

LIMITATIONS AND IMPLICATIONS FOR EGYPTIAN SOIL SPATIAL DATA INFRASTRUCTURE

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ABSTRACT

The land master plan (LMP) of Egypt was issued in 1986, as a joint cooperation between the Egyptian Government represented by Ministry of development, new communities and land reclamation; and kingdom of the Netherlands, represented by Ministry of foreign affairs - directorate general for international cooperation. Euroconsult-Pacer consultants carried out the activities, based on the results of check-surveys of the high dam soil survey (FAO, 1965), and new reconnaissance and semi-detailed soil studies performed by General Authority for Rehabilitation Projects and Agricultural Development (GARPAD) in 1985. The LMP included maps for land capability, land management categories and soil units, at scales 1:250,000 (reconnaissance) and 1:50,000 (semi-detailed). The present study aimed to create a Spatial Data Infrastructure (SDI) in Geographic Information System (GIS) environment, for West Nubaria region, using 3 adjacent maps. Each map sheet was digitized separately, and processed to create the topology. Attribute data associated with each polygon included soil unit, land capability class, and land management categories. Up to this point, no limitations were encountered in building-up separate geodatabase. Problems started to occur when creating a seamless coverage for the three map sheets. The first and most important limitation was the inconsistency among the polygons boundaries at the edge of two map sheets. This represented a serious outcome, since each of the polygons

had different attributes. Edge matching failed at this point. Different processing techniques were elaborated (union and merging), and each method resulted in a different output, depending on which map is chosen first for the processing. None of the above mentioned techniques produced a satisfactory result. Another encountered limitation was the discrepancy in the calculated acreage of each mapping unit between the report and the GIS database. This might be attributed to methodology employed in measuring the 1986's areas using the planimeter, and the error associated with these measurements. Moreover, land capability classes were incompatible with the results obtained using recent software. The main implications for these limitations are

- i) To apply the new techniques of Remote Sensing (RS) to map the different soil units, especially in vast desert and bare areas;**
- ii) To determine the location of soil observations by Global Positioning System (GPS); and**
- iii) To transfer all the gathered data into GIS environment for processing and manipulation.**

Keywords: Digital land master plan, GIS, Land Evaluation, Remote sensing, Spatial Data Infrastructure (SDI).

INTRODUCTION

Soil surveys, soil maps, spatial soil information systems, and soil geographic databases, are all designed for fulfilling the requirements and demands of society for characterizing soils, which increased dramatically in the last decades (Mermut and Eswaran, 2000). Traditional soil survey is time consuming and expensive, new conventional surveys in the near future are very unlike, consequently methods exploiting existing information are becoming increasingly important (Nachtergale and van Ranst, 2002). In the recent digital era, spatial soil information systems (SSISs) are playing a more and more important role in this context (Lagacherie and McBratney, 2004; Rossiter, 2004). A key issue of applicability of SSISs is their accuracy. Essentially, the main practical aim of soil surveys and soil

maps is prediction of soil attributes (Leenhardt et al., 1994). It simply means that certain soil feature is estimated for a whole region based on available soil data collected at localized sample points.

The traditional tool of this information extension is the classical soil map using soil mapping units. Crisp soil maps subdivide the region into disjunctive units in a way that within heterogeneity of soil properties is less than for the whole territory (Beckett and Webster, 1971). Numerous novel methods have been developed for producing more accurate soil maps; traditional crisp soil maps however are still extensively applied, since they offer the most easily interpretable results for the majority of users (Leenhardt et al., 1994). On the other hand accuracy of crisp soil maps can be increased in several ways: with the refinement of soil contours; with the subdivision of mapping units taking into consideration smaller unit within patch heterogeneities; and with the refinement of attribute information (more recent data, more precise measurement, up-to-date methodology, more appropriate classification etc.).

Digital soil mapping (DSM) integrates the recent developments in numerical soil mapping techniques with the knowledge on soil cover which has been accumulated by soil surveyors. A body of research work in geographical information science heralds the evolution from classical raster or vector GIS tools limited to the collection and storage of all kinds of spatial data, to more sophisticated systems able to represent more complex spatial models, and to embed spatial reasoning procedures such as inductive learning, or hierarchical reasoning. The development of DSM methods has been a growing activity for the past decades. DSM with the computational power integrated into modernized GIS packages provides new solutions for the improvement of SSISs (Pasztor and Szabo, 2006).

Remote Sensing (RS) can provide valuable and timely information about natural resources and environment, which are very important for sustainable developments. Geographic Information Systems (GIS) provide indispensable tools for decision-makers. Both RS and GIS techniques are considered very important geometric tools, which are fully utilized in the developed countries. However, in the developing countries, the utilization of such advanced technologies

differs from one country to another due to one or more of the following reasons; a) lack of tools and infrastructure, b) inadequate training, c) lack of coordination between aid agencies, d) too much emphasis on technology push rather than on application, e) restrictions and regulations, and f) lack of basic information and maps (Arafat 2003).

The benefits from using RS and GIS technology depend on the level of success of its application for solving a concrete task. In general, these benefits can be divided into four categories such as scientific, technological, methodological, and economic efficiency (Badarch, 1990). The scientific efficiency of remotely sensed data also includes obtaining new facts for corroboration and quantitative clarification of previously known, qualitatively studied data. Technological efficiency means increasing of the work productivity (mainly the most expensive field job), making norms for fieldwork and speeding up of natural resources mapping, reducing the fieldwork volume, shortening the time necessary for territorial surveys and reducing the number of personnel engaged in natural resources surveys. Methodological efficiency means increasing the accuracy and detail of spatial research of natural resources and also of observing widespread and dynamic processes and phenomena. Finally, economic efficiency of remote sensing data applications to natural resources can be expressed both directly (in the reduction of the cost of mapping) and indirectly (by an increase in the quality, reliability, detail, and information of the results).

The integration of image data into GIS is one of those great ideas whose time has come. Furthermore, remote sensing is often the most cost-effective source of information for updating a GIS and it is a valuable source of current land use/land cover data. Remote sensing techniques has been utilized successfully in certain areas of application, including agriculture and related fields, especially in the developed countries where agricultural patterns are well defined and methodologies developed. The areas of applications in agriculture have been the identification or classification of crops, inventory of crop acreage, forecasting of crop yield, soil survey, design and operation of irrigation projects, and assessment of flood damage. Soil has an easily distinguishable characteristic reflectance pattern in the

visible, near-infrared and mid-infrared wavelengths. The characteristic of soil reflectance pattern is easily distinguishable from green vegetation. Economic efficiency of remote sensing data applications can be expressed both directly as reduction of the cost and indirectly by an increase in the quality, reliability, and details of information. Remotely sensed data, when complemented by existing and supporting GIS, could improve management decision in agriculture for the next millennium (Syam, and Jusoff 1999).

MATERIALS AND METHODS

Datasets

Soil maps from land master plan:

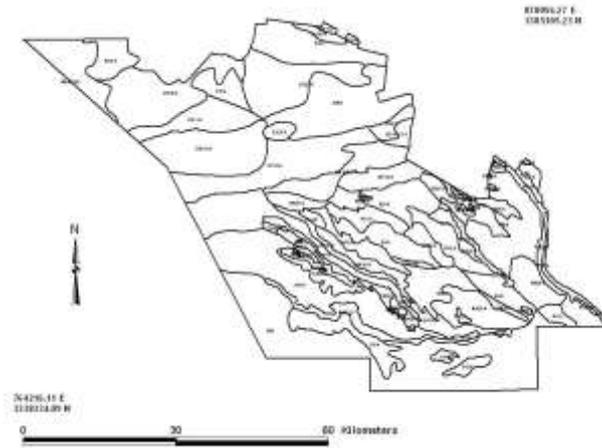
Three soil units map sheets were used in this study to characterize the soil of West Nubaria region at scale 1:250000. The first one (the right) was covered by 2 seamless sheets having 22 soil units (map, 1 and table, 1) which describe each soil units and its area measured by land master plan team. The second soil units map (the left) describes the soil units and their areas (map, 2 and table, 2).

Satellite image:

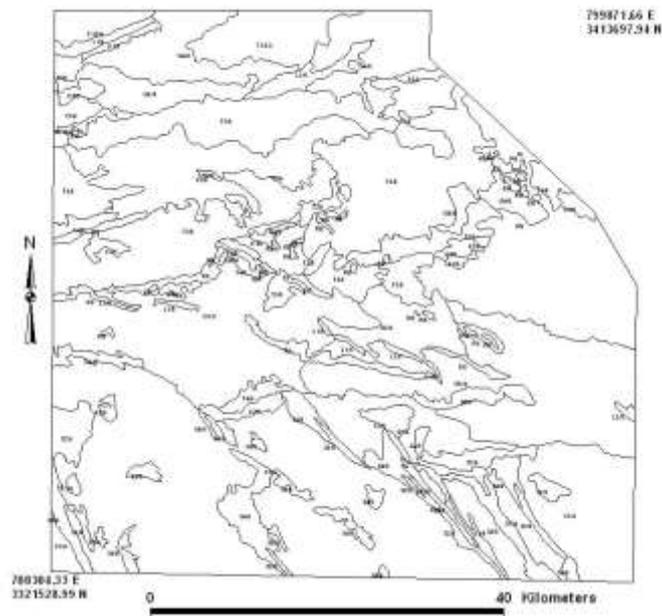
Landsat MSS satellite image acquired in May 1985 (path176 and raw 38) was geometrically corrected (RMSE of 0.31) to match the same coordinates of the land master plan maps. The image was visually enhancement applying liner stretch histogram manipulation (Research Systems Inc., 2003).

GIS Data input:

The three LMP map sheets (soil units) were digitized and georeferenced in UTM using TerraSoft GIS software (Digital Resource System, 1991) having Helemert 1906 ellipsoid, and old Egyptian 1906 horizontal datum. The edges between map sheets were matched to form a seamless datasets, and then merged into one map sheet.



Map (1): Soil units of the right map of the study area.



Map (2): Soil units of the left maps of the study area.

RESULTS AND DISCUSSION

Area inconsistency:

GIS data showed that there are area differences in soil units which were calculated from the LMP maps with those measured by GIS. These differences resulted from the method of measuring the area in 1985, which depends on field and manual datasets and now which depends on satellite images and GIS. The planimeter is less accurate than those of GIS method, knowing that the error of digitizing is less than 0.003. Tables (1) and (2) indicate that some units had increased in their areas, while others were decreased, for both right and left soil units maps, respectively.

Minimum mappable areas:

Since the LMP maps were at 1:250,000 scale, so the minimum mappable area should at least 250 hectares. This condition was not met since, may small polygons were included, having areas less than that. To overcome this problem, the small polygons were combined into the larger polygons containing them. This was resulted in increasing the areas of those large polygons.

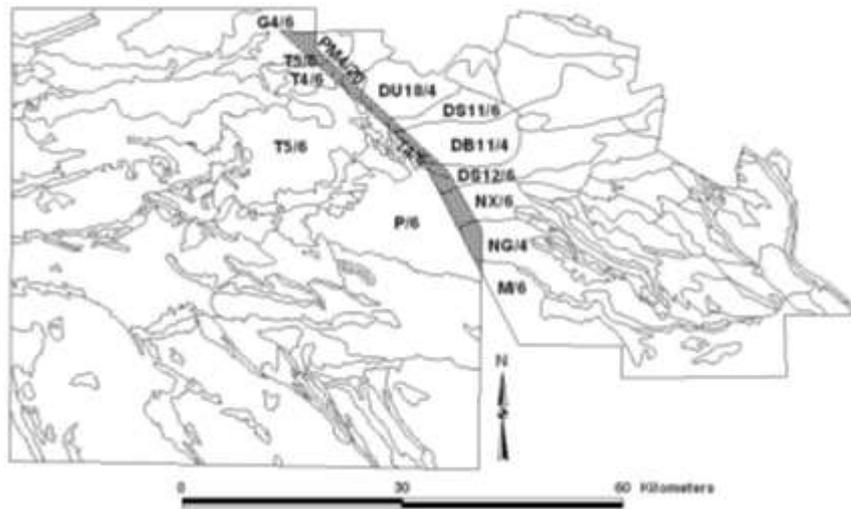
Matching the two soil units maps:

The left map and the right map were merged for the sake of creating seamless soil unit coverage. When doing so, the process indicated that the boundaries of the two map sheets does not match (map 3), regardless of which one was on top of the other. This created a problem to be solved. The solution came from remote sensing, as the landsat MSS image of the same date was available. By overlaying the map on the satellite image (map 4), it was clear that the boundaries of the units on the margin of the two maps needed adjustment. The process for adjusting the boundaries included deleting the boundaries and performing union operation to merge the same units together. The final output was a clean seamless soil unit map covering most of the West Nubaria region (map 5).

CONCLUSION

The paper addressed the role of NSDI as a framework for recognizing the different land mapping units with the assistance of remote sensing as a background tool for accurate verification of the

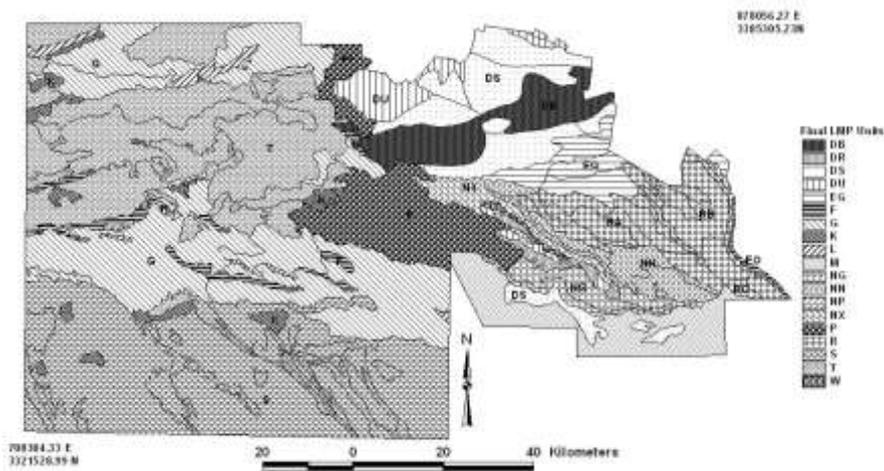
consistency of the land mapping units. Digital Mapping technology is knowledge-based, and the use of GIS and RS technologies helped bring a spatial perspective to environmental phenomena, allowing the visualization of relevant environmental information to correct the problem.



Map (3): Merging the right and left soil units maps



Map (4): Overlay of map on satellite image after correction.



Map (5): Matching right and left soil units maps after correction.

REFERENCES

- Arafat, S. M. 2003.** The utilization of geoinformation technology for agricultural development and management in Egypt. Presented to Diffuse Pollution Conference Dublin 2003. http://www.ucd.ie/dipcon/docs/theme10/theme10_24.PDF
- Badarch, M. (1990).** "An Assessment of the Economics of Remote Sensing Applications to Natural Resources and Environment Development in Mongolia". In The Economics of Remote Sensing. Report of Regional Conference on the Assessment of Economics of Remote Sensing Applications to Natural Resources 214 and Environment Development Projects in the ESCAP Region. p.62-64. (Cited from Syam, T. and Jusoff, K. 1999).
- Beckett, P. H. T., and Webster, R. (1971).** Soil variability: a review. Soils and fertilizers 34, 1-15 (Cited from Pasztor, L. and Szabo, J. 2006).
- Digital Resource System 1991.** Terrasoft Version 10.03, User Manual. British Columbia, Canada.

- Lagacherie P., and McBratney A.B. 2004.** Spatial Soil Information Systems and Spatial Soil Inference Systems: perspectives for digital soil mapping. DSM Montpellier 13-17 September 2004. Elsevier, (Cited from Pasztor, L. and Szabo, J. 2006).
- Leenhardt D., Voltz M., Bornand M., and Webster R. 1994.** Evaluating soil maps for prediction of soil water properties. European Journal of Soil Science, 45(3): 293-301.
- Mermut A.R., and Eswaran, H. 2000.** Some major developments in soil science since the mid-1960s. Geoderma 100 (3-4): 403-426.
- Ministry of Development, New communities and Land Reclamation. 1986.** Land Master Plan of Egypt.
- Nachtergaele F., and van Ranst E. 2002.** Qualitative and Quantitative Aspects of Soil Databases in Tropical Countries. In "Evolution of Tropical Soil Science: Past and Future", 2002. (Cited from Pasztor, L. and Szabo, J. 2006)
- Pasztor, L. and Szabo, J. 2006.** Increasing accuracy of a spatio-temporal soil information System by digital soil mapping and field GIS. Presented at the 9th AGILE Conference on Geographic Information Science, Visegrad, Hungary, 2006. <http://www.agile2006.hu/papers/a104.pdf>
- Research Systems Inc. 2003.** ENVI software, version 3.5 User Manual.
- Rossiter D.G. 2004.** Digital soil resource inventories: status and prospects. Soil Use & Management 20(3): 296-301.
- Syam, T. and Jusoff, K. 1999.** Remote Sensing (RS) and Geographic Information System (GIS) Technology for Field Implementation in Malaysian Agriculture. Paper presented at Seminar on Repositioning Agriculture Industry in the Next Millenium, 13-14 July 1999. Bilik Persidangan IDEAL, Universiti Putra Malaysia, Serdang, Selangor. <http://www.econ.upm.edu.my/~peta/tamaludin/tamaludin.html>

المخلص العربي المعوقات والتحديات للبنية التحتية الرقمية للأراضي المصرية

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يهدف هذا البحث إلى إنشاء البنية التحتية الرقمية للأراضي المصرية عن طريق إدخال الخرائط إلى قاعدة البيانات الجغرافية وعمل خريطة موحدة للمناطق المتجاورة. وقد تم اختيار خريطين من خرائط المخطط الرئيسي للأراضي، وقبول البحث ببعض المعوقات التي تمثلت في عدم تطابق حدود الوحدات الموجودة على الإطار المشترك للخريطين، مما استلزم استخدام صور الأقمار الصناعية لمحاولة تصحيح هذه التجاوزات. تم تصميم وإنتاج المخطط الرئيسي للأراضي في جمهورية مصر العربية عام 1986 وهو عبارة عن ثمره التعاون الدولي بين كلا من الحكومة المصرية ممثلة في وزارة التعمير والمجتمعات العمرانية الجديدة واستصلاح الأراضي والمملكة الهولندية ممثلة في وزارة الخارجية واعتمد أساسا على نتائج حصر أراضي مشروع السد العالي الذي تم عام 1965 ونتائج الحصر الاستكشافي والنصف التفصيلي للأراضي الذي تم بواسطة الهيئة العامة لاستصلاح الأراضي عام 1985. يشتمل المخطط الرئيسي للأراضي في مصر على العديد من الخرائط ومنها خرائط القدرة الإنتاجية للأراضي وخرائط إدارة الموارد الأرضية وخرائط الوحدات الأرضية المختلفة بمقاييس رسم مختلفة تتراوح من الاستكشافي (1:250000) والنصف تفصيلية (1:500000). وتهدف هذه الدراسة إلى بناء قاعدة معلومات رقمية للبنية التحتية لقطاع غرب النوبارية داخل بيئة نظم المعلومات الجغرافية ولتحقيق هذا الهدف تم عمل مسح وإدخال لعدد 3 خرائط منفصلة تغطي منطقة الدراسة تشتمل على الوحدات الأرضية المختلفة الموجودة بالمنطقة وكذلك وحدات قدرة الأرض الإنتاجية وأيضا وحدات إدارة الموارد الأرضية وحتى هذه النقطة لا توجد أي معوقات ولكن ظهرت المعوقات عندما تم دمج حدود هذه الخرائط الثلاثة معا (Edge matching) حيث وجد اختلاف في حدود الوحدات وعدم توافق حدود الوحدات (Polygons boundaries) في الخرائط مع بعضها البعض مع استخدام تقنيات مختلفة (Merging and Union features) لعمل عملية دمج الخرائط مع بعضها البعض ولكنها لم تصلح سواء كانت إحدى الخرائط أعلى الأخرى أو العكس كذلك وجد أن المساحات المحسوبة عام 1986 باستخدام (Planimeter) لكل وحدة من الوحدات مختلفة عن تلك التي تم حسابها بواسطة نظم المعلومات الجغرافية كذلك تم العثور على وحدات صغيرة المساحة (أقل من 250 هكتار) داخل الوحدات الأساسية وهذه لا تصلح في أنواع الحصر الاستكشافي. وكانت التحديات الأساسية هي:

- 1- استخدام التقنيات الحديثة وخاصة تقنيات الاستشعار عن بعد واستخدام صور الأقمار الصناعية لتحديد حدود الوحدات المختلفة وخاصة في الأراضي الصحراوية الغير منزرعة.
- 2- لا بد من تحديد مواقع اخذ العينات بدقة متناهية وذلك باستخدام Global Positioning System (GPS).
- 3- وإدخال كل هذه البيانات والمعلومات إلى نظم المعلومات الجغرافية للحصول على نتائج صحيحة ودقيقة.

