GIS SPATIAL ANALYSIS FOR DIGITAL ELEVATION MODEL (DEM) APPLICATION

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ABSTRACT

The study area of this paper is Alsukhna city; which located along the Cairo – Hurgada highway. The problem arraised when the Egyptian authority needed to know the actual amount of cutting and filling in the mountains exist in the city during the project of city construction for environmental assessment purposes.

Two digital terrain models (DEM) have been created; one was before the city project construction and the other one was after the city project construction by using extensive studies, satellite images, field visits, field measurements and topographic maps. GIS spatial analysis was applied to compare and analyse the two DEMs results.

By analyzing the two DEMs; it was found that: the total amount volume of cutting from mountain is 116 405 841 m³ and the the total amount volume of filling is 113 612 511 m³ with percentage of 98% of using the cut material in filling process.

It could be concluded that the cut and fill process that had been done were very important in order to protect the project area from the rainfall risks and mountain collapse.

INTRODUCTION

Geographic Information System (GIS) is a computer-based system that provides the following four sets of capabilities to handle geo-referenced data: input, data management (data storage, maintenance and retrieval), manipulation and analysis, and output. GIS allow interpreting and visualizing data in many ways that reveal relationships, patterns and trends in form of maps, globes, reports and charts.

The main objectives of this study are to investigate the actual situation of Alsukhna city project and to get the amount and places of cutting and filling that had been done in the mountain at the project area. This paper will based on extensive studies using satellite images and field visits and topographic maps that contain the geographic features produced by Surveying in the ground prior to the commencement of the project and the existing topography of the project in addition to a series of scientific reports.
MATERIALS AND METHODS

The collected data consist of topographic maps that contain the geographic features produced by Survey Authority and Military Survey scale 1:2500 (1990), field survey using Total station (XYZ), satellite images, and statistical data.

AutoCAD, Arc-GIS, and Erdas Imagine software are used in data entry and analysis, in addition to land-use/land-cover data are checked in the field by using GPS and Total station to update and upgrade the topographic map. These data are collected from different sources for verification. The procedures followed to build a GIS for the project (Porto El-Sokhna) and make it ready for analysis are: (1) data capture, (2) data preparation, (3) data extraction, (4) data integration. These steps are followed to develop the required GIS based on various types of data available from multiple sources.

A vector-based GIS was developed by digitizing the available maps, construct topology of various layers, editing errors, reconstruct topology, and adding attributes. The GIS includes layers of land uses, roads, elevations, census tracts and population characteristics. A LANDSAT-MSS satellite images are used to obtain data on the extent of urban areas in. The satellite image is rectified to the same projection system of the base map and classified using maximum likelihood technique. The classified images are integrated within the multi-layered GIS.

METHODOLOGY

The technique used in this study is based on building up and analysis of a geographical information system layers. The main steps involved in building a geographical information system include; data collection, input spatial data, edit & create topology, input attribute data and data analysis.

- A first step includes the technical measuring of the ground levels and borders by using different surveying instruments, such as total station and GPS.
- A second step includes the data processing of the measurements by using different surveying software.
- A third step includes the technical conversion from file format DXF and/or DWG to GIS software to prepare a georeferenced geodatabase and classify it as layers.
- From the digital data it could be build up a model of 3D topography which is called Digital Elevation Model (DEM); that gives more easier realization and interpretation after and before construction. The data file of DEM before construction was as following:
  Vector data information; ESRI description; Vertical; Minimum elevation: 0.000000; Maximum elevation: 286.000000; Node Geometry Node; Topology: TRUE; Feature count: 45766; Spatial Index: TRUE; Linear referencing: FALSE. Geometry type: Edge; Topology: TRUE; Feature count: 274299; Spatial Index: TRUE; Linear referencing: FALSE; SDTS description; Feature class: SDTS feature type; feature count; Triangle: Ring composed of chains, 91433; Node: Node, planar graph, 45766; Edge: Link, 274299.

The data file of DEM before construction was as following:
  Vector data information; ESRI description; Vertical; Minimum elevation: 0.000000; Maximum elevation: 286.000000; Triangle; Geometry type: Triangle; Topology: TRUE; Feature count: 571074; Spatial Index: TRUE; Linear referencing: FALSE; SDTS description; Feature class: SDTS feature type; feature count; Triangle: Ring composed of chains, 571074; Node: Node, planar graph, 285556; Edge: Link, 1713222.
RESULTS AND DISCUSSIONS

Using the above data files; two digital elevation models have been created. Figures (1; 2) illustrate the DEM results.

Figure (1): Digital Elevation Model before construction

Figure (2): Digital Elevation Model after construction
A Slope map is important in identifying constraints and evaluating potential environmental impacts related to landform alteration. Major constraints can be tied to grades/inclinations that are either too steep (to reasonably construct structures, roads, etc.) or too gentle (for playfields, etc.) Major impacts related to inclination include erosion/loss of soil/non-point source pollution and slope failure (linked to weak rock, soils with low bearing capacity, steep slopes, etc.) Coupled with aerial photographs, slope maps are excellent tools to look for potential erosion areas, drainage patterns, landform and soil patterns, land use suitability, etc. Figures (3; 4) illustrate the slope map before and after construction.

![Slope map before construction](image1)

**Figure (3):** Slope map before construction

![Slope map after construction](image2)

**Figure (4):** Slope map after construction

Contour maps are a useful way to visualize the spatial relationships among data and the spatial distribution of data values, which represent the locations that have the same altitude Fig.(5; 6) show the contour map before and after construction.
Figure (5): Contour map before construction

Figure (6): Contour map after construction
The volumes of work that had been done in the project could be determined and compared with the current situation from the two surfaces of land before and after the project; also we identified the zones of cut and fill into GIS Analysis to produce the TIN- Difference and profiles. Figure (7) illustrates the TIN differences.

![TIN Difference](image)

**Figure (7):** TIN- Difference between the two surfaces (before and after the project)

Eight profiles have been selected randomly to cover the all site to display the difference between the two surfaces (before and after construction). Figure (8) shows the eight profiles and Figures (9; 10) show the profile number five.

![Profiles](image)

**Figure (8):** The 8 profiles that distributed in the all site
CONCLUSIONS

The project is located on the area of El-Galala mountain; which its height is reaching 1200 m, with a total area of 1 303 324 m². The height in the project area is ranging between 0 and 286 m. A number of 109 points are chosen as observation points to cover the all project area for height comparison.

By analyzing the satellite image and comparing the heights before construction (using the topographic contour map) and after construction (using actual field measurements); through the creation of two digital elevation models; we found that: the total amount volume of cutting from mountain is 116 405 841 m³ and the total amount volume of filling is 113 612 511 m³ with percentage of 98% of using the cut material in filling.

The average height of the project area after finishing the project is remaining 82 m as the same height before starting the project.

The cut and fill process that had been done were very important in order to protect the project area from the rainfall risks and mountain collapse.
REFERENCES

1. Egyptian Military Survey (1985): Topographic Sheets, scale 1:100,000, Cairo Egypt, 34 sheets.