Assessment Lake Nasser Egypt Within The Climatic Change

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Abstract-Changes of water level interacted with physical features in Lake Nasser to yield positive and negative geoenvironmental impct. In the current search, the problem postulated in two strangle portions in the course of the lake. First, El Madiq strangle zone where sands fall down and drifted on stream gradient to narrow course which exhibit shallow water on satellite imagery. Second, the entrance of the lake subjected to new delta initiation, with maximum thickness concentrated in a zone lies between Km 350 and 420 from the Dam. Two positive implications also determined, in Allaqui the difference in water area between 1987 and 2000 is 91.9 $km^{2.}$ and the difference in water extension is 25.54 km. Fine soil in an area about 30121 km^2 in the basin can be cultivate in Allaqui. The saturated water zone in Kurkur is closed to the land surface and subjected to transpiration and evapotranspiration. Kurkur vadose water can flow to the lake course and interflow water can also migrate back to the land surface to evaporate. An area of 392 km^2 ready for agriculture that can avoid Kurkur area from evaporation. [Journal of American Science 2010;6(7):305-312]. (ISSN: 1545-1003).

key words; Lake Nasser, strangle, sand drift and High Dam.

1- Introduction

The stored water in Lake Nasser, was, in a way, the multi mate testimony of the value of the High Dam to the welfare of Egypt, of River Nile flows and provides reserve from normal and above normal water years where the River Nile is only water source for Egypt. Lake Nasser extended in 500 km, 350 in Egypt and 150 in Sudan with average width about 12 km at water level 180 m. Lake Nasser mainly affected by climatic change on east Africa where the influences from the lake shore was neglected because the following functions; i-Geo-environment of the lake is a desert without vegetation or Human activities at the time of its formation. ii-The lake has one source of water, the River Nile because it has other few tributaries, precipitation iii- Only evaporation impact led to exciting changes on the lake due to the arid climate. Consequently, water level in Lake Nasser is a good indicator of the cycles of wet climate followed by droughts in East Africa. The main water supply sources are the Ethiopian Plateau, the equatorial lakes and Bahr El- Gazal water shed. The River Nile has under gone a wide variety of the floods over history, the inflow is ranging from a maximum value of 150 Bm3/year (1878-1879) to a minimum value of 42 Bm3/year (1913-1914).

The problems could be postulated down in two strangle portions detected in the course of River Nile. First, El Madiq portion strangled by sand encouragement inside the reservoir with help of physical features are main problem that reduce the reservoir capacity and affecting its useful life. After lake initiation, the water velocity decreased and the water go to narrow incised wadis in the Nile. Second, sedimentation of suspended materials coming from the Ethiopian plateau cause initiative a new delta in Halfa. Before the dam 1964), the suspended sediments were deposited along all the Nile valley to the Mediterranean Sea. And due to decrease of water velocity after lake foundation (1968), the suspended sediments were flushed down in the lake around the old Second Cataract and the water spillway in E-W small wadis. Therefore the total storage capacity of Lake Nasser in 1964 was 9115 Mm^3, in 1977 was 7904 Mm^3, 1988 was 7293 Mm^3, 2000 was 4930 Mm^3 and in 2006 it reduced to 4148 Mm^3.

Water level changes in Lake Nasser give another attraction to positive geoenvironmental implications in Kurkur area in the western side of the lake and Allaqui area in the eastern side. These wide areas have physical features promising for agricultural reclamation. For these reasons, this paper aim to asses the water fluctuations from water level 160 to 183 m within lake parts and monitor the causes of strangle problems on one side and the benefit areas for people on another.

2- Methodology

Use of remote sensing technique in change detection of water level in Lake Nasser required Landsat TM images in dates 1972, 1987, 2000, 2003 and 2008 using ARC-map program and Geographic Information system GIS (Fig.1). The water level changed (from 160m to 182 m), in different rates from part to another within the lake. There are high water fluctuations in Allaqui and Kurkur areas, consequently, the current search investigated their drainage basin characteristics and delineate new areas inside Kurkur and Allaqui basins for agricultural reclamation. Whilst there is

no fluctuation in El Madiq and Halfa portions. These multi-temporal Landsat TM images delineated the recent position of the El Madiq portion and the sand dunes morphology and concentration were interpreted from the satellite images and field work. Also we followed the sedimentation steps in the entrance of the lake (Halfa) on satellite imageries. The lithological characteristics, were extracted from the available geological maps of southern Egypt [2]. The geomorphological landforms were interpreted from integrating geological data with visual analyses of Landsat TM images and the spatially variable relief from the DEM and field verifications. Morphometric analyses of the lake shore and the stream gradient of the lake were necessary to understanding the impact of water level in the reservoir. Additionally, in El Madiq and Halfa portions, the E-W structural trends have thrown down the north flanks inside the River Nile before the lake foundation forming suddenly fall in stream gradient. Consequently, sedimentation retained within the reservoir bottom in both portions by lowering water velocity specially in the entrance of the lake. Moreover, the impact of changing hydro-climatic conditions in this region after the dam construction cause hazards in El Madiq as strangle zone due to sand encouragement and initiate a new delta in Halfa were also determined. The treatment of available data on the sedimentation in Halfa integrated with the Landsat TM images to delineate the volume and place of sedimentation. These measured hydraulic data collected from the Nile Research Institute reports [13] and other references before and after the High Dam construction. Overall, the satellite imagery and field work within hydro-climatic changes on east Africa developments will use in assessment
Lake Nasser.

3- Strangle Problems

3- a- El Madiq Strangle (Gorge) Zone

The shallow water gorge portion stretched from El Madiq to Kurusku in length 27.6 km and average width 2.7 km (including El Madiq strangle locality which has 1.1 km width and 4.6 km length) has been determined in the course of River Nile (Fig. 1). Before the High Dam the water velocity was high speed with more erosion in flanks and can pass toward the north. After the dam, the water velocity decreased and sand deposition increased due to change in global climate. And the water go to narrow incised wadis (khors) in eastern bank with altitude 150 m in trough periods (Fig. 2). These khors are traced in hard Nubia sandstone which already saturated by water and it
consider underground water reservoir before the dam construction.

The established natural hazards of sands on Lake Nasser from satellite imagery and field work delineate two sources of sands: First source, sand encouragement from Western Desert divided into two aeolian landforms; a- elongated dune fields (Figures 3 and 4) seem to have their source from a location found to the north [5]. b- sand sheet, Gurf Hussein on the western side of Lake Nasser as an example area covered by sand sheets on Landsat TM images (Fig. 5) and in the field (Fig.6). Second source is sand generated directly at the Lake's wall from the Nubia sandstones Kursku plateau in the eastern side and fall down inside the lake by gravity in this arid region (Fig.7). Workers investigated sand movements, but not study sand sources, and never study the second source. Unfortunately, the two sand sources are founded in "El Madiq" area therefore it can be regarded as danger area and the sands quantity calculated only for the first sand source.

Sand encouragement concentration

The amount of sand deposited in the Lake Nasser were estimated to be 1.5 million m³/year [3]. El Gammal and Cherif [5] studied Ghurd Abu Muharik dune field (the biggest dune field dunes in Western Desert) and stated that the dunes increase in size down southwards and moves 17 m/year to the south. Afify [1] considered the main meteorological parameters related to wind and atmospheric conditions (barometric pressure and air temperature) which are playing essential part in the phenomenon of sand moving by wind and selected the wind action stations in Wadi El Arab and Adindan to consider the sand transport to the lake in wind modeling and concluded that there are 100 to 110 cm³ /day in summer and spring in Wadi El Arab station at 2006 (in El Madiq zone, Fig. 2). Overall, the field work and Landsat TM images in multi-temporal dates (Fig.1) with the topographic map 1944 and 1980 [6&7], elucidated that "El Madiq" became more risk due to combining the following functions.

i- Topographic function

The western side of El Madiq zone has altitude range from 200 to 280 m covered by sands with about 10 m thick, these sands continuously supported by others from the north encouragement the lake. The strong wind from NNW to SSE pass on the western side and stopped by hills in eastern side to fall down inside the course of River Nile besides the suspended sediments coming from the Ethiopian plateau (Fig.3). The eastern side vertical scarped hills of Kurusku plateau has altitude range from 260 m and to 380 m. The course-shape in El Madiqu zone is thin incised water passage in the River Nile which restricted by NE and NW faults seen on Landsat images as shallow water part in Lake Nasser and there is no changes in water level through 40 years of lake initiation (Fig.1).

ii- Geomorphological landform and features

Yardangs and sand dunes landforms covered the western side of this portion. Yardangs are striking in NNW- SSE coincide with the wind direction in this region and separated from each others by corridors for mobile-sand dunes towards the lake. Yardang is an aeolian landform indicate to long time of wind action in this side in Quaternary arid periods (Fig.3). While in the eastern side there are short incised narrow wadis cutting the Kurusku dissected plateau and these wadis declined toward the lake from altitude 300m to 150 m (in drought periods) where the water collected from lateral movement within the dissected plateau together with the surface water in the lake.

iii- Stream gradient

Stream gradient is an important factor controls the stream's velocity, the downhill slope of the bed , if a river flows out of steep onto a flatter plain, the river 's gradient may change suddenly from steep to gentle, such a change in gradient causes the river to slow down , and the sudden loss of velocity can cause sediment deposition at the base of the steep slope [4]. Inside El Madiq portion (in the water), the sands drift from Wadi El Arab downward (>10m) passing on a NW-SE fault with northern downthrow the water velocity decrease and the sands deposited to the north of Wadi El Arab bottom in an area lies between Wadi El Arab and El Madiq locality causing more strangle in this portion.

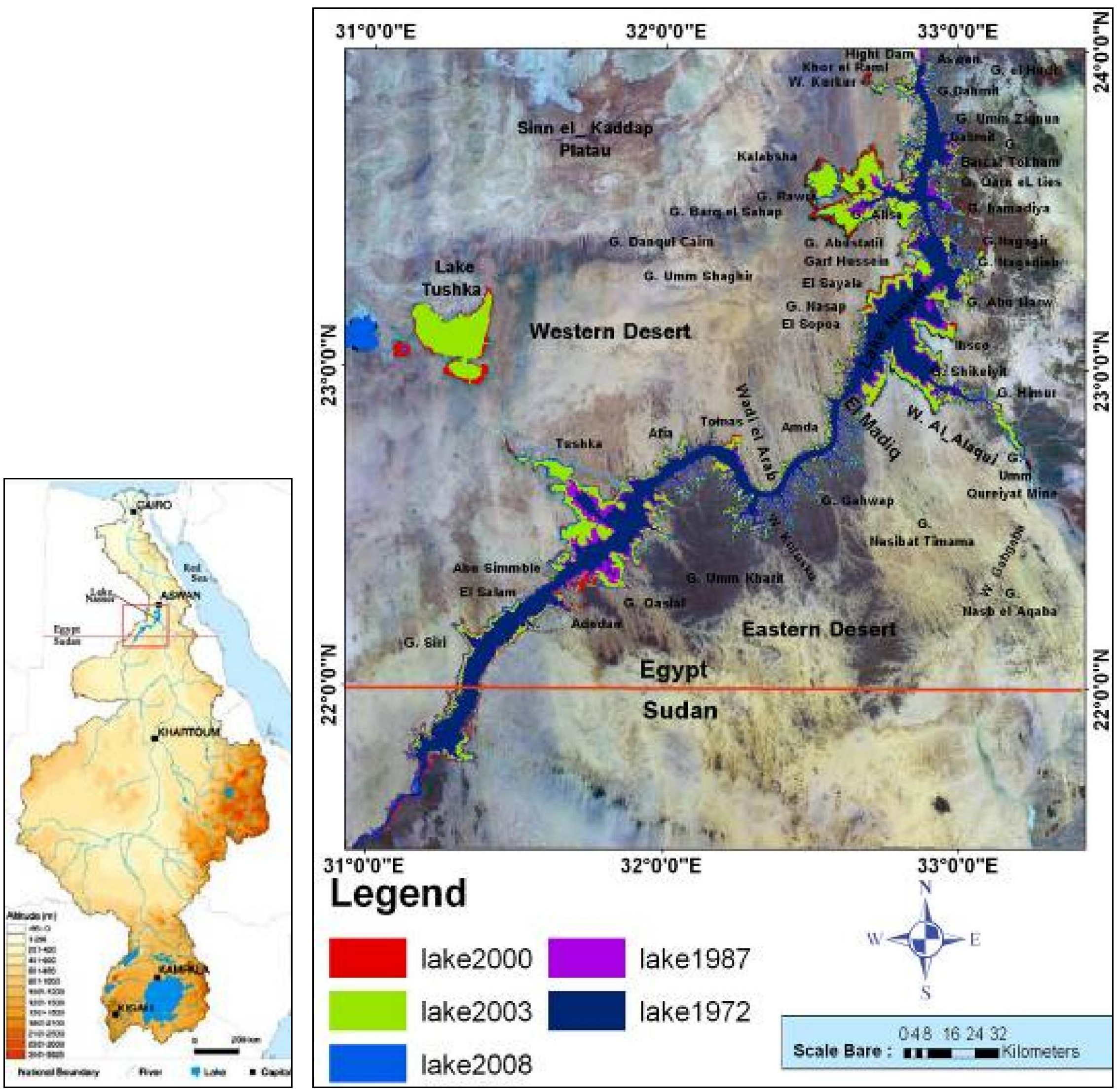

Figure 1. Change detection on Lake Nasser in multi temporal dates 1972, 1987, 2000, 2003 and 2008 using ARC-GIS, shows localities discussed in the text. Lake Nasser marked by frame in Nile Basin

3- b- New Delta Initiation in Lake Nuba

The suspended materials carried by the flood during the period 1929-1955 by weight are 30% fine sand fraction, 40% silt, and 30% clay but there is no presence of coarse sand [12]. The estimated Montnorillonite is so fine grains absorb water and swell then it consolidated in dry months forming bed.

Sediments Concentration

Before construction of the High Dam, in 1964, about 93% of the total average annual suspended load of 124 million tons/year was carried out to the Mediterranean Sea. After the High Dam construction, flood discharge of Nile downstream has been greatly modified and more than 98% of the total suspended load was retained within the reservoir and the total amount of sediment transported downstream the dam dropped to only 2.5 million tons/year due to decrease of water velocity. At year 2000 the average water velocity was 0.52 m/ sec at 487 km south the High Dam and at year 2001,it reduced to 0.46 m/sec in the entrance of the Lake to 0.04 [8].

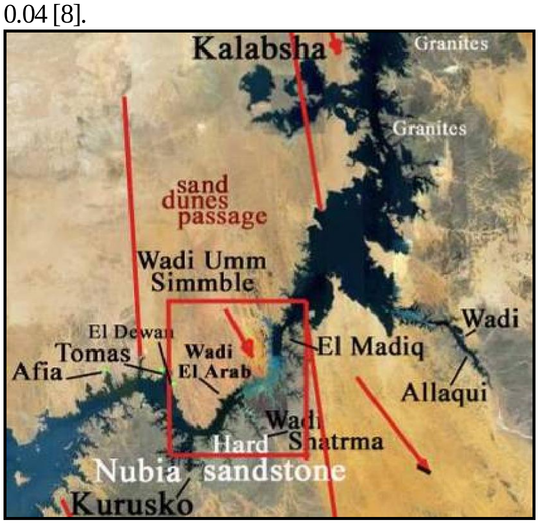

Figure 2. Sand encouragement on lake Nasser from the Western Desert, the arrow refer to the wind direction and sand movement. El Madiq shallow zone marked by frame

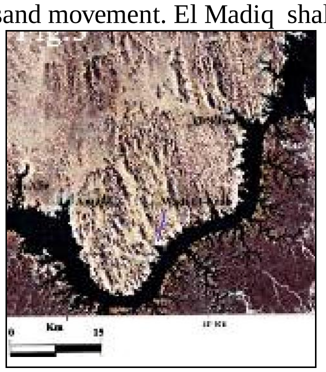

Figure 3. Landsat TM image shows sand and yardangs in the west and plateau in the east. Figure 4. Photograph shows elongated sand dune.

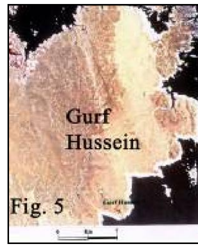

Figure 5. Landsat TM image shows sand sheet encouragement Gurf Hussein area. Figure 6. Photograph shows the sand sheet in Gurf Hussein.

Figure 7. Sand generation directly from the walls of the lake, derived from sandstone plateau

The deposited materials in Egyptian border equal to 56 Mm³ from February 2007 to March 2008 and the total sedimentation volume until March 2008 is 1123 M m³. While in Sudan, the sedimentation from February 2007 to March 2008 equal to 200Mm³ from Feb 2007 to Mar 2008 and the total sedimentation volume until March 2008 is 5161M m³ (Nile Research Institute reports 2000 and 2006). In the year 2006 at Halfa, the total volume of sedimentation 1.673 Bm³ at water level under 147 m and 3.345 Bm³ between water level 147 m to water level 175 m and no sedimentation above water level 175m. Consequently, the water can spillway to the north at 170m.

The total volume of sedimentation in the lake is 6284 million m^3 during 1964-2008 (18% in Egyptian and 83%, in Sudan), whilst in one cross section 26 (Second Cataract at 357 km from the High Dam, Figure 8) it is 1037.44 million m^3 during the same time in Halfa forming new delta from 1968 to 2008 in a zone including the following localities; 1- Gemi (372 km from the dam), the sedimentation thickness is 59.82 m. 2- Qengari 6 (394 km from the dam), the sedimentation thickness is 57.89 m. 3- Murshed 3(378.5 km from the dam), the sedimentation thickness is 54.49 m. 4- Old Second Cataract the sediment thickness is 52.10 m (Fig. 8). An estimated average of 160 million tons annual of sediment reached El-Gaafra Gauging Station (34 km to the north of the High Dam down stream) during the period from 1904 to 1963, the annual sediment load varied from 50 million tons to 228 million tons per year [13]. The suspended sediment concentration peaks at EL-Gaafra have dropped from 3000 ppm before lake initiation to only 50 ppm after the construction of the lake [9].

Stream Gradient

Stream gradient is an important factor controls a stream's velocity , the downhill slope of the bed, if a river flows out of steep onto a flatter plain, the river 's gradient may change suddenly from steep to gentle. Such a change in gradient causes the river to slow down, and the sudden loss of velocity can cause sediment deposition at the base of the steep slope lock-like that mentioned above in sand encouragement [4]. Inside Lake Nuba, the sediments drift from south to north downstream perpendicular on E-W fault (Fig.9**)** with northern downthrow (17m) forming delta. Hence, the water passage has been partially changed toward the east within E-W fault plain (Fig. 8 &9).

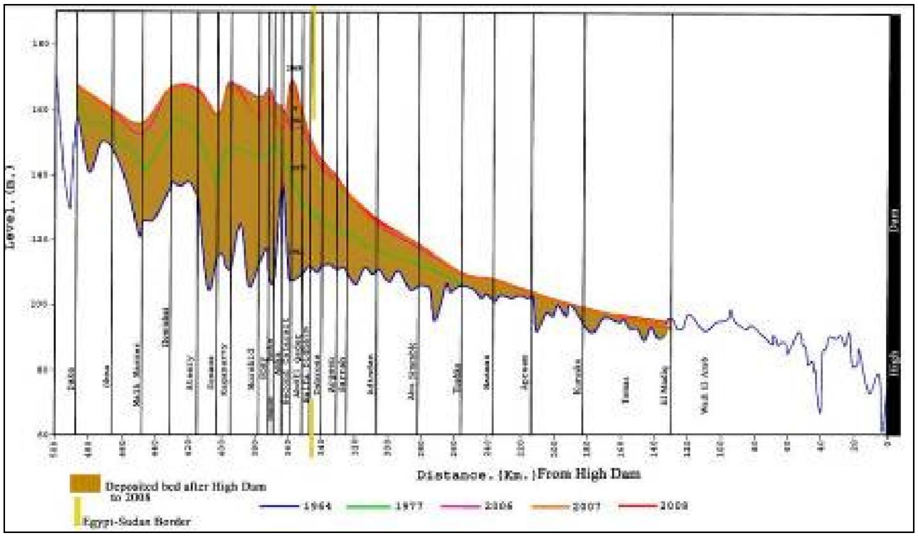

Figure 8. Diagram illustrates the deposited bed inside Lake Nasser prepared from data collection of the mentioned references.

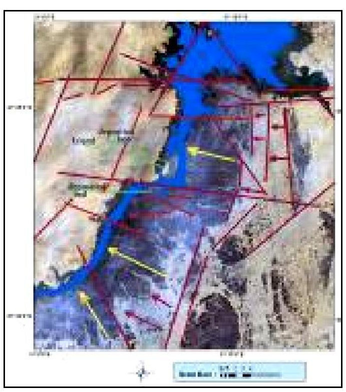

Figure 9. Lake Nuba physiographic map shows the structural elements (red lines) affecting in Halfa and slope directions (yellow lines).

Sediments on Satellite Images

However the water increase in some lake margins on Landsat TM images from 1972 to 2008 (Fig.1), there is a sharp demarcation line appears between the two kinds of water, the turbid brownish flood water in Sudan sector pushes the old green transparent water mass towards the north. Although the sedimentation can see northward until Wadi El Arab (170 km from the High Dam), the suspended materials had been deposited in a sector between 340 and 430 km from the dam (Figure 8), the new sediments formed in decreasing flood water parallel to the shore slightly emerged low dams separating the lotic and limnetic water masses indicating probably the shore of the future water-way in time to come in filling process of this part of the lake by sediment bed and the water spillway caused by shrinking volume of the lake due to mud deposits (Figure10).

After High Dam construction, firstly in year 1972, the water was go in restricted way without sedimentation (Fig.10). Then in year 2008 the deposition altitude reached up to 170 m at at Halfa, Abd El Qader and Ateery cross sections (between 347 km and 420 km from the Dam, measured at the lowest points of deposition in the lake), the same locality seen on the Landsat ETM images 1988 and 1998. In 1988, a year that the mud bed exposed when water level was 170 m in the lake and formed southern edge to Lake Nuba (Figure10). This mud bed merged by water in 2000 and 2003 (Fig.10) when the water elevated to 180 m and the water over-swell (spillway) on the mud bed in high flood only and in low flood there is no way for water to go to the north especially with the continuation of suspended sediments. At the end of the gorge section to the wide confluence area near Amka, just above the old Second Cataract, the current speed was reduced at once to about 10 cm/sec. suspended matter started there forming a more than 1m thick new sediments layer year by year and this incredible sedimentation underwater and exposed forming new delta in Halfa appeared on Landsat images (Figure 10).

4. Useful Localities Detected With High Change Rate

Kurkur, Kalabsha Tushka and Al Alaqui areas show high water fluctuation. Several workers investigated Kalabsha and Tushka, there are several projects had been created in Tushka, Kalabsha and Garf Husein while Kurkur and Allaqui are seeking to scientific study and development projects. Here, Kurkur and Alaqui areas have been investigated in this study.

4-a- Kurkur Area

Kurkur drainage basin had been extracted from Landsat TM image equal to 988 km^2 divided into two parts, the lower stream part is nearly flat area with natural plants and fine soil, the second part is slightly slopping area (Fig.11). Kurkur Oases lies at the upper stream part of Kurkur drainage basin at the foot-slope of major scarp (220 m) of Sinn el Kaddab plateau (Fig.11). Kurkur Oases get the water from canyon karst inside the limestone Sinn el Kaddab plateau and from the quick runoff across the steep scarp. Because of the oases position in relative high topography upstream drainage inside the Kurkur basin, the oases not support by water from the lake (Fig.11). The water depth in Wadi Kurkur is ranging from 0.7m to 2 m seen in the field trip in wide area after high flood in September 2008 (Fig.12).This lead to high evaporation in temperature reach up to 50º in summer and in May 2009 the area was still wet fine soil where natural plants grown (Figure 12).

In Kurkur, there is a saturated zone where the water table appear in Kurkur Oases (pond and springs in local depression at the upstream parts) and interflow water is pulled downward by gravity known as gravity drainage [10] to downstream parts in Kurkur basin to the lake. Exposure of water bodies in Kurkur area far from the lake and occurrences of gypsum sands near to the tidal zone of water fluctuation in dry and wet periods (Fig.13) delineate the high ground water table in Kurkur basin. The aeolian deposition and wind deflation stopped at the Stocks's surface indicating to the ground water table [11].

This saturated water zone had been exposed to evaporation in high flood years (Fig.13), where the water nearly closed to the land surface in Kurkur subjected to transpiration and evapotranspiration in low flood years (Fig. 13). In 1984 the year that water diversion began the surface of Lake Nasser was 155 m when the lake elevation declined by 15 m to 1989 the year that surface area shrank to 180 m. One consequence of the reduction of the volume of Lake Nasser has been increase in salinity of the lake margins in Kurkur. Kurkur is a vadose zone (zone of aeration) in low floods the vadose water can flow to the lake course and in vadose zone the process known as interflow water in vadose zone can also migrate back to the land surface to evaporate.

4- b- Allaqui Area

The maximum perpendicular width (11.6 km) in Lake Nasser lies in it's conduction with Allaqui. Three dimensions elevation model (3DEM, Fig.14) illustrates big difference between year 1987 in drought period in east Africa and year 2000 in rain period where the water extended to 29.1 km 2000 in Wadi Allaqui course (Fig.14). The water area in Allaqui in 1987 was equal to 112 km^2 and the water extension (length) equal to 62.46 km. In 2000, water area 203.9 km^2 and the water extension (length) equal to 88 km. The difference in area between 1987 and 2000 equal to 91.9 $km^{2.}$ and the difference in water extended length between 1987 and 2000 equal to 25.54 km (Fig.14). In 2008, the water arm extended 26.2 km length and 2.1 km width wedged to .8 km width. An area of 91.9 km^2 water exceeded in the high flood periods on east Africa can be utilize in irrigate the fine soil in Allaqui. Wadi Allaqui have 250 km length and 2 km average width , it is a fifth order drainage channel inside the large basin extracted from Landsat TM image (Fig.15). Allaqui Basin area equal to 67868.12 km^2. Wadi fill in Allaqui composed of silt-size friable soil with depth reach up to 5 meters. Allaqui basin subjected two times annually to flash flood exceed than 25 cm. The igneous and metamorphic mountains in Allaqui basin reach up to 1148 (Gabal Eiqat and Gabal Seiga) and to 1152 m in Gabal Hileikonti with steep slopes and not infiltrate any precipitated water giving quick runoff to the course of Wadi Allaqui. The course of Wadi Allaqui declined from 600 m asl to 200 m inbetween the mountains then sloped to 150 m in the downstream trend with nearly horizontal surface in area about 30121 km^2 in the basin suitable for cultivation without the risk of flash flood (Fig.15) but it have ground water marked by playa exposure inside the Allaqui basin far from the tidal zone of high flood periods.

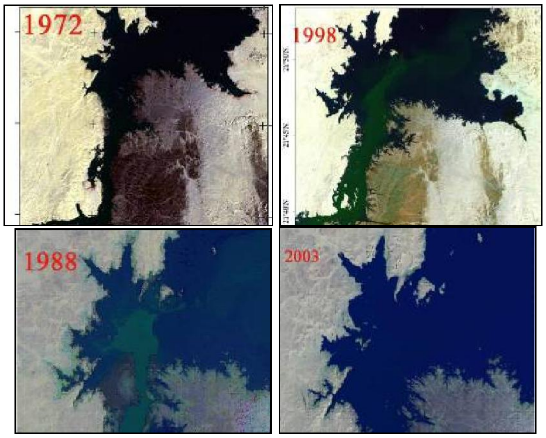

Figure 10. Landsat images in 1972 when the water has restricted passage with rare sedimentation, 1988 a year that the mud bed exposed when water level was <170 m in the lake and do southern margin end to the lake and 1998, this mud bed merged by water in 2003.

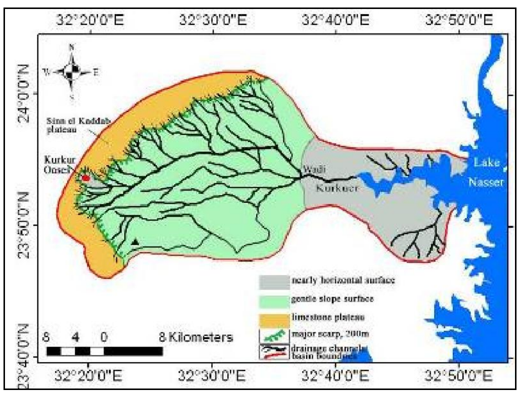

Figure 11. Kurkur drainage basin prepared from Landsat images and topographic maps using ARC

Figure 12. Natural plants and shallow water covering wide area in Wadi Kurkur.

Figure 13. Exposure of water bodies far from the lake (right) and wind deflation stopped at Stocks's surface in Kurkur area (left).

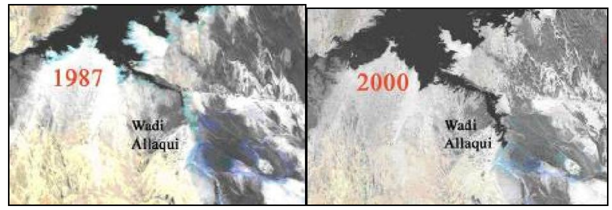

Figure14. The 3DEM in years 1987 and 2000 in Alaqui illustrates big difference in water extension.

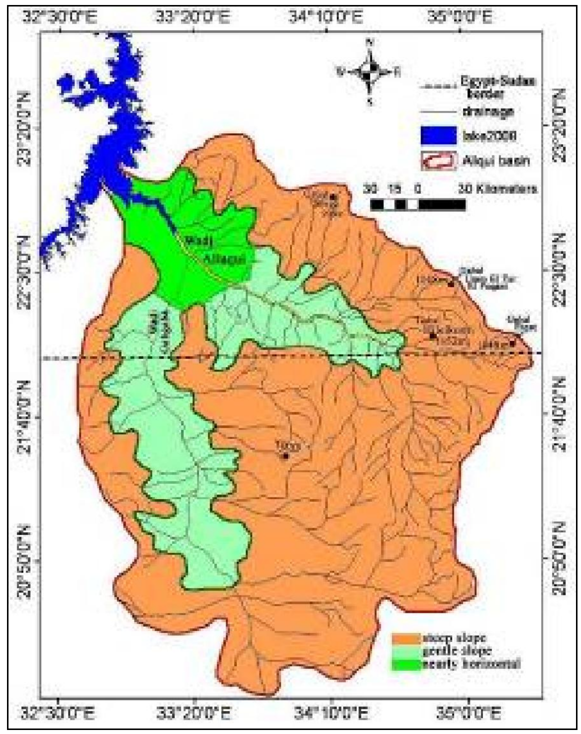

Figure 15. Allaqui drainage basin prepared from Landsat images using ARC-GIS.

5. Conclusion

Climatic changes on east Africa caused positive and negative geoenvironmental implications inside and around Lake Nasser. Inside El Madiq zone, 151, 2m^3 sands accumulated only in Wadi El Arab and drifted on the stream gradient to more narrow zone in down stream trend due to E-W fault with 17 m northern down-throw. Then, this zone exhibit shallow water in the Lake course and have not water excess in high flood years. The entrance of the lake in Halfa is subjected to sedimentation of suspended materials forming new delta. The maximum sedimentation thickness is concentrated in a zone lies from Km 350 to 420 km from the High Dam. It produced a delta sediments with long 70 km and 60m thickness from altitude 105 to 170 m (till 2008) to elucidate that the best water level for avoid the sedimentation risk is 175-180 m suitable circumstance for less sedimentation and allow to water spillway on the consolidated mud bed giving suitable storage capacity. The satellite images illustrated the strangles both in El Madiq and Halfa, coincided with the field observation and hydrologic data.

Kurkur basin can support the Nile course and ready for agriculture. The saturated water zone in Kurkur is nearly closed to the land surface subjected to transpiration and evapotranspiration in low flood years. Kurkur is a vadose zoe, water can flow to the lake course and the process known as interflow water can also migrate back to the land surface to evaporate. Consequently, cultivate 392 km^2 can avoid Kurkur area from evaporation In Wadi Allaqui, the difference in water area between 1987 and 2000 equal to91.9 $km^{2.}$ and the difference in water extention arm is 25.54 km. An area of $91.9km^2$ water exceeded in the high flood periods can be utilize in irrigate the fine soil in nearly horizontal surface of about 30121 km^2 in Allaqui basin suitable for cultivation without the risk of flash flood but it have ground water marked by patches of playa inside the Allaqui basin before the construction of the High Dam.

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