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Land Information Database for the Optimum Use of the Newly Reclaimed Soils

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ABSTRACT

The main objective of the current research is to establish a digital database for the land resources in new reclaimed soils. This database could be used for optimum management of cultivated land and then sustainable agriculture could be achieved. Located to the west of the Nile Delta El Bustan Extension Area was selected for this study. To fulfill the objective of the current work remote sensing and GIS were employed. The Landsat-8 image of the year 2014 was used to map the land use/ land cover (LU/LC) and the thematic maps of roads, canals and drainage network of the investigated area. The Shuttle Radar Topography Mission (SRTM) data was used to generate the Digital Elevation Model (DEM) which has a great importance in irrigation issue. Field survey has been done to describe the morphological features of the area and collect soil samples. Laboratory work was completed to extract the physical and chemical properties of the investigated soils. The data collected from field work and lab analyses were stored in the established database and linked with their relevant geographic locations. The results indicate that the main LU/LC over the area includes cultivated land, degraded land, arable land and water logged areas. The surface elevation differs from 5 m below sea level to 64 m above sea level. Total length of roads, canals and drainage are 457.71, 235.9 and 2.3 respectively.

Key words: GIS, Remote sensing, Land, El Bustan area, Egypt

Introduction

Today there is excessive request for accurate soil information over large areas from environmental researchers and land use planners as well as more traditional agricultural users of soil resource inventories. All these users want interpreted information; that is, soil properties directly relevant to their application (Gad and Ali, 2011). The soil information so generated was interpreted for various purposes like land capability classification, crop suitability studies, management of watersheds and prioritization of watersheds (Rossiter, 2005 and Ali, 2008).

In recent years thematic mapping has undergone a revolution as the result of advances in geographic information science and remote sensing. For soil mapping archived data is often sufficient and this is available at low cost. Green (1992) stated that integration of Remote Sensing within a GIS database can decrease the cost, reduce the time and increase the detailed information gathered for soil survey. Particularly, the use of Digital Elevation Model (DEM) is important to derive landscape attributes that are utilized in land forms characterization (Brough, 1986 and Dobos, 2000). A DEM is an electronic model of the Earth's surface that can be stored and manipulated in a computer (Brough, 1986). It provides greater functionalities than the qualitative and nominal characterization of topography. A DEM can be manipulated to provide many kinds of data that can assist the soil surveyor in mapping and giving a quantitative description of landforms and of soil variabilities. By itself the DEM can yield maps of slopes, aspects, rate of change of slope, drainage network on catchments areas (Brabyn, 1997). Information derived from a DEM, such as elevation, slope and aspect maps can also be used with the images to improve their capabilities for soil mapping (Lee *et al*. 1997). The slope class maps produced from 10 m DEM appears to have great potential use for soil survey and land use planning (Hammer *et al*., 1995). With information on geology and surface deposits a DEM could be used to predict soil types, (Moore *et al*. 1992). The use of digital data sources, such as digital elevation models (DEMs) and satellite data can speed up the completion of digital soil databases and improve the overall quality, consistency and reliability of the database. Soil information is needed for a wide range of environmental and agricultural applications (Dobos and Montanarella, 2007). Knowledge of soils, combined with climatic and ecological data, is essential for understanding recent and future changes in ecosystems. The principal manifestation is soil resource assessment using geographic information systems (GIS), i.e., the production of digital soil property and class maps with the constraint of limited relatively expensive fieldwork and subsequent laboratory analysis (McBratney *et al.*, 2003 and Ali *et al*. 2007).

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In this research paper remote sensing data and GIS techniques were used to establish a land resources database of El Bustan Extension Area as one of the newly reclaimed areas located to the west of Nile Delta, Egypt.

Material and Methods

Study area:

El Bustan Extension Area (Fig. 1) is one of the Newlands located to the west of Nile Delta, Egypt that targeted to the reclamation processed by the year 1990 (IFAD, 1992).The area is bounded by latitude 30º 26´ & 30º 39´ N and longitude 30º 80´ 30" & 30º 27´ E, occupying about 341 km2. According to FAO climatic database produced in (1993) the study area is characterized by a Mediterranean climate and could be considered semiarid with very low precipitation (35 mm) occurred during winter season (October - March). Temperatures are high during summer months and relatively low in the winter. The hottest and the coldest months are August (35°C) and January (8°C), respectively, while relative humidity averages 73.5%. Two main landforms dominate the area; the relatively low altitude undulating coarse sand sheets, and sandy plain sediments of the deltaic stage of river Nile (Sadek, 1993). The geological deposits represent the Pliocene, Holocene, and Pleistocene eras (Said, 1990).

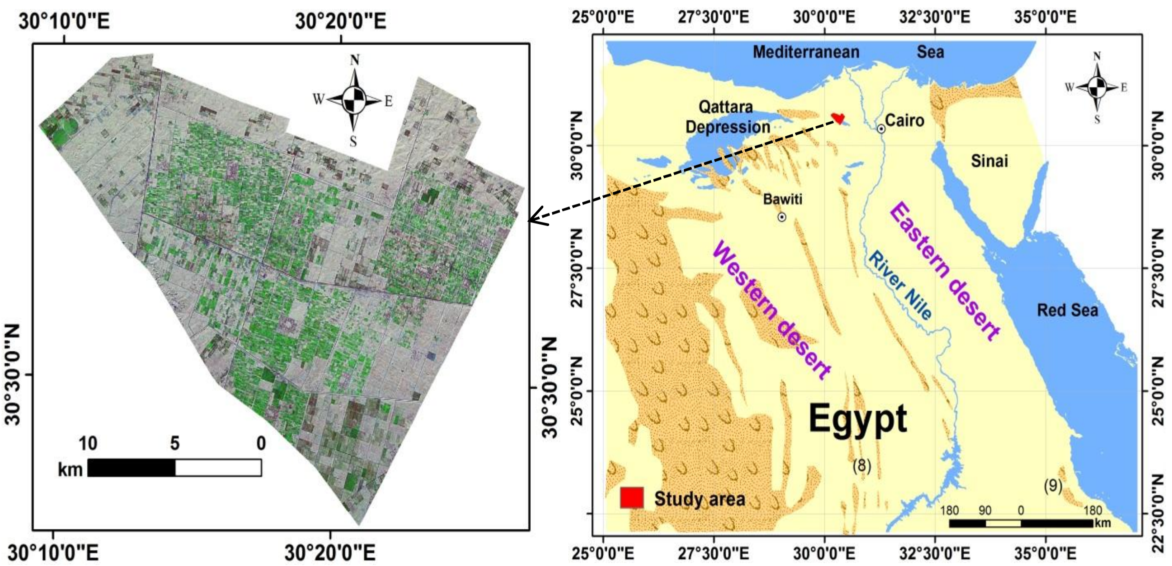

Fig. 1: Location of the study area on Egypt map (right), and as appear on Landsat-8 image of the year 2014 (left)

Remote sensing data:

Landsat-8 image (path 177/ row 39) acquired during the year 2014 was calibrated to radiance using the inputs of image type, acquisition date and time. The image is stretched using linear 2%, smoothly filtered, and their histograms are matched according to Lillesand and Kiefer (2007). The atmospheric, radiometric and geometric corrections were done according to ITT (2009) by using ENVI 4.7 software. Land use/ Land cover (LU/LC) map of the study area was produced through the supervised classification following the maximum likelihood algorithm. The Shuttle Radar Topography Mission (SRTM) is one of the most significant space surveys of earth ever undertaken, using precisely positioned radar to map its surface at intervals of 1-arc seconds (~30 meters). The SRTM data can be used in conjunction with controlled imagery sources to provide better visualization of the terrain. The digital elevation Model of the area was extracted from SRTM data Using ENVI 4.7 software.

Field work and laboratory analyses:

Field work is carried out throughout the investigated farm in order to gain an appreciation on soil patterns, and collecting soil samples. A total of 15 soil profiles were observed using the guidelines of FAO (2006). Representative disturbed soil samples were selected and prepared for laboratory analyses using the soil survey laboratory methods (USDA, 2004).

Establishing land information database:

The data extracted from satellite images; land survey and laboratory analyses were linked with their relevant geographic locations using Arc-GIS 9.2 software.

Results and Discussion

Land use / Land cover map

The land use and land cover over the study area is represented in Figure 2. The obtained data reveal that the area is dominated by four type of LU/LC including cultivation, degraded land, arable land and water-logging areas. Data illustrated in Table 1 indicate that the cultivated areas cover 9.74% of the investigated area i.e. 33.20 km^2, while the arable lands (high capable for cultivation) represents 62.79% of the total area i.e. 214.10 km^2. Degraded land and water-logging areas represents 25.57 and 1.91% respectively. This indicated that the area have a high potential for reclamation processes.

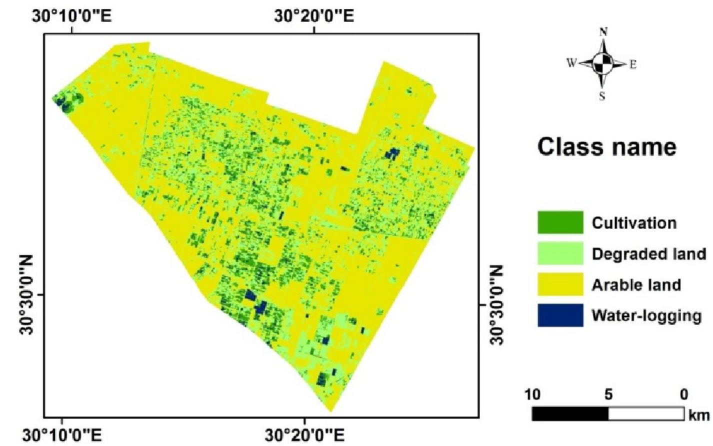

Fig. 2: The Land Use/ Land Cover of El Bustan Extension Area

Table 1: Areas of Land Use/ Land Cover of El Bustan Extension Area

Class	Area (km^2)	Area (%)
Cultivation	33.20	9.74
Degraded land	87.20	25.57
Arable land	214.10	62.79
Water-logging	6.50	1.91
Total	341.00	100.00

Surface features

The Digital Elevation Model (DEM) of the area was generated from the SRTM data; the surface elevation and slope direction were mapped and presented in Figures 3 and 4. The obtained data revel that the surface elevation ranges between 5 m below sea level and 64 m above sea level. Highest surfaces attribute the south parts of the area, while the lowest parts are random patches characterizes the north of the area. The slope direction map show that the area is flat except some parts that have a north and south directions on the other hand the rest of slope direction attribute very small areas. These data have a great importance when planning for establishing irrigation canals and drainage network.

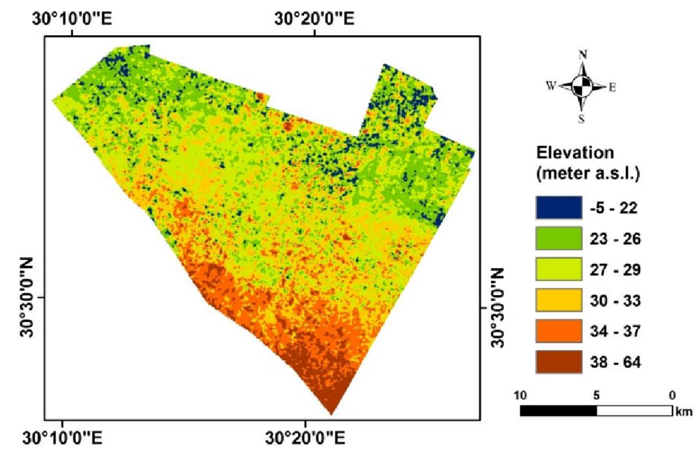

Fig. 3: Surface elevation of El Bustan Extension Area.

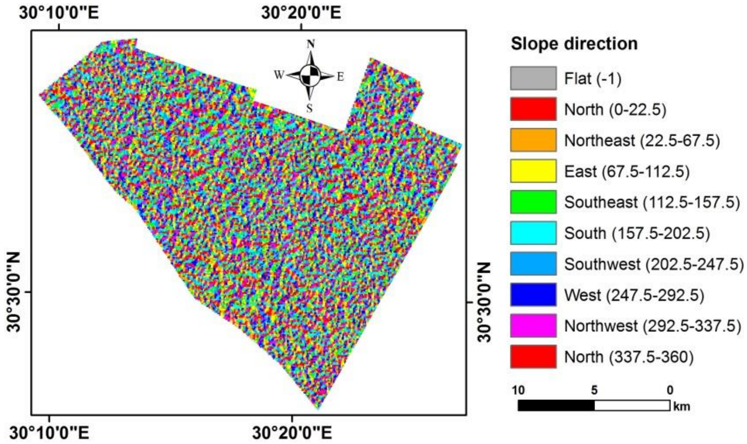

Fig. 4: Slope direction of El Bustan Extension Area.

Irrigation canals and drainage network

Figure 5 represent the irrigation canals and drainage network over El Bustan Extension Area. The given data indicate that there unbalance between the total lengths of canals and drainage, where the total length of canals reaches 235.9 km while the drainage total length is equal to 2.3 (Table 2). This could explain the evidence of water logged areas in spite of the sandy soil texture.

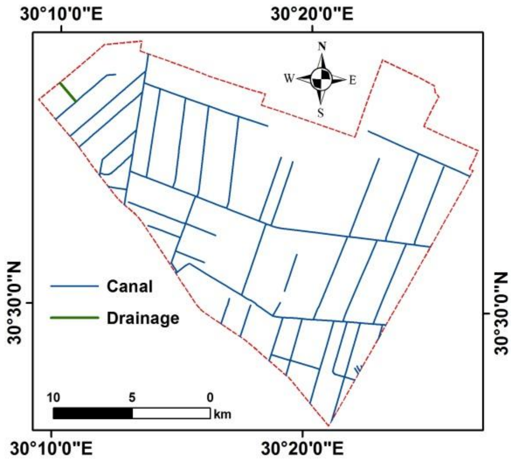

Fig. 5: Irrigation canals and drainage network of El Bustan Extension Area

Table 2: Total length of irrigation canals and drainage network

Canal	Length (km)
Irrigation	235.9
Drainage	2.3

Roads network

Roads network in El Bustan Extension Area is presented in Figure 6, while the total lengths of road types are illustrated in Table 3. The data indicated that the area is supported by a good road network reached to 457.71 km. the roads in the area were divided to three types i.e. main roads (99.74 km), non-paved roads (128.35 km) and tracks (229.62 km). The roads networks are sufficient to link this are to the main cities in Egypt.

Soils

General characteristics of the soils in El Bustan area are illustrated in Table 4. The given data reveal that the micro relief (R) differs from flat to undulating while the surface elevation (E) of the sampled sites located in the range 21 - 32 m above sea level. The soil depth (D) of the investigated sites differs from 90 to 150 cm. Aeolian deposits is the main parent material (PM) in the area. Percent of native vegetation (V) cover differ from 5 - 22%. Natural drainage is poor to good depending on the effective soil depth. The soils are classified as Typic Torripsamments and Typic Quartizipsamments. The main soil properties confirming that the soils are characterized by low quality and low productivity is expected. The area requires more attention in land use planning where the poor soil fertility, various surface elevation and poor drainage should be considered.

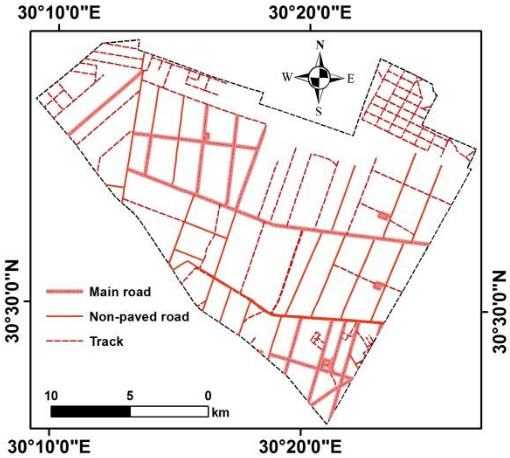

Fig. 6: Roads network in El Bustan Extension Area.

Table 3: Lengths of roads network in El Bustan Extension Area

Road type	Length (km)
Main roads	99.74
Non-paved	128.35
Track	229.62
Total	457.71

Table 4: general characteristics of the soils in El Bustan Extension Area

Site No.	Longitude	Latitude	R	E	PM	D	V	Dr	Soil classification
1	30.3199	30.4967	Flat	27	Aeolian	120	11	Good	Typic Torripsamments
2	30.3202	30.4967	Flat	28	Aeolian	100	10	Poor	Typic Torripsamments
3	30.3139	30.4969	Undulating	28	Aeolian	100	12	Poor	Typic Torripsamments
4	30.3142	30.4971	Flat	32	Aeolian	90	14	Poor	Typic Torripsamments
5	30.3150	30.4972	Flat	21	Aeolian	90	14	Poor	Typic Torripsamments
6	30.3187	30.5038	Undulating	30	Aeolian	90	16	Poor	Typic Torripsamments
7	30.3190	30.5033	Undulating	31	Aeolian	110	9	Good	Typic Torripsamments
8	30.3177	30.5000	Flat	27	Aeolian	120	8	Good	Typic Torripsamments
9	30.3178	30.4994	Flat	28	Aeolian	150	10	Good	Typic Torripsamments
10	30.3197	30.4989	Undulating	29	Aeolian	140	10	Good	Typic Torripsamments
11	30.3196	30.4991	Undulating	29	Aeolian	130	5	Good	Typic Quartizipsamments
12	30.3230	30.4972	Flat	31	Aeolian	120	5	Good	Typic Quartizipsamments
13	30.3219	30.4987	Flat	30	Aeolian	100	19	Poor	Typic Quartizipsamments
14	30.3218	30.4989	Undulating	30	Aeolian	100	22	Poor	Typic Quartizipsamments
15	30.3224	30.4995	Undulating	31	Aeolian	110	5	Good	Typic Quartizipsamments

Conclusion:

The results of this work are of great importance as they represent the soil productivity constraints of all over the region. This is mostly important when planning for optimal land uses, also it benefits the existing land users in determining the most appropriate management practices. The digital database allows policy makers, planners and experts to overcome some of the shortfalls of data availability. It also facilitates the integration of the data in internal and external network, this can realize by a systematic manner of the digital database. The incorporation of the obtained data from different resources can be achieved to fulfill the sustainable development requirements.

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