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USING REMOTELY SENSED DATA, GIS, AND FIELD INVESTIGATION FOR PRELIMINARY CONSIDERATIONS OF SUSTAINABLE DEVELOPMENT: WEST QENA AREA, EGYPT

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ABSTRACT :

The Egyptian Government and the private sector are interested in developing the low desert zone outside the flood plain of the River Nile. The low desert zone, west Qena Governorate, represents large future sustainable zone for different types of activities including agricultural, urbanization, wastewater disposal and landfill sites, and industrial zones. This zone covers ~1432 km^2 and will be considered as a development corridor for Qena Governorate. The current study focuses on the analysis of the landuse changes in the area since 1972 as well as the evaluation of the groundwater resources for different purposes using the remote sensing and GIS techniques.

The results show that the landuse has been dramatically changed since 1972 till present by ~153.4 km^2 including ~134.4 km^2 of agricultural activities, which consider 9.4% of the total area of the low desert zone and other activities cover ~19 km^2. Most of these changes that have been detected in the area range from 64 to 150 m (above sea level). In addition, the evaluation of groundwater for different uses in the study area using water quality index shows that some of the groundwater wells are not suitable for domestic, agricultural, and other activities.

INTRODUCTION:

During the past few decades, with increasing of the population and developing the technologies, people have emerged as the most powerful and universal instrument of environmental change in the biosphere. Both globally and locally the land cover today is altered primarily by direct human use.

Viewing the Earth from space has become essential to comprehend the cumulative influence of human activities and its natural resource base. Remote sensing (RS) and Geographic Information Systems (GIS) have become prevalent methods in the analysis, compile, and process spatial data and they consider a powerful tool in the geological and environmental engineering applications. Data from remote sensing satellites has become

important in different aspect such as monitoring, mapping, infrastructure, environmental landuse studies, and sustainable development, as well as to create a model of the different conditions and considerations facing any future developments.

Several studies have been established good correlation between vegetation indices and remotely sensed data[1,2]. Latham and Som[3] mentioned that by using Remote Sensing in a Geographic Information System environment would be a powerful tool in landuse changes and sustainable development, as well as have the potential to facilitate the flow of information to planners and decision makers. Sustainable development and planning in general requires comprehensive data on landuse, water, economic, and human resources available in a given area. Remote sensing technique coupled with GIS is gainfully used for such comprehensive analyses, and can support decision makers to develop successful strategies for sustainable projects.

Recently, the Egyptian Government has selected many regions all over the country for different types of developments. One of these regions is the west Qena Governorate in Upper Egypt, which considers one of the most promising development areas. The low desert zone, west Qena Governorate, covers an area of ~1432 km^2. Fanglomerates and Wadi deposits are the mainly deposits covering the low desert zone. The study area ranges in its elevation from 64 m above sea level (a.s.l.) to 300 m (a.s.l.) with a gentle slope towered north. This area will drive the region to the horizons of good economic activities. It will embrace a number of development activities in agriculture, industry, transport, communications and roads, as well as in social aspects and services, aiming to create several new job opportunities and consequently improve the Egyptian economic situation and living standards for the people in that region. Therefore, there is an urgent need for evaluating the landuse changes, suitability of the area for different uses, and the suitability of groundwater for different purposes. These factors are important in the preliminary consideration of the sustainable development and for the future assessments of the area.

The current study aimed to use GIS, RS, field and laboratory investigations to aid in predicting the landuse changes and evaluating the groundwater quality in the area as a preliminary consideration for the sustainable development. By using remote sensing and GIS techniques, the advantage is not only in time and cost effectiveness but also in achieving a more comprehensive and integrated treatment of the development criteria, which is difficult throughout the conventional techniques[4,5]. This will be a backbone for the sustainable development and can greatly improve the efficiency and effectiveness of these investigations.

ENVIRONMENTAL SETTING OF THE AREA:

Location: The area is located West of Qena Governorate between Latitude 26^o $10^\backslash$ $00^{\backslash\backslash}$ to 26^o $50^\backslash$ $00^{\backslash\backslash}$ N and Longitude 31^o $50^\backslash$ $00^{\backslash\backslash}$ to 32^o $45^\backslash$ $00^{\backslash\backslash}$ E (Fig. 1). The study area is located in an arid zone characterized by very dry, with precipitation less than 100 mm/yr, hot weather condition. The daily average temperatures range from 14^o C with relative humidity of 45% in January to 45^oC with relative humidity of 19% in July.

Geomorphology: West Qena area is generally characterized by some geomor-phological units including 1) the flood plain of the River Nile, which is young alluvial plain of the Nile,

bounding the study area from the north; it is flat with a mean elevation of about 60 to 70 m (a.s.l.) and characterized by presence of several irrigation canals, 2) The old flood plain of the Nile, which is called the low desert zone (the study area); It is mainly covered by sand and grave or loamy soils; it occupies an area between the young alluvial plain from north and limestone plateau from west, east, and south; this zone is characterized by a gentle slope toward the north; its elevation ranges from 64 to 300 m (a.s.l.), and 3) Limestone plateau, which is bounded the study area from south, west, and east, and characterized by an irregular surface and dissected by dry channels trending S-N, NW-SE, and SE-NW.

Geology: The study area is mainly composed of sediments and sedimentary rocks having different degrees of hardness[6]. It is covered by different geologic units according to the Egyptian General Petroleum Corporation[7], (scale 1: 500,000) (Fig. 2) including fanglo-merates, wadi deposits, prenile deposits, travertine, pliocene deposits (compose mainly of fluviatile siltstone, sandstone, and clay stone), Dakhal Formation, and Esna Formation, which cover an areas of 646.7 km^2, 546.5 km^2, 24.6 km^2, 65.9 km^2, 142.8 km^2, 2.8 km^2 and 2.6 km^2 respectively and represents 45.2%, 38.2%, 1.7%, 4.6%, 9.9%, 0.2%, 0.18% of the total area, respectively. The study area is surrounded from south, east, and west by Eocene rocks belonging to Thebes formation[8]. It is mainly composed of an alternating medium to thin bedded limestone and chalky limestone which are abundant of flint bands and nodules.

Water resources in the area: Water represents the main objective part in the sustainable development of an area. The distribution of the aquifer and its water quality represent the backbone in the continuity of these projects. The Nile Valley aquifer system in Qena area is composed of quaternary and late tertiary sand and gravel deposits intercalated with clay lenses. The Pliocene clay is located at the base of this aquifer.

Many authors studied the ground water aquifer system of west Qena Governorate (the low desert zone)[9, 10]. Their interpretations were depending on the vertical electrical sounding (VES) methods. They concluded that the area of the low desert zone is characterized by multilayer aquifer sections in which the first groundwater aquifer is shallow, with a limited extension and is possibly recharged from the infiltration of the surface water coming from the Eocene plateau. The second aquifer is deeper, has a reasonable thickness, and is recharged from the infiltration of surface water and/or the River Nile.

OBJECTIVES AND METHODOLOGY:

The objective of this paper is to use remote sensing and geographic information systems with the help of field and laboratory investigations for better management of the preliminary considerations of sustainable development for the area west Qena governorate. This would be accomplished and illustrated throughout the following objectives: (1) Using the multi-temporal resolution images including Landsat Multi Spectral Scanner (MSS); Landsat Thematic Mapper (TM); and Enhanced Thematic Mapper Plus (ETM+); (2) Using Digital Elevation Models DEMs to model the relationship between these landuse changes and elevation zones; (3) Evaluating the groundwater quality for different uses, where water represents the backbone of the sustainable development activities.

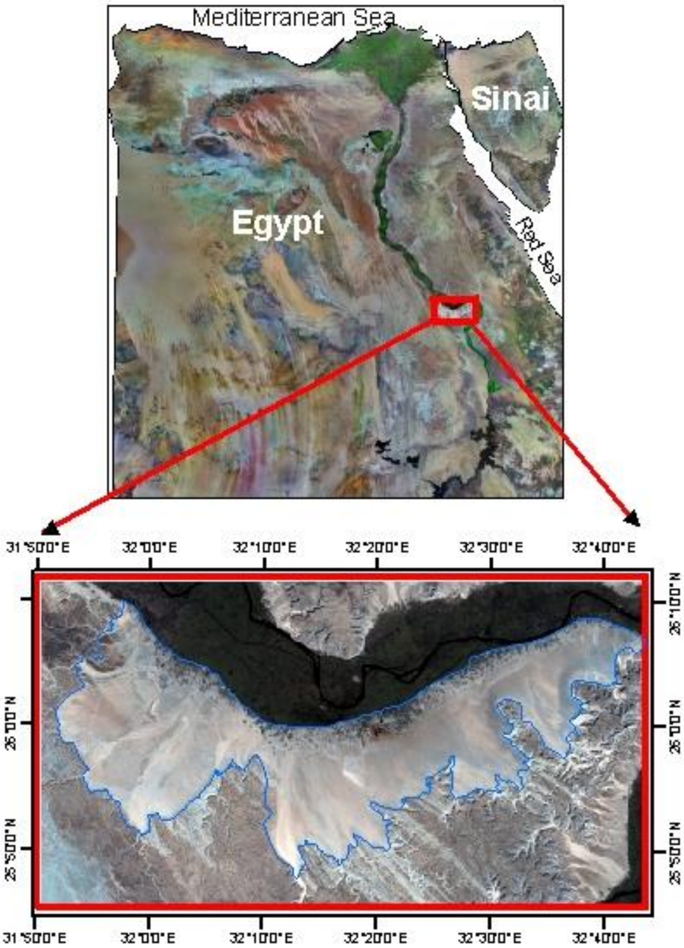

Fig. (1): Location map of the study area.

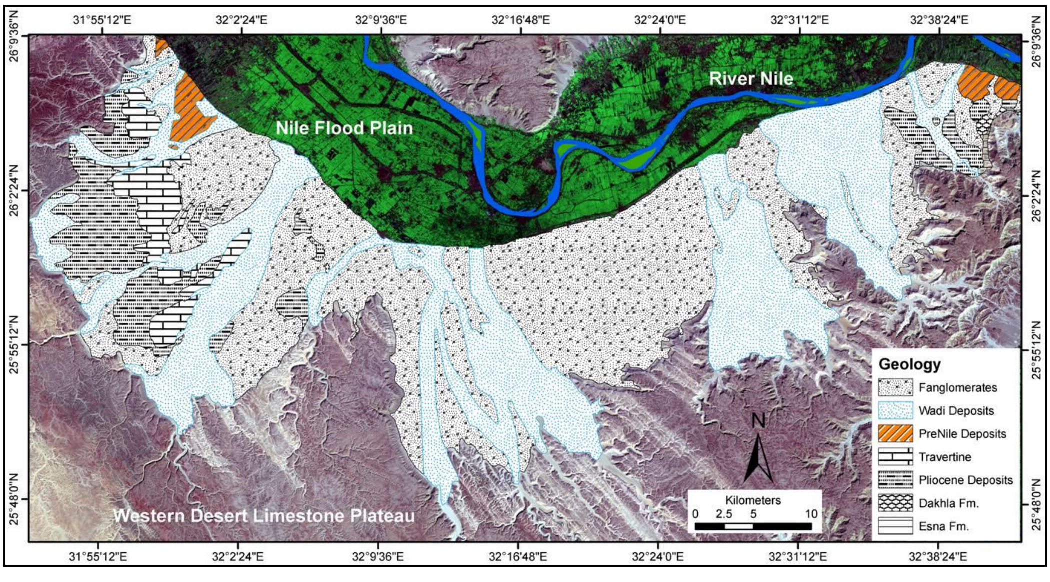

Fig. (2): The Geology of the area draped on the ETM image (bands 742 in RGB).

Data and Software Used: **In the present study, various types of data have been used including multi-temporal satellite images including, (MSS 1972), (TM 1984), and (ETM+ 2001and 2005), Digital Elevation Models (DEMs 90 m) extracted from the Shuttle Radar Topography Mission (SRTM) data, and previously published geological map (1: 500,000), Field and laboratory investigations, and other relevant published information. Some software's were principally used, including ERDAS Imagine 8.7 and ENVI 4.3 digital image processing software and ArcGIS 9.1.**

Image Preprocessing: **The images that were used in the study area were already geometrically rectified. Band subset, layer stacking, and image fusion methods were used; the final resolution used in this study is 30 m. However, 15 m resolution of ETM+ 2005 image was used to establish on screen digitizing and plotting of the other recent activities and future planned projects. Image processing has been done to improve the image false color composites (FCC) bands 7, 4, and 2 in RGB respectively, which used for visual interpretation. Normalizes Difference Vegetation Index (NDVI) was used to evaluate the agricultural changes in the area.**

Field and Laboratory investigation: **Field investigations were done to collect data about the recent developments using ground positioning system GPS as well as to collect water well samples. About 22 water samples were collected along a stretch of about 100 km. On the other hand, the laboratory analyses of 22 water samples were done to determine their chemical characteristics including pH, EC_{iw}, TDS, Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, CO_3^{-2}, HCO_3^{-}, SO_4^{-2}, Cl^{-} and NO_3^{-}.**

RESULTS AND DISCUSION:

1-Development of landuse maps:

Landuse planning provides a mean for managing the growth to permit a maximum use of a limited resource base and retain for future decisions using a maximum number of available alternatives. Development, no matter how respectful of nature, will cause impact on the environment. Geologic hazards and resources must be recognized and evaluated, and the information derived from these evaluations should be used in the planning process to make an intelligent decision about landuse for development. The study area has been subjected to landuse changes over the last few decades, which in some locations represents substantial changes and new activities as well as the future sustainable planning which also make extra changes. Developments of the land resources are very urgent particularly in the low desert areas, due to the increases in population. The strip of the low desert zone was the most prone areas for landuse changes, future activities, and new projects.

Medrial *et al.*[1] mentioned that the vegetation indices are a combination of different spectral responses coming from the surface layer and commonly used in the remote sensing studies. These indices are usually used to identify and address the status of the vegetation. In general, there are many studies have been conducted regarding the spectral response from vegetated and non-vegetated area using visible, near infrared, and middle infrared regions of the electro-magnetic spectrum. Medrial *et al.*[1], documented that the accuracy of estimating the vegetation percentage from the image data are influenced by different factors including

atmospheric condition, soil brightness, leaf inclination, leaf optical properties, and vegetation density. They also mentioned that almost 90% of the remotely spectral information are collected from a vegetation cover belongs to the red and near infrared bands which represents a significant fraction of solar irradiance, and a high change of the reflection rate between red and near infrared is an indication that it characterizes the spectral response of vegetation.

Part of this research was initiated to develop the landuse change maps since 1972 for the area. There are three main parts in the development of the final landuse map including: 1) Interpretation of satellite images and field survey. For the satellite image analysis, the images were used to predict all the changes that have been occurred especially in the reclamation activities by applying Normalizes Difference Vegetation Index (NDVI) using ENVI 4.3 program. The NDVI value can be calculated according to this equation:

$$NDVI = NIR - Red / NIR + Red$$

These NDVI images were exported into ArcGIS 9.1; then they were classified and overlaid over each other to create the final landuse map. Other type of activities and projects in the study area were mapped through the filed investigations with the help of GPS unit. These data helped in developing a series of different landuse maps and determining the changes in five periods before 1972, from 1972 to 1984, from 1984 to 2001, from 2001 to 2005, and from 2001 to present as well as the future projected activates (Figs. 3B, 3C, 3D, 3E, and 3F). By applying the NDVI technique, using ENVI 4.3 and using these data on the GIS environment change detection since 1972 was shown in (Fig. 4). For the future projected areas and sustainable development, the field data collection with the help of government records was used to get the accurate location about the areas that specify for different other uses by the help of the GPS unit. The calibration of the remotely sensed data with the field check showed that high values of NDVI have a correlation with the percentage of green coverage. On other hand, the study shows how GIS approach eases the data archiving, map generation and also provides interpretational possibilities not available with more traditional procedures[11].

The study shows that before 1972, there is no any landuse change in the area, and the total area, which represents ~1432 km^2 was desert. The land use from 1972 to 1984 was determined, and the increase in the reclamation area was ~34 km^2; The increase in the reclamation areas from 1984 to 2001 was ~57 km^2 and the increase in the reclamation areas from 2001 to 2005 was ~43.4 km^2. On the other hand, most other activities have been mapped from, ETM+ 15 m resolution (acquired in 2005), other field data collection and governmental records, using on screen digitize on the ArcGIS 9.1. The results showed that these activities including industrial zones, new urban areas, landfill sites, and wastewater sites. They cover an area of ~19 km^2.

The DEMs 90 m resolution was used to create the elevation zones in the area (Figs. 3A and 5). By using DEMs, the study area (the low desert zone) has been classified into five elevation zones including; zone 1 from 64 to 75 m (a.s.l), zone 2 from 75 to 100 m (a.s.l), zone 3 from 100 to 150 m (a.s.l.), zone 4 from 150 to 200 m (a.s.l) and zone 5 from 200 to 300 m (a.s.l). These zones cover areas of 29.59 km^2, 305.01 km^2, 514.43 km^2, 428.47 km^2 and 154.50 km^2 respectively. They represent 2.07%, 21.3%, 35.92%, 29.92%, 10.79% of the total area of the low desert zone, respectively.

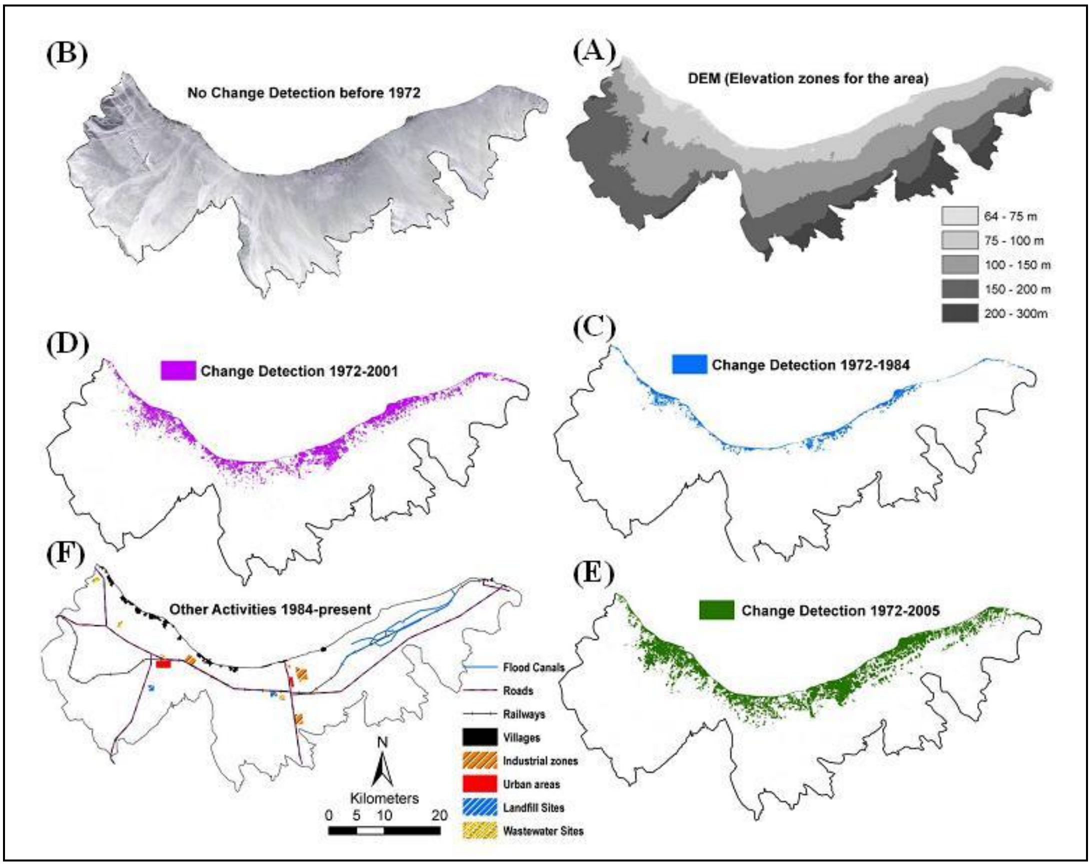

Fig. (3): Different types of maps for the study area showing A) different elevation zones extracted from DEM, B) image of 1972 with no Landuse changes, C) Land use changes from 1972-1984 D) Land use changes from 1972-2001, E) Land use changes from 1972-2005, and F) Other activities from 1984 till present

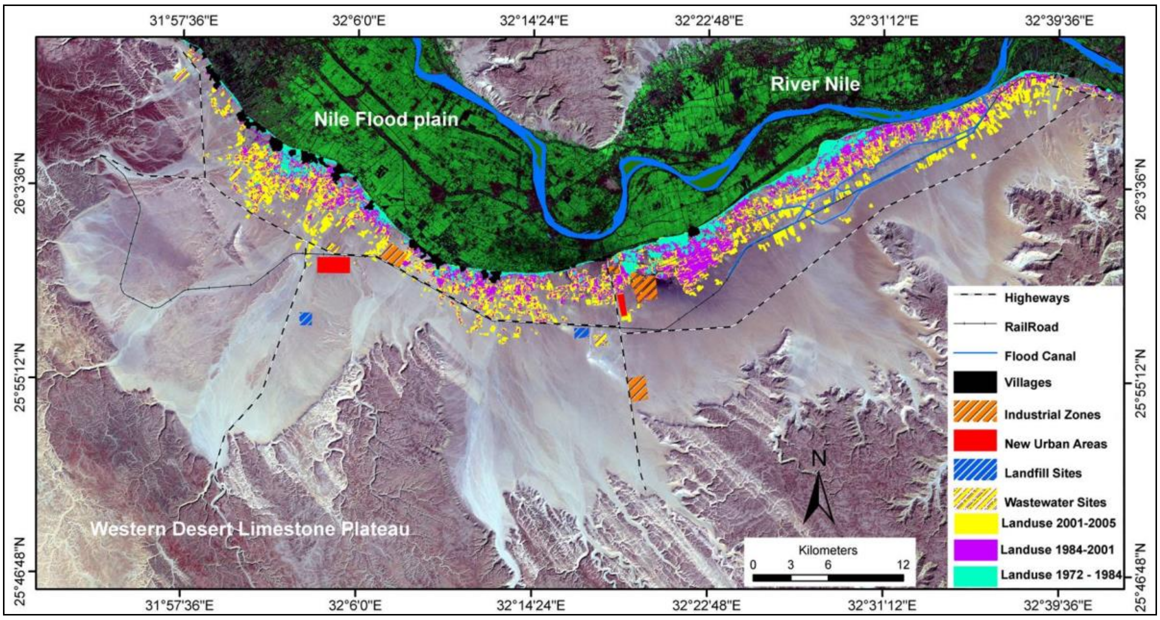

Fig. (4): The final Landuse changes model in the study area draped over the ETM image bands 742 in RGB

By using ArcGIS 9.1 (map calculation), the relationship between the landuse changes in the area and the elevation zones were determined. The data show that ~128 km^2 are located in the elevation (64–100 m a.s.l) which they represent zone 1 and 2 (Fig. 5). However, ~6 km^2 are located in zone 3 (100-150 m a.s.l.). On the other hand, other activities such as industrial zones, urbanization areas, landfill and wastewater sites cover ~9 km^2 from which ~9 km^2 are located in the elevation zone 2 (75–100 m a.s.l), ~7 km^2 is located in the elevation zone 3 (100–150 m a.s.l), and ~3 km^2 is located in the elevation zone 4 (150-200 m a.s.l). Finally, the linear activities such as roads, railways, and flood canals have been dramatically increased in the study area since 1984. The total lengths were determined as 156.2 km, 97.9 km, and 49.5 km for roads, railways, and flood canals respectively.

2-Evaluation of the groundwater quality for different uses:

The most important factor for the sustainable development for different types of projects that have been mapped in the previous section is the groundwater quality and quantity. In this section groundwater quality has only been discussed. Hundreds of wells have been developed in the recent few years. In this study twenty-two groundwater samples were collected from wells in the study area and chemically analyzed in order to evaluate their chemical characteristics, calculate their quality indices, as well as to evaluate them for different uses (Fig. 6 and Table 1). The evaluation of groundwater of the study area is one of the most important targets of this study, where different development plans will be depended on this water. The quality of groundwater depends on the uses of water for different purposes, where physical, chemical and bacteriological properties are the main factors, which are taken in consideration. In the following study, only chemical characteristics of the water samples have been determined.

The chemical analysis shows clearly that the water type in the study area is mainly varied. The groundwater of the quaternary aquifer has a salinity value range between 404.4 and 3634.9 ppm. According to Chebotarev[12], this ground-water is classified into two classes, fresh and brackish water, and six subclasses (Table 2).

a-Using groundwater for domestic purposes:

Generally, water should be colorless, odorless and free from turbidity, while the harmful microorganisms and radioactive components or elements must be absent. The chemical characteristics of the water samples for the study area have been subjected to the evaluation for domestic purposes using the water quality index[13, 14], which has been used before by Farrag[15] and expressed in the following equation.

$$Q_r = 100\ F/SV$$

where,
Q_r = Quality rating for the parameter F.
F = the observed value of the parameter.
SV = water quality standard value.

International standards of drinking water set by World Health Organization (WHO)[16], were used for the standard value (maximum absolute limit) of the 9 factors (Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, HCO_3^{-}, Cl^{-}, SO_4^{-2}, TDS (total dissolved solids), and NO_3^{-}) (Table 3). However, for the total hardness (TH), Kilemntov[17] mentioned that water is used for the domestic purpose if it has a total hardness value less than 7 epm or 345 ppm (Table 3). If the quality rating (Q_r) for each factor reaches 100, it means the water is not desirable for the domestic uses. Table (3)

shows the sample numbers that are undesirable for domestic purposes due to Q_r for each factor.

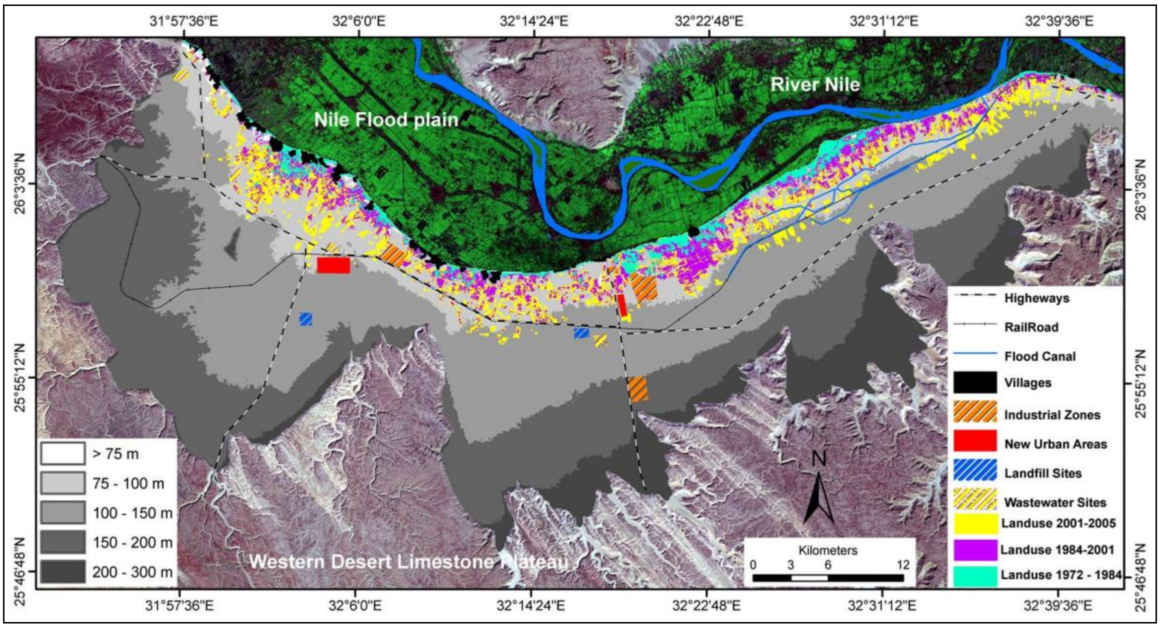

Fig. (5): Landuse changes draped over the DEM model including five elevation zones and both draped as well on the ETM image bands 742 in RGB (prepared using ArcGIS 9.1)

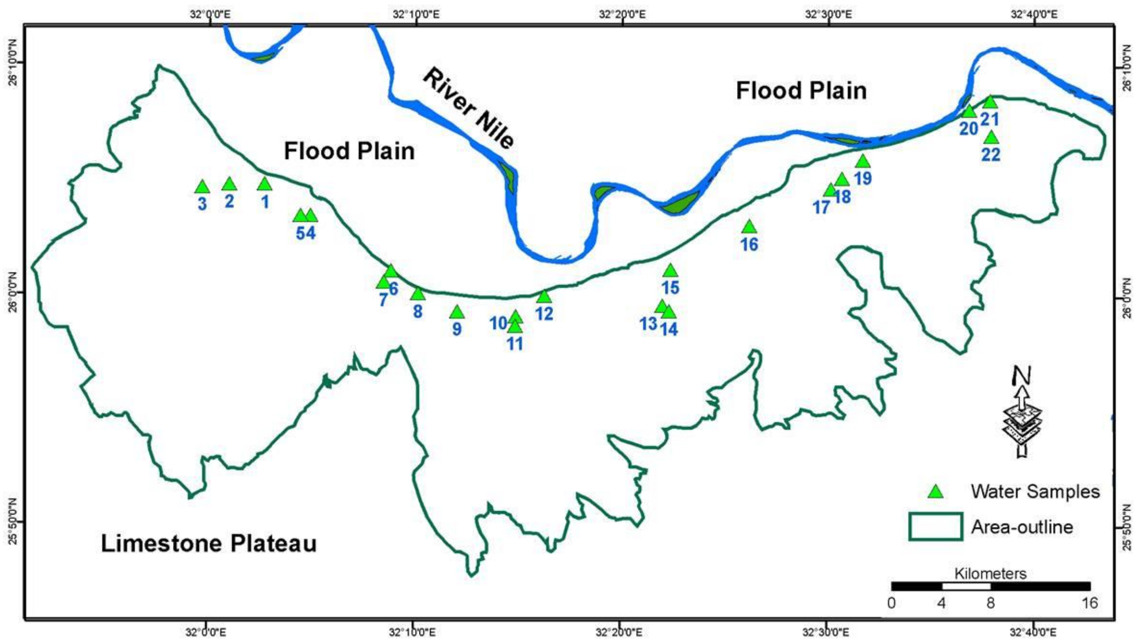

Fig. (6): Groundwater wells location in the Low desert zone area, used for collect the ground water samples for the chemical analysis

Table (1): The hydrochemical data of the groundwater samples in the area

S. No.	pH	EC µS/m	TDS ppm	Ca^{+2} Ppm	Mg^{+2} ppm	Na^{+} ppm	K^{+} ppm	HCO_3^- ppm	Cl^- ppm	$SO_4^=$ ppm	NO_3^- ppm	TH	SAR
1	7.39	2400	1536	40	68.4	450.8	13.3	198.4	603.5	110.9	49.3	380.4	5.09
2	7.87	2785	1782.2	70	36	500.7	9.8	173.6	603.5	356.6	31.8	322.6	6.70
3	8.23	2314	1480.9	44	45.6	317.4	9.8	173.6	404.7	404.2	81.5	296.9	4.60
4	7.81	2023	1295	30	30	317.4	8.6	198.4	284	360	65.8	198	6.90
5	7.99	1675	1072.1	50	37.2	317.4	7.8	272.8	85.2	274.1	23.5	277.5	4.93
6	8.03	1640	1049.7	30	72	217.4	10.9	223.2	305.3	122.4	68.1	370.2	2.52
7	8.4	631	404.4	18	14.5	72.2	4.3	148.8	24.85	51.84	69.7	104.5	2.98
8	8.17	1658	1061.6	200	187.2	60.03	10.9	570.4	21.3	9.12	0	1267.5	0.20
9	8.25	1326	848.7	14	8.4	51.9	4.3	744	21.3	1.44	3.2	69.4	3.23
10	7.6	971	621.8	24	22.8	67.8	5.5	341	99.4	57.1	3.9	153.5	1.90
11	7.84	747	477.9	24	21.6	92	4.3	124	142	54.7	14.9	148.6	2.67
12	7.63	1070	684.8	18	25.2	100.5	7.8	272.8	49.7	180	30.4	148.3	2.91
13	7.81	5523	3534.6	175	84.6	834.2	19.5	297.6	915.9	1055.5	151.9	784.4	4.59
14	8.54	3738	2392	70	19.2	917.5	9.8	74.4	319.5	903.8	77.6	253.7	15.64
15	8	4990	3327.8	164	91.2	984.2	21.8	223.2	972.7	750.2	120.2	783.9	5.42
16	8.18	5679	3634.9	272	166.8	750.9	17.9	161.2	1341.9	771.4	152.5	1363.9	2.37
17	8.12	2222	1421.9	100	66	300.6	11.7	223.2	426	270.2	24.02	520.6	2.49
18	8.31	4603	2945.9	210	114	767.5	15.2	173.6	795.2	870.2	0	992.4	3.34
19	8.26	3166	2026.1	150	74.4	334.2	13.3	421.6	269.8	663.8	98.6	680	2.12
20	8.08	1599	1023.4	120	60	134.1	10.9	198.4	227.2	234.2	38.1	546	1.06
21	7.89	2364	1512.8	140	54	467.4	14.04	446.4	269.8	36.5	84.3	571.4	3.53
22	8.09	3902	2497.2	50	39.6	917.5	13.3	322.4	1043.7	81.1	29.1	287.4	13.76

Table (2): Salinity classification according to Chebotarev[12] and the water samples classification according different subclasses

Class	Sub-class	Salinity (ppm)	Sample Number
Fresh water	Good potable	< 500	7, 11
	Fresh water	500 – 700	10,12
	Fairly fresh	700 – 1500	3, 4, 5, 6, 8, 9, 17, 20
Brackish water	Slightly brackish	1500 – 2500	1, 2, 14, 19, 21, 22
	Brackish	2500 – 3200	18
	Definitely brackish	3200 – 4000	13, 15, 16
Salt water	Slightly salt	4000 – 6500	
	Salt	6500 – 7000	
	Very salt	7000 – 10000	
	Extremely salt	>10000	

Table (3): The absolute maximum limit for each factor was used for the domestic purpose and the results of undesirable well numbers for each factor

Factor	Absolute Max. Limit	Reference	Unsuitable samples according to (Q_r)
Ca^{+2}	200 ppm	(WHO 1996 and 1998)	8, 16, 18
Mg^{+2}	125 ppm	(WHO 1996 and 1998)	8, 16
Na^{+}	200 ppm	(WHO 1996 and 1998)	1, 2, 3, 4, 5, 6, 13, 14, 15, 16, 17, 18, 19, 21, 22
K^{+}	12 ppm	(WHO 1996 and 1998)	1, 13, 15,16, 18, 19, 21, 22
Cl^-	250 ppm	(WHO 1996 and 1998)	1, 2,3, 4, 6, 13, 14, 15, 16, 17, 18, 19, 21, 22
SO_4^{-2}	400 ppm	(WHO 1996 and 1998)	3, 13, 14, 15, 16, 18, 19
HCO_3^-	350 ppm	(WHO 1996 and 1998)	8, 9, 19, 21
NO_3^-	50 ppm	(WHO 1996 and 1998)	3, 4, 6, 7, 13, 14, 15, 16, 19, 21
TDS	1000 ppm	(WHO 1996 and 1998)	1, 2, 3, 4, 5, 6, 8, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22
TH	345 ppm (7 epm)	Kilemntov (1982)	1, 6, 8, 13, 15, 16, 17, 18, 19, 20, 21

To overcome the complexity of the interpretation of the suitability of groundwater for the domestic purpose, the quality average value (Q_a) has been adapted. The average water quality index "Q_a" for the studied factors is the summation of all Q_r values divided by the number of the factors. In the current study, the quality of water can be determined using not only one factor, however, 10 factors have been used, including Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, HCO_3^{-}, Cl^{-}, SO_4^{-2}, TDS (total dissolved solids), NO_3^{-}, and TH (total hardness).

When the average quality value (Q_a) reaches 100, it means that the water sample is saturated regarding the measured factors, compared with their standard values. If the quality index is less than 100 it means that the water is desirable for domestic use. On the other hand, if the average quality index is more than 100, it means that the water is over-saturated or polluted and it is not suitable for the domestic uses. The average Quality index for the water samples shows that well numbers 4, 5, 6, 7, 9, 10, 11, 12, and 20 are suitable for the domestic uses; however, well numbers 1, 2, 3, 8, 13, 14, 15, 16, 17, 18, 19, 21, and 22 are not suitable for the domestic purposes (Table 4).

b-Evaluation of groundwater for irrigation:

The area has many reclamation projects and it will be increased in the near future. So, it is so urgent to evaluate the groundwater for the irrigation purposes. Water used for irrigation can vary greatly in quality depending upon type and quantity of dissolved salts. These salts are carried with the water to wherever it is used. The salts remain behind in the soil as the water evaporates or the crops use it. Saline water affects the growth of plants physically and chemically and may disrupt the soil structure, permeability and aeration, resulting in a decrease in the plants growth. The water quality index[13-15], which is expressed in the previous part, was also used for the evaluation of the water quality for irrigation purpose. Several factors are used to classify the suitability of water for irrigation, including chloride content, Electric Conductivity (EC_{iw}), and sodium adsorption ratio (SAR) (Table 5).

To overcome the complexity of using different factors and interpretation of each factor separately, the quality average value (Q_a) has been used. As it mentioned previously, the average water quality index "Q_a" for the studied factors is the summation of all Q_r divided by the number of the factors. In this part, the quality of water for irrigation purpose can be determined using three factors including Cl^{-}, EC_{iw}, and SAR. The standard values have been used according to 1) Taylor and Oza[18] who concluded that the irrigation water will be considered undesirable for irrigation if the chloride content is > 500 ppm. 2) According to the U.S. Salinity Lab. Staff[19], they concluded that if the SAR is > 26 that represents very high sodicity and the irrigation water will be undesirable. On the other hand, if EC_{iw} is > 2250 it means the water is characterized by a very high salinity and it is not suitable for irrigation under ordinary conditions and may be used under a very specific circumstances.

When the average quality value (Q_a) is less than 100, it means that the water is desirable for irrigation use. However, if the average quality index is more than 100, it means that the water is over-saturated and not suitable for the irrigation use. The average quality index of the water samples shows that the water quality of well numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 17, 19, 20, and 21 is suitable for irrigation use, whereas well numbers 13, 15, 16, 18, and 22 is not suitable for irrigation purposes (Table 6).

Table (4): The average Quality value (Q_a) for water samples for domestic uses

S. NO.	Q_a Value	S. NO.	Q_a Value	S. NO.	Q_a Value	S. NO.	Q_a Value
1	109.8	7	36.7	13	233.3	19	140.1
2	111.0	8	101.4	14	143.3	20	80.8
3	100.7	9	40.4	15	226.8	21	119.1
4	84.7	10	37.3	16	263.3	22	154.5
5	69.2	11	33.7	17	99.2		
6	83.6	12	45.8	18	187.3		

Table (5): The absolute maximum limit of three factors used for the irrigation purpose and the results of undesirable well numbers for each factor

Factor	Absolute Max. Limit	Reference	Unsuitable samples due to (Q_r)
EC_{iw}	2250 ppm	(US Salinity Lab, 1954)	1, 2, 3, 13, 14, 15, 16, 18, 19, 21, 22
Cl^-	500 ppm	(Taylor and Oza, 1954)	1, 2, 13, 15, 16, 18, 22
SAR	26	(US Salinity Lab, 1954)	-

Table (6): The average quality value (Q_a) of water samples for irrigation purpose

S. NO.	Q_a Value	S. NO.	Q_a Value	S. NO.	Q_a Value	S. NO.	Q_a Value
1	82.32	7	14.82	13	148.77	19	67.61
2	90.08	8	26.24	14	96.73	20	40.19
3	67.16	9	25.20	15	145.72	21	57.54
4	57.75	10	23.45	16	176.64	22	145.02
5	36.81	11	23.95	17	64.51		
6	47.88	12	22.90	18	125.48		

c-Evaluation of groundwater quality for livestock and poultry:

The groundwater quality of the quaternary aquifer has been evaluated according to the limitations for livestock and poultry, which are reported by the National Academy of Science[20]. The current study shows that the analyzed water is classified into; class 1 has a low salinity (<1000 ppm), which is excellent for all classes of livestock and poultry. This class includes well numbers 7, 9, 10, 11, and 12; (2) class 2 has a salinity ranges from 1000 to 2999 ppm, which is very satisfactory for all classes of livestock and poultry; but it may cause some temporary and mild diarrhea in livestock not accustomed to them or watery dropping in poultry. It includes well numbers 1, 2, 3, 4, 5, 6, 8, 14, 17, 18, 19, 20, 21, and 22; and (3) class 3 has a salinity range from 3000 to 4999 ppm. It is satisfactory for livestock, but it may cause temporary diarrhea or refused at first by animals not accustomed to them; it often causes water faces, increases water motility and decreases growth, especially in turkeys. It includes well numbers 13, 15, and 16.

CONCLUSION:

Integration of remote sensing with GIS techniques has been employed in the current study to detect the landuse changes in the low desert zone west Qena Governorate since 1972. In addition, field and laboratory investigations have been done to map the recent development and the evaluation of the groundwater quality in the area for different uses. The study area covers ~1432 km^2 which is composed of

Fanglomerates, Wadi deposits, and Prenile deposits (85.1%) and represents the most suitable for the reclamation activities and ~14.9% of Travertine, Pliocene deposits, Dakhal and Esna Fmormation that represent the non-suitable areas for most of the activities.

Our findings indicate that the landuse in the low desert zone have experienced dramatic changes in the last few decades. By using NDVI method, for satellite images of Multi Spectral Scanner (MSS 1972), Themtic Mapper (TM 1984), Enhanced Thematic Mapper Plus (ETM+ 2001 and 2005), as well as the help of field survey using GPS unit, the change detection in the low desert zone has been mapped. The total landuse changes in the study area are ~153.4 km^2. The growth in reclamation area shows that the reclamation activities before 1972 were absent. However, during the time span from 1972 to 1984, the reclamation lands in the low desert zone increased by ~34 km^2; from 1984 to 2001, the reclamation lands increased by ~57 km^2; from 2001 to 2005, the reclamation increase was ~43.4 km^2. On the other hand, most other activities have been mapped using on-screen digitize on the ArcGIS 9.1 using ETM+ (2005) 15 m resolution, other field data collection, and governmental records. The results show that these activities including industrial zones, new urban areas, landfill sites, and wastewater disposal areas cover an area of ~19 km^2. In addition, the changes in the road network and flood protection canals have been mapped and the results indicate that since 1984 till present, the changes in the total lengths have been determined as 156.2 km, 97.9 km, and 49.5 km for roads, railways, and flood canals, respectively.

Therefore, it can be concluded that the expansion of reclamation and other activities in the low desert zone west Qena governorate have been shown a dramatic changes. These changes were predicted as follow: ~137 km^2 is located in the elevation zones 1 and 2 (64–100 m a.s.l), ~13 km^2 is located in elevation zone 3 (100-150 m a.s.l.), and ~3 km^2 is located in the elevation zone 4 (150-200 m a.s.l). However, the total area for zone 1 and 2 is ~334.6 km^2, zone 3 is 514.43 km^2, and zone 4 is 428.47 km^2. This indicates that there is still more than 1000 km^2 need to be managed for the future planning and activities.

On the other hand, the chemical analysis of groundwater samples shows that the groundwater type in the study area is mainly varied. The total salinity ranges from 404.4 to 3634.9 ppm, which classified into two classes including fresh and brackish water. The average water quality index "Q_a" was used to determine the quality of water for domestic uses. Ten factors have been used, including Ca^{+2}, Mg^{+2}, Na^+, K^+, HCO_3^-, Cl^-, $SO4^{-2}$, TDS (total dissolved solids), NO_3^-, and TH (total hardness). The average Quality index for the groundwater samples shows that well numbers 4, 5, 6, 7, 9, 10, 11, 12, and 20 are suitable for domestic use. However, well numbers 1, 2, 3, 8, 13, 14, 15, 16, 17, 18, 19, 21, and 22 are not suitable for domestic purposes.

The evaluation of the groundwater for irrigation purposes was used according to the standard values, which adapted from Taylor and Oza[18] for chloride content and U.S. Salinity Lab. Staff[19] for EC_{iw} and SAR. The average quality value (Q_a) using the mentioned three factors were used and the results show that well numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 17, 19, 20, and 21 are suitable for irrigation use; however, well numbers 13, 15, 16, 18, and 22 are not suitable for irrigation purposes.

Finally, the groundwater quality of the study area shows that well numbers 7, 9, 10, 11, and 12 are excellent for all classes of livestock

and poultry; well numbers 1, 2, 3, 4, 5, 6, 8, 14, 17, 18, 19, 20, 21, and 22 are very satisfactory for all classes of livestock and poultry; and well numbers 13, 15, and 16 are satisfactory for livestock with some cautions.

RECOMINDATIONS:

The study shows that the low desert zone west Qena Governorate needs more attention for the reclamation and other activities, since the groundwater quality for some wells is not desirable for different uses. On the other hand, the haphazard increase in the reclamation by private sector will be the most challenging problem in the area. The government has to bay attention to the environmental changes and to conduct environmental assessment impact studies for all the activities in the area. As well as establishing some regulations that could help in mitigate the existing problems and manage the future projected areas.

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استخدام بيانات الاستشعار عن بعد ونظم المعلومات الجغرافية والدراسات الحقلية للاعتبارات الأولية للتنمية المستدامة بمنطقة غرب قنا- مصر

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يوجد في الوقت الحالي العديد من الاهتمامات الجادة من جانب الحكومة المصرية وكذلك المجتمع لتنمية النطاق الصحراوي، والذي يقع بين هضبة الحجر الجيري والأراضي الزراعية.

يعتبر النطاق الصحراوي غرب محافظة قنا من أهم وأكبر هذه النطاقات للتنمية المستدامة المستقبلية للعديد من المشروعات الكبرى، والتي من أهمها التنمية الزراعية، المدن السكنية، مشروعات الصرف الصحي والمخلفات الصلبة، وكذلك المشروعات الصناعية. ويمثل هذا النطاق مساحة تقدر بحوالي ١٤٣٢ كم^2، والذي يعتبر كممر تنموي لمحافظة قنا.

تركز الدراسة الحالية على تحليل التغيرات في استخدامات الأراضي بالمنطقة منذ عام ١٩٧٢، وحتى الوقت الحاضر وكذلك تقييم مدى ملائمة المياه الجوفية للاستخدامات المختلفة.

وتعتمد الدراسة الحالية على استخدام التقنيات الحديثة، والتي تشتمل على تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية وكذلك الدراسات الحقلية.

بينت نتائج هذه الدراسة أن هناك تغيرات واضحة في استخدامات الأراضي منذ عام ١٩٧٢ وحتى الوقت الحالي، وتقدر بحوالي ١٥٣.٤ كم^2 منها ١٣٤.٤ كم^2 استصلاح أراضي، والتي تمثل ٩.٤% من جملة المساحة الكلية وحوالي ١٩ كم^2 للأنشطة الأخرى. ومن الملاحظ أن معظم هذه التغيرات حدثت في النطاق الواقع عند منسوب أرضي بين ٦٤ وحتى ١٥٠ متر عن سطح البحر.

وبالإضافة إلى ذلك بينت الدراسة من خلال تقييم مدي صلاحية المياه الجوفية للاستخدامات المختلفة أن هناك كثير من الآبار غير صالحة لأغراض الاستخدام الآدمي والزراعة والأغراض الأخرى.