

INTEGRATION OF GEO IMAGERY AND VECTOR DATA INTO SCHOOL MAPPING GIS DATA-MODEL FOR EDUCATIONAL DECISION SUPPORT SYSTEM IN JORDAN

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ABSTRACT:

The objective of this work is to build a proper Geographic Information System (GIS) data-model that can be used for school mapping planning, where all schools with attribute data would be available for problem solving and decision-making in Education. Thus, the end product of the GIS will be part of an Educational Decision Support System that provides the user with a map of specific region with focus on the schools locations and all related info to assist decision-makers in either expanding current school or suggesting sites for new schools in Jordan, and also, for student and resources location/allocation.

The built GIS-Data-model is composed of the schools layer, large-scale streets, directorates, sub-districts and Governorate layers with population data. IKONOS Geo imagery and more reliable small-scale vector data format are to be integrated with the current GIS-data-model to build a detailed geospatial-database for school mapping planning purposes. However, there are several problems associated with this mainly because of the different projection systems each dataset is based on and due to the scale problems.

This paper reviews the original GIS-data-model format, the used projection systems, the management of the geospatial database and aspects of the project to collect data from ground and satellite semi-rectified image sources and combine the data sets together so that a high level of tractability and integrity are offered. A status report of the existing uses of the model is given together with an outlook of expected future uses as an Educational Decision Support System for planning purposes. The paper concludes with the future trend to build an Internet Wep-mapping site to be available to fit various needs for GIS School Mapping applications, which would be perfect for decentralizing the Decision Support System between Educational Directorates for data updates.

1. INTRODUCTION

1.1 General Instructions

The contribution of the rapid advancement and innovations in the applications of Geographical Information Systems and Geo Imaging technology to planning and decision making is not only a useful visual tool, but it constitutes an essential role in the process. It acts as the infrastructure base for building on top other information from various perspectives. Examples are numerous on utilizing GIS for planning purposes, such as GIS and multi-criteria analysis for land management (Joerin F. et. Al. 1998 and 2001), towards flexible GIS user interfaces for creative engineering (Golay F. et. All 2000), System integration of GIS and rule-based expert system for urban mapping (choi and Usery). Other work put even more focuses on the rote of using geospatial information as a base infrastructure to designing a GIS-based computer supported collaborative system for urban planning (Chen et. All 2004). It is in fact, the current trend in modern organization towards flatter structures and the involvement of many stakeholder groups in solving decision problems based on what can be called spatial decision support systems (Jankowski et. All 1997). On the other hand one has to decide on the role, limits and development of using/institutionalize GIS and Geo-Imagery in planning and decision support systems (Golay and Major 2000).

In developing courtiers, the need for GIS and Geo-Imagery is even more as there are more urban planning problems, and in many situations, almost no planning strategies. Thus, you need more resources and information to help visualise the complication of the problem for decision making analysis. However, a major complication is to build suitable geospatial database that is, normally, not available at local municipalities, or if available, would be at a very high price. Many efforts are done to build low-cost geospatial database from available paper tourist and topographic maps with the aid of Geo-imagery, example of that is for determining ATM bank locations in Amman city, Al-Hanbali 2003.

The trend towards using GIS and school mapping to support decision making for Ministries of Education in the world is becoming very important for planning purposes and is in the implementation stages in may leading countries of the world, and also in the development countries, see Al-Hanbali 2003, Makino and Watanabe 2003, Rice et. all. 2001). In fact, building geo-spatial database and using GIS is becoming a standard and/or a requirement for funding agencies to approve loans/grants, such World Bank DFID and US Aid. For example the workshop conducted for DFID (Rice et. All. 2001) about the contribution of infrastructure and planning to education strategies, school mapping constitutes a major chapter.

The contribution of this work is to show a real implementation example and thus to share such experience with others. Therefore, summary and discussion of the built GIS data-model for school mapping planning application in Jordan is presented. Most importantly, presentation of the GIS implementation examples as a major role player in the educational decision support process to assist decision-makers in either expanding current school or suggesting sites for new schools in Jordan. This will be used eventually, once all statistical data are available, for student and resources location/allocation. The design of the Educational Decision Support System (EDSS) for Ministry of Education, Jordan, will combine Geospatial database and EMIS database with modeling techniques to support problem-specific semi-structured decisions while allowing the decision makers to use their experience and insight. It is important, to illustrate the importance and usefulness of using Geo-Imagery (Ikonos data) to help in managing, resolve error-checking and assist in integrating large and small-scale vector data format with the current GIS-data-model for school mapping planning purposes.

A status report of the existing uses of the model, the model development stages and the EDSS strategies is given together with an outlook of expected future uses as an Educational Decision Support System for planning purposes. The paper concludes on the future strategy in implementing the decentralizing process of the Decision Support System between Educational Directorates for data updates and usage.

2. SCHOOL MAPPING AND DECISION SUPPORT SYSTEM

2.1 Introduction

School mapping is the art and science of building geospatial databases with relational databases of educational, demographic, social and economic information for schools and educational directorates to support educational planners and decision makers.

In order to do proper planning, the educational sector should not start any project before making available to all involved parties a comprehensive database of all schools, pupils, teachers and resources. Building that part of GIS layers with showing school locations and other significant geographic features such as streets, railroads, city-zoning, school-directorates, sub-districts, districts, governorates and other features would provide an excellent tool for planners. For example, school mapping was utilized in Jordan to approve proposal (ERfKE proposal 2002) for constructing new schools and/or renovating existing schools. Also, it is very important to build the management capacity and the staff in general to be capable of utilizing such technology as it is an ongoing process. Furthermore, the data has to be updated regularly.

On the other hand, experts are of major importance to train and guide, and can be considered as a link between the geospatial database, the stakeholders who are managing and/or using the data. Their major role is to ensure an efficient use of available data, models, developed software and the basic theoretical knowledge. Doing this, will make Education Decision Support Systems usable and applicable, and at the same time, will make the Decision makers creative to ensure alternative solutions as they who really knows the reality and what is considered applicable solution.

This paper put focus on our very interesting and demanding project, as it is very useful to share and communicate such experience with others. Since, this is a leading and emerging technology in our fast evolving era of technology and economy reform. Thus the know-how and implementation strategies are our continuous seek towards improving our practices and quality of life. In fact, in year 2002, the Ministry of Education were preparing a major educational reform proposal to be approved and launched in year 2003 titled “**EDUCATION REFORM FOR THE KNOWLEDGE ECONOMY: PROJECT PROPOSAL**”, which represents a landmark step in the progress of change in education in Jordan (ERfKE 2002). Four initiatives constitute four components. Components one and three are related to this work. Component one is about reorientation of education policy objectives and strategy through governance and administrative reform, part of it is to build a suitable Education Decision Support System. Component three is about support provision of quality physical learning environments. Major part of it is school buildings for population growth.

2.2 School Mapping Phases and Strategies

In order to achieve funding for the ERfKE proposal, it was required to be backed up with on-ground feasibility study based on school mapping recommendations. This required at the time to built suitable geospatial database within six months, although it is a very time-consuming work. Thus, three implementation stages were planned for this according to the required tasks and phased over time.

2.2.1 PHASE I: The aim of the first implementation phase is to provide good tool to backup recommendation and to take decision of where to build new schools, extended and/or renovate existing schools based on the following criterion:

- Maintain school capacity in terms of the ratio of available class room area per student following the UNRWA standard ratio of 1.2 m²/student.
- Renovate or build new school building based on building condition, rating criteria is provided by the department of Engineering at the Ministry of Education (MOE) according to international standards.
- Illuminate and/or minimizes double shift schools (i.e. morning and afternoon schools in the same building).
- Illuminate and/or minimizes rented schools to provide stability and reduce long-term cost.
- Match the increase in population of the area for the next ten years (based on a computed ratio of about 3%)
- Show the overall distribution of current schools in the area in a map with all related info.
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Time guideline for this phase was about six months, and thus, according to what is available in GIS vector formats and at the same time affordable in price, it was decided to use maps with 1:250000 scale. The resultant maps with the built GIS-data model provided a very good visual of current schools distribution with available information data. All are integrated into a GIS customized software The statistical data added were based on year 1999/2000, which were sufficient for the required goal. The build GIS-model is called the Basic model. The next sections discusses the built GIS-model and the resultant layers.

2.2.2 PHASE II: The aim of this stage is build a very detailed geospatial database with extensive statistical database to allow all types and kinds of indication marks and trend analysis studies. The geospatial database will be in parallel connection to the Oracle database of the Education Management Information System (EMIS report 2003), which is on-going project to be completed by the end of Year 2005.

The map scale of the geospatial database will be better than 1:50000 scale. More reliable small-scale vector data format based on the parcels data from the Department of Lands and Surveys (DLS) along with other vector formats from other ministries are to be integrated with the current GIS-data-model to build a detailed geospatial-database. This introduces several problems because of the different map-scales and the projection systems of each vector dataset. Geo-Imagery is expected to play a major role in resolving these problems and provide a better visual. This GIS-model is called the Extensive model.

The geospatial database with the EMIS database will be integrated into a specifically designed EDSS to be used by all administration levels in the MOE and Directorates for planning purposes. The time frame of this project is three years.

The following are some ongoing projects using the partially build geospatial data for this stage:

- Discovery and Broad-band schools: the main task was to define the best 100 schools locations to be connected through a broad-band network with the main computer center of the ministry (Queen Rania Center) for E-learning purposes. The main task is to define best location based on several criterions and also the best root for wiring purposes.
- Creation of or dividing current directorates to two or three.
- Re-engineer the distribution and decision for renovation and/or building of new schools
- Check current school location to fit into the new geospatial database
- Show the overall schools distribution with specific indicators with respect to the public places and parks, streets and transportation routs to be used for decision making and planning processes (Makino and Watanabe 2002) and Rice et al 2001.

2.2.3 PHASE III: The projected goal of this stage is the decentralization process of school mapping utilization and geospatial data updating. In other words, each Directorate and may be even at the school level will be able to use the EDSS, to update its database according to the administration level and the given privileges. Furthermore, customization GIS software is required to be developed that will be suitable to integrated geospatial database, EMIS database into the planned Education Decision Support System. The time frame of this stage is two years including testing and launching processes.

3. GEOSPATIAL DATA MODEL

Expertises have been evolving rapidly in Jordan towards building suitable geospatial databases. In fact creating of the required GIS data model followed previous experiences in municipalities (Al-Hanbali and Aqel 2001), Land valuation (Al-Hanbali and Al-Qudah, 2004) and the banking sector (Al-Hanbali 2003b). The real problems however is that there is no ready detail digital mapping geospatial infrastructure built in Jordan. Each public institute is, in fact, building its own

geospatial database based on available resources and geo-imagery information. This makes the process more time consuming and costly. Figure (1) illustrates the work flow of the GIS data model to build the geospatial database, see for more details Al-Hanbali 2003a and 2003b. The following sections discuss the built Basic Model, the Extensive Models and the associated problems. The potential of using Geo-Imagery to help resolving encountered problems.

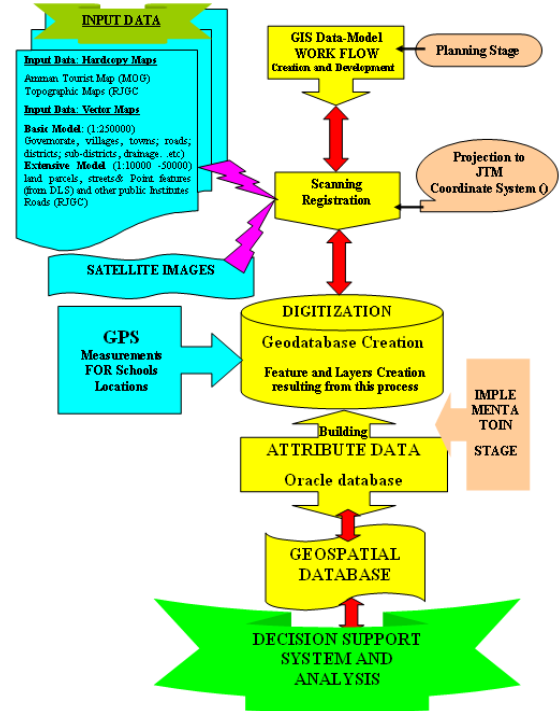


Figure (1): GIS Model Work Flow.

3.1 The Basic Model

The base platform map used to fuse all available data sourced is based on using the 1:250000 vector layers provided by the Royal Jordanian Geographic Center (RJGC). Four polygon layers for the towns, governorates, districts and sub-districts with only the name attribute. Two line layers for the streets, contour and drainage with no attribute data except for the height of the contour lines. Three point layers for the villages and school layers with names attribute. The projection system is based on the Jordanian Transverse Mercator (JTM) projection

Based on the sub-district layer, the directorate boundaries layer was extracted and then based on this all other layers were customized to be within its boundaries (Al-Hanbali 2003a). Population for years 2000 till 2003 and projected one for year 2005 and 2010 are added as attributes to all polygon layers to perform demographic analysis for school capacity. Then, the paper tourist maps of major cities were scanned and registered to act as a background for these extracted layers. Topographic maps are used instead for other areas in Jordan. Attribute data are then linked to each layer to add the required information that constitute basic info for the user. The resultant school layer is linked with the statistical data of the fiscal year 1999/2000 to be used for decision making and analysis. Section 4 illustrates the utilization of these in justifying suggest new site school locations.

3.2 The Extensive Model

In order to provide better visual and analysis, MOE purchased the parcel layers from the Department of Lands and Surveys (DLS) with scale of 1:10000 and also, street layers with scale of 1:50000 from RJGC. This will allow building detailed geospatial information around the school building in terms of: available land parcels to purchase, populated areas, buildings blocks, city blocks, municipality land use and zones, parks, streets with all categories, public places such as mosques and churches, commercial building such as shopping centers and Banks...etc. It is important also to add population data to all land use and city polygon features. Noting that, in Jordan, the new population data based on the latest census data will be available in 2004, instead of projected and sample data currently used. Furthermore, the statistical educational database will be imported from the EMIS for all previous years, which will be available by the end of year 2004. In order to achieve seamless data, one has to resolve the associated problems with these newly added geospatial data. The three major problems are explained in the following subsections.

3.2.1 Projections Problems: The major problem emerged as the land parcel data from the DLS are in the old projection system that inherited lots of distortions based on the Cassini-Soldner projection using Clark 1880 ellipsoid. The transformation parameters (using 3D conformal) between this system and the UTM system (WGS 84 ellipsoid) are well defined. On the other hand all other vector data are based on the newly standard Jordan Transverse Mercator projection using the European Ellipsoid 19950, and also has known transformation parameters with respect to the UTM system. The direct transformation between the JTM and Cassini systems has distortions ranges from 3 meters to 25 meters. The DLS worked out some solutions to minimize that by dividing Jordan into zones of 5 by 5 Km polygons, defining for each zone its own transformation parameters. In any case, distortions are inherited in the transformation of the geospatial data from Cassini to JTM. The Key solution for this problem from our perspective however, is our required accuracy for the resultant merged maps, which is within a map scale of 1:25000. Ikonos Geo Imagery can be used provide a base for re-adjusting shifted layer to be within the acceptable precision as resulting from our preliminary testing.

3.3.2 Scale Problems: As mentioned earlier we have data with various scales, e.g. 1:2500000, 1:50000, and 1:10000. The easiest procedure followed is that when working with map on the country level or the directorate level with map scale over 1:100000 for analysis that required illustrating or using large scale map format. However, this is not applicable for small scale maps as all data has to be seamlessly integrated or adjusted, what is referred to interoperability and standards by Heipke 2004. The key solution for this is based on the accuracy requirements for these maps, as it doesn't have to be better than 5-10 m, which is equivalent to map scale of 1:25000, as suggested by Fraser 2003. The role of GeoImagery to resolve this problem proofed to be much faster than just speculating which is true or accurate or not. GeoImagery acts as the base template when merging these data and deciding which to keep and/or ignore.

3.2.2 Land Parcels DLS-Key Problem: Each parcel has a unique DLS key number, which theoretically can be used to identify the parcel of interest. The main usage for our applications is to build from these parcels the following:

- Owned and rented schools parcels layers
- Street layers

- Public property parcels classified according to its usage
- Sectors, blocks, city-blocks, sub-districts, districts, directorates, villages, and governorates boundaries built based on parcels boundaries.

However, there are lots of discrepancy in the built DLS-key, which gave false search/identification results. One major problem is the conflict between the new numbering scheme followed by DLS the old records of the villages, blocks, and sectors respectively. Also, some street parcels are falsely assigned a DLS-key, instead of a null value.

GeoImagery helped a lot in this, as it also provide visual information about the type of feature and validate the search.

3.3 GeoImagery Solution

The new technology of high-resolution satellite imagery has demonstrated its metric potential for mapping using either Ikonos or Quickbird imaging systems with potential map scales as large as 1:10000, Fraser 2002 and Fraser et. all. 2001. The author/s has/have the opportunity to use both in addition to SPOT 10 m resolution. This is still in its early testing and experimenting stage, doing feasibility study to justify the investment of purchasing such imagery for major parts in Jordan. Three types of imagery were tested, the Geo reference imagery, Geo ortho kit with RPC file imagery for Amman area, and a stereo Ikonos sample. Accuracy assessments were based on GPS control points distribution in Amman and the vector formats. The 2-D affine and polynomial functions models were used for the geo reference imagery and the affine model given in RPC terms were used for the ortho kit imagery, Fraser 2002 and Kaichang et. all. 2003. Software used for processing imagery is the ENVI and SOCET Set software. GIS softwares used are Geomedia and ArcGIS.



Figure (2): Example in using Ikonos Imagery to validate streets layers built from parcels vector layer.

The accuracy results showed that geo reference images of either Ikonos is better than 5 meter, which is very suitable for our application to assess in resolving the encountered problems. Many literatures proved that running cost-benefits are beneficial compared to savings in time and effort (Baccardo et. all. 2003).

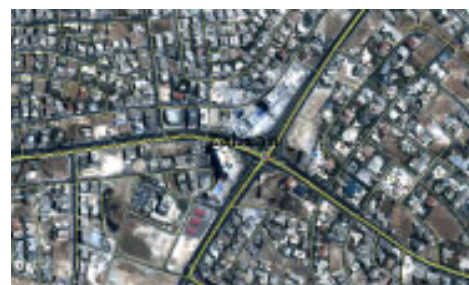


Figure (3): Example of using Ikonos Imagery to validate the streets vector layer, the shifts in street range from 5 to 15

meters.

4. SCHOOL MAPPING IN ACTIONS

4.1 Built Geospatial Database Layers

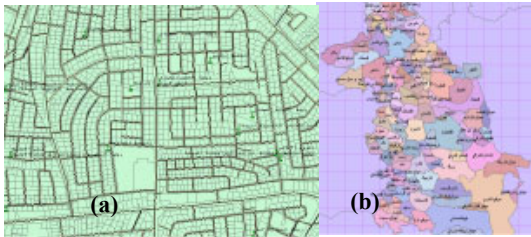


Figure (4): (a) Building parcel data with streets layers. (b) Villages Administrative Layers.

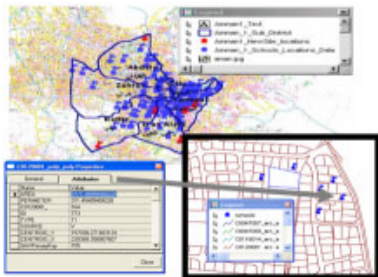


Figure (5): Building parcel data with streets layers.

4.2 Prepared reports for the establishment of new field directorates



Figure (6): Establishing new directorates based on some indicators. (a) Dividing one directorate to two in Irbid Governorates. (b) Reorganized the Capital Governorate by expanding the directorates from four to six.

4.3 Conducting a needs assessment for building new schools based on schools density, distribution, population density.

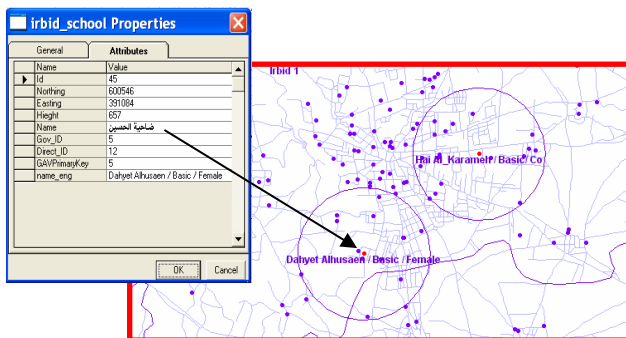


Figure (7): New school location

4.4 Prepared reports about actual educational indicators and affecting factors using our geospatial databases

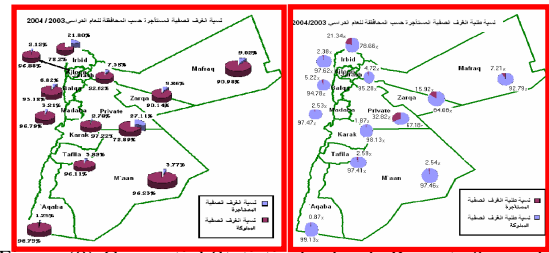


Figure (8): Geospatial Statistical schools Reports for each Governorate (a) Percentage of rented class rooms to owned ones (b) Percentage of students per rented class rooms to owned ones

4.5 Supported the Discovery Schools Program (Module One) to:

4.5.1 Case One: Find the most suitable schools to be connected by the broadband connectivity

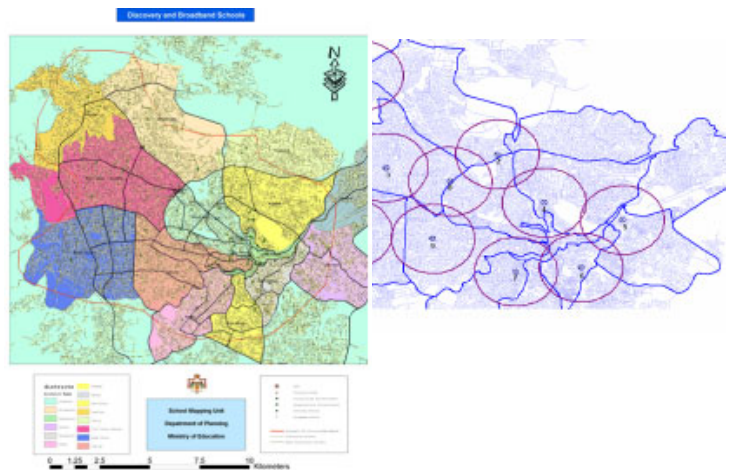


Figure (9): Locating Best Discovery Schools locations

4.5.2 Decide on the best route-path to the designated pops

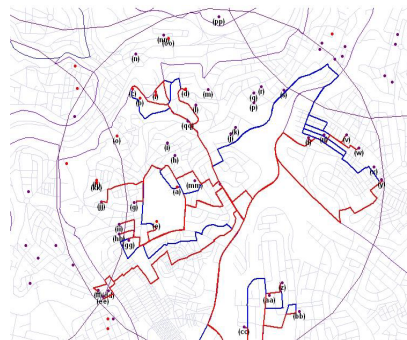


Figure (10): Locating Best Route for Broad-Band wiring and networking between Schools

5. DISCUSSION AND CONCLUSIONS

The use of GIS technology in modelling for decision support systems brings many new capabilities and commodities to the planning process. The paper summarizes the various phases of building the Education Decision Support System in MOE, Jordan. It illustrates the success implementation of the planning process taking many decision and projects based on such technology. To merge geospatial database using all vector layers is quite complex environment and is the scope of many research projects. However, our experience and testing shows that it can be done within our accuracy requirements of a map

scale of 1:25000 to 1:50000. This will overcome the various problem discussed in the paper resulting from projection, scale precision and uncompleted DLS information. The paper discussed the potential of using Geo-Imagery to assess in resolving these problems by using it as goereferenced-layer for merging all other vector formats, since its precision can be better than a scale of 1:25000.

6. FUTURE DEVELOPMENT

The automation and software development for the EDSS is still a focus and requires more work and efforts, which is planned to be done within two years. There will be more focus on what EDSS indicators and criterions are needed, how will be utilized, how to visualize and combine these factors in final map-decision form through proper atomization scheme. Web-mapping and decentralization is also essential implementation for our system, which will be a reality in a year time. In order to succeed in implementing the EDSS at MOE, intensive training has been conducted at all levels from administration to users, which is in fact a major part of the MOE future plans.

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