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# Applying Remote Sensing And Geographic Information System For Geo-Environmental Application

**Dr. Tarek A.E. El-Damaty[1], Dr. Ismail Elkhrachy[2]**

*Banha University, Faculty of Engineering, Cairo, Egypt.[1,2]*
*Al-Azhar University, Faculty of Engineering*
*Civil Department, Cairo, Egypt.[3]*

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## ABSTRACT

*Satellit images, Remote Sensing (RS) and Geographic Information System (GIS) are perfect tools for geo-inviromental applications in science and engineering. While the egyption ministry of electricity is planning to establish a new electrical station at Nuweiba city in Egypt, to cover the increasing demand on electricity in this area. In this paper an integrated approach using satellite data and GIS techniques in conjunction with ARC / GIS program is used to study some issues related to the environment surrounding the project and get its impact. land use map with scale 1:100,000 for the main geo-environmental features and landforms of study area is produced by using ArcMap program. The produced map taks consideration of land use changes within 1984, 2000 and 2007. Nuweiba city, the Gulf of Aqaba has the potentials to be developed and need to support such developments by establishing the essential services projects such as the proposed electrical power station. Remote Sensing and GIS are the best tools of acquiring and analysis the basic information particularly on the environmental applications.*

**Keywords** : GIS, Remote sensing, Satellit images, geo-inviromental ,Land use**,** ArcMap .
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## INTRODUCTION

Remote Sensing (RS) is considered as asuccessful tool to study various environmental activities. It has been used successfully in the monitoring and mapping of natural resources, air temperature, air poullution, soil moisture .conditions, vegetation changes, urban development analysis, land use, ..etc. RS- can be defined as the collection of data about an object from a distance. Geographers use the technique of remote sensing to monitor or measure phenomena found in the Earth's surface.

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 Gulf of Aqaba is the northern extension of the Red Sea und is part of the about 6,000 km long Syrian-African rift system, which extends from Mozambique to Turkey. The gulf occupies the southern segment of the approximately 1,000 km long, so-called Dead Sea rift. This rift is a plate boundary of transforms type, connecting the Red Sea, where sea-floor spreading occurs, with the Zagros-Taurus zone of continental collision. The Gulf of Aqaba is one of the two rift systems (the Gulf of California is the other) where a mid-ocean ridge system passes into a transform system and runs into a continent (Figure 1).The ministry of electricity is planning to establish a new electrical station at Nuweiba city, cairo, Egypt to cover the increasing demand on electricity in this area. The first step of establishing the target station is to study some issues related to the environment surrounding the project and get its impact. Land use is a major and important one of these issues.

## MATERIALS AND METHODS

### OBJECTIVES

The main objectives of this study are:

1. Produce of recent land use map scale 1:100,000 for the main geo-environmental features and landforms of the coastal belt Nweibea city, Gulf of Aqaba.
2. Investigate the spatial significance of the main features in determining potential land use maps for sustainable development of the coastal zone, as well as the natural hazards to propose any required mitigate measures.
3. Study land use changes within 1984, 2000 and 2007.

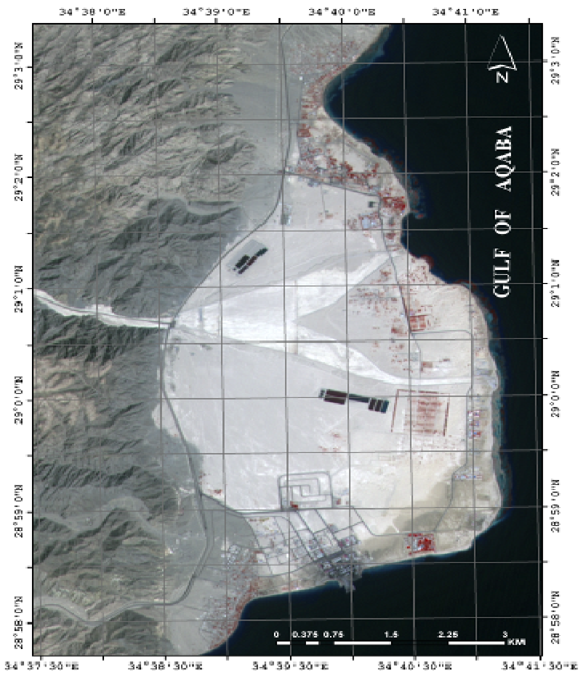


Figure 1: Spot Image dated in 2007 for the

### GEO-ENVIRONMENTAL ASPECTS

The Gulf of Aqaba extends from the Strait of Tiran to port of Aqaba, with length of about 180 km. It is narrow in the north (5 Km) and widening to the south (reaching a maximum width of 28 Km opposite Dahab). The Gulf of Aqaba follows a NNE-SSW direction from Aqaba at latitude 29° 33'N and to the Strait of Tiran at latitude 28° N and longitude 34° 51'E.

Study area shows three principal physiographic: extremely rugged mountains in the south, the table land and the narrow coastal plain. The Gulf of Aqaba is bounded from the west by intricate complex of very rugged mountains of southern Sinai formed of igneous and metamorphic rocks. The eastern edges of these mountains form vertical or steeply-dipping scarps whose descent can be made by certain routes locally known as "Naqbs". Some of these scarps overlook the depression of Wadi Araba, of which the Gulf of Aqaba graben forms part. The mountains are dissected by several incised wadis and deep gorges draining eastwardly into the Gull of Aqaba. Among the main wadis reaching the Gull are Wadi Araba, Wadi Watir, Wadi Dahab and Wadi Kid. The watercourses issuing from the mountains excavate deep ravines with deep sides and steep gradients. On the coast, opposite one of these breaks, about 113 Km. north of the entrance of the Gulf, is a sandy spit and the town of El-Qarnus. In this area, there is a large grove of dale palms and some 5 Km north there smaller grove and a fort. The other break, with a trail, farther towards the head of the Gulf, there is a broad route to the interior, through Wadi Araba, extending in a NE-SW direction there flat land between mountains at the head of the Gulf is a bout 6.5 K.m. wide with potential economic development, (Figure 2).

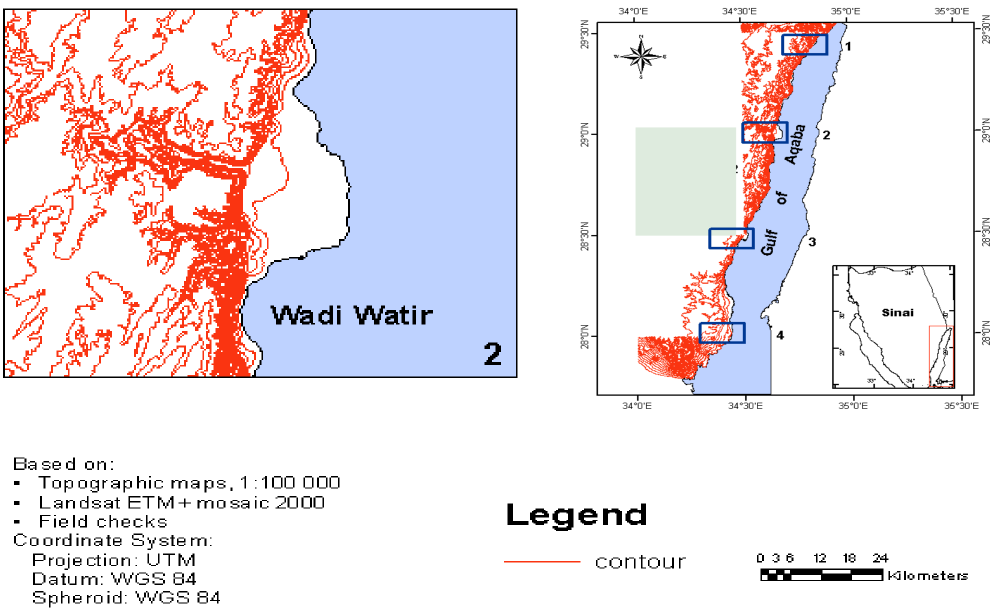


**Figure 2: Topographic map of Nuweiba area, Gulf of Aqaba**

## Land Use /Land Cover Mapping

Accurate, current information on land-use and land-cover is essential for planning of many development activities. Also, detection of changes in land use and land-cover is helpful to monitor environmental impacts of both natural parameters and human activities. Remote sensing data, from aircrafts and satellites, are becoming important for mapping land-use and land-cover particularly for large and remote and inaccessible areas. They provide an unbiased permanent data set that may be interpreted for a wide range of land-use/land-cover (Sabins, 1994). Remotely sensed data can be acquired from various systems on bound satellites on aircrafts, with a spatial resolution that matches the degree of detail required for the survey. The interpretation of remote sensing data is faster and less expensive than conducting ground surveys. Furthermore, the application of digital methods of image processing on the remotely sensed data to delineate the major categories of land-use and land-cover to produce a classification map. Digital processing is becoming essential because as spatial resolution and spectral coverage increases, the volume of data also increases. The analysis and interpretation of remote sensing data should be supplemented by ground checks of areas that represent various categories of land-use and land-cover.

Geographical Information System application and digital analysis of Spot data has been utilized in this study to recognized and defined land use in Nuweiba coastal plain area. The different steps involved in this work could be explained as follow:

- Defining a comprehensive legend according to the scale of Spot-4 image (1:100 000).
- Field checking and necessary modification of the primary maps applying the auxiliary data and extant maps to promote the formation depicted on the land use /cover maps.
- Measurement of land unit surface by applying geographical information system (GIS) facilities to accomplish the work.

**Techniques of Analyses**

In order to prepare the land use / land cover map with scale of 1:100.000, various maps, Spot-4 images, ground observations, and related ancillary data have been compiled and processed in different ways. These data have been systematically used to prepare the necessary layers to constitute an appropriate geographical information system (GIS) for the study area. These data were integrated to establish a digital data base which could be useful for site selections of proposed electrical power station, planning and management of such this development projects in the area.

The data available that are used in this study can be grouped in four main types: (1) Geological maps, (2) Satellite data (3) Topographic maps at scale 1:100 000, all of these materials are discussed in the following:

In the present work, Spot-4 imagery data dated in 2007 and covering the coastal area of Nuweiba city have been digitally processed, analyzed and interpreted to produce a land-use/land-cover map at a scale of 1: 100.000, (Fig.10). The main classes of recognized land use (activities) and land cover (resources) at this scale are given in Table (1). This is based mainly on the multilevel land-use/land-cover classification system for use with remote sensor data adopted by the U.S. Geological survey (Anderson *et al*., 1976). Spot-4 image, clearly displays the major classes of land-use and land-cover of Nuweiba coastal zone, Gulf of Aqaba.

**Data Acquisition**

Satellite data required accomplishing the objectives of remote sensing activities and consequently achieving the current work objectives surveyed from NARSS archived scenes The spot image 2007 that cover the study area were collected for the purpose of establishing a comprehensive GIS database (Figure 3).

**Table (1): The main classes of land-use / land –cover in Nuweiba coastal zone, Gulf of Aqaba, Interpreted from Spot-4 Image dated 2007, Scale 1:100.000.**

| Layer | Type | Sympol |
|---|---|---|
| Fild Locations | Point | |
| Road | Line | |
| Shoreline | Line | |
| Urban | Polygon | |
| Agriculture | Polygon | |
| AqabaGulf | Polygon | |
| Flash Flouds | Polygon | |
| Space area | Polygon | |
| Preceptation Basins | Polygon | |

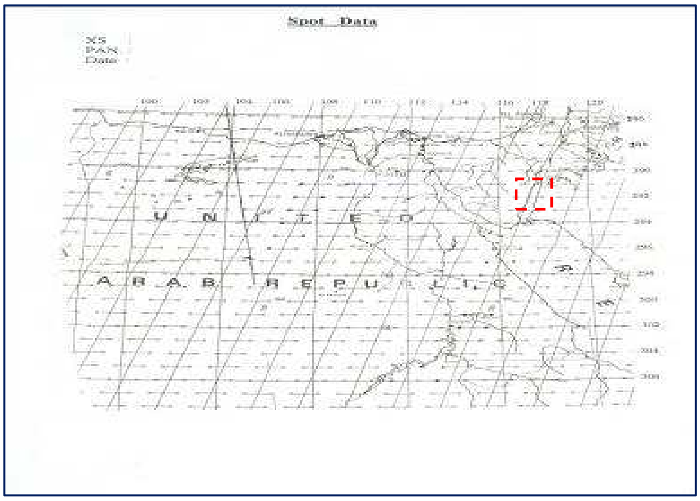


**Figure 3: An Index map shows the location of the acquired Spot Images**

## Image Processing:

Physical parameters related to earth surface and atmosphere show different behaviors when observed at different space-time scales by using remote sensing or traditional ground based techniques. Monitoring techniques rely on the principles that land cover changes result in persistent changes in the spectral signature of the affected land surface. The accuracy of the result is strongly dependent on the processing procedure. This mainly consists of geometric correction, spectral enhancement, image classification… etc.

## Geometric Correction:

The geometric correction process is carried out firstly, for Spot-4 scene 176/38, dated 2007 that covers the study area. This is done by selecting 19 ground control points (GCP) from topographic maps of scale of 1:50,000. These points represent features that are clearly seen in both, satellite image (source points) and topographic map (reference points). Since both the source and the corresponding reference points are representing the same features with different coordinates system, they are used to generate the transformation polynomial (TP) by regression analysis method. The acceptance of the TP depends on the error reported between the two sets of points while the selection process.

This error should not be greater than 1 or 2 pixel size in both X and Y directions, with total RMS error less than one. Consequently, the transformation polynomial is used to transform/resample the satellite image to the map coordinate system, by using nearest neighbor re-sampling technique. Figure 4 is showing the image after resembling, oriented toward the north direction.

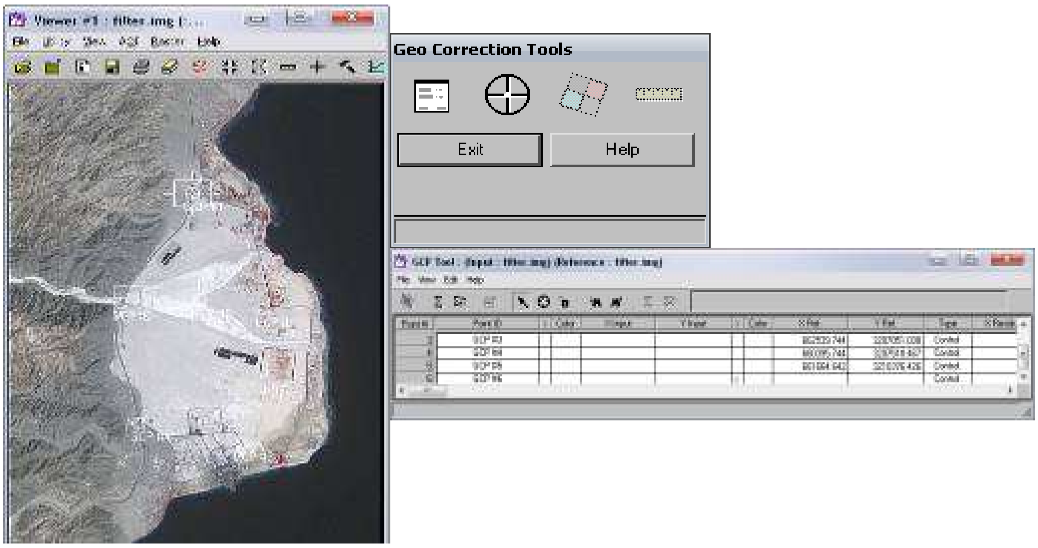


**Figure 4: The image after resembling oriented toward the north direction.**

**Image Enhancement:**

The principal objective of enhancement techniques is to process a given image so that result is more suitable than the original for a specific application, more effective for display for subsequent visual interpretation, and for more information to be extracted. That means modification of a subjective feature of the image to emphasize certain information and to improve the delectability of the target of interest by amplifying the slight differences to make them readily observable. For instance, high pass filter technique may be used to discriminate between the different features in the image.

**Data Conversion**

The files include all the digitized layers along with their thickness values. Various layers of the dxf files are converted into their corresponding Sahpe files using ArcGIS. In this step, each layer of these files is separated into a thematic GIS layer.

**Geo-referencing**

Georeferencing is an essential step of the spatial data management. Georeferencing aims at the conversion of the coordinates from the digitizing screen coordinates into a real world coordinate. Each GIS layer is georeferenced using the following parameters:

| | |
|---|---|
| Projection | : Universal Transverse Mercator (UTM) |
| Unit | : Meters |
| Spheroid | : WGS 84 |
| Datum | : WGS 84 |
| Zone | : 36 |

**Editing**

Various editing operations have conducted over GIS layers to make them ready for display and analysis. These operations include the following:

1-GIS layers: GIS layers have been overlain on the georeferenced scanned map to check that all layers in the maps have been extracted.

2- Features: Check the occurrence or the absence of various features in each GIS layer. Verify that each polygon is closed (No overshoots or undershoots). Verify that each line is smooth and connected with other line if necessary.

3- Attributes: Removing all the non-required fields of the DXF files from the shape files except the thickness field, Create a new field called “Code” in the shape files, Transfer values of “Thickness field” into the new created code field, Display the features in each GIS layer using code values to assure the accuracy of data entry by comparing them with the source.

**Edge matching**

Having two GIS layers edge matched, they should be georeferenced to the same projection parameters, they should be the same feature class, and the corresponding features should have the same attribute. Using these fundamentals, all the contiguous GIS layers in the study area have been edge matched.

**Land Use-Land Cover (LU/LC) Classification Scheme**

The produced land-use/land-cover map of 2007 (Figure 5) clearly displays the major classes of land use and land cover in the coastal area of Nuweiba coastal zone. The system includes all major categories of land use and land cover, and can be expanded for special situations. Basically, it could provide an accurate database for inventory of the existing patterns of land-use/land-cover at scales ranging from regional to local. Furthermore, image acquired in different data for the same area may be digitally registered and compared to produce change detection images that emphasize changes in land-use and land-cover. Regulating these changes is an important action to minimize negative impacts on the environment.

**Figure 5: Spot-4 satellite Image dated in 2007 for Nuweiba city shows the field check sites in red points.**

## Appending GIS layers

This is the final step of data automation process where all the contiguous GIS layers that have the same feature class were appended to one GIS. At this point, we are having the following final layers as shown at Figure 6.

Accurate, current information on land use-land cover is essential for planning of many development activities. Also, detection of changes in land-use and land-cover is helpful to monitor environmental impacts of both natural parameters and human activities. Remote sensing data, from satellites, are becoming important for mapping land-use and land-cover particularly for large and remote and inaccessible areas. They provide an unbiased permanent data set that may be interpreted for a wide range of land use-land cover. Remotely sensed data can be acquired from various systems on bound satellites or aircrafts, with a spatial resolution that matches the degree of detail required for the survey. The interpretation of remote sensing data is faster and less expensive than conducting ground surveys. Furthermore, the application of digital methods of image processing on the remotely sensed data to delineate the major categories of land use-land covers to produce a classification map. Digital processing is becoming essential because as spatial resolution and spectral coverage increases, the volume of data also increases.

## Temporal Change in Land Use/Land Cover for Nuweiba City

The results of study disclose the major distinct land use changes occurring in the Nuweiba area due to the extension of urban, tourism activities and protectorates which develops the southern coastal plain and the northern isolated fans.

The present status of landuse-land cover in the districts of the Nuweiba coastal plain as evaluated by digital analysis of satellite data indicates that majority of areas in these districts are used for tourism purpose. The coastal plain of Nuweiba exhibits fair development of resorts (30% and 9% respectively).

Considering the change detections, about 115.06 hectares of these changes were due to development of settlements as well as constructed lands over orchards, which occurred mostly on the urban fringe of Nuweiba city. About 17.77 hectares of these changes mostly are related to changes due to construction and resorts build on Barren and Wet land in the coastal plain, which are recognized as an environmental impact. Development changes in the min towns along the coastal plain between the period 1984 and 2000 are shown in Figures 7-11.

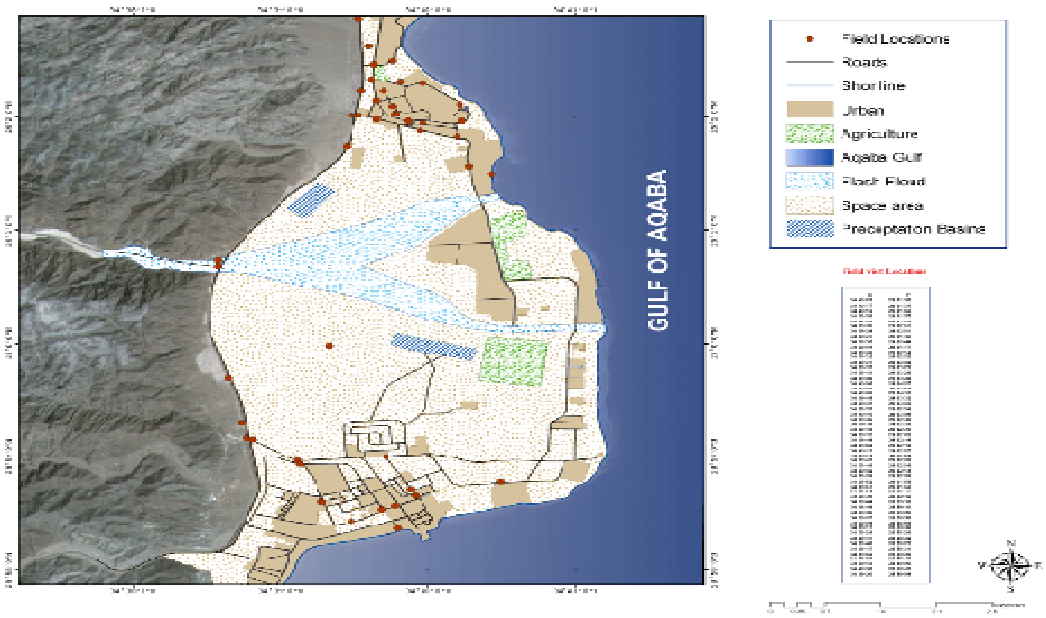


Figure 6 :reaA tudyS uweibaN fo lassC seU andL Main

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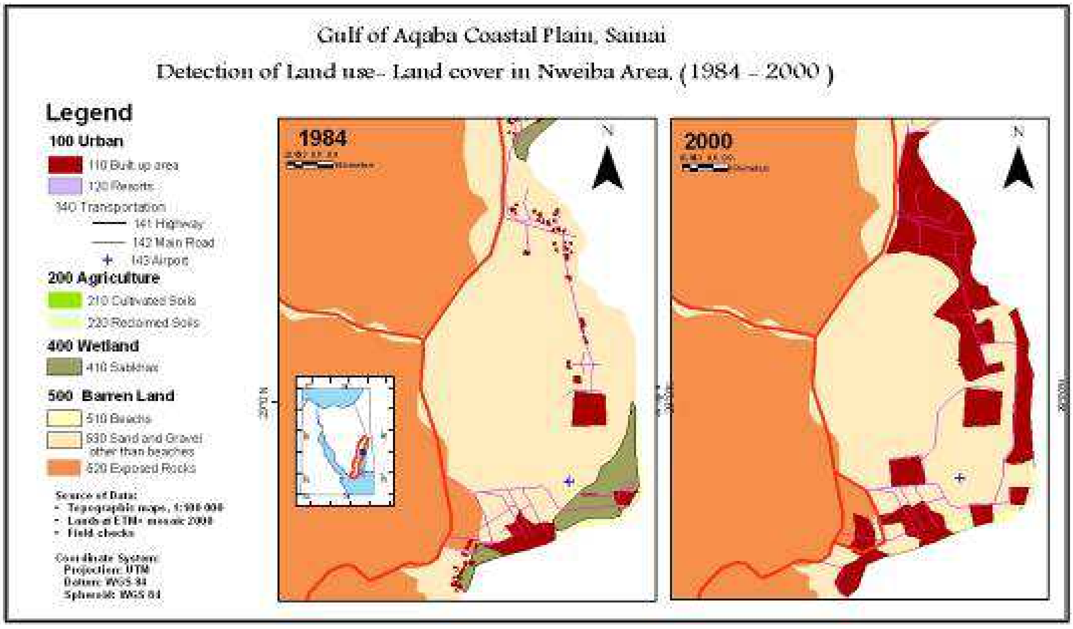


Figure 7: Land Use- Land Cover in Nuweiba area (1984-2000)


**Figure 8: Land Use map of Nuweiba City in year 2007**

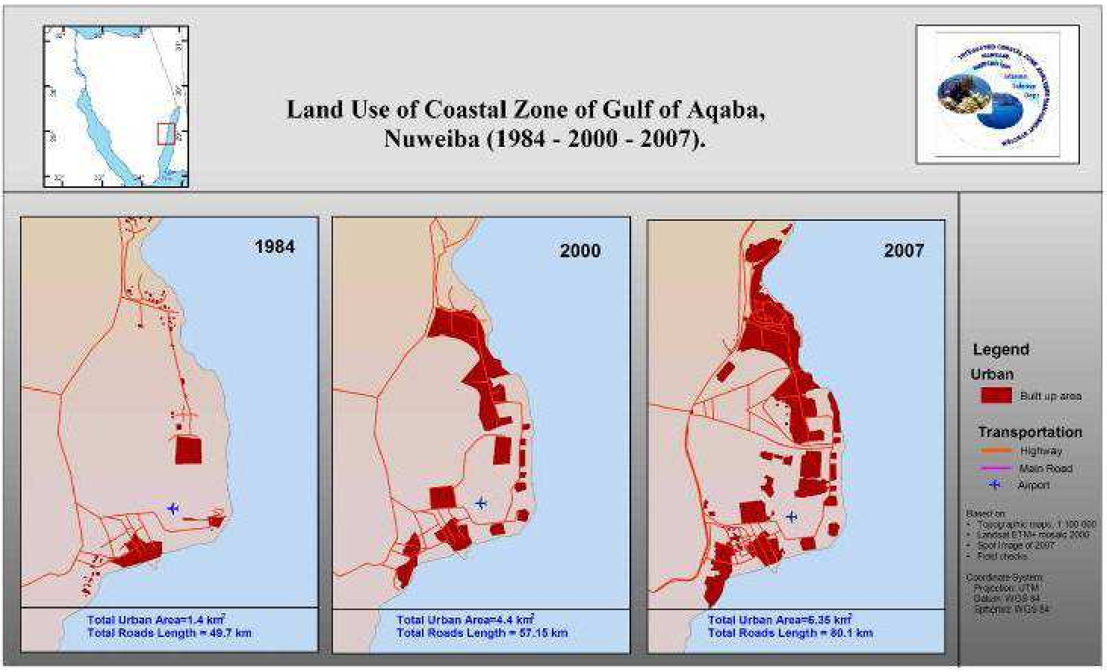


**Figure 9: The Landuse development in Nuweiba City during last three decades (1984-2000-2007)**

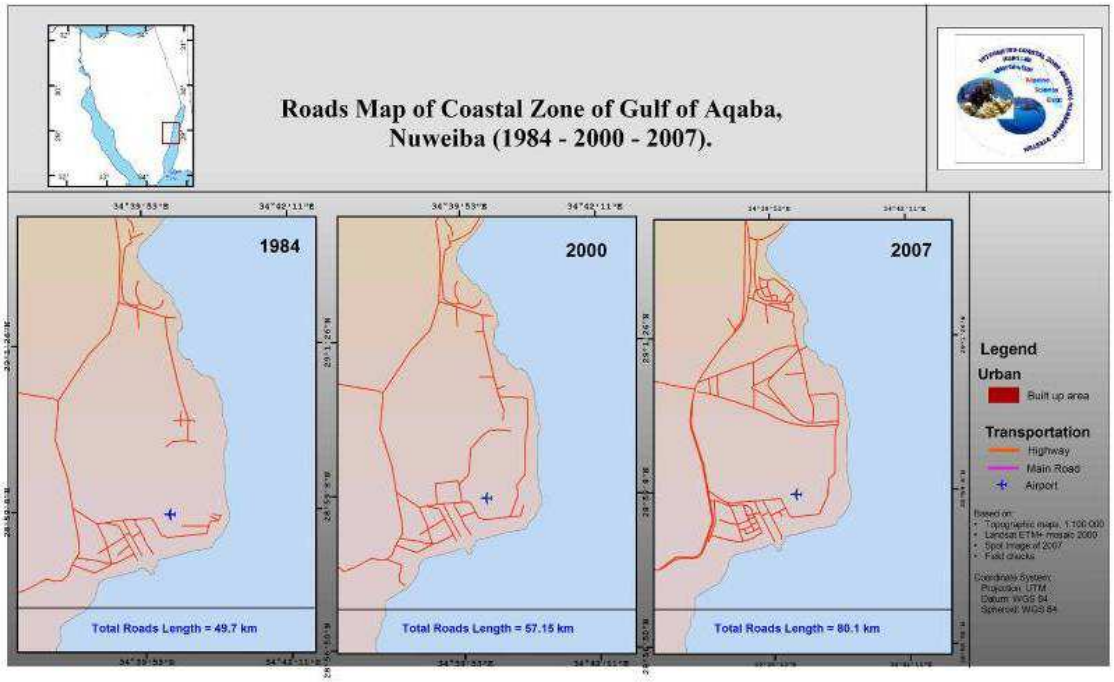


**Figure 10: The Roads development in Nuweiba City during last three decades (1984-2000-2007)**

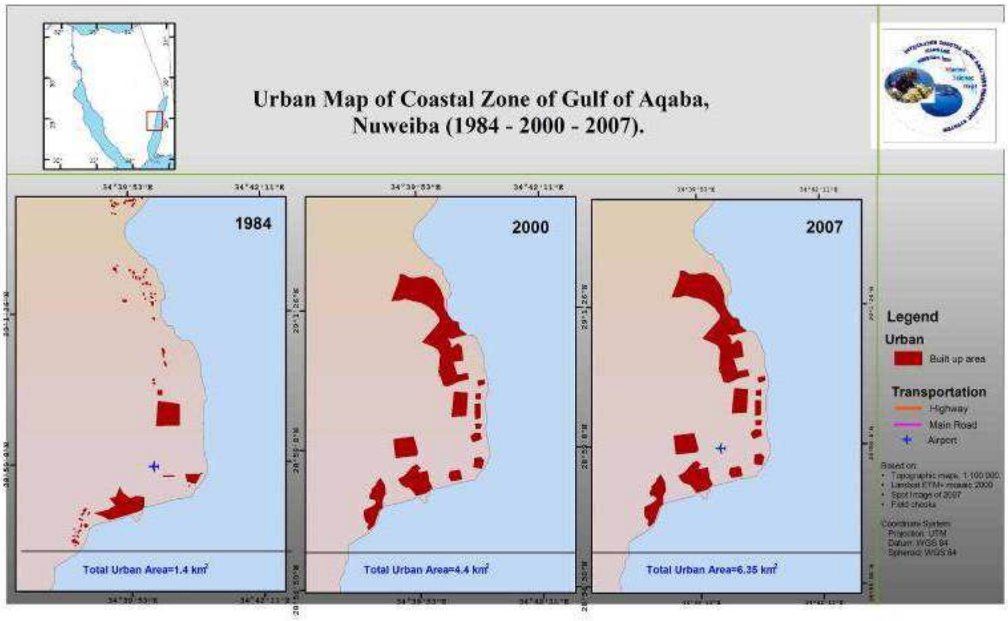


**Figure 11: The Urban development in Nuweiba City during last three decades (1984-2000-2007)**

## CONCLUSION

This study has been done on Nuweiba city; The Gulf of Aqaba to fulfill the requirements needed for constructing a new electrical station in the city by ministry of electricity. It has been done using remote sensing and GIS techniques with maps and satellite images of 1984, 2000 and 2007. From the above study we can conclude that:

1- The majority of areas in Nuweiba districts are used for tourism purpose.
2- The major distinct land use changes occurring in the Nuweiba areas are due to the extension of urban, tourism activities and protectorates which develops the southern coastal plain.
3- The industrial areas at Nuweibas are very limited.
4- Nuweiba city, the Gulf of Aqaba has the potentials to be developed and need to support such developments by establishing the essential services projects such as the proposed electrical power station.
5- Remote Sensing and GIS are the best tools of acquiring and analysis the basic information particularly on the environmental applications.

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