Digital Geopedological Mapping of Some Study Areas in Western Desert, Egypt

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Abstract: Updated soil surveys are considered quite helpful for planning, developing monitoring and for the sustainable management of the limited agricultural soils available. Information about soil properties and behavior over tracts of land is vital for making decisions on proper land use and management, environmental protection, and land use planning. This has been the motivation for systematic soil surveys, soil survey interpretations, and maps of soil properties required by empirical or process models. Egypt has directed major efforts to explore the natural resources in the Western Desert Oases. Thus, storing data files in a digital geographically correlated format is considered of prime importance for the successful management of the natural resources in the study area of Bahariya oasis and for a better land use planning. Some previous studies were done on it, but they have not been integrated or applied by the decision makers. One of the main aims of this study is to identify, characterize and map the major soils in the study area(s) following a geopedologic approach. Therefore, all mapping units were digitized in vector mode, and then those digitized maps were loaded into ArcView GIS system for the followed geo-reference spatial analysis. In this research, based on US Soil Taxonomy and the manifested information about morphological features together with the relevant soil properties, soils of the studied areas fit into two main orders: Entisols and Aridisols and nine taxonomic units (at sub group level) were identified. Nevertheless, the relation between the different soils taxonomic and the physiographic mapping units for each area is obviously occurred. [Journal of American Science 2010;6(9):23-29]. (ISSN: 1545-1003).

Keywords: physiographic maps, GIS, geomorphologic approach, geopedologic approach.

1. Introduction

In recent years thematic mapping has undergone a revolution as the result of advances in geographic information science and remote sensing. Soil survey, or more properly, soil resource inventory, is the process of determining the pattern of the soil cover, characterising it, and presenting it in understandable and interpretable form to various users (Dent & Young, 1981).

It is thus a kind of thematic mapping. Despite the increasing demand for interpreted soils information, soil mapping has not fully shared in this revolution. This is mostly due to the complexity of soil geography and the hidden nature of the soil: it is a three-dimensional body, which also varies in time, which we only observe at widely spaced sampling points, and almost always only at one point in time. An added problem is the high cost of field sampling and laboratory analysis.

The soil resource is important for most land evaluation and decision making systems. In fact, land evaluation originated with soil surveyors' desire to make their surveys useful to land users.

The modern name for soil survey is soil resource inventory (avoids the confusion with 'survey' meaning cadastral survey). The soil resource is important for most land evaluation and decision making systems. In fact, land evaluation originated with soil surveyors' desire to make their surveys useful to land users.

The practical purpose of soil survey is to enable more numerous, more accurate and more useful predictions to be made for specific purposes than could have been made otherwise [i.e., in the absence of location-specific information about soils]. To achieve this purpose, it is necessary to:

1. determine the pattern of the soil cover; and to
2. divide this pattern into relatively homogeneous units; to
3. map the distribution of these units, so enabling the soil properties over any area to be predicted; and to
4. Characterize the mapped units in such a way that useful statements can be made about their land use potential and response to changes in management." (punctuation and emphasis is mine) (Dent & Young, 1981).

It is worth to mention, that with the great explosion in computation and information technology has come vast amounts of data and tools in all fields of endeavor. Soil science is no exception, with the ongoing creation of regional, national, continental and worldwide databases. The challenge of understanding these large stores of data has led to the development of new tools in the field of statistics and spawned new areas such as data mining and machine learning (Hastie et al., 2001).

In addition to this, in soil science, the increasing power of tools such as geographic information systems (GIS), GPS, remote and proximal sensors and data sources such as those provided by digital elevation models (DEMs) are suggesting new ways forward. Fortuitously, this comes at a time when there is a global clamour for soil data and information for environmental monitoring and modelling.

Consequently, worldwide, organizations are investigating the possibility of applying the new spanners and screwdrivers of information technology and science to the old engine of soil survey. 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.

The production of digital soil maps ab initio, as opposed to digitized (existing) soil maps, is moving inexorably from the research phase (Skidmore et al., 1991; Favrot and Lagacherie, 1993; Moore et al., 1993) to production of maps for regions and catchments and whole countries. The map of the Murray– Darling basin of Australia (Bui and Moran, 2001, 2003) comprising some 19 million 250_250 m pixels or cells and the digital Soil Map of Hungary (Dobos et al., 2000) are the most notable examples to date.

Geographic database techniques offer powerful capabilities to manage and integrate vast amounts of environmental data (Zölitz-Möller *et al.*, 1993). GIS, a tool for collating all kinds of spatial information (Burrough and McDonnell, 1998), in it self is incapable of soil mapping; it requires an intellectual framework. Remote and proximal active and passive sensing gives detailed information on the soil themselves—these reflections or emissions or transmissions are intrinsic properties of the soil material and profile they may indicate other soil attributes like texture or mineralogy. This factor is likely to becoming increasingly important as technology advances.

The Bahariya depression is a natural excavation in the central part of the Egyptian Western Desert, some 130km west of El-Minia governorate in the Nile valley and about 360km S-W of Cairo. It situated essentially between 27º 48´ and 28º 30´ N, and 28º 29´ and 29º 08´ E. It comprises an area of approximately 2250 km^2 (Figure, 1). (Salem, 1987).

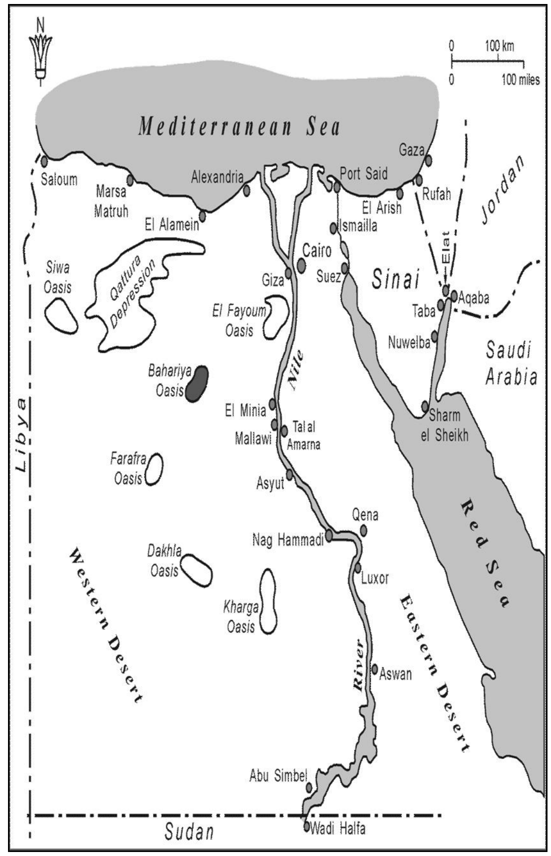

Figure 1. Location of Bahariya Oasis (IDSC, 2000).

It is obvious that land use planning has to be adapted **(Darwish, 2004).** Storing data files in a digital geographically correlated format is considered of prime importance for the successful management of the natural resources **(Maitra, 2001).** This study clearly shows that the Geographic Information System (GIS) constitutes an efficient and versatile tool to manipulate and produce physiographic maps of the selected plot areas within Bahariya depression that are needed for decision system.

One of the main aims of this study is to produce physiographic and geo-pedologic soil maps of the selected study areas. These maps were used as the basic geo-referenced documentations for the land evaluation decision support system.

In this research, ArcGIS 9.3 system is used as the main tool to perform the geo-pedological soil maps of the study areas in Bahariya Oasis.

2. Material and Methods

Interpretation of aerial photographs taken at different intervals provides valuable information of physical features such as land use, soils, vegetation, stream networks, and landforms at different time scales (Burrough and McDonnell, 1998).

In this research, two study areas were selected. One in the Northern part of Bahariya (plot area-1), which is covering most of the villages located there, i.e., (El-Bawiti, El-Qasr, Zabu, Mandisha and El-Ayun).

The second located in the southern part of Bahariya (plot areas 2 & 3), where (El-Heiz, Aiwon Tahblamon and El-Heiz El-Bahary) villages are situated there (Figure, 2).

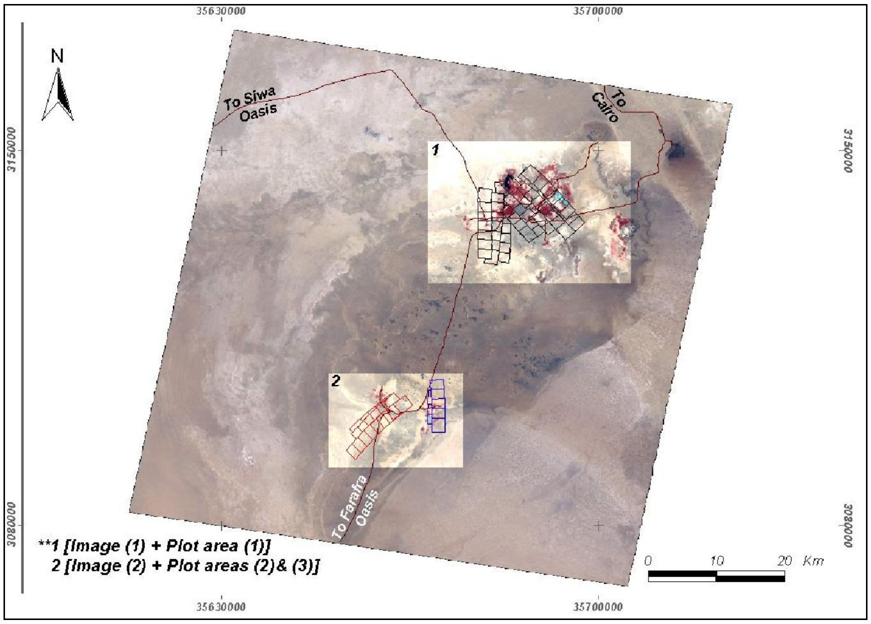

Figure 2. Two study areas are selected in the North and South of the oasis (Darwish, 2004).

Based on the digitized aerial photo interpretation, the field check and the ground truth information of the plot study areas of Bahariya Oasis, the workable physiographic legend was formulated. Furthermore, according to the pre-field interpretation, six sample areas were chosen. These sample areas were selected within the plot areas, so that they cut across the different mapping units in the area.

Forty-five soil profiles were examined in different locations in the selected sample areas covering all physiographic map units available. In addition, number of auger observations was drilled to stand on the validity and accuracy of the mapping boundaries, the exact locations of the soil profiles and auger observation points were precisely defined in the field by using the GPS. Detailed morphological description were recorded for each of the studied soil profiles, on the bases outlined by FAO guideline for soil profile description (2006) and classified according to USDA Soil Taxonomy (2006) and USDA Field book (2004).

In addition to the previous field work, the ground truth locations were visited to interview farmers and collect data.

3. Results

In this research, based on **US Soil Taxonomy (2006)** and the manifested information about morphological features together with the relevant soil properties of the three plot study areas in Bahraiya, nine taxonomic units (at sub group level) were identified and given in Table 1.

The correspondence FAO classification (FAO-Unesco, soil map of the world, 1990) (up to the soil unit level) was done and given as well.

In the soils of Bahariya Oasis, the dominant soil moisture regimes are Torric and Aquic with Thermic soil temperature regime. In this research, the occurred diagnostic horizons in the studied area are salic and calcic. Therefore, two suborders within Aridisols order are recognized; Calciorthids and Salorthids (Figures, 3 and 4).

It is note worthy to mention that, the relation between the different soils taxonomic and the physiographic mapping units for each area is obviously occurred. The present geo-pedagogical study, which is based on aerial photo interpretation, field observation and analytical data, is demonstrated here.

Table 1. The soil taxonomic classification of the study area(s)*.

	US Soil Taxonomy				FAO classification
	Order	Suborder	Great group	Subgroup	
1	Entisols	Psamments	Torripsamments	Typic Torripsamments	Haplic, Ferralic, Albic, Calcaric Arenosols (Qh, Qf, Qa, Qc)
2				Lithic Torripsamments	Calcaric Lithosols (Ic)
3		Aquents	Pasmmaquents	Typic Pasmmaquents	Eutric Gleysols (Ge)
4		Fluvents	Torrifluvents	Typic Torrifluvents	Eutric or Calcaric Fluvisols (Je or Jc)
5				Vertic Torrifluvents	Eutric Fluvisols (Je)
6		Orthents	Torriorthents	Typic Torriorthents	Eutric or Calcaric Regosols (Re or Rc) or Calcaric Lithosols (Ic)
7				Lithic Torriorthents	Eutric Lithosols (Ie)
8	Aridisols	Othids	Salorthids	Typic Salorthids	Orthic or Gleyic Solonchaks (Zo or Zg)
9			Calciorthids	Typic Calciorthids	Haplic Xerosols (Xh)

* (Source: Darwish, 2004).

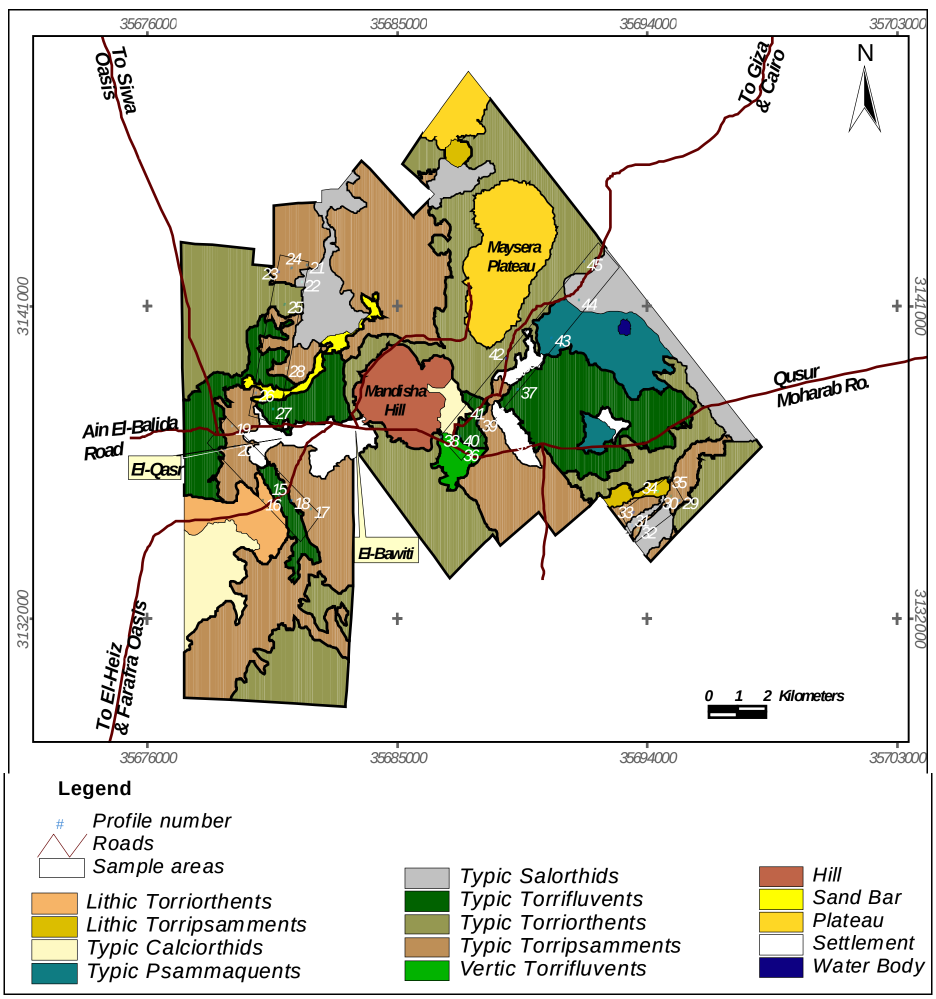

Figure 3. The geo-pedological soil map of plot area 1 in the Northern part of Bahariya depression (Darwish, 2004)

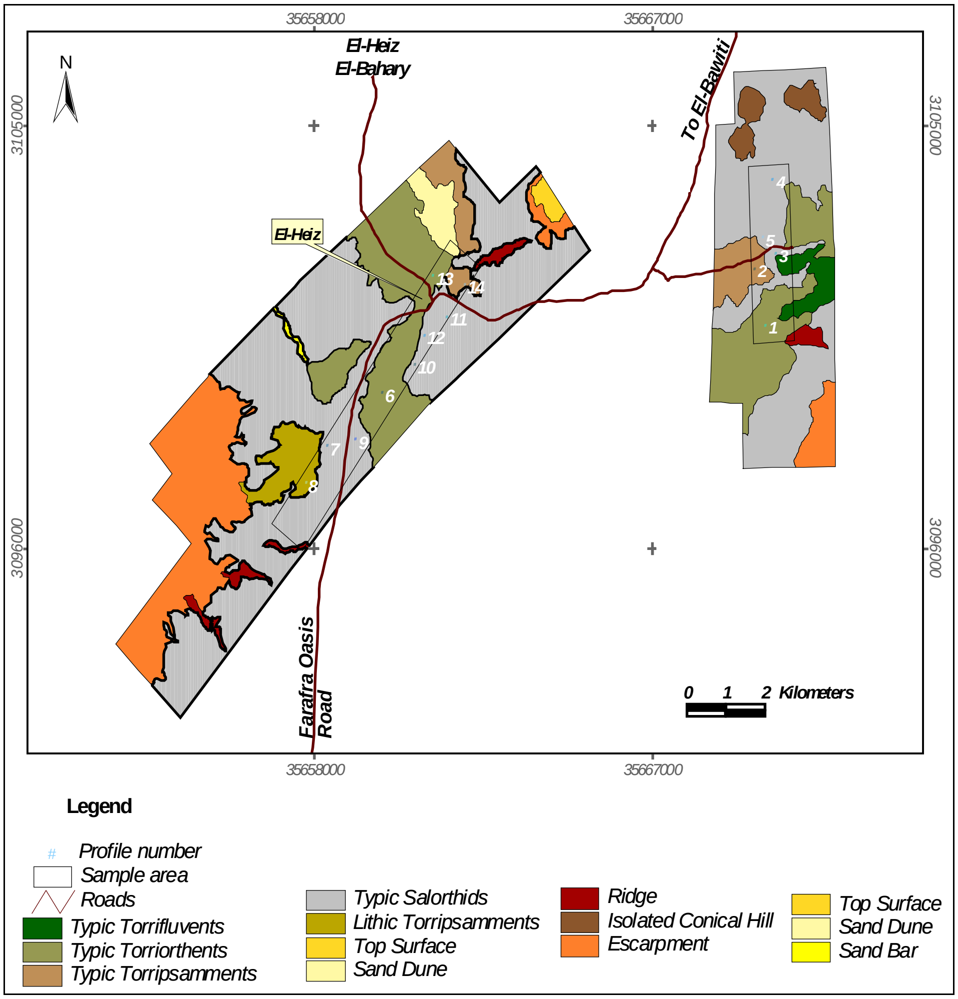

Figure 4. The geo-pedological soil map of plot areas (2) and (3) in the Southern part of Bahariya depression (Darwish, 2004).

3.1 Geopedology approach

Considering the criteria mentioned, in the US Soil Taxonomy classification (Soil Survey Staff, 2006), soils of the studied areas can fit into two main orders; namely Entisols and Aridisols.

As the soil moisture regime is torric and soil temperature regime is warmer than cryic, these soils are classified as Torrifluvents at the great group level. Since these soils do not have cracks at any period in most years, do not have 35% or more clay, do not have Anthropic Epipedon, they can be placed in the Typic Torrifluvents at the sub group level.

Concerning the soils belonging to the order Aridisols, they are soils that have one or more of the following diagnostic horizons, salic, calcic, petrocalcic, gypsic, petrogypsic, nitric and/or duripan that may be formed in the present environments or that may be relicts from a former pluvial period. They are usually dry between 18 and 50 cm depth, or a lithic or paralithic contact shallower than 50 cm. As the soils belonging to this order do not have an Argillic horizon, they are classified as Orthids at the sub order level. Two great soil groups are recognized in the Orthids sub order; Salorthids and Calciorthids. They placed in the Typic Salorthids and Typic Calciorthids sub-groups.

In this research, the occurred diagnostic horizons in the studied area are salic and calcic. Therefore, two suborders within Aridisols order are recognized; Calciorthids and Salorthids.

3.2 Soil classification

Traditional landform classification is based on qualitative description from surface shape. Automated classification of the landform from quantitative digital terrain models is the ultimate desire. Land cover classification is one of the principal motivations and successes of satellite remote sensing. This classification is obtained by supervised classification from some ground-control points. The interest for digital soil mappers is to detect areas of bare soil, or of particular crops representing where humans have picked out soil with particular qualities.

In the soils of Bahariya Oasis, the dominant soil moisture regimes are Torric and Aquic with Thermic soil temperature regime. The soils presented by profiles (2, 8, 14, 17, 18, 19, 20, 21, 23, 24, 26, 28, 29, 30, 32, 33 and 39) are mineral soils without any diagnostic horizons, they have below a depth of 25 cm a sandy particle size class in all sub-horizons, to a depth of 1 m; have a Torric soil moisture regime; these soils could be classified as Typic Torripsamments.

The soils presented by profiles (8 and 34) are similar to the abovementioned Typic Torripsamments, except they have a lithic contact within 50 cm of the surface; these soils could be classified as Lithic Torripsamments.

The soils presented by profile (43) have an Aquic soil moisture regime. They are mineral soils without any diagnostic horizons; they have below a depth of 25 cm a sandy particle class in all sub-horizons to a depth of 1 meter, they could be classified as Typic Psammaquents.

The soils presented by profiles (15, 27, 37 and 40) are mineral soils without any diagnostic horizons, they have below a depth of 25 cm a texture of loamy, very fine sand or finer in some sub-horizons, don't have a lithic contact within 50 cm of the surface, these soils could be classified as Typic Torrifluvents.

The soils presented by profile (36) are similar to the above mentioned Typic Torrifluvents, except they have >35% clay in all sub-horizons, these soils could be classified as Vertic Torrifluvents.

The soils presented by profiles (1, 6, 13, 25, 35, 38, 42 and 45) are mineral soils without any diagnostic horizons, they have below a depth of 25 cm a particle size class that is loamy or finer in some horizons or have a sandy skeletal particle size class, and have a low holding capacity and Torric moisture regime, these soils could be classified as Typic Torriorthents.

The soils presented by profile (16) are like the Typic Torriorthents, except they have a lithic contact within 50 cm of the surface, these soils could be classified as Lithic Torriorthents.

The soils presented by profiles (3, 4, 5, 9, 10, 11, 12, 22, 31 and 44) are mineral soils that have a salic horizon, whose upper boundary is within 75 cm of the soil surface. These soils can be considered as Typic salorthids.

The soils presented by profiles (41) are mineral soils that have a calcic horizon, whose upper boundary is within 1 m of the soil surface. These soils can be considered as Typic Calciorthids.

4. Conclusion

In this study, the above mentioned approach it is been introduced and reviewed beside the soil data acquisition and proposed a methodology for producing digital soil maps in the study area of Bahariya.

The data obtained from soil survey indicates that except for the shallow soils of the plateau (Pu211 and Pu212), and some places of the peneplain (Pe211 and Pe312) with high amounts of gravels and the surface salinity in some patches there are not other soil-related limiting factors. Soils are generally sandy, well to moderate-drained, non-alkaline and moderately-saline, with light to moderately texture, and low organic matter of about 1%, except in the lower attitude areas like the depressions and playa (Pa135) that suffer of soil salinity, which is normally associated with inadequate drainage conditions.

The information needed to carry out a land evaluation for land use planning can mainly be extracted from the geopedologic maps. Nevertheless, all of the hardware and software tools, technologies and knowledge, are in place to make this approach operation-able. This is clearly an exciting time for soil resource assessment.

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5/1/2010