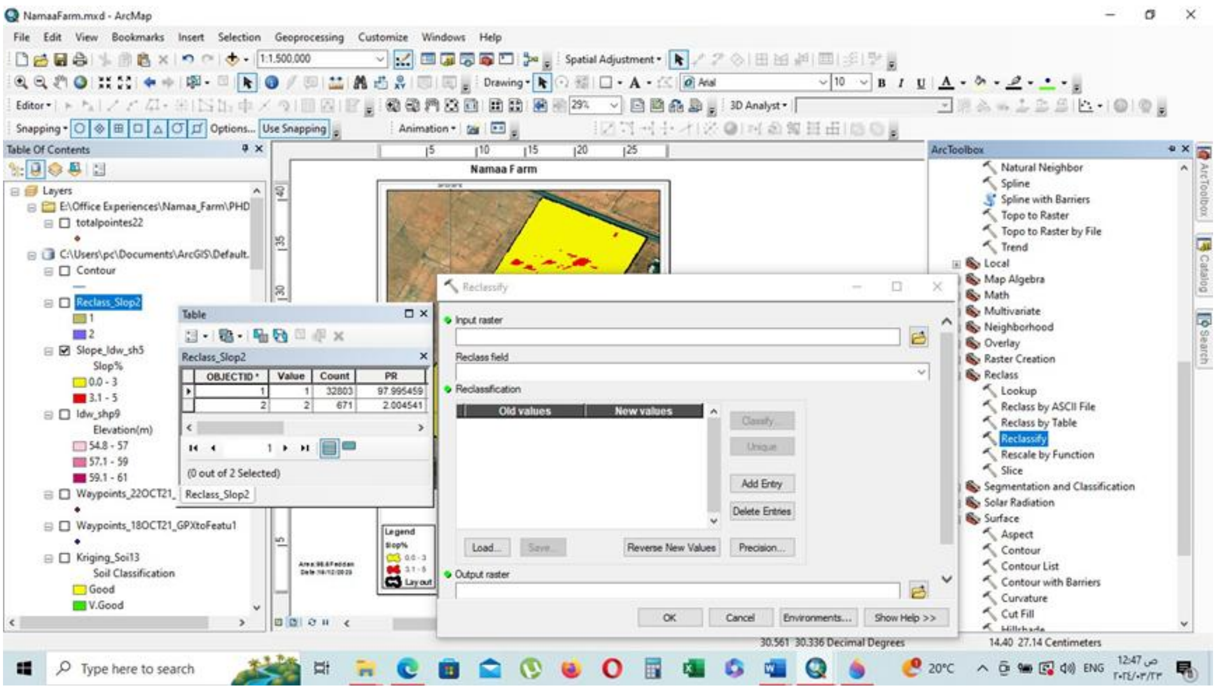

Fig. 8. Determine the slope ratio in the map keys.

3.3.2. Design soil maps

Spatial analysis is performed in ArcMap using the IDW tool on the point values entered the database, which represent soil profiles. This analysis is used to create soil maps based on the results of chemical analyses of soil elements, as well as maps illustrating specific soil properties such as the EC Map, pH Map and SAR Map. By referring to these soil maps, we can assess the suitability of the land for agriculture and select the appropriate crop for the soil type.

The Steps are as follows:

Arc Toolbox > Spatial Analyst Tools > Interpolation > IDW, as shown in Fig. 9.

3.3.2.1. Electric conductivity (EC) map

As shown in Fig. 10, most of the soils in the study area are classified as non-saline to slightly saline, with electrical conductivity (EC) values ranging from 0.2 to 12 dS/m. However, some profiles were salt affected, exhibiting saline EC values between 8 and 12 dS/m, where the most dominant soluble salt was sodium chloride (Scianna, 2002). Additionally, the EC values ranged from 0.2 to 4 dS/m, 4 to 8 dS/m, and 8 to 12 dS/m, representing 70%, 29%, and 1% of the study area, respectively.

In general, if the soil salinity in the surface soil (seeding area) exceeds 4 dS/m, it may inhibit or delay germination and early seedling growth. This slowed germination can delay emergence, leading to issues such as soil crusting and increased susceptibility to diseases, ultimately reducing crop stand. Moreover, it is evident that salinity levels ranging from 0.2 to 4 dS/m and 4 to 8 dS/m are suitable for most crops and do not adversely affect their productivity. In contrast, salinity levels between 8 and 12 dS/m can lead to reduced crop yields of more than 50% (Ayers and Westcot, 1985).

3.3.2.2. Soil reaction (pH)map

Soil reaction values were neutral with relatively alkaline tendency, where pH ranged from 8 to 10.2 for the whole area (100 % of the study area). All of the study area were alkaline Fig. 11. This results according to (Scianna, 2002).

3.3.2.3. Sodium adsorption ratio (SAR)map

In arid regions like Egypt, limited rainfall results in minimal leaching of bases and salts under non-irrigated conditions, so soluble salts of Ca, Mg, and Na remain in high concentrations in the soil. As shown in Fig. 12 the sodium adsorption ratio (SAR) no mor than 12 and varied in a wide range from >0.5 to <12.

Most of the study area (100%) were (SAR) less than 12. This means that, most of the study area especially that had EC about less than 4 dS/m and SAR less than 12 represented normal soil and suitable for most crops (100% of the study area), (Horneck et al., 2007; Scianna, 2002). Granted, sodium adsorption ratio (SAR) describes the ratio of Na relative to Ca and Mg - two cations that moderate the adverse effects of Na. The greater the SAR, the more Na relative to Ca and Mg, the greater the toxicity to plants.

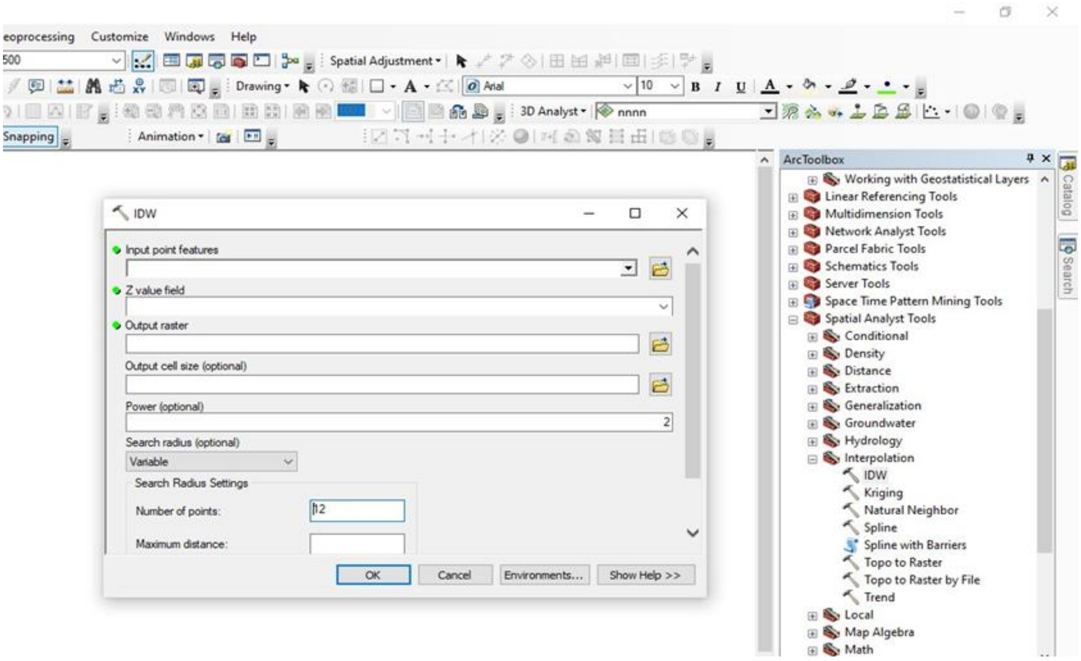

Fig. 9. Data analysis process for extracting soil maps.

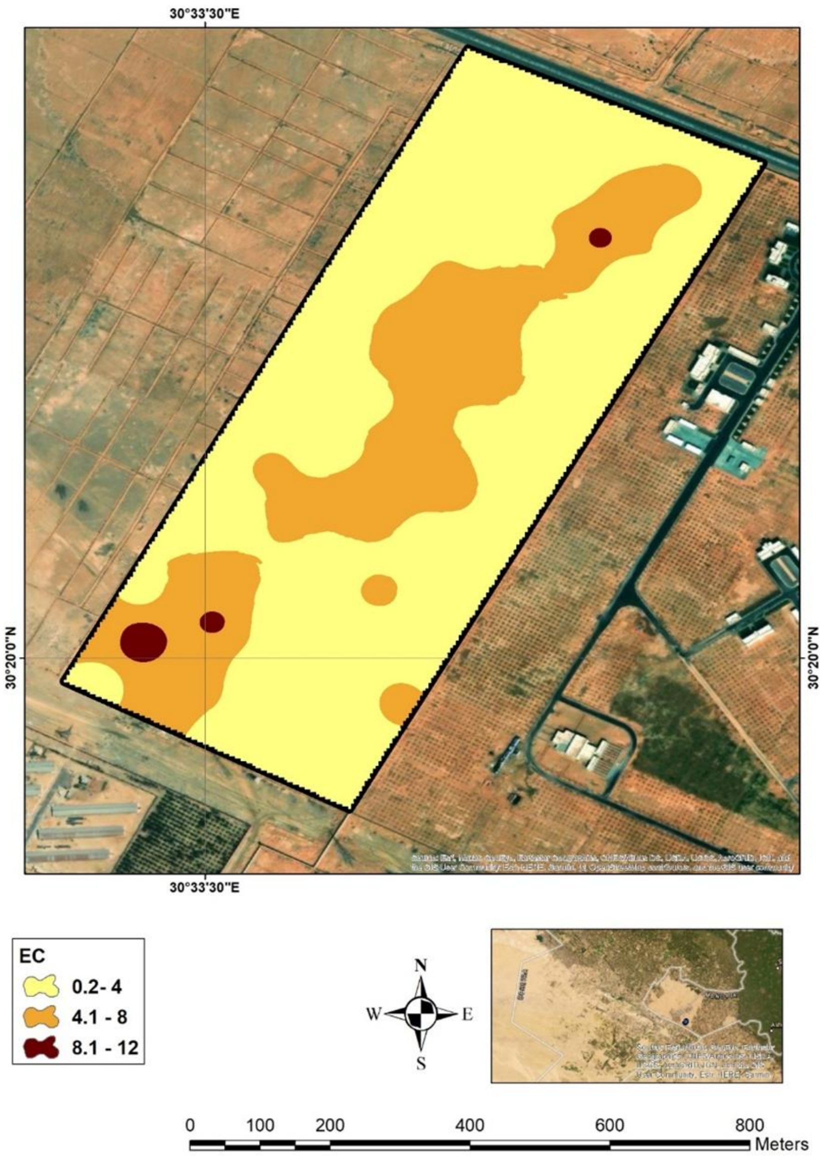

Fig. 10. Electric conductivity (EC) of the study area at Sadat City, El-Menoufia governorate.

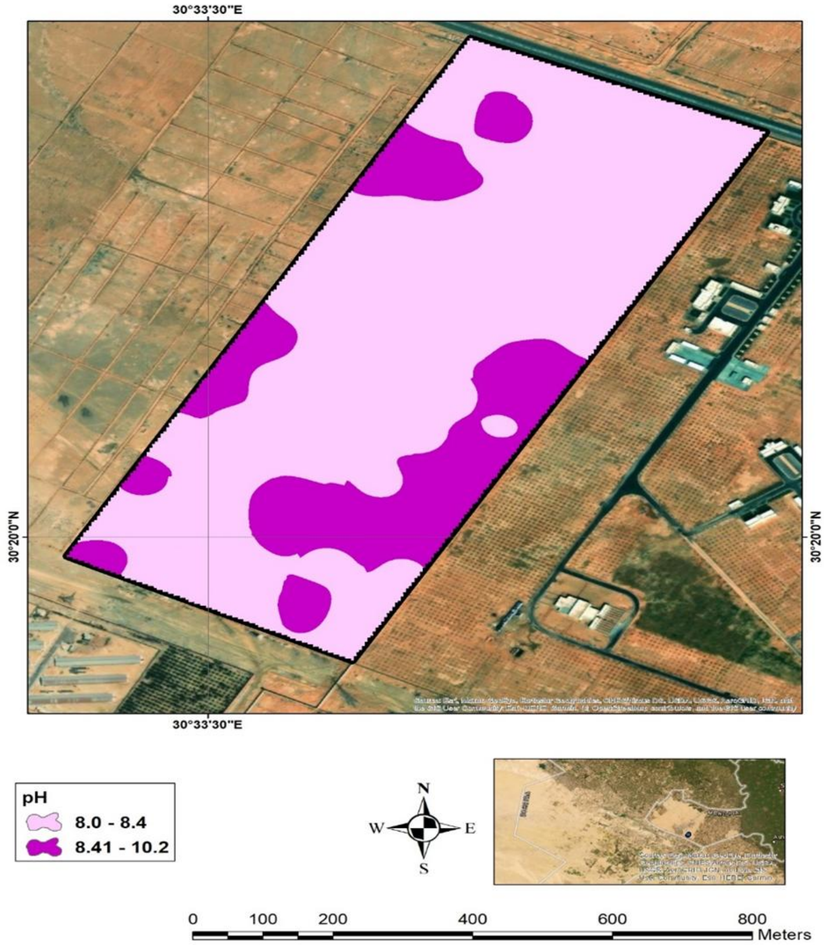

Fig. 11. Soil reaction (pH) of the study area at at Sadat City, El-Menoufia governorate.

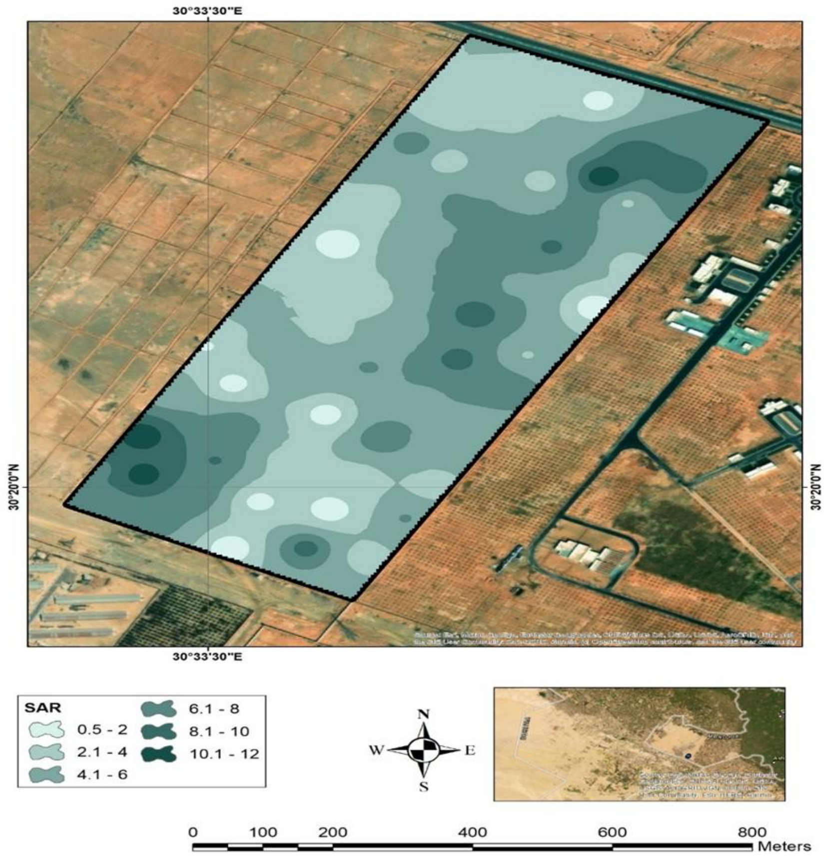

Fig. 12. Sodium adsorption ratio (SAR) of the study area at Sadat City, El-Menoufia governorate.

3.3.3. Determine the irrigation system

From the previous results, we find that the study area, in terms of the difference in elevations and slopes, is suitable for all irrigation systems, as well as in terms of soil properties and soil analysis results. The drip irrigation system was chosen to save water and energy, given that the irrigation source is groundwater.

3.3.4. Dividing farm into plots

ArcMap program is characterized by many engineering drawing tools linked to an advanced database. Once the engineering shape is drawn, the shape is analyzed and its data such as the length of the line and the area of the polygon are recorded automatically, which helps the designer to reach the optimal design. Using these features, the study area was divided into plots with similar areas, as illustrated in Fig. 13, so that it could be subdivided into irrigation shifts with comparable flowrates., which facilitates the selection of the appropriate pump flowrate and optimal utilization of the water source and operating energy.

The types of crops were chosen, planting distances were determined for each crop, the appropriate irrigation system for each crop was determined, and the crops were distributed to the plots as illustrated in Fig. 14.

3.4. Determine irrigation shifts

An initial plan is developed to divide the farm into irrigation sections that operated using irrigation valves such that the flowrate of the main valve or more main valves aligns with the well flowrate capacity.

3.4.1. Proposed irrigation and suggested plan

In the study area, there are two wells with a flowrate of 120 cubic meters per hour each. Accordingly, the design involves configuring plot1 and plot 2 for a single irrigation shift, while the remaining plots, from plot 3 to plot 12, are each assigned to an irrigation shift corresponding to one of the wells. This arrangement allows for the complete allocation of water from a single well to one of the designated shifts

3.4.2. Calculating flowrate of each plot

To calculate the flowrate for each plot, data on the distances between planting lines, the number of laterals per planting line, the spacing between emitters, and the emitter flowrate are entered into the ArcMap 10.4.1software database. The program is distinguished by its capability to perform the calculations for all plots in a single step, despite the differing data for each plot. This efficiency saves time and assists the designer in achieving the most optimal design.

For example, the following data were entered into the ArcMap 10.4.1software database

Distance between planting lines Citrus 6m, Grapes 3m, Mango 3.5m, Peaches 5m, Plums 5m and Pomegranate 4m

The selected drip lines feature inline emitters with a flowrate of 4L/h, and the distance between emitters is 50 cm. All crops are equipped with two drip lines per planting line, with the exception of grapes, which are provided with only one drip line per planting line.

A database has been entered into the ArcMap program as follows:

Open Attribute Table > Add Field

Fields were done for: Area in Feddan, distance between planting lines, numbers of drip lines in the planting line, numbers of emitters per meter, emitters flowrate, flowrate per Feddan, and flowrate per plot

Data has been entered for:

Distance between planting lines, numbers of drip lines in the planting line, numbers of emitters per meter, emitters flowrate.

Then the Field Calculator was used to calculate the area/ Feddan, flowrate / Feddan and flowrate /plot

Where the arithmetic equation is entered once and once you click "ok" The result of the equation is calculated for each plot and recorded in the database.

In case of calculating the field area in Feddan, the equation is entered as follows: [SHAPE_Area] /4200

The area of each plot is calculated and registered in the database as soon as you click "Ok" without the need to perform the calculation more than once.

In case of calculating the flowrate of feddan, the equation is entered as follows: **4200/ [Tree_Line] * [No_Emitter_Line] * [Emiter_Q_L_h] * [Emitter_In1m] /1000**

In case of calculating the flowrate of plot, the equation is entered as follows: **[Q_Feddan] * [Feddan]** As shown in the Fig. 15.

The program's tools are used to obtain many accurate and fast information by arranging and processing data, where the discharge of the plots can be raised from the smallest to the largest or vice versa as the Statistics tool allows know the highest value, lowest value, sum of values and average values for each field. All this and more helps in obtaining sufficient information to develop the most appropriate design, and the ease and speed of conducting calculations helps in knowing the results of many possibilities and choosing the most appropriate ones.

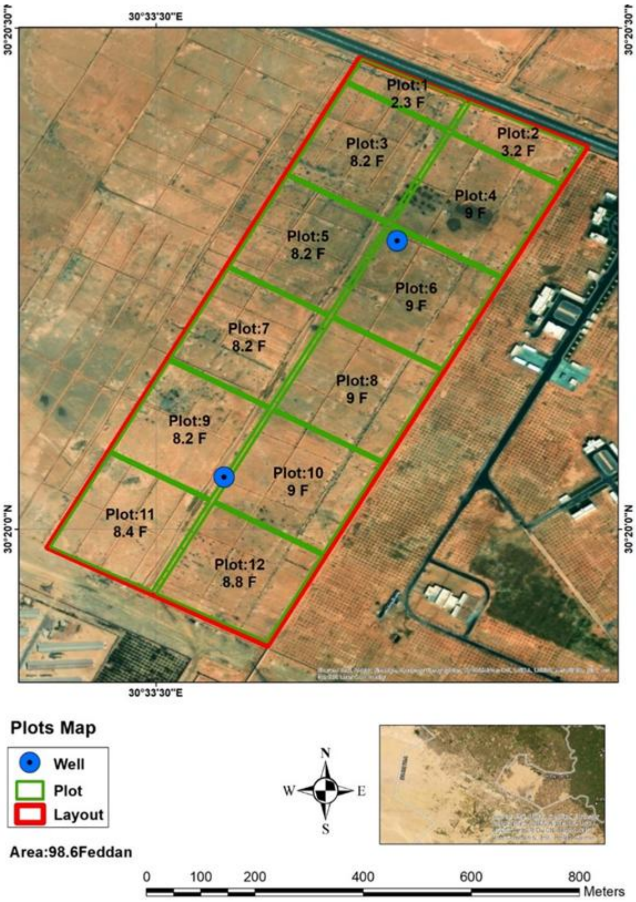

Fig. 13. The study area Farm at Sadat City divided into plots using ArcMap software.

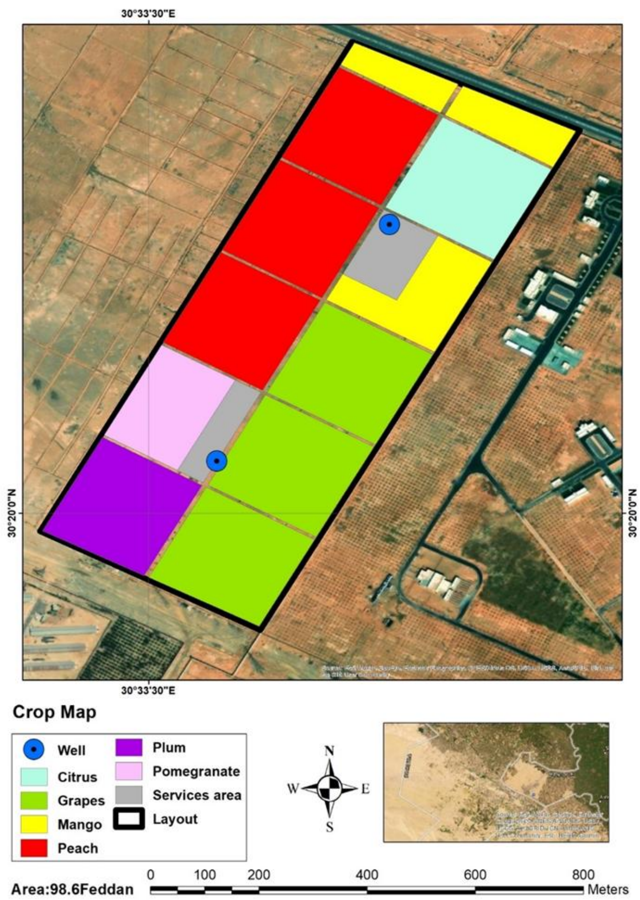

Fig. 14. Farm divided according to the types of crops for the study area at Sadat City using ArcMap Software

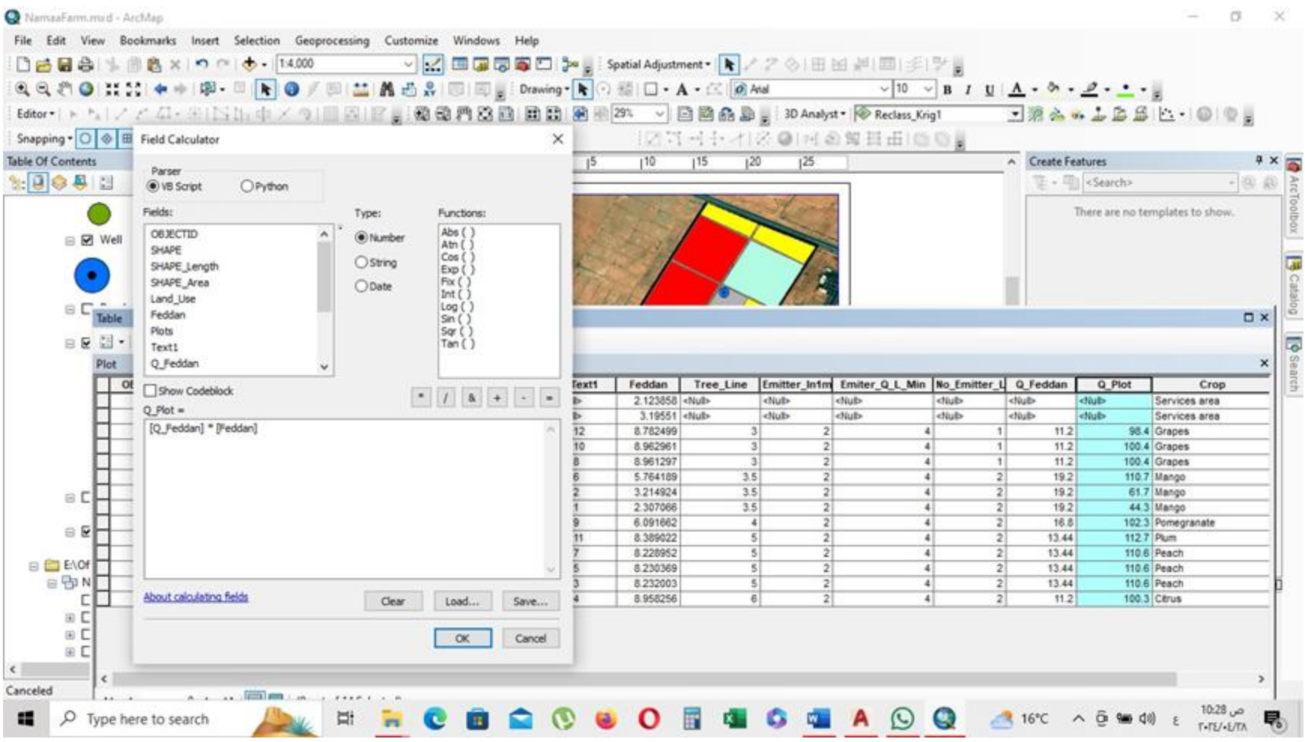

Fig. 15. How to use the database and software tools to calculate the flowrate of each plot.

3.4.3. Determine pump flow rate

From the above, it was found that the flow rate of the plots ranges between 99 to 112 m^3/h after combining plot 1 and 2 and considering them as one irrigation shift.

Accordingly, the required pump flow rate is 112 m^3/h as it is suitable for the flowrate of each well which is defined by 120 m^3/h.

4. Conclusions

The results show that the GIS maps are based on soil properties, most of the study area was suitable for cultivation, limiting in suitable area for surface irrigation system and increasing of suitable area for sprinkler and drip irrigation systems according to slope.

Also, most of the study areas were alkaline soil according to pH. The shift from surface irrigation to modern irrigation systems, e.g., sprinkler and drip irrigation systems, therefore, offers significant water-saving potential. Moreover, the main limiting factors in choosing the appropriate irrigation system in this area were slopes, SAR and electrical conductivity (EC) for soil.

Finally, from the results, some data can be entered on GIS (ArcMap 10.4.1software) and analyze this data using the software tools to extract soil maps, farm planning, calculate the different flowrate of farm plots, choose the appropriate pump flow rate, and prepare databases that help manage various irrigation systems.

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الاستفادة من نظم المعلومات الجغرافية (GIS) في تصميم شبكات الري

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الملخص العربي

الهدف الرئيسي لهذا العمل هو استخدام أدوات برنامج نظم المعلومات الجغرافية (ArcGIS) في تحديد نظم الري والمحاصيل المناسبة من خلال الاعتماد على تصميم خرائط التربة والخرائط الكنتورية وتخطيط المزرعة وحسابات التصرفات الرئيسية لحوش

مزرعة جديدة بمناطق الاستصلاح بمدينة السادات. وقد تم حصر أراضي منطقة الدراسة والتي تمتد لمساحة ٩٨,٦ فدان باستخدام ٦١ قطاع أرضى ممثل لمنطقة الدراسة والمشاكل السائدة بها. وخصائص التربة لمنطقة الدراسة تتمثل في العمق (طبقات قطاع التربة)، التوصيل الكهربي (EC)، درجة حموضة التربة (pH)، كربونات الكالسيوم، نسبة الصوديوم المدمص (SAR)، مناسيب وميول التربة. وبمجرد الانتهاء من تحليل وتقييم خصائص التربة، تم عمل مجموعة من الخرائط المناسبة لمنطقة الدراسة باستخدام برنامج ArcMap 10.4.1 ووجد من خلال الدراسة أن:

- منطقة الدراسة غير ملحية إلى متوسطة الملوحة (EC يتراوح بين ٠,٢ إلى ١١,٨٨ dS/m).
- التربة رملية: نسبة الطين (٤: ٥ %)، نسبة السلت (١: ٢٪) ونسبة الرمل (٨٩: ٩٦ %).
- درجة حموضة التربة (pH) يتراوح بين ٨,٠٣ – ١٠,١٢.
- نسبة الصوديوم المدمص (SAR) يتراوح بين ٠,٥٦ إلى أكبر من ١١,٩٤٪.
- وميول التربة تتراوح بين ٠,٠١٪ إلى ٤,٧٥٪.

ويتضح من النتائج السابقة ما يلي:

- ٩٩٪ من مساحة الدراسة صالحة للزراعة و١٪ من مساحة الدراسة غير صالحة للزراعة طبقا لملوحة التربة ونسبة الصوديوم المدمص .
- ٩٨٪ من المساحة الصالحة للزراعة يناسبها جميع نظم الري و٢٪ من المساحة الصالحة للزراعة يناسبها نظامي الري بالرش والري بالتنقيط طبقا لميول التربة.
- ٩١,٥٪ من مساحة الدراسة تعتبر أرض قلوية و٨,٢٥٪ تعتبر أرض متعادلة و٠,٢٥٪ تعتبر أرض حامضية وذلك طبقا لدرجة الحموضة (pH). إضافة إلى أن المياه المستخدمة في عملية الري هي مياه جوفية والتربة رملية، فإنه يفضل استخدام نظامي الري بالرش والتنقيط بدلا من الري السطحي. ومن ناحية أخرى، فإن من أهم العوامل التي تحد من استخدام نظم الري بمنطقة الدراسة (نوع التربة، كربونات الكالسيوم، والميول)، وملوحة التربة تحد من استخدام بعض المحاصيل. والخلاصة ان استخدام أدوات برنامج نظم المعلومات الجغرافية يمكن الاعتماد عليها في تحديد أنظمة الري والمحاصيل المناسبة وحسابات التصرفات وأوضاع الري المختلفة وإعداد قاعدة بيانات تستخدم في نظم الري الذكية.