

## Relational GIS and Remote Sensing Database System for Al-Salt Area, Jordan

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**Abstract:** Due to the importance of database systems, integration between two Geomatics sciences, GIS and Remote Sensing has been made in order to support and serve various sectors in Jordan. GIS has been used to create layers that can show decision makers in a simple, easy and flexible manner. Remote Sensing will be used in creating images of how Jordan is seen from space, which will give the users more information and an overview about the study area. Satellite images could be converted into digital image maps, using digitizing procedures. The features viewed in the original scene could be studied by using different remotely sensed techniques. Landsat-7 (ETM+) and SPOT images were implemented, in order to extract the information needed for the topography of the region, land cover areas, boundaries, drainage patterns, road networks, man-used areas, vegetated areas and many other features in Al-Salt areas. The validity and the appropriateness of GIS and Remote Sensing techniques, particularly data fusion of images were evaluated in relation to visualization.

**Key words:** Geomatics science, GIS analysis, satellite images, data fusion, 3D analysis and relational database

### INTRODUCTION

Among the advantages of GIS and Remote Sensing integration are to capture, accumulate, model, analyze and present spatial and descriptive data directly or indirectly from satellite image and from available maps. An electronic map makes a basic element of the GIS. The map functions in dialog mode providing access to non-cartographic Database (DB) accumulating reference, descriptive, statistic information connected with the object on the map. Non-cartographic data are visualized as tables, diagrams, graphs, images, including satellite images. Electronic maps are created in the instrumental GIS environment. Various sources like geographic maps, atlases, geographic descriptions, statistic and reference information, materials of local surveying compose the information basis for the electronic map. The interface should be designed taking into account the demands and abilities of the wide range of users. Therefore, implementing GIS and Remote Sensing techniques in order to produce relational data base for Al-salt area due to its rapid development was needful.

**Location and access:** Al-Salt region Study Area is located about 25 km north-west of Amman and could

be approached from the capital via Sweileh-Salt highway (Fig. 1). The region covers an area of 655 km<sup>2</sup>.

**Topography:** Jordan River is a recent geomorphic feature; a well developed meandering system exists within its floodplain and the surrounding river terraces.

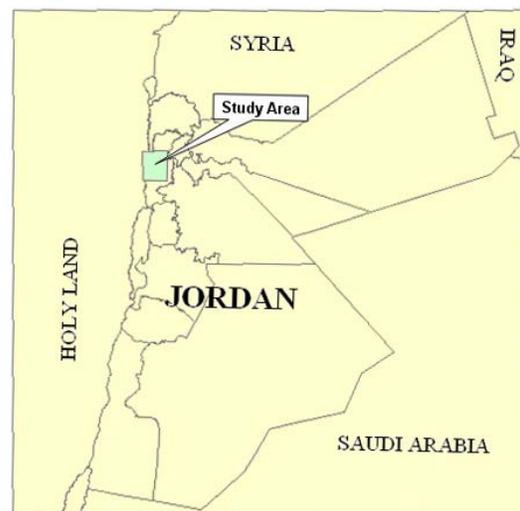


Fig. 1: Location of the study area

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The lisan marl is heavily dissected by a dense drainage system to form typical badland topography, or what is locally termed katar. Such topography indicates the role of scattered rainfall and fluvial processes in shaping the weak marl formations in such arid areas. Along the base of the fault scarps, a series of alluvial fans developed by major Wadis (i.e., Wadi Kufrinja and the Zerqa River) and form a bajada plain. The general gradient of the bajada is less than  $5^\circ$ .

The second terrain is the fault scarps. This is up to 1000 m in elevation and overlooks the Jordan rift. Step faulting which initiated the rift has resulted in major fault scarps. The latter have been heavily modified by fluvial erosion during the fluvial periods of the Pleistocene-recent. In certain localities (i.e., arda road), the displaced down faulted blocks form pronounced foothills along the scarp line base. However, a complex system of slopes exists here (convex, concave and straight). The scarps are heavily dissected at present by a series of valleys ranging in depth between 1 and 3 m. Some of them are terminated by minor alluvial fans.

The third terrain system comprises a hilly terrain exceeding 1000 m in elevation. Here the high rainfall, the folded strata and the presence of faulting have combined to form a hilly region of diversified scenery and innumerable outcrops of limestone, marl, shale, clays and sandstones.

**Objectives:** The main objectives of this study are:

- Building a relational database system that includes GIS layers and RS image maps and managing them
- Producing digital image maps for Jordan (Al-Salt)
- Evaluating the validity and the appropriateness of data fusion in relation to visualization

In order to reach the main objectives, we will pass through several stages each one has an objective. These secondary objectives are:

- Create a mosaic image for Jordan from SPOT image and Landsat-7 image
- Make band combinations
- Create different layers
- Create TIN for Al-Salt area
- Create terrain surfaces, slope, aspect, hill shade, view shade for Al-Salt area and perform 3D analysis

**Methodology:** SPOT satellite image, Landsat-7 image, topographic and geologic maps at scale 1:50,000 were employed in this study. Spectral enhancements and

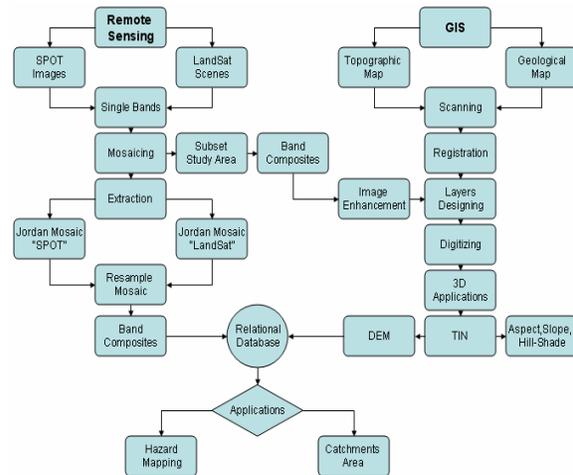


Fig. 2: Methodology flow-chart

textural analysis utilizing false color composite, high-pass filter and directional edge enhancements were applied on the study area. New maps for Al-Salt area such as, drainage pattern, road network, vegetated areas, soil and faults were produced, thereafter, all the produced maps and their attributes have been stored as a relational GIS Database using Arc GIS software (Fig. 2).

## MATERIALS AND METHODS

**Images:** Geo-referenced satellite images in the WGS84 UTM 36N and 37N coordinate system were used. The spatial resolution of these images is 10 m resolution for SPOT images captured in year 2002 and the Landsat-7 images at 25 m resolution taken in year 2000.

**GIS data:** There are numerous definitions of GIS, none of which actually describe or explain it sufficiently. Sometimes we simply say Advanced Computer Mapping, but better definition is A computer-based technology and methodology for collecting, storing, managing, analyzing, modeling and presenting geographic data for a wide range of applications. A GIS is not simply a computer system for making maps, although it can create maps at different scales, in different projections and with different colors. A GIS is an analytical tool<sup>[2]</sup>.

The major advantage of a GIS is that it allows us to identify the spatial relationships between map features. A GIS does not store a map in any conventional sense: or does it store a particular image or view of a geographic area. Instead, a GIS stores the data from which you can draw a desired view to suit a particular

purpose. GIS links spatial features with attributes about a particular location on a map. The information is stored as attributes of the graphically represented feature. For example, the centerline that represents a road on a map does not tell us much about the road except its location. To find out the road's width or pavement type, we must query the database.

Using the information stored in the database, we could create a display symbolizing the roads according to the type of information that needs to be shown. A GIS also uses the stored feature attributes to compute new information about map features, for example, to calculate the length of a particular road segment or to determine the total area of a particular soil type. In this study, there are two data sources for GIS: Hard Copy Maps and Existing GIS Layers.

**Hard-copy maps:** Maps can be defined as extremely accurate sketch which simulate the reality with three fundamentals special effects. The first is the map scale that applies the ratio between any distances on the map to the same distance on the ground, such as:

- Small map scale > 1:250 000
- Medium map scale > 1:100 000 and < 1:250 000, used to determine the region boundaries
- Large map scale > 1: 25 000 and <1:100 000, used to determine the directions
- Details map scale < 1:25 000, used to any civil applications

The second, it is the map projection which is defined as regular geometrical shape such as cylindrical, conical, that applied by equation to make transformation from the Earth coordinates (Three dimensions) to the map coordinates (Two dimensions), this transformation preserve the distance or shape or area, such as in the Universal Transverse Mercator (UTM).

The third is to determine the coordinates systems such as geographic coordinates (longitude, latitude and height) or Cartesian coordinates (X, Y and Z), notice that for coordinates systems the reference axis and origin point must be determined, for example to the terrestrial reference frame it is the World Geodetic System (WGS\_1984). Therefore, it is important to collect the maps with the suitable projection system and scale. Maps have to cover the study area. The purpose of the maps collection is to determine the areas, the distances, to collect the Ground Control Points (GCPs) and to collect the satellite images covering the study area. So, maps collection is fundamental equipments for any surveying application. After that many processing,

computations and analysis could be done to extract the purpose that you need from the maps<sup>[1]</sup>. Two maps were available in this study:

- Al-Salt Topographic Map at a scale of 1:50 000
- Al-Salt Geological Map at a scale of 1:50 000

**Existing GIS layers:** Layers are groups of features organized into an object called a Shapefile. In this study different vector layers were available from Department of Lands and Surveying (DLS). These layers are: buildings layer, road networks layer and Parcels layer.

**Software:**

**ENVI 4.3:** The Environment for visualizing images, is the most advanced, yet easy-to-use remote sensing software available. ENVI will transform the way you work with remote sensing data. ENVI software combines a complete image processing package with the most advanced spectral tools. ENVI also provides geometric correction, terrain analysis, radar analysis, raster and vector GIS capabilities, extensive support for images from a wide variety of sources and much more.

ENVI is a powerful tool for analyzing the content of hyper spectral images that is adaptive and easily modified for the desired workflow. A Government-funded independent assessment of a broad range of software tools indicated ENVI Software was the #1 product for automated feature extraction and assisted target recognition. ENVI also earned Top Rating from NIMA Pathfinder 2002 Evaluation.

**Project me:** Project me is a type of programs that deals with transformations between projections, in order to convert the coordinates from one case to another and vice versa. This software was used to convert the coordinates from Geographic (WGS84) to WGS 1984 UTM zone 36.

**ArcGIS (version 9.2):** ArcGIS is the most important program for the GIS application exactly nowadays. The ArcGIS supports the virtual reality program, additionally with ArcScene and ArcGlobe we can consider it a type of virtual reality software (with some lack), the ArcGIS supports all type of data that is needed by Geomatics, for example all statistics data that must be joined with the features and stored in a database.

**Processing:** The collected data should be processed in order to get the desired results. The data type and the quality of the required results must be taken into consideration in the data processing. For example, the



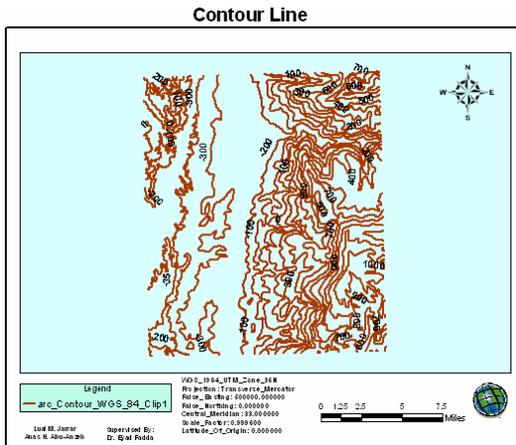


Fig. 5: Contour line layer

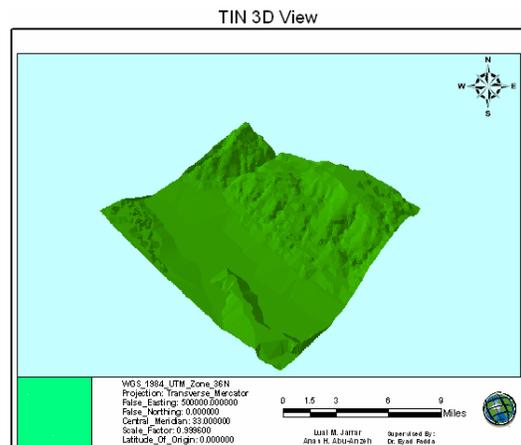


Fig. 7: TIN 3D View layer

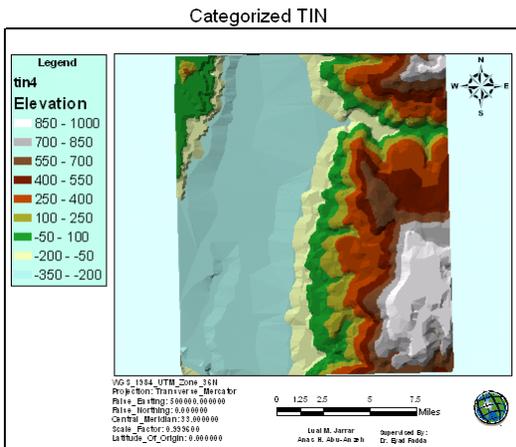


Fig. 6: Categorized TIN layer

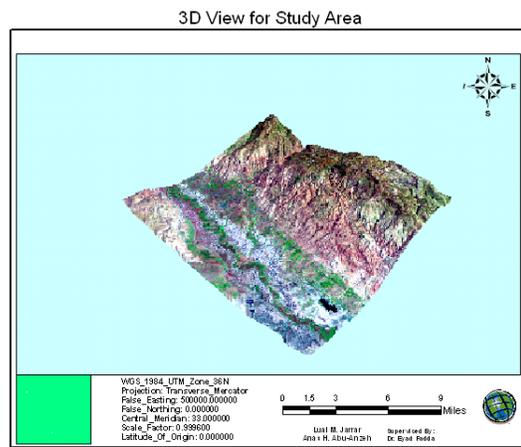


Fig. 8: Satellite image draped over 3D layer

But TINs are special data presentations that do not integrate with standard raster or vector data formats very well [9,10]. However, they are excellent visual description of the landscape. Based on Al-Salt Topographic Map, which has contour interval (20meter), we created contour layer, it contained a field for height of contour line, to take the base height in (3D) applications.

**Create TIN:** After digitizing the contour layer, the (3D ANALYST TOOLS) can be used to create TIN for Al-Salt. Figure 5-8 show 3D analysis in the GIS environment.

**Slope and aspect:** Because TIN confirm to the surface, they can be used to calculate the degree of slope and aspect (direction characteristics) of the land. Slope is very important in many applications because it

determines steepness, indicates environmental conditions and influences the land cover, land use. Slope is one of the most critical information needs for resource managers and urban planners. After we made the tin, we used it to create TIN surface such as Aspect and Slope. Figure 9-10 show slope and aspect for study area.

**Shaded relief views:** Illumination applying 3D data creates shaded relief views. Shaded relief actually means that one part of the topography is illuminated and the other is in shade, with intermediate that parts in gray tones. To the eye, this gives an appearance of reality, making landscape interpretation easy and promoting further use of the data. Differences in topography can be very important spatial factors in many applications; shaded relief views are ideal data visualization presentation (Fig. 11-12).

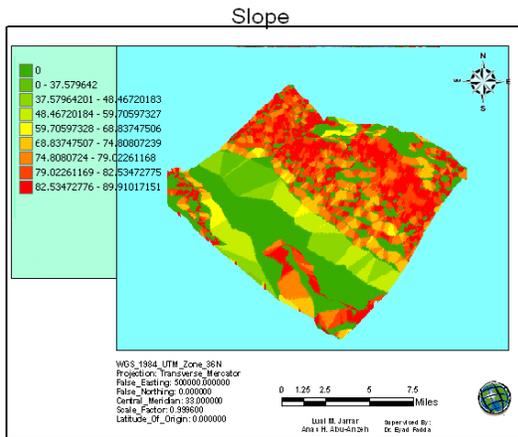


Fig. 9: Slope layer for the study area

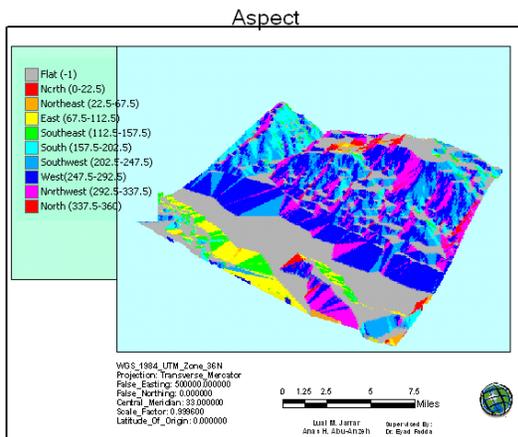


Fig. 10: Aspect layer for the study area

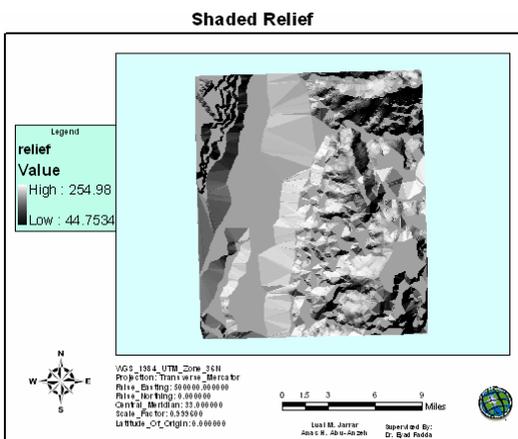


Fig. 11: Shaded relief layer for the study area

The efficiency of a database depends on how the data from different sources are managed, stored

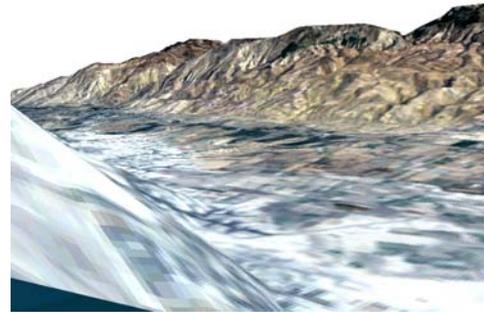


Fig. 12: Actual view for study area

andrelated with each other. The capability of future retrieval of the data, updating and analyzing, is where the power of a relational database exists.

## CONCLUSION

Data Fusion as an advanced technique in digital image processing was used in order to integrate between SPOT (10 m) resolution images and the Landsat-7 (25 m) resolution image. This technique concerned in geometric integration on one hand and integration between the 4 bands of SPOT images with the 3 (R G B) bands of Landsat-7 image as a radiometric integration on the other hand.

The major advantage of a GIS is that it allows identifying the spatial relationships between map features. GIS does not store a map in any conventional sense: or does it store a particular image or view of a geographic area. Instead, a GIS stores the data from which you can draw a desired view to suit a particular purpose.

GIS was used to store feature attributes to compute new information about map features, for instant, to calculate the length of a particular road segment and to determine the total area of a particular soil type.

Digital image maps for Jordan and for Al-Salt area in particular, in addition to their attributes were produced. All the resultant images, digital maps, attributes, layouts have been stored as a relational GIS & RS Database System for A-Salt area. The relational GIS & RS Database System for Al-Salt area can be used for retrieval, updating, analyzing and modeling any required map or information.

## REFERENCES

1. Bobrowsky, P.T., 2005. Geoenvironmental mapping-method. Theory and Practice, Swets and Zeitlinger BV. 2nd Edn. Taylor and Frances, ISBN: 9054104872.

2. Chavez, P.S., S.C. Side and J.A. Anderson, 1991. Comparison of three different methods to merge multiresolution and multispectral data landsat TM and SPOT panchromatic. *Photogrammet. Eng. Remote Sens.*, 57: 295-303. <http://www.fao.org/agris/search/display.do?f=/1991/v1705/US9117278.xml;US9117278>.
3. Goodchild, M., R. Haining and S. Wise *et al.*, 1992. Integrating GIS and spatial data analysis: Problems and possibilities. *Int. J. Geograph. Inform. Sci.*, 6: 407-423. DOI: 10.1080/02693799208901923.
4. Haydn, R., G.W. Dalke, J. Henkel and J.E. Bare, 1982. Application of the IHS color transform to the processing of multisensor data and image enhancement. In: *Proceedings of the International Symposium on Remote Sensing of Arid and Semi-Arid Lands*, Cairo, Egypt, pp. 599-616. 607.
5. Jensen, J.R., 2007 *Remote Sensing of the Environment: An Earth Resource Perspective*. 2nd Ed., Upper Saddle River, NJ: Prentice Hall. <http://www.cas.sc.edu/geog/rsbook/Exercises/Rse/index.html>.
6. Lillesand, T.M. and R.W. Kiefer, 2000. *Remote Sensing and Image Interpretation*. 4th Edn. Chichester: John Wiley and Sons, Inc., New York. ISBN: 0471255157.
7. Ranchin, T. and L. Wald, 2000. Fusion of high spatial images: The ARSIS concept and its implementation. *Photogrammet. Eng. Remote Sens.*, 66: 49-64. <http://direct.bl.uk/bld/PlaceOrder.do?UIN=072575192&ETOC=RN&from=searchengine>.
8. Robinove, C.J., 1989. Principles of Logic and the Use of Digital Geographic Information System. In: *Fundamental of Geographic Information Systems: A Compendium*, Ripple, W.J. (Ed.). American Society for Photogrammetry and Mapping.
9. Sui, D.Z. and M. Ball, 2006. *Geospatial Matters: Exploring the Implications of a Digital Earth*. 1st Edition. San Francisco.CA. GeoTec Media.
10. Sui, D.Z., 1992. A fuzzy GIS modeling approach for urban land evaluation. *Comput. Environ. Urban Syst.*, 16: 101-115. <http://cat.inist.fr/?aModele=afficheN&cpsidt=5374796>.
11. Wald, L., 2002. *Data Fusion, Definitions and Architectures fusion of images of different spatial resolutions*, 1<sup>st</sup> edition. Les Presses. Paris, - Mines Paris. ISBN: 291176238X.