THE GEO-ENVIRONMENTAL CHARACTERISTICS OF THE DOWNSTREAM OF WADI ALLAQI BIOSPHERE RESERVE ON THE LIGHT OF THE CLIMATIC CHANGES

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ABSTRACT

The erection of the Aswan High Dam resulted in the creation of a great lake and forty two branches – commonly termed khors - which were created afterwards. The formation of the huge reservoir of Aswan High Dam produced remarkable changes in the ecology of the local desert ecosystem. Inundation from the lake has penetrated through the wadis deeply into the hyper arid environment of the Eastern Desert. The accumulation of water after the construction of the High Dam participated in changing the landscape geomorphology of the shorelines of the southern part of the River Nile in Egypt.

The current article focuses on the overall geomorphological outlook of the northern downstream part of Khor Allaqi. The impacts of the climatic changes reflected in the transgression and regression of the water body inside Wadi Allaqi due to the amounts of the rainfall on the Ethiopian plateau as well as the major meteorological parameters and the associated vegetation cover have been assessed and investigated. The vegetation cover decreased about 12.9 ha in the period from 1960's to 2016 which is attributed to climatic changes.

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INTRODUCTION

Lake Nasser has an area of about 6540 km2 and a length of about 500 km., 350 km. of which lies in Egypt and 150 km. in Sudan. The lake has an average width of about 10 km., an average depth of 25 m, and a maximum depth of about 90 m. Khor Allaqi is considered the biggest khor amongst the forty two khors forming up the lateral extensions of water bodies, which are branched from High Lake Nasser. Some parts of Wadi Allaqi were flooded after the completion of the construction of the High Dam (1960 – 1970).

Springuel et al. (2003) concluded that the fluctuation of Lake Nasser's water level has led- during recedes- to temporal exposure of about 40 km in Wadi Allaqi, of the once inundated area where a new ecosystem has been established.

This ecosystem, which is generally known as an ecotone (a region of transition between two biological communities), represents a transitional zone between an aquatic area and a desert. The variation in timing and magnitude of flooding events that are directly related to fluctuations of the water level of Lake Nasser has large random components. One meter of vertical fluctuation of the water level in the lake causes more than one kilometer of lateral surface water movements.

Water fluctuation of Aswan High Dam Lake (AHDL) is a governing factor in forming the morphology, top soil geochemistry and structure of Khor Allaqi as well as the rest of the forty two khors behind the High Dam. The annual fluctuation of the lake's water during a period of about forty years (1964 to 2010) indicated that, Lake Nasser reached its first peak of 178 m. (above sea level) in 1978, but by 1988 the level dropped to 154 m. above sea level.

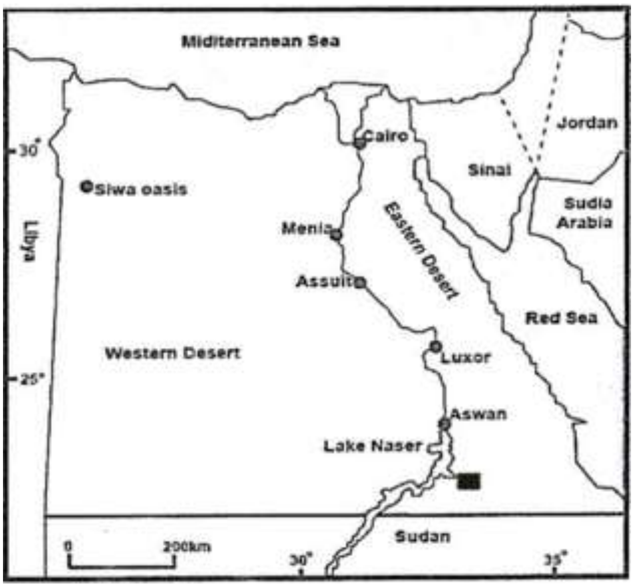

Fig.1: Location map of the study area (The studied distric)

The study area named Wadi Um Ashirah which extends between latitudes and longitudes: 22□ 49□ to 22□ 54□ N and 33□ 11□ to 33□ 15□ E, respectively (Fig.1) is scarcely populated and accessibility is possible through the asphaltic road, which begins on the southeastern suburb of Aswan and runs for a distance of about 180 km. Water transgression and regression during the last decades is a key factor in the formulation of the dominating geomorphological units as well as the landscape in the study area.

MATERIALS AND METHODS

1. Climate and water resources

The climate of the south Eastern Desert of Egypt is extremely arid with an aridity index of less than 0.05 (Ayyad and Ghabbour, 1986). The investigated meteorological data obtained from the major meteorological stations in Aswan. Data showed that the annual mean temperature is 25.2ºC. A mean minimum temperature of 8.1ºC has been recorded in January 1960. On the other hand, the mean maximum temperature of 41.8ºC has been recorded in July, which can often reach above 45ºC especially in August (Salem et al., 2009). Moreover, the long term monthly mean relative humidity (RH) during the period (1960 to 1980) ranged between 14 - 38%, while the annual mean of (RH) was 22.8% and reached 45.9% during the period (1996 to 2009).

The ultimate fate of shallow water associated with Lake Nasser is to descend to the deeper aquifers lying between 30 and 80 m below the surface.

2. Data collection and interpretation

2.1. Land forms overview

The major geomorphological units were checked in the field and sketched (Fig.2). Sand sheets and desert plains are regarded as the most dominating geomorphological units in the study area.

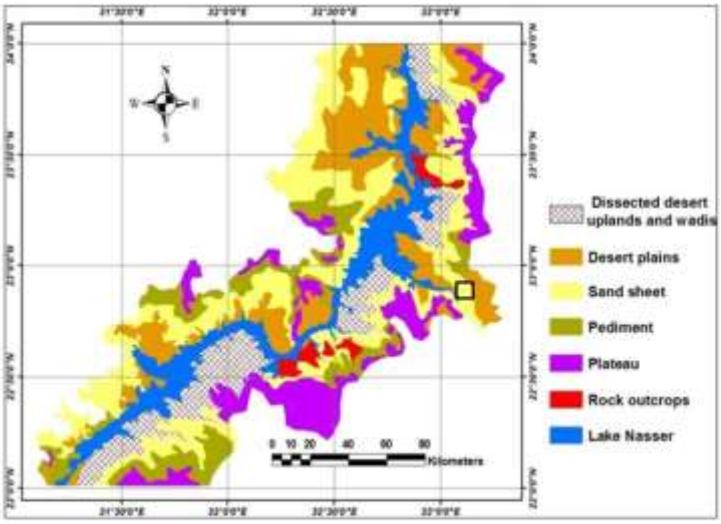

Fig.2: The different landforms of the study area - (the downstream of Wadi Allaqi) - is outlined by the black square (supervised and modified after the GIS Unit, Aswan High Dam Lake Authority, 2010).

3. Morphometric data about Lake Nasser

The morphometric parameters which are indicated in Table (1) are quantitative attributes derived from the terrain or elevation surface within a drainage basin. They are regarded as important criteria to characterize the current topographic features, ecology and landscape.

The manipulated morphometric values can be recently calculated directly from a DTM (Digital Terrain Model), through applying Arc GIS software (version 10.2) tools, which determine the specific elevation data associated to each cell of the raster grid.

Based on DEM (Digital Elevation Model) analysis, the upstream part is elevated approximately 500 m above sea level. However, the surrounding mountains are high such as Gabal Eqat in the upstream part of Wadi Al Qulayb. Slope tool is the most utilized tool on an elevation dataset.

Table (2) indicates the values of the accretion length (km) of water inside Khor Allaqi during the years; 1984, 1989, 1994, 1999, 2004, 2008, 2009, 2012, and 2013. The corresponding values of the consequent years from 2014 to 2016 were almost the same like 2013 according to the history of the satellite images extracted from Google Earth Pro software (Area calculating tool).

Figure (3) illustrates the linear relation between the flood plain accretion distance of water inside Khor Allaqi and the corresponding flood year. The history tool of Google Earth Pro software was applied to obtain the manipulated data.

Table 1:. Morphometric measurements of Lake Nasser at 160m and 180m (Entz, 1976):

Parameter	**160m**	**180m**
Length (km)	291.8	350
Shoreline (km)	5380	7844
Surface area (km^2)	2585	5248
Mean width (km)	8.9	18
Depth (m) Mean Maximum	 21.5 110	 25.2 130

Table 2: The values of the accretion length distances during the years (1984 – 2016), according to the history of the satellite images extracted from Google Earth Pro software:

Year	Water intruded distance inside Khor Allaqi (km)
1984	**30**
1989	**40.5**
1994	**41.4**
1999	**55.4**
2004	**51**
2008	**53.2**
2009	**52.6**
2011	**42**
2013	**42.7**
2015	**48**
2016	**39**

The distance of the intruded water inside Khor Allaqi during the years 1989 and 1994 were 40.5km and 41.4km, respectively. The accretion length of water inside Khor Allaqi in the years; 1999 and 2004 were 55.4 km and 51 km, respectively. The year 1999 witnessed the highest value of water accretion inside Khor Allaqi, since the construction of the High Dam in 1960 (Table 2 and Fig.4).

The geomorphology of the shorelines of the forty two khors of Nasser Lake as well as Khor Allaqi was influenced by the vertical increment and decrement of the water level and accordingly the associated ecosystems got modified because of the different phases of water level of Lake Nasser.

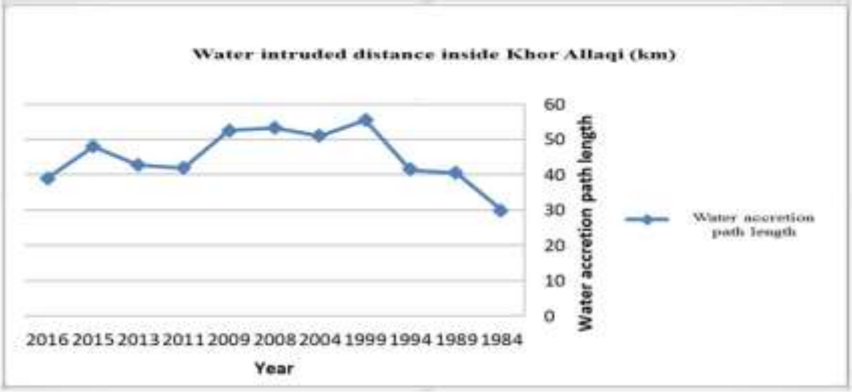

Fig.3: A diagram shows the relationship between the accretion path length of water inside Khor Allaqi and the corresponding flood year.

RESULTS

Data processing:

The tributaries of Wadi Allaqi are characterized by positive topographic forms, including low to moderate, high and very high relief hills and mountains, the highest elevations of these mountains increase eastwards. The hills form ridge like shapes (trending NE-SW direction) are composed of serpentinites and talc carbonate rocks such as Wadi Um Araka, while metasediments metavolcanics are more abundant at a nearby locality named Wadi Al-Qulayb.

Wadi Um Ashirah is filled with recent Quaternary sediments. These sediments consist mainly of mixtures of mud, sand, gravels and boulders. According to the immaturity of the sediments associated in the area under investigation they will be termed as regosols. The topsoil was weakly developed in the upstream, rather than in the downstream.

1. Classifying the land covers

According to the successive field surveys conducted during the years (2006 – 2016) with the aid of LANDSAT ETM+8 image, it was found that; the inundation from Lake Nasser has penetrated through the wadis deeply towards the east direction of Khor Allaqi. Fluctuation of the water level of the floodplain surrounding the lake during decades led to temporal exposure of 40 km in Wadi Allaqi, (Fig.5).

Supervised classification method was performed using the maximum algorithm based on a set of user-defined classes, through creating the appropriate spectral signature (s.s method), from LANDSAT ETM+8 satellite image of the district under investigation. It was found that; the land cover changes of the amount of woody vegetation at the downstream part decreased from 55 hictar to 42 hictar. This represents a total decrease of approximately 12.9 ha during the interval (1960's to 2016).

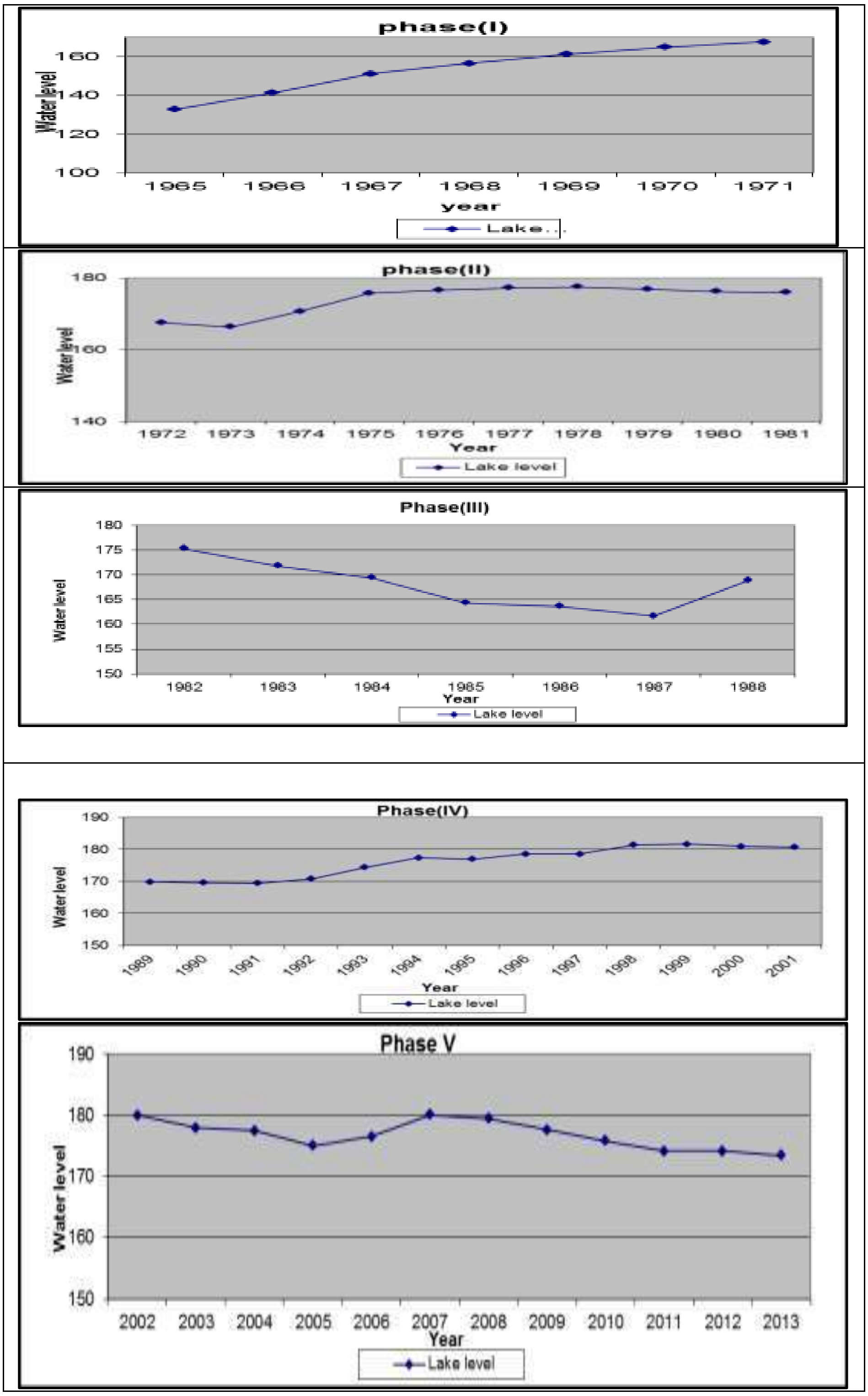

Fig.4: The phases diagrams of the water levels of Lake Nasser from 1965 to 2013 and remained constant till 2016.

2. Drainage Pattern Framework

2.1. Slope impact

The DEM is a digital representation of the earth's surface terrain (Abo El-Magd et al., 2010) that could be beneficially integrated into the structural geology for the identification of lineaments and fracture systems that may represent the surface expression of certain geological structures (Pena and Abd El-Salam, 2006).

Hills slopes have an important effect on both biodiversity as well as landscape. The drainage pattern regimes may influence the microclimatic conditions, such as local temperature, air humidity and evaporation. All such aspects will have a direct effect on the distribution of the various floristic species in the study district. The elevations and slopes values were plotted on raster dataset. Nine classes of slopes can be derived; from class 1 (0° -14°) up to class 9: (80° - 89°), (Fig.6) and (Fig.7).

2.2. Primary and secondary drainage systems

Drainage systems can be defined on a geomorphological basis as the pattern formed by the streams, rivers and lakes in a particular drainage basin. Drainage system is controlled by the topography of land, whether a particular region is dominated by hard or soft rocks and the overall framework of the land relief.

Drainage basins are important for hydrologists in order to detect the possible aquifers through determining the direction of the prevailing water flows of flood water and/or rainfall. A drainage basin is the topographic region from which a stream receives runoff, through flow and accordingly the groundwater flow. Drainage basins can be distinguished from each other by topographic barriers called a watershed. A watershed represents all of the stream tributaries that flow to a certain location along the stream channel. The number, size, and shape of the drainage basin vary according to the severity of watershed (Thompson and Turk, 2000).

Figure (8) indicates the (DEM) -Digital Elevation Model- of the study district and its adjacent surrounding regions. It can be noticed that the highest elevation of the study district reached 647m represented in Nosub El-Zurar and Nusub El-Hamary mountains. Meanwhile, the lowest elevation is 178m (Fig.8a) at the shoreline of Khor Allaqi, which permits the flow down of the water floods from the upper crests and mountain heights towards the lower elevation regions at downstream of Khor Allaqi. Mineralized materials can be leached out from the nearby mountains and carried by the produced drainage system.

Figure (8b) explains the process of creating the prevailing drainage pattern, starting with the thin secondary drainage pathways, which are termed as "first order drainage system". When two or more primary drainage got united "second order drainage pattern" is formed up. The routes of two or more second order drainage system can meet and unify creating the "third order drainage system". A Three dimensional framework is created to the district of study (Fig.8c), relying on the slope angle dominated throughout the prevailing topography of the study district and its nearby vicinity, which yield to the smooth flow down of the accumulated flash floods water towards the water body of Khor Allaqi and its outlining shoreline. A composite utilization of the successive satellites images and Elevation Digital Model (DEM) produced a semi detailed drainage pattern map of the studied district (Fig.8d).

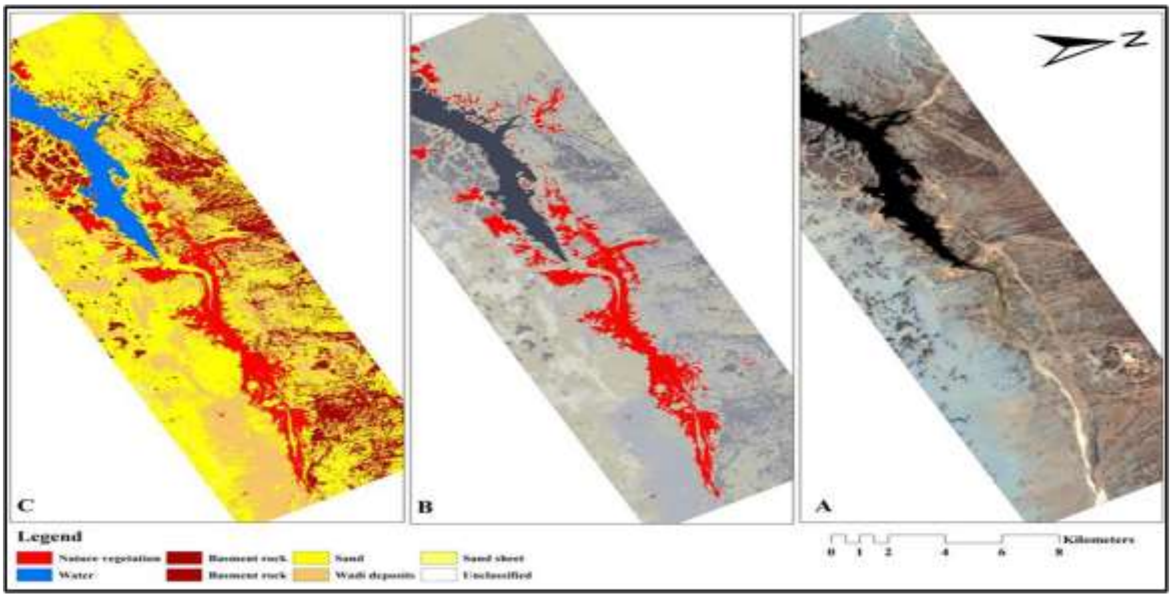

Fig.5: Land cover classification of LANDSAT ETM+8 image, dated on 2016, Red color class repesented the expanded vegetation cover between 1960s and 2016. A: A raw image, B: classified image, C: color classified image of the studied area.

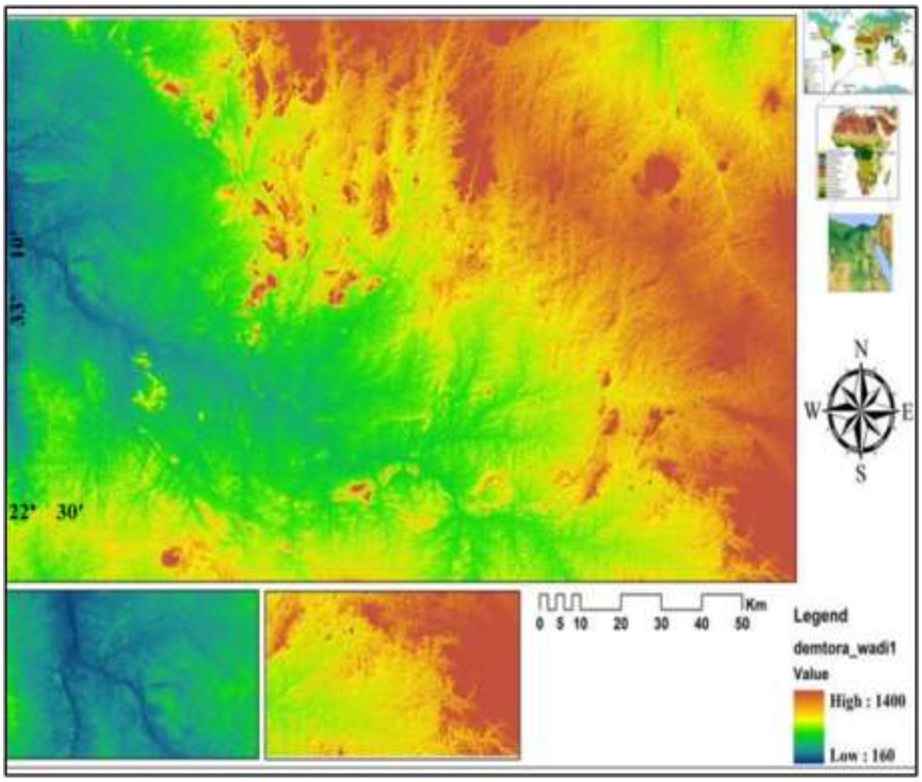

Fig.6: A regional ASTER image of Wadi Allaqi represents the dominating Digital elevations Models (DEM) at the upstream, midstream and downstream.

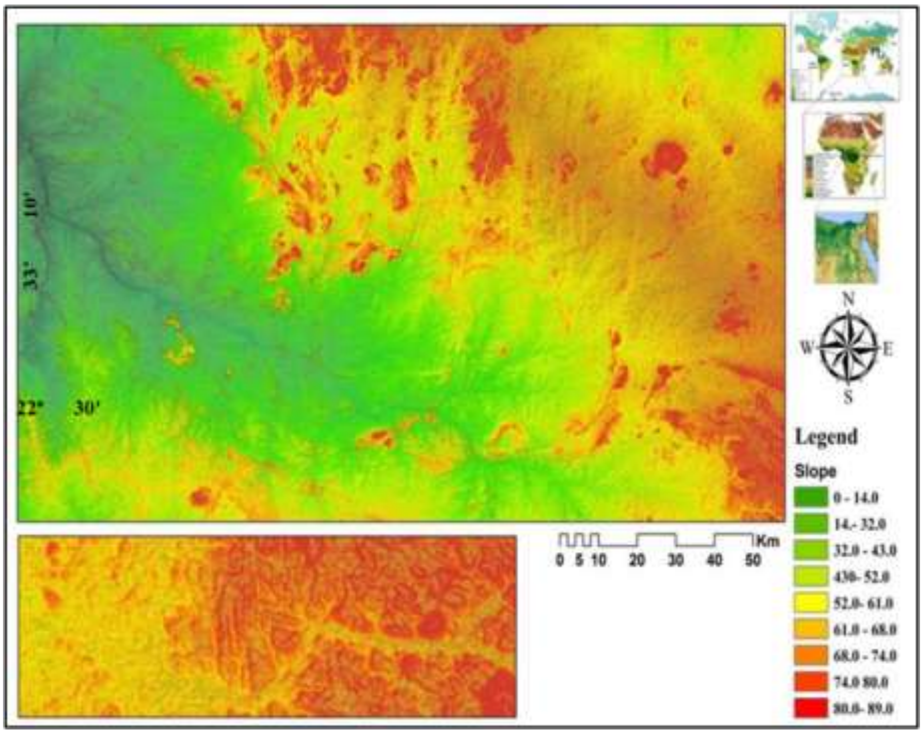

Fig. 7: Wadi Allaqi ASTER image represents the dominating landscape slope classification into 9 classes (0° – 14° as class 1) up to (80° -89° as class 9).

Figure (8d) exhibits the dominating drainage patterns scattered alongside the study district and its surrounding regions. It can be noticed that are considerable number of dendritic secondary order drainage pattern spoor into the primary ones carrying the mineralized detrital deposits from the high elevation topography (1000 – 1400m) high as shown in (Fig.8d) then redeposit them alongside the low elevation flood plain at 160m high. This process lead to the accumulation of transported mineralized fragments such as copper ores (malachite "copper hydroxide" from Abu Swayel old mine of copper) and even native gold particles as a placer deposit from the nearby gold mines (Um Ashirah east, Um Ashirah west, Um Ashirah west, Um Araka and Um Shakaiet gold mines).

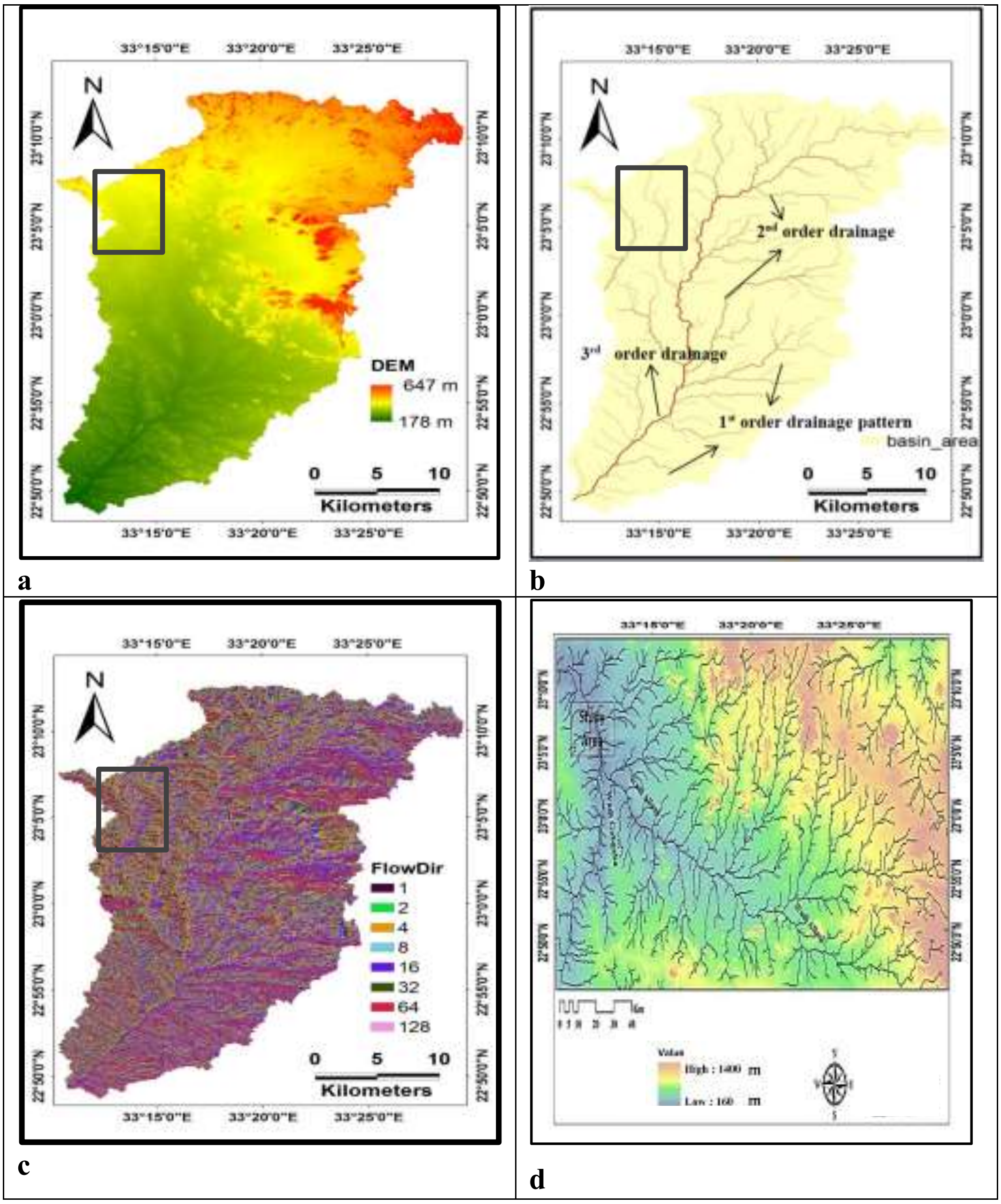

Fig.8 a-d: Digital Elevation Models (DEM) maps, representing the study district (a & b) and the flow orders direction (c) . The downstream of Wadi Allaqi drainage system,where the short secondary drainge spour water into the longer primary watersheds (d).

The area of each topographic element occurring in the study district and its nearby surrounding regions can be estimated through applying (Calculate Area) sub tool. (Fig.9) illustrates the obtained estimated area of each topographic feature as following:-

Sand sheets area occupied the most widely spread topographic component, more than 6000 km2. Desert plains are secondly ranked, as they occupy an area estimated to slightly exceeding 4000 km2.

Plateaus can be classified as third ranked. They occupy about 3000 km2. Pediments total area is estimated to be 2800 km2, so it is fourth ranked. Desert uplands occupy about 2300 km2, fifth ranked. Rock outcrops which are scattered alongside the study district and its surrounding regions have a total area estimated to reach 200 km2.

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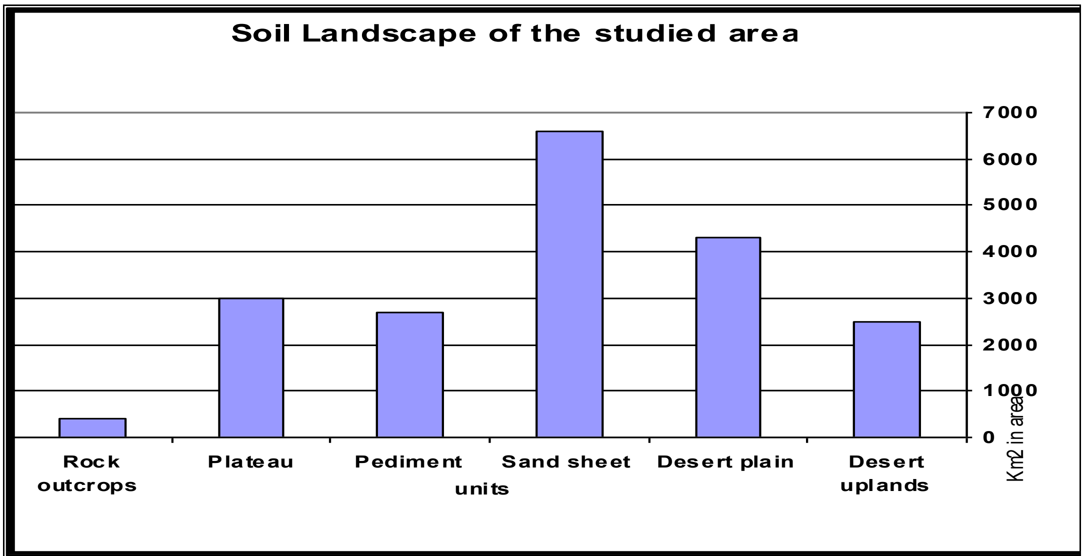

Fig.9: A diagram representing the abundance of the areas (km^2) dominating major geomorphological units and landscape in the study area and its nearby surroundings.

2.3. The climatic changes prevailed in the study area

The climatic parameters representing the years between 1996 and 2016 were collected and organized as shown in (Table 3).

Table (3) refers to the gradual increment of the measures temperature values during 1996 and 2016. The years 2014 and 2016 recorded highest values of temperature, 47.5 (°C) and 49 (°C), respectively. The worldwide phenomenon which is known as "Global Warming" is the major influencing key factor which leads to the noticeable increment of temperatures values, during the last two Relative humidity sensation and values are proportional to the increment of temperatures degrees values during the last two decades. Traces of scattered rainfall had been recorded in the years 1996, 1999 and 2002, on the other hand, almost severe drought dominated during the last decade, which lead to the decrement and remarkable inclination of the density of the vegetation cover in terms of their living individuals and their recorded species according to the regular s ecological and biodiversity field survey conducted by the ecologists of Wadi Allaqi Biosphere Reserve.

2.4. Land Covers Changes of imageries between 1960's and 2010

The satellite images of the study area, represented in the downstream part of Wadi Allaqi Biosphere Reserve reflecting the changes of the land vegetation covers that occurred between 1960s and 2016 were collected and overlapped (Fig.10). The density of the vegetation cover at the study area in 1960′s decreased remarkable as illustrated in Fig. (10). The land cover amount of woody vegetation at downstream part decreased from 54.8 ha to 42.3 ha. This represents a total decrease of approximately 12.9 ha during the 50 years.

(Wadi Allaqi Meteorological Stations Sources: Wadi Allaqi metrological station 1997 and Lake Nasser authority 2016).

Table 3: The major climatic records of mean, minimum (min) and maximum (max) air temperature (°C), relative humidity (RH), rainfall (RF) and baro- pressure (BP), during 1996 – 2016

	Month	Temperature (°C)			RH	RF	BP
		Min	Max	Mean	(%)	(mm)	(mm)
Wadi Allaqi	1996	17	44	30.5	38.4	traces	990.7
	1999	16.8	43.5	30.1	47.6	traces	992.0
	2002	19	43	31	48.9	traces	990.2
	2005	18.8	44.8	31.8	40.0	-	989.3
	2008	19	46	32.5	46.1	-	991.1
	2011	17.3	46	31.6	47.1	traces	991.5
	2014	17.5	47.5	32.5	46.6	-	990.4
	2016	19.4	49	34.2	52.3	-	992.0

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(Wadi Allaqi Meteorological Stations Sources: Wadi Allaqi metrological station 1997 and Lake Nasser authority 2016).

DISCUSSION

One meter of vertical fluctuation of the water level in the lake causes about one kilometer of lateral surface-water movement.

The obtained results indicated that the vegetation cover class was about 5%, water ratio around 3%, basement rocks cover about 18%, sand covers 53%, while sand sheets ratio was about 15% of the total area. Remarkable climatic changes parameters had occurred during the last two decades, in particular, more five degrees of temperature values had been added to the corresponding values recorded in the year 1996. Rainfall which permits the vanishing of the encountered vegetation cover had been recorded once - in the year 2011 - during the last decade.

The dominating drought which is represented in the form of temperature degrees values and scarcely happening rainfall lead to remarkable changes in the morphometric patterns, landscape and decrement of the densities of the prevailing vegetation cover in Wadi Allaqi Biosphere Reserve.

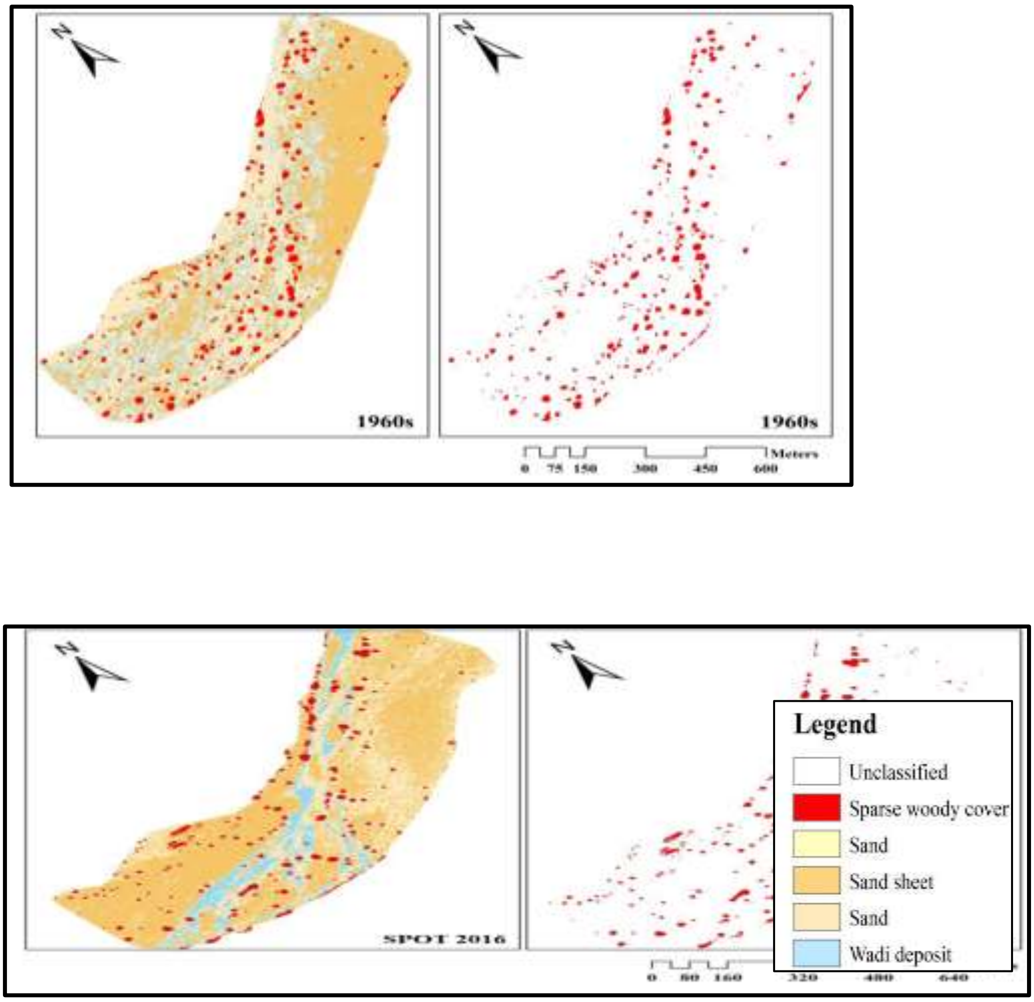

Fig.10: Two processed satellite images representing the changes of the vegetation covers between the years 1960's and 2016.

CONCLUSION

As a result of the prevailing climatic changes and global warming manifestated in the scarcity of rainfall and pronounced elevations in temperature degrees, noticeable discrepancies were recorded in the morphometric measurements, landscape and vegation cover , during the last two decades. Mitigation measures and executive procedures should be adopted to reduce the impacts of the climatic changes. The most recommended and important mitigation measures are represented in adopting long-termed rehabilition and recultivation of the endangered and threatened floristic species to keep up their distribution as distinguishing ecological elements of the Egyptian flora.

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