DEVELOPMENT OF SOIL/GEOGRAPHIC INFORMATION SYSTEM FROM AVAILABLE NON – REGISTERED HARD COPY MAPS IN EGYPT

Mohamed Ismail
Remote Sensing & GIS unit, Soil, Water, and Environment Research Institute

ABSTRACT

The Soil, Water, and Environment Research Institute (SWERI), Agricultural Research

Center, Ministry of Agriculture and Land Reclamation in Egypt has acquired large data sets for soil characteristics, soil classification, and soil suitability for agricultural purposes.

Such data have been collected for large areas of Egypt in hardcopy format with various scales ranging from 1: 50000 to 1: 250000 over a long period of time.

Unfortunately, these valuable soil maps have been developed in hard copy maps that did not contain any information regarding datum, map projection, or coordinate system. Some of these soil maps contain few topographic features background (River Nile, shore line, few canals or drains).

Others do not contain any topographic features at all and share only an overlap area with other maps, preventing the usage of such huge valuable data.

A new approach has been adopted to transform the soil maps and data into a usable geo-reference format utilizing GIS tools. All soil maps are scanned and transformed to raster format. Topographic data sets with scales 1: 50000 and 1: 250000 sharing the same coverage of soil maps have been digitized and transformed to a comprehensive topographic GIS database, which are then used for raster soil maps geo-referencing.

Then the on screen digitizing process is performed to develop a soil GIS database for large area of Egypt, including various soil parameters and characteristics. On this basis, the available maps and soil data could be collected in one data set, allowing for comprehensive soil investigation analysis and planning as well as establishing a base reference for change detection throughout various decades utilizing available remote sensing satellite images and soil data at SWERI in the future research.

Key Words: GIS, Data Conversion, Soil maps, Soil Classification, Soil Suitability.

INTRODUCTION

GIS is the most advanced technology for data acquisition, verification, compilation, storage, updating, management, exchange, retrieval, processing, combination, analysis, and presentation.

GIS organizes and exploits geo-referenced spatial data stored in a database. The real world is described using digital spatial data, which define positions in space and attribute data, which usually consist of alphanumeric characters, documents, sound files, digital images, and multimedia files. A geographic Information System can process geo-referenced data and provide the answer to questions involving, the information of a given spatial object, the distribution of selected phenomena, the changes of an occurrence, the impact of specific event, and the relationships between data elements. **[Bernhardsen, 1992].**

Vector GIS represents spatial data in forms of objects, points, lines, and areas (polygons), with associated coordinates. Two processes must be performed on vector spatial data, which are coding and building topology. All data elements must be given unique codes. These codes are used to relate spatial and attribute data. The data must be topologically built. The topology model utilizes nodes and links. A node can be a point where two lines intersect at end point on a line or a given point on a line. Links connect to each other only at nodes. The coordinates tie these features to real world and permit computations of distances, areas, perimeters, intersections and other numerical parameters. **[Burrough, 1986].**

GIS encompass four components that are managed and controlled by GIS experts. The qualifications and skills of those human experts vary according to the configuration, structure, incorporated data, and required functions and tools of the developed GIS system. GIS components are: Hardware, software, database, as well as methods and applications. GIS hardware performs five main processing functions, which are: data collection, data storing, data manipulation, presentation, and communications **[ESRI, 2002].** GIS software is a general software system or "tool kits" from which users may select components suited to their own specific applications. GIS software packages vary in structure, price, functions, and data accepted. Hundreds of GIS software exist in the market. ArcGIS Developed by ESRI, the largest GIS software developer in the world is used for carrying out all tasks to develop the proposed GIS database and application. GIS database is vital in all GIS systems. GIS database consists of two integrated (separate or mixed) components, the spatial database and the attribute database. A GIS application is developed according to the user requirements to satisfy all needs and perform different functions and tasks. The application is developed using a Visual Basic for Applications (VBA) programming language and has a friendly user interface (UI) which executes the desired operations using commands, queries, messages, menus, icons, buttons, dialogs, and windows.

The present work aims towards the utilization of advanced and sophisticated GIS technology for the development of a GIS database for soil maps, reconnaissance maps, productivity maps, classification maps, potentiality maps from available hardcopy maps at the Soil, Water, and Environment Research Institute (SWERI) with various scales utilizing digital topographic maps, as well as the development of a GIS application for archiving, managing, updating, editing, and analyzing the established GIS database.

MATERIALS AND METHODS

Various tasks have been executed to transform the non-registered hardcopy maps to digital format and hence build the desired GIS database, including data collection & preparation, scanning, geo-referencing of raster maps, data conversion, reviewing and editing, data entry, and Quality control. **[Hanson, 1989].**

1. Data Collection & Preparation

Available hardcopy soil maps, reconnaissance maps, productivity maps, classification maps, and potentiality maps with various scales at SWERI were collected. Various topographic maps including 1: 50000 & 1:10000000 map series produced by the Egyptian Survey Authority (ESA) and 1: 250000 maps developed by the Military Survey Department (MSD) were acquired. These maps were used to produce the required features for geo-referencing of the hardcopy soil maps, reconnaissance maps, productivity maps, classification maps, and potentiality maps.

2. Scanning

Hardcopy maps were scanned using A0 scanner in color format with a reasonable scanning resolution (150 dpi) that is suitable to the required accuracy. Maps were transformed into digital raster form using the scanning process.

3. Geo-referencing of Raster Maps

Raster topographic map files were geo-referenced to the map coordinates system using the grid layers. The grid layers were developed by AutoCAD software package. All grids printed out on the hardcopy topographic maps were drawn in AutoCAD files using the coordinates given on the original maps. Then, the AutoCAD files were imported to the ARC GIS software to create the grid layers, which have the same coordinates system as the source maps. The geo-referencing process of the raster topographic maps was performed by aligning the printed grids of the raster maps with the reference grid layer using all grid intersection points at the original scale of the maps with a Root Mean Square (RMS) error that did not exceed 0.5 mm divided by the map scale. Figures (1) & (4) show samples of the output geo-referenced topographic map sheet.

Raster soil maps, reconnaissance maps, productivity maps, classification maps, and potentiality maps do not have a grid or a coordinate system at all. Some of these maps [group (1)] have few topographic features (shore line, River Nile, canals, or drains). Other maps [group (2)] do not have any topographic feature at all, but have some overlapping features with other map sheets.

Group (1) was geo-referenced in two-steps procedure. In the first step, the raster file maps were scaled to match the graphic scale bar with the specified mentioned map scale. Then, available topographic features in the raster map file were aligned with similar features at the digital topographic maps, during the rectification process after being selected utilizing information written in the legend, such as region or map name.

Group (2) was geo-referenced in two-steps procedure. In the first step, the raster file maps were scaled to match the graphic scale bar with the specified mentioned map scale. Then, overlapped features shared with any available map of group (1) were drawn and the raster map of group (2) was aligned with these overlapped features during the rectification process utilizing information given in the legend, such as region or map name and key plan showing adjacent map sheets.

Fig. 1,2

4. Data Conversion

Data conversion is mainly concerned with transforming raster spatial data into digital vector format. The adopted technique for data conversion is raster-to-vector conversion using on-screen manual digitizing method.

The output raster files from the geo-referencing process were then displayed on the computer screens and converted to vector format using manual on-screen digitizing technique at the scale of the original map and the outputs were stored on different vector layers with the appropriate GIS features representation. Figure (2) shows example from the outputs vector maps.

5. Reviewing and Editing

Vector data were edited after being transformed to digital form. Tasks included error correction and entering missing data. Data were verified visually on screen. As many layers were complied, each layer was given different color during comparison. Revision process included finding errors, locating missing data, and checking for proper features and layer presentation. Errors were then corrected and missed data were added.

6. Development of Soil/GIS Database

The Soil/GIS database was developed from vector digital data of the topographic maps, soil maps, reconnaissance maps, productivity maps, classification maps, and potentiality maps. The executed tasks were database conceptual design and data model development, GIS data preparation, data entry, and QA/QC.

6.1. Database Conceptual Design & Data Model Development

The conceptual design of the GIS database included the definition of the database layers, data description, and data model development. The developed GIS database was performed based on open platform as well as scalable architecture.

All data in soil maps, reconnaissance maps, productivity maps, classification maps, and potentiality maps were transformed to corresponding GIS layers. Some data were chosen from the topographic maps. The selected GIS database layers from topographic maps included: maps, grids, roads, river, canals, drains, lakes, shoreline, and islands. The data model was then developed from available attribute data. Data model included the definition of various layers, the GIS format (Polygons, lines, and points) as well as fields description.

6.2. GIS Data Preparation

Adjacent map sheets were individually transformed to digital format. The final output must be stream-less without gaps, distortions, or inconsistency between map borders. Hence an edge matching process was performed where all individual maps were grouped together and all data were ensured to have the same position, layer, orientation, and data along both sides of any two adjacent maps. Digital data were then topologically built and prepared to the appropriate GIS format using “building topology” functionality in the ARC GIS / ARC Info software, (Figures 3 and 4).

6.3. Data Entry & QC/QA Procedure Implementation

Data entry procedure included three successive tasks, namely data preparation, data entry, and editing. Entering data was done directly using the data entry functions built-in the GIS software.

Quality Control (QC) procedure was applied through these operations. It was done manually and with automatic verification functions that reveal only formal errors. incorrect information was detected and edited by manual copy reading. The links between spatial and attribute data were checked at the end. Finally, the GIS database was developed from available data sources.

Fig. 3

RESULTS & DEVELOPMENT OF SOIL/GIS APPLICATION

A Soil/GIS application was developed to perform various GIS functionality, including archiving, managing, updating, editing, and analysis of the database. Executed tasks include application requirements analysis, application design, and implementation. Figures (5) to (7) show snap shots from the developed application. Visual Basic for Application (VBA) programming language was used for application development and interface design and implementation various analysis tasks can be performed by the GIS/application including:

- Database analysis
- Soil maps generation
- Charts and reports generation
- GIS spatial analysis (buffering, overlay, geo-processing)
- Statistical analysis

Fig. 4

Fig. 5

Fig. 6

Fig. 7

DISCUSSION OF RESULTS

A powerful Soil/GIS database has been developed from non-registered hardcopy soil maps utilizing robust technique and topographic maps. The developed digital maps and GIS database covered a wide area of Egypt, including valuable information regarding soil characteristics, soil classification, and soil suitability for agricultural purposes. A comprehensive Soil/GIS application has been developed to carry out various database, GIS, and statistical analysis functions and tools regarding soil classification and soil suitability.

All available maps and soil data have been collected in one data set, allowing for comprehensive soil investigation analysis and planning as well as establishing a base reference for change detection along various decades utilizing remote sensing satellite images and soil data in future researches.

REFRENCES

Bernhardsen, T., **"Geographic Information Systems",** Norway , 1992.

BURROUGH, P.A., **"Principles of Geographical Information Systems for Land Resources Assessment",** *England,1986* .

ESRI, **"Understanding GIS. The ARC/INFO method",** U.S.A., 2002.

Hanson, R.J., **"Data Conversion Processes for GIS's",** ASPRS & ACSM, U.S.A., 1989.

Maguire, D.J., "**Geographical Information Systems -Principles and Applications**" England, 1992.

إنشاء نظام معلومات جغرافى للأراضى من خرائط التربة الورقية الغير مناسبة جغرافيا والمتاحة فى مصر

محمد اسماعيل

معهد بحوث الاراضى والمياه والبيئة – مركز البحوث الزراعية

يمتلك معهد بحوث الأراضى والمياه والبيئة بمركز البحوث الزراعية حجم هائل من بيانات خرائط خصائص وتصنيفات التربة وصلاحية الأراضى للإستزراع تم تجميعها لمناطق شاسعة فى مصر فى صورة خرائط ورقية بمقياس رسم يتراوح بين ١:٥٠٠٠٠ & ١:٢٥٠٠٠٠ وهذه البيانات القيمة لا تحتوى أية معلومات توضح سطح الإسناد أو إسقاط الخرائط المستخدمة او نظام الإحداثيات وقد يحتوى بعضها على بعض المعالم الطبوغرافية مثل نهر النيل وساحل البحر والترع والمصارف والبعض الأخر من الخرائط لا تحوى أية معالم طبوغرافية ولكن أجزاء مشتركة مع خرائط أخرى مما يقلل من تعظيم الاستفادة من هذه البيانات العالية القيمة وخاصة عند استخدام الطرق الرقمية الحديثة لدراسة وتحليل البيانات.

وقد تم فى هذا البحث اتباع أسلوب مبتكر لإنتاج الخرائط الرقمية وقاعدة بيانات نظم المعلومات الجغرافية بنظام إحداثيات موحد بالاستعانة بالخرائط الطبوغرافية مقياس رسم ١:٥٠٠٠٠ & ١:٢٥٠٠٠٠ والتى تغطى نفس النطاق الجغرافى لخرائط التربة باستخدام أسلوب ضبط الخرائط والتنسيب الجغرافى وقد تم فى هذا البحث تجميع كافة الخرائط فى تطبيق نظام معلومات جغرافى تم بناؤه بأحدث تقنيات وبرامج نظم المعلومات الجغرافية مما يتيح افضل استفادة من هذه البيانات وتحليلها والبحث عنها واستخدامها مستقبليا فى عمليات تحديد التغيرات المكانية الزمنية بالاستعانة بصور الأقمار الصناعية الملتقطة فى تواريخ لاحقة لهذا البحث.