King Fahd University of Petroleum & Minerals

CRP 514: Introduction to GIS - Term 111

Term Paper

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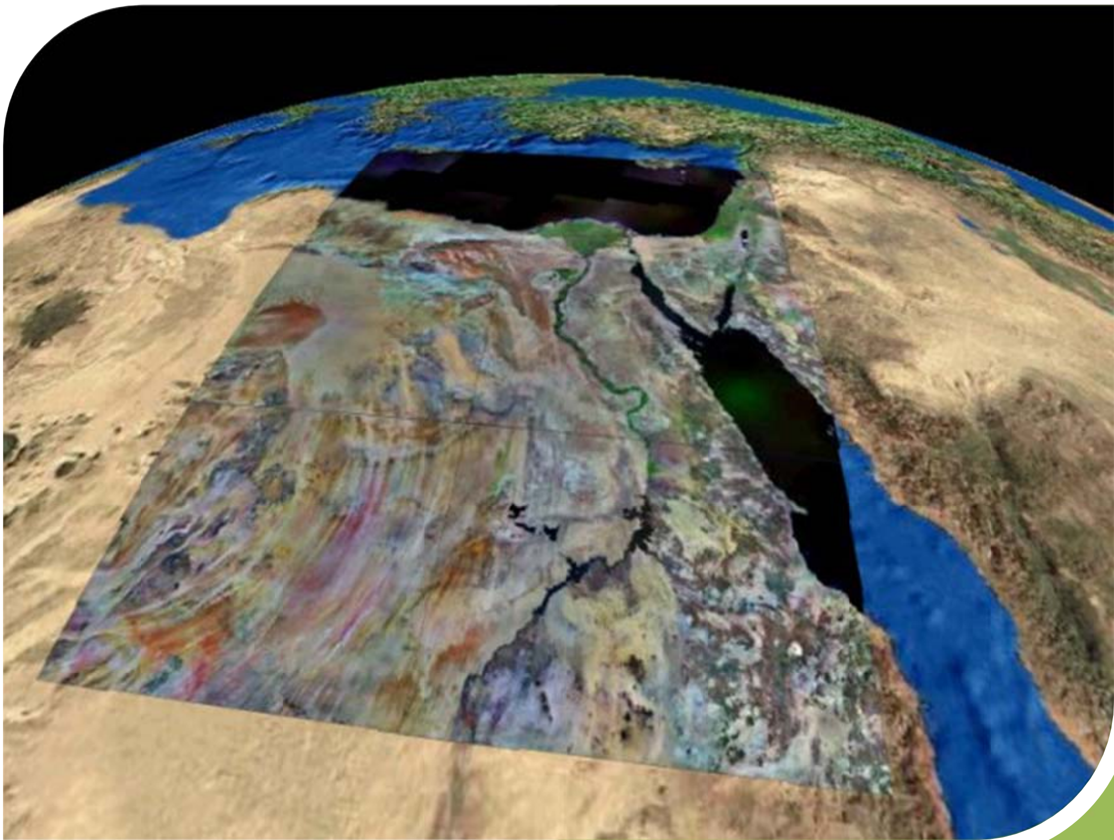

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Table of Contents

Table of Figures

The Use of GIS in Geological Research and Exploration in Egypt

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Abstract

In geological research and exploration, information comes in many different ways, including e.g. paper maps, digital data, publications, internal company reports and regional consultants' syntheses. A geographic information system "GIS" allows you to bring all types of data together based on the geographic and locational component of the data.

But unlike a static paper map, GIS can display many layers of information. This allows integrating, visualizing, managing, solving, and presenting the information in a new way. The data will become more valuable. Many authors of geological maps and reports today offer their reports in GIS format, which facilitates integration of data from different data sources.

In my term paper, I am going to explain the advances in GIS within Egypt. GIS learning and training has been developed during the last decade. The uses of GIS in Oil Exploration and Scientific Research are variable in such a relatively oil-rich country. Many other aspects will be considered, specially the data resources and the problem of data transfer.

A case study is included. This study investigated the impact of oil exploration and production activities on the physical and environment parameters of a coastal zone area, Ras Ghareb, Egypt. The authors used GIS to integrate all data types and locate the location of contaminated water in the area. GIS proved its capability of doing such kind of research.

1. Introduction:

i. What is GIS?

A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.[i]

GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared.

GIS technology can be integrated into any enterprise information system framework.

ii. Applications of GIS:

GIS has a wide range of applications in all aspects of life around us. Those include: facilities management, marketing, health, insurance, natural resources management, forestry/wild life management, environmental impact assessment, geology and oil exploration and many more applications.

In this paper I am focusing on the use of GIS in geological research and exploration. GIS is a very effective technology that enables petroleum exploration teams to share information, analyze data in new ways, and integrate the evaluation process. In any exploration department, you will find one or more GIS specialists. The need for GIS experts has been increased recently.

In recent years, GIS technology has become very affordable and easy to use. The true power of GIS is that it presents a new way to analyze databases. GIS enables the analyst to visualize the data as they are represented spatially.

2. GIS in Egypt:

The first GIS projects that were carried out in Egypt date back to the early 1980s and they were the results of individual attempts carried out by entrepreneurs who have dealt with this new technology in North America and Europe and thought of pioneering it in the new emerging market (Ahmed, 2009).

The Egyptian government has designed a number of useful GIS-based applications in different sectors throughout the country, however, the use of GIS is still limited and GIS remains, to a large extent, a technology restricted to the public sector and academia, unknown to the majority of the public (Sobeih, 2005).

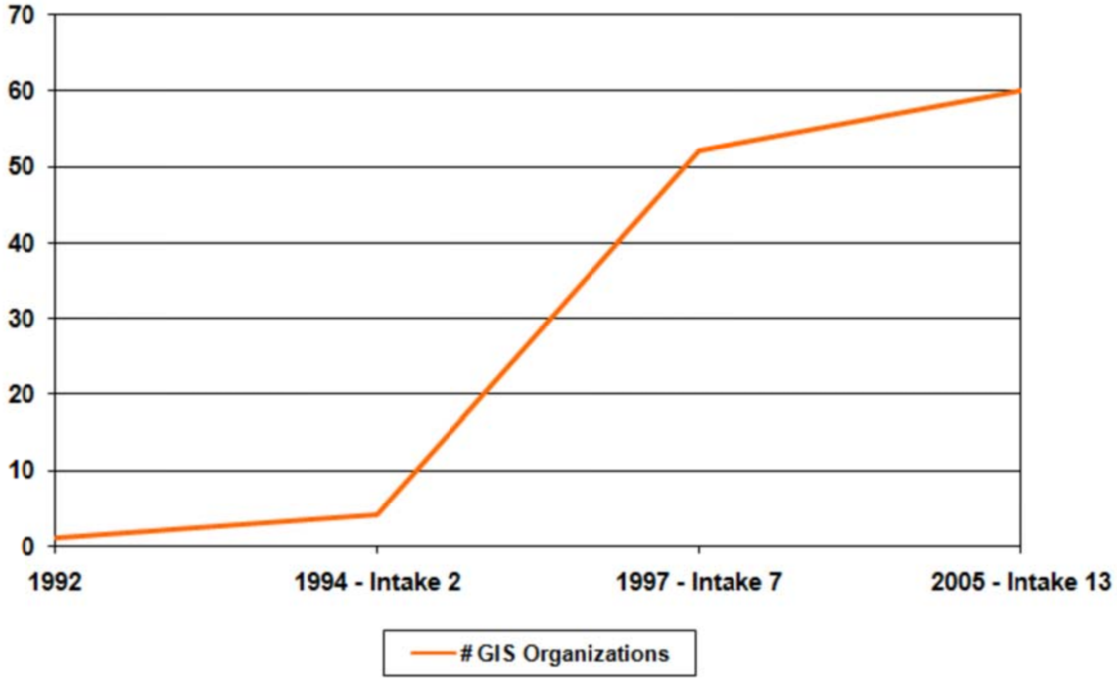


Figure 1: Number of GIS Organizations, since ITI was established. (Ahmed, 2009)

Till now, no dedicated department or unit for GIS exists in any ministry or governmental corporation. However, the GIS specialist may be employed for certain departments. These departments may have different names depending on the nature of the corporation or the organization. Those include, for instance, the cartography, data management, surveying, maps or decision making departments.

Fairly speaking, we have to mention that the Egyptian government has drawn on GIS technology in a number of promising projects in various disciplines throughout Egypt.

The government established the Information Technology Institute (ITI) with the objective of supporting the Information Technology industry (including the GIS industry) in Egypt by providing the qualified human resources. Since then, the GIS industry is growing to a large extent (Figure 1).

3. GIS Application in Geological Research and Exploration:

GIS is a powerful tool for petroleum exploration, particularly with regard to exploration mapping. Such mapping is usually performed across large geographic areas, where many data sets or map layers are used in the analysis of hydrocarbon potential. Raster data, such as aerial photos or satellite imagery, can be incorporated with vector data, and surface culture, such as hydrography, elevation contours, and topographic landmarks or points of interest, can be presented.

A typical petroleum exploration team might consist of one or more geologists, geophysicists, engineers, petrophysicists, landmen, and geotechnicians. Each discipline approaches the problem-solving process in different ways. In addition to the diversity of disciplines and problem-solving approaches, petroleum industry teams, particularly those involved in exploration and development, have historically used and relied on a wide variety of computer software, hardware, and databases, which has added to the need to seek common ground and synergy.

i. Requirements:

(Mazzo, and Burroughs, 2000) defined the seven main features required of a GIS for regional geological studies. Such a GIS must:

(1) Have the ability to deal with many different formats of mappable and non-mappable data. This includes complex polygons common in small-scale geological maps typical of regional studies, and simpler exploration contour maps common at a larger scale;

(2) Encompass coordinate systems that can be easily rescaled and transformed;

(3) Be able to readily organize large volumes of information. A given regional study may be composed of 1000 or more products. A GIS provides maximum flexibility in setting up a hierarchical data structure with appropriate slots in which to organize the products. This feature, in turn, allows distinct geological elements and interpretations to be instantly accessible for use in many different types of maps. The data structure allows data to be captured and stored only once in the system without having to copy it into every drawing that uses the information;

(4) Provide a database which stores meaningful geological information (attributes) for map features, such as faults, field closures, or geological polygons. This property eliminates redundant data and facilitates the creation of a variety of products from a few sets of input layers. The database must be flexible because many of the map features found on regional study maps (e.g., basement-type polygons) are not conventionally found in industry-standard data models;

(5) Have the ability to digitally overlay and suture layers of data together into new graphic and tabular relationships. Overlay requires a series of “proximity” operators, which act to join multiple tables of data together; based on the fact that the geographic features they are attached to are “close” to each other in space. This capability is fundamental to quantitative exploration resource appraisal, which seeks to identify zones of high oil and gas potential in regional work;

(6) Have the ability to store metadata (data about the data). That is, such a system must be able to produce a kind of a card catalog that references all the maps in the system;

(7) Have the ability to provide high-quality graphic output.

ii. Advantages:

Advantages to the GIS approach, as described by Mazzo and Burroughs, include the following:

(1) *All spatial information is available for interpretation in essentially one system.* The GIS database acts as a digital light table, allowing different layers of information to be combined to

help constrain new interpretations. For instance, to define basin outlines, color relief grids of gravity and magnetic can be combined with sedimentary-fill contours, structural elements, and basement type and zonation maps. The quality and consistency of interpretation are improved by such an approach.

(2) *New maps can be created from old maps.* All new interpretive maps loaded into the GIS have an attached database (a suite of information about each fault, igneous body, contour, lithofacies polygon, etc. for each feature on the map). It is therefore a simple process to subset, isolate, highlight, and combine any layers from many maps to create a new collection of products.

(3) *Multiple products can be easily "zippered."* Regional studies covering multiple basins are often compiled on a geographic or thematic basis. A regional team, in collaboration with explorationists working on discrete plays or prospects, may create a whole suite of separate products for an area. At some point, the individual projects are compiled into the final regional interpretation. Merging or zippering maps in a GIS saves extensive hand fitting, rotating, cutting, and redrafting to resolve boundary interpretation differences. In addition, maps can be generated directly from the GIS in the proper scale and projection for use.

(4) *The capability to develop early correlations between hydrocarbon occurrence and mapped geology is provided.* This understanding is fundamental to any regional study undertaken in an exploration setting. This correlation helps to better define hydrocarbon plays, petroleum systems, and the ultimate quality or potential of basins for further exploration. The early focus guides later efforts in the study, and using a GIS simplifies the ultimate reporting at the end of the study. Typical products include field size distributions and estimates of oil and gas reserves per basin and horizon, all of which can be derived using GIS overlay capabilities on different layers of data.

(5) *The system is self-documenting;* methodically loading the data into a standard database and cataloging layers and maps in a standard archival structure results in a largely documented study by the end of a project. Using the GIS approach, a project becomes a continual stream of work products, which are compiled into finalized review products. Customary drafting and documentation can be virtually eliminated. In addition, products are easily located and are retrievable.

(6) *Projects are completed in a timely manner.* The planning and discipline required for the GIS approach pay significant dividends throughout the life of the project. Defining a project in terms of a predefined map series creates efficiencies in process flow, documentation, and drafting, as well as elimination of duplicate effort.

(7) *Projects are completed at a reduced cost compared to more traditional methods.* Based on the CARP experience, it is estimated that, on average, the cost of a regional study completed using GIS methodology will be 80% of the cost of completing the same study by conventional methods. A portion of the cost savings stems from the near elimination of a separate documentation phase at the end of the project. However, it is equally clear that "front loading" a large study with a

carefully defined product list and production plan, although initially more time-consuming, allows a much more measured and structured pace of work throughout the course of the project. Such planning also results in a generally more efficient work process on both the geological and database sides.

4. Case Study:

This case study can be a good example of the application of GIS in Exploration in Egypt. The study is entitled “Monitoring some environmental impacts of oil industry on coastal zone using different remotely sensed data”. The research was conducted by (Effat and Hegazy, 2010). It was managed and approved by the National Authority for Remote Sensing and Space Sciences in Egypt.

i. Study Area:

The coastal area of Ras Ghareb is located in the north Eastern Desert, Egypt, on the western coast of the Gulf of Suez. It is located between latitudes 27° 45´ and 28° 45´ N and longitudes 32° 00´ and 33° 30´ E (Figure2).

The main town in the area is Ras Ghareb which represents a huge oil exploration, production and export town. The population of the city exceeds 60,000.

The first commercial oil field in Ras Ghareb was discovered in 1938. Since then, oil resources provide an important foundation for life and development in the area. The study area includes six large oil fields and there are several others in its vicinity to the north and south.

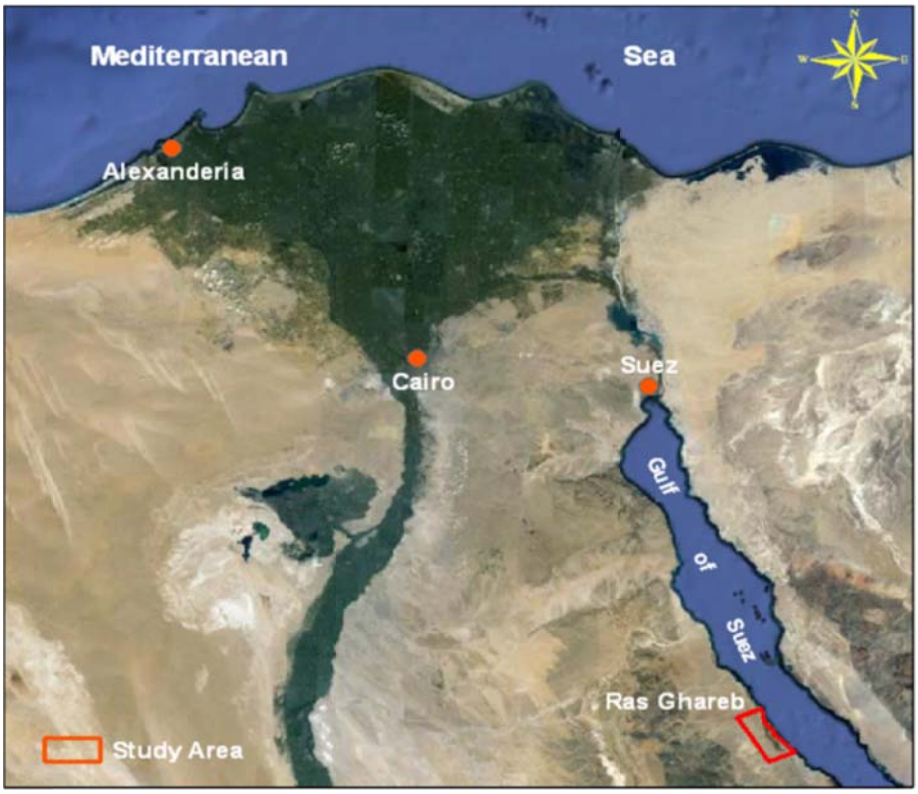


Figure 2: Location map of the study area.

ii. *Problem Statement:*

Water is considered the main environmental problem in the study area, where fresh water is a critical resource. Currently, the supply of fresh water is based mainly on groundwater aquifer and desalination of sea water, where there are small salt marshes at Ras Ghareb.

With the increasing activities in oil industry and the consequent development projects in this area, there is an environmental threat of oil pollution to soil and groundwater as well as to the coastal and marine ecosystem.

iii. *Study Objective:*

The main objective of this study was to identify the hot spots that are or could be subjected to environmental deterioration, in order to carry out the appropriate protective or remedial actions and measures.

iv. *Materials and Methodology:*

Different remotely sensed data were used in an integrated way for conducting this research.

The remotely sensed data include images from landsat enhanced thematic mapper (ETM+), shuttle radar topography mission (SRTM), and data from ground geo-electrical investigation.

Sequential landsat satellite images were used to identify changes that occurred in the land-cover and land-use classes including changes in water bodies, sabkhas, vegetation cover and areas of crude oil leakage as a point contamination source.

SRTM data was used to build a digital elevation model (DEM) and to study some terrain characteristics of the area, including surface topographic features and surface water and contamination regime.

Based on the findings of a geo-electric survey using Schlumberger geo-electric sounding, the ground water level was measured and the presence of fresh, brackish or salt water was identified.

A field investigation was conducted and the surface and ground water contaminations were monitored and measured.

Examples of the data used in this project include:

- Elevation zones map of the study area derived from SRTM data (Figure 3).
- Slope angles map of the study area derived from SRTM data (Figure 4).
- Lithology map of the study area (Figure 5).
- Location of ground water monitoring wells related to pollution hotspots (Figure 6).

A geographic information system (GIS) was applied to include all these data layers as an active database for the area.

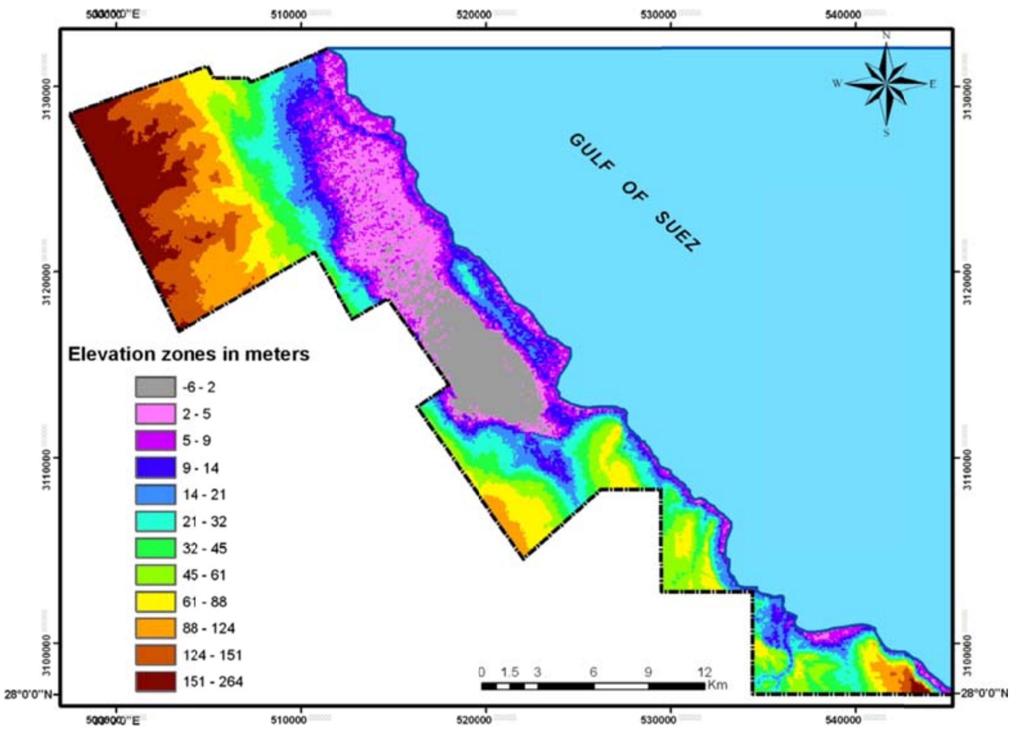


Figure 3: Elevation zones map of the study area derived from SRTM data.

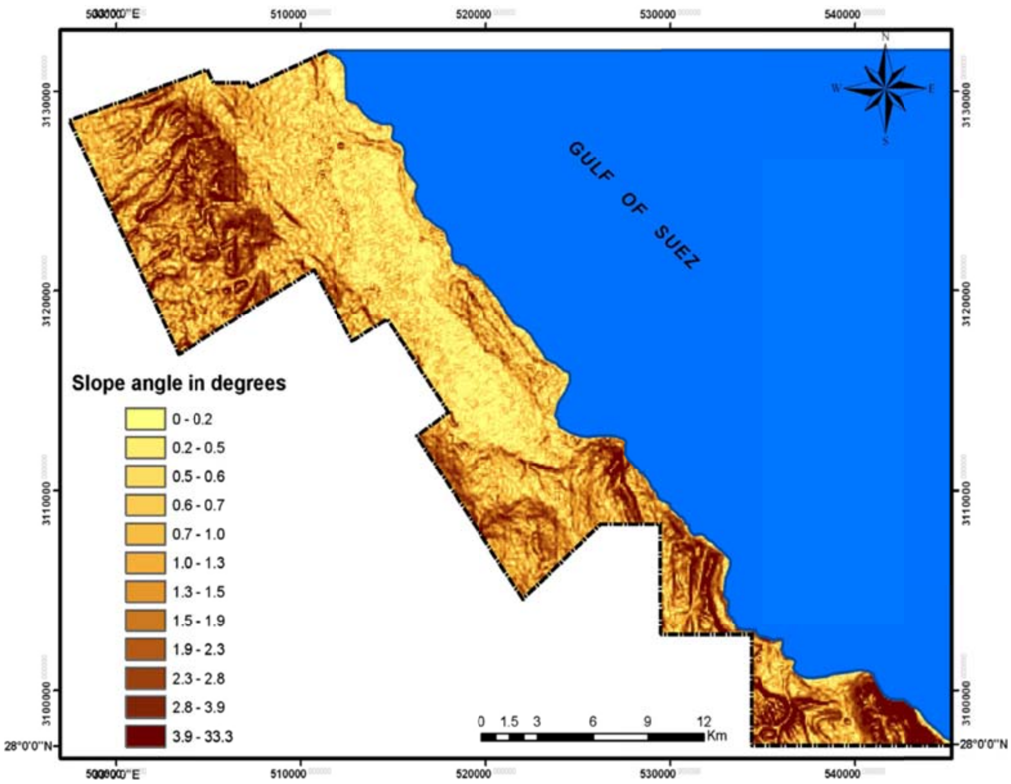


Figure 4: Slope angles map of the study area derived from SRTM data

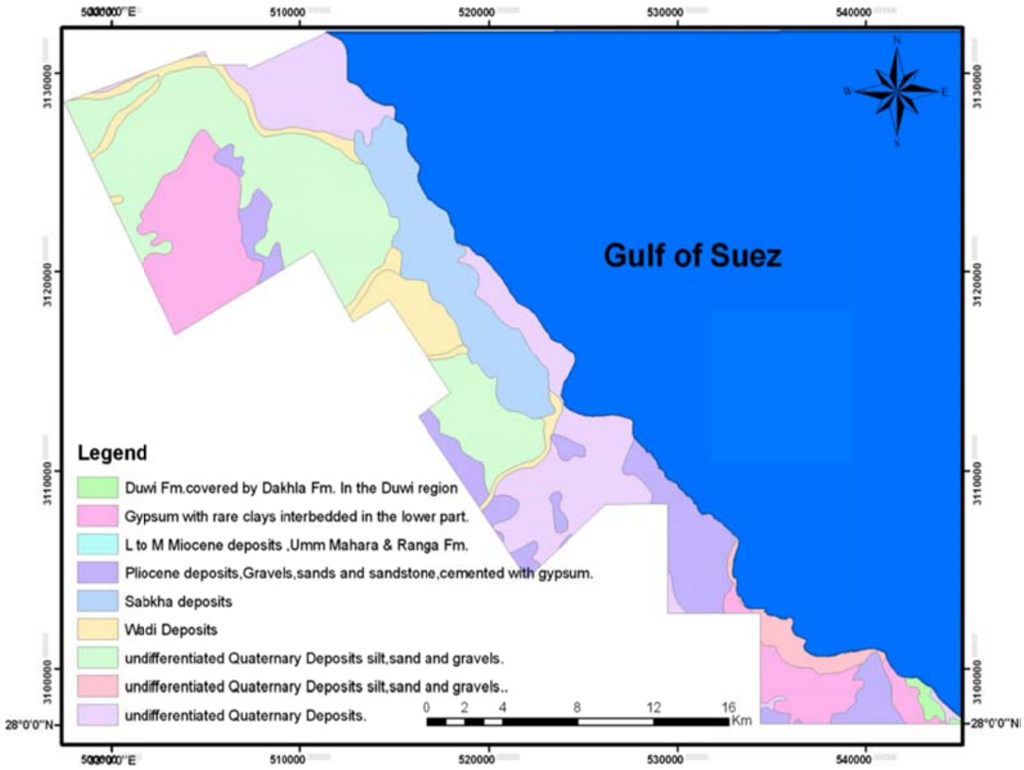
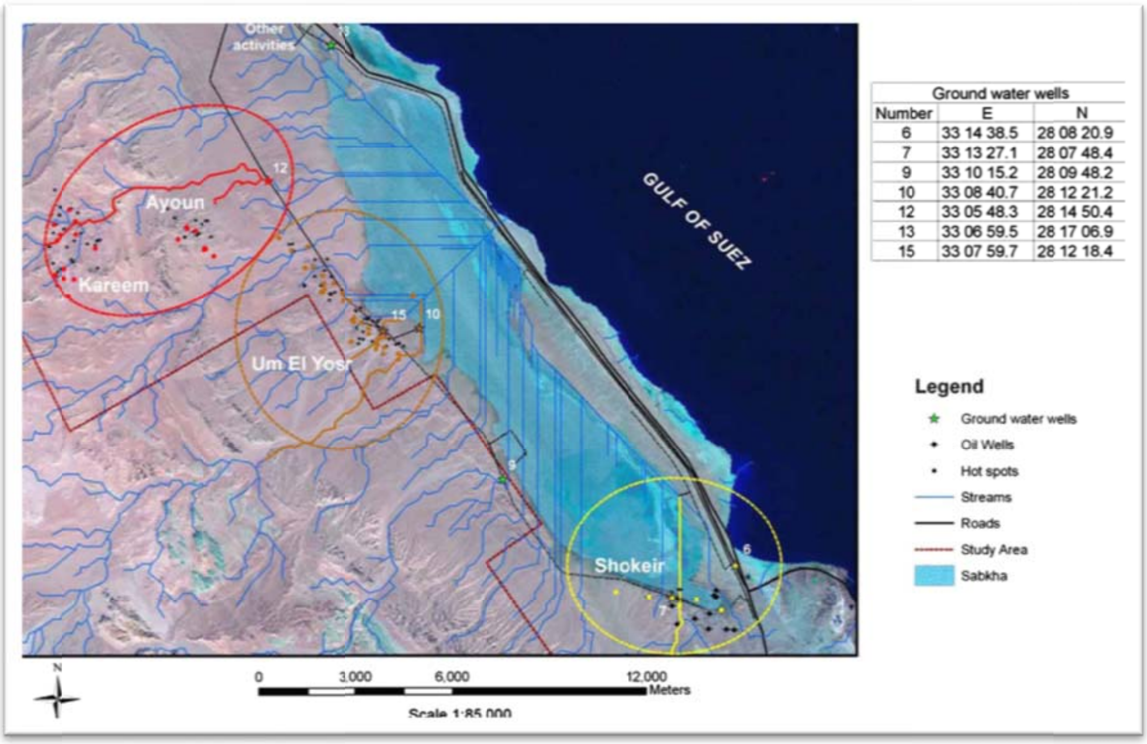


Figure 5: Lithology map of the study area



Ground water wells		
Number	E	N
6	33 14 38.5	28 08 20.9
7	33 13 27.1	28 07 48.4
9	33 10 15.2	28 09 48.2
10	33 08 40.7	28 12 21.2
12	33 05 48.3	28 14 50.4
13	33 06 59.5	28 17 06.9
15	33 07 59.7	28 12 18.4

Figure 6: Location of ground water monitoring wells related to pollution hotspots

Conclusion

The Egyptian government has drawn on GIS technology in a number of promising projects in various disciplines throughout Egypt. Since the government established the Information Technology Institute (ITI), the GIS industry is growing to a large extent in Egypt. GIS is a powerful tool for petroleum exploration, particularly with regard to exploration mapping. The applied methodology and techniques in the case study proved the feasibility of using different remotely sensed data, field investigations and measurements in a GIS environment for pollution monitoring and environmental management.

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[i] http://www.gis.com