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The relationship between the development of the morphometric characteristics and the variances of the vegetation cover's density during the last fifty years at the downstream of Wadi Allaqi Biosphere Reserve, Aswan, Egypt

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ABSTRACT

This study was conducted to detect the development of the morphometric characteristics downstream of Wadi Allaqi Biosphere Reserve (WABR) via the successive flood years and the impacts on the subsequent changes in the dominating vegetation cover's density. The downstream part of Wadi Allaqi is commonly termed Khor, which refers to the lateral extensions branched from the water body of Aswan High Dam Lake or what is commonly named Lake Nasser. Khor Allaqi is regarded as the biggest khor amongst the forty-two khors of Aswan High Dam Lake (AHDL) which was created after the construction of Aswan High Dam (1960– 1970). The geomorphologic units which predominate at the study area and its nearby vicinity were identified and classified in the current research. The outcomes of the present study reflected that the flood years (1999, 2008, and 2019) witnessed the highest values of water accretion distances inside Khor Allaqi and were estimated to be 55.4 m, 53.2 m, and 54.4 m, respectively through applying the "History Tool of Google Earth Pro software". The discrepancies in the woody vegetation cover's densities via the flood years are combined with the successive changes of the amounts of the rainfall - as a major parameter of climatic changes - basically on the Ethiopian plateau, in addition to the considerable thickness of the flood plain soil overlying the basement rocks distinguishing Wadi Allaqi. The land cover changes of the scattered floristic species of shrubs individuals were calculated by applying the "Calculate Area Tool of Arc GIS 10.2 software" on the supervised LANDSAT ETM$^+$ satellite image. It was proved that the woody cover expanded and reached 17.5 km^2 in the flood year 2019/ 2020.

INTRODUCTION

The importance of the khors is manifested in its storage capacity of the fresh water course deserved for Egypt; (55.5 billion m^3/year) coming basically from the Ethiopian Plateau, which forms up the most important component of the water course of Egypt **(Aswan High Dam Lake Authority Annual Report, 1997)**. Fishing is regarded as an additional value of these khors as the quite velocities of water permits the suitable habitat for fishes to settle and multiplicate. Tilapia is the most common species of fishes in Lake Nasser **(Environmental Status of Egypt Report, Ministry of Environment, 2010)**. More than 95 % of the water demands of Egypt for agriculture, industry and domestic utilization are covered from Lake Nasser. The morphometric variances, in terms of fluctuation of water level inside Khor Allaqi, particularly during the last five decades, have led to several changes in the densities of the vegetation cover, which was targeted for studying in the present work.

Many researches were conducted to address Wadi Allaqi and Lake Nasser **(Hefny *et al.*, 1988; Zoheir & Emam, 2012; Zaki, 2017; Shalaby *et al*., 2019)**. They concluded that Wadi Allaqi is mainly covered by Late Proterozoic igneous and metamorphic rocks; namely, serpentinites, metavolcanics, metasediments, biotite gneiss, marble, calcareous schist possessing a general trend NW- SE, metagabbro-diorite-tonalite complex, granitoid rocks and alkaline ring complexes. The climate of the south Eastern Desert of Egypt is extremely arid with an aridity index of less than 0.05 **(Ayyad & Ghabour, 1986)**. The meteorological data obtained from the meteorological station installed at Wadi Allaqi Biosphere Reserve showed that the annual mean temperature is 25.2ºC. A mean minimum temperature of 8.1ºC was recorded in January 1960. On the other hand, the mean maximum temperature of 41.8ºC was recorded in July, which can often reach above 48ºC especially in August. Moreover, the long term monthly mean relative humidity (RH) during the period from 1960 to 1980 ranged between 14.0 - 38%, while the annual mean of RH was 22.8% and reached 45.9% during the period from 1996 to 2009. The ultimate fate of shallow water associated with Lake Nasser is to descend to the deeper aquifers lying between 60 m and 240 m below the surface. There appears to be at least two separate aquifers, probably interconnected and already containing very large amounts of old water to which the new resources from Lake Nasser are constantly added **(Springuel *et al.*, 2010)**.

MATERIALS AND METHODS

1. Study area

The study area is the downstream of Wadi Allaqi Biosphere Reserve which extends between latitudes and longitudes: 22° 49′ to 22° 54′ N and 33° 11′ to 33° 15′ E, respectively (Fig.1). This area is scarcely populated and the accessibility is possible through the asphaltic road, which begins on the Southeastern Suburb of Aswan and extends for a distance of about 180 km.

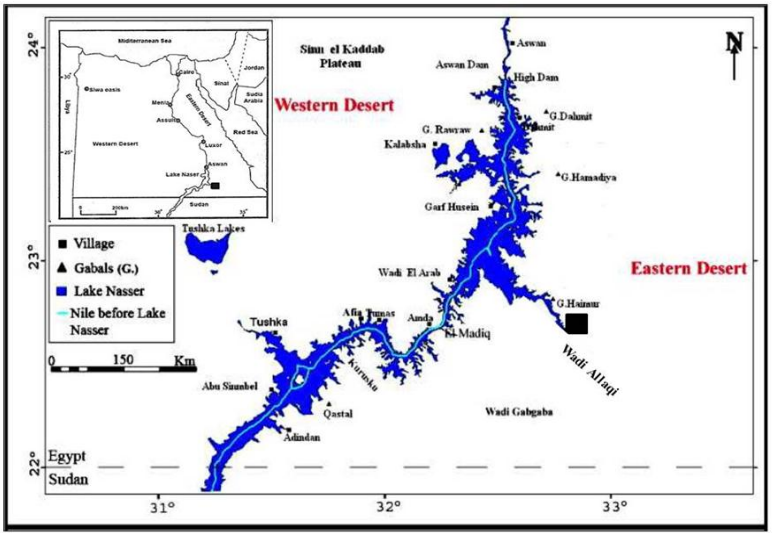

Fig. 1. Location map of the study area **(Aswan High Dam Lake Authority, 2000)**.

2. Data collection

The area of Lake Nasser is about 6540 km^2 with 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, a maximum width of about 60 km, an average depth of 25 m, and a maximum depth of about 90 m. Water fluctuation of Aswan High Dam Lake (AHDL) is a governing factor in forming the morphology, top soil geochemistry and the structure of Khor Allaqi as well as the rest of the forty two khors behind the High Dam **(Aswan High Dam Lake Authority, 2010)**. The fluctuation of the lake’s water during the last five decades (1970 to 2020) 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 **(Entz, 1976)**. Table (1) shows the morphometric measurements of Lake Nasser at water datum of 160 m and 180 m.

Table 1. Morphometric measurements of Lake Nasser at datum160 m and 180 m

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

3. Software applications

In order to fulfill the purpose of identifying and classifying the major morphological units, Digital Elevation Model (DEM) was extracted to the study area and its vicinity. The targeted Digital Elevation Model was extracted from Shuttle Radar Topography Mission (SRTM); data available at the United States Geological Survey website was considered (*www.usgs.gov*). The values of the different land covers of the study area were checked and supervised during the field work which extended between the years 2016 -2019 by utilizing GPS Garmin Etrex H7262 instrument. A contour isoline map representing the in-situ elevations and slope directions at the study area was produced throughout **Surfer 10** software (Fig. 2A). Drainage patterns system was produced according to the obtained DEM and SRTM composite data (Fig. 2B). The areas of the most common geomorphologic units were measured through applying Calculate Area tool in Arc GIS 10.2 (Fig. 2C).

3.1. CORONA aerial image representing the 1960s - (www.usgs.gov) archive-(Fig. 3A) and SPOT image in 1983 (Fig. 3B) were correlated to reflect the initiation of water accretion inside Khor Allaqi.

3.2. Google Earth Pro software (History Tool**)** was applied to detect the development of water fluctuation and accretion distances inside Khor Allaqi since 1984 till 2019 (Figs. 4 & 5) and (Table 2).

3.3. LANDSAT ETM $^{+}$ and Arc GIS (10.2) were utilized to calculate the differences in the vegetation cover induced during the last fifty years (Fig. 6).

RESULTS AND DISCUSSION

1. Identification of the drainage patterns system and the major geomorphologic units

The variations in duration and magnitude of flooding events via years had direct influences on the fluctuation of water level alongside Lake Nasser as well as Khor Allaqi. It was deduced that one meter of vertical fluctuation of the water level in the lake causes more than one kilometer of lateral surface water movements. DEM and a contour map illustrating the isoline of the different elevations encountered in the study area were produced. Accordingly, the dominating major geomorphologic units and the landscapes' areas (km^2) in the study area and its nearby surroundings were estimated (Figs. 2A, B & C).

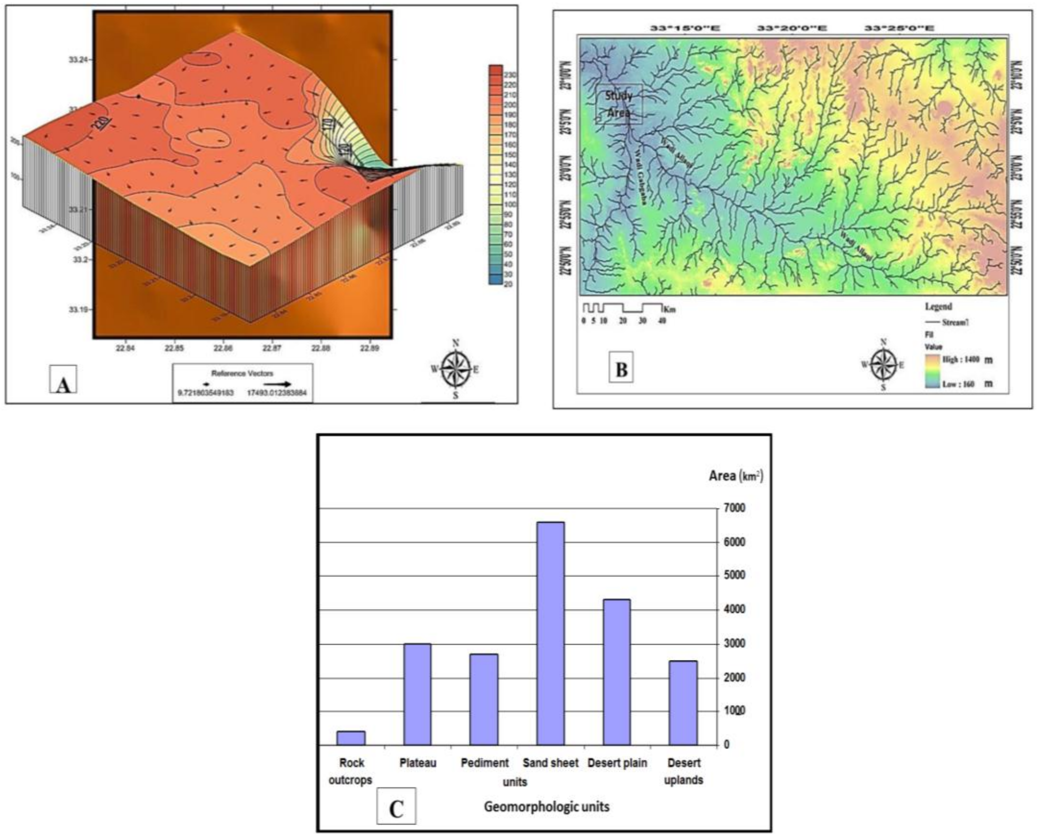

Fig. 2. **(A)** Contour isoline **(B)** Drainage system map of Wadi Allaqi downstream and **(C)** Diagram representing the overall surface areas (km^2) of the dominating major geomorphologic units and landscape in the study area and its nearby surroundings

2. Change detection of the water body increment in the study area between 1960s and 1983

The fluctuation of the water level of the lake during 1960s till the beginning of 1980s had led, during recedes, to a temporal exposure of about 40 km in Wadi Allaqi of the once inundated area where a new ecosystem was established (Figs. 3A & B). The produced ecosystem, which is generally known as an ecotone (a region of transition between two biological communities), represented a transitional zone between the aquatic and the desert zones.

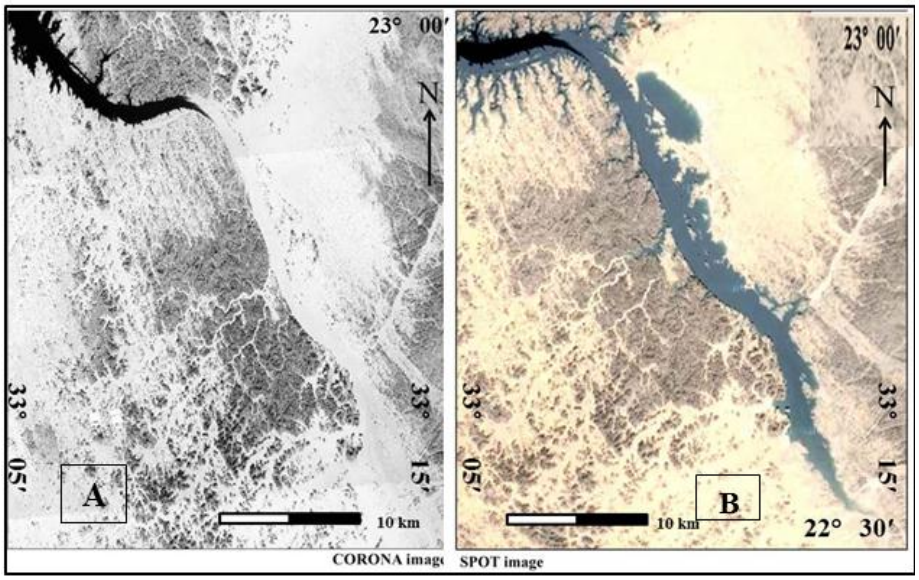

Fig. 3. Two satellite images indicating the change detection of the water body increment inside Khor Allaqi between 1960s & 1983. **(A)** Satellite (CORONA) image shows almost no water inundation inside Khor Allaqi during 1960s, **(B)** Satellite (SPOT) image shows the entrance of water into Wadi Allaqi up to about 40 km (grey colour) in 1983.

3. Changes detection of Khor Allaqi during the years 1984 till 2020

Google Earth Pro software (History tool) was applied on the corresponding satellite images representing the accretion distances of water inside Khor Allaqi during the interval extended from the flood years 1984 till 1999, 2004 till 2013 and 2015 till 2020, (Figs.4, 5 & 6), respectively. Table (2) refers to water accretion distances inside Khor Allaqi via the corresponding flood years. For instance; the increment distance of water, which inundated the terrestrial part of Khor Allaqi, was estimated to be 30 km in 1984. The peak of water accretion distance took place in 1999 reaching 55.4 km. (Fig. 7).

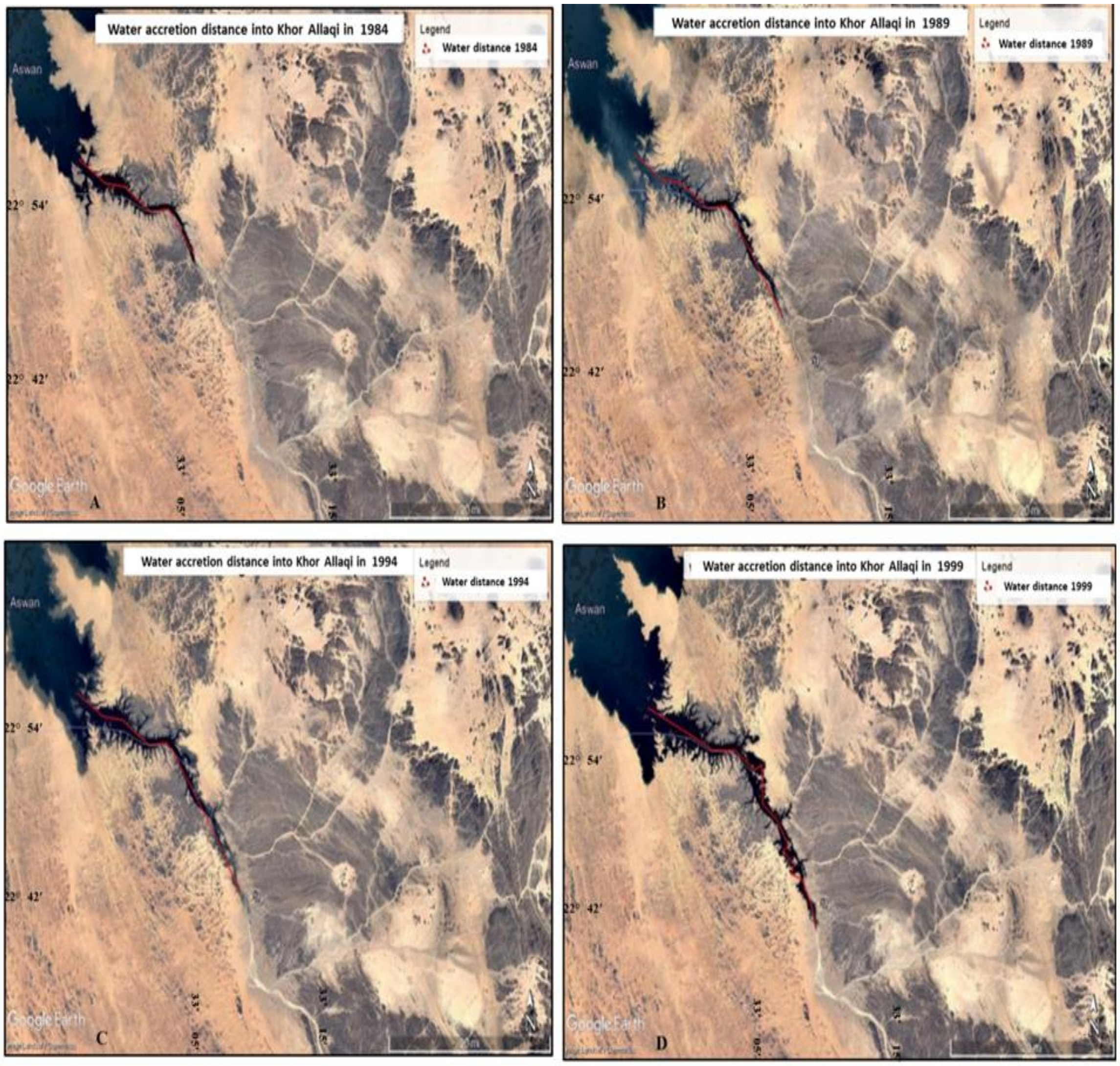

Fig. 4. Satellite images exhibiting the development of water accretion length distance (red line) into Khor Allaqi from 1984 till 1999 **(A)** 1984, **(B)** 1989, **(C)** 1994 and **(D)** 1999.

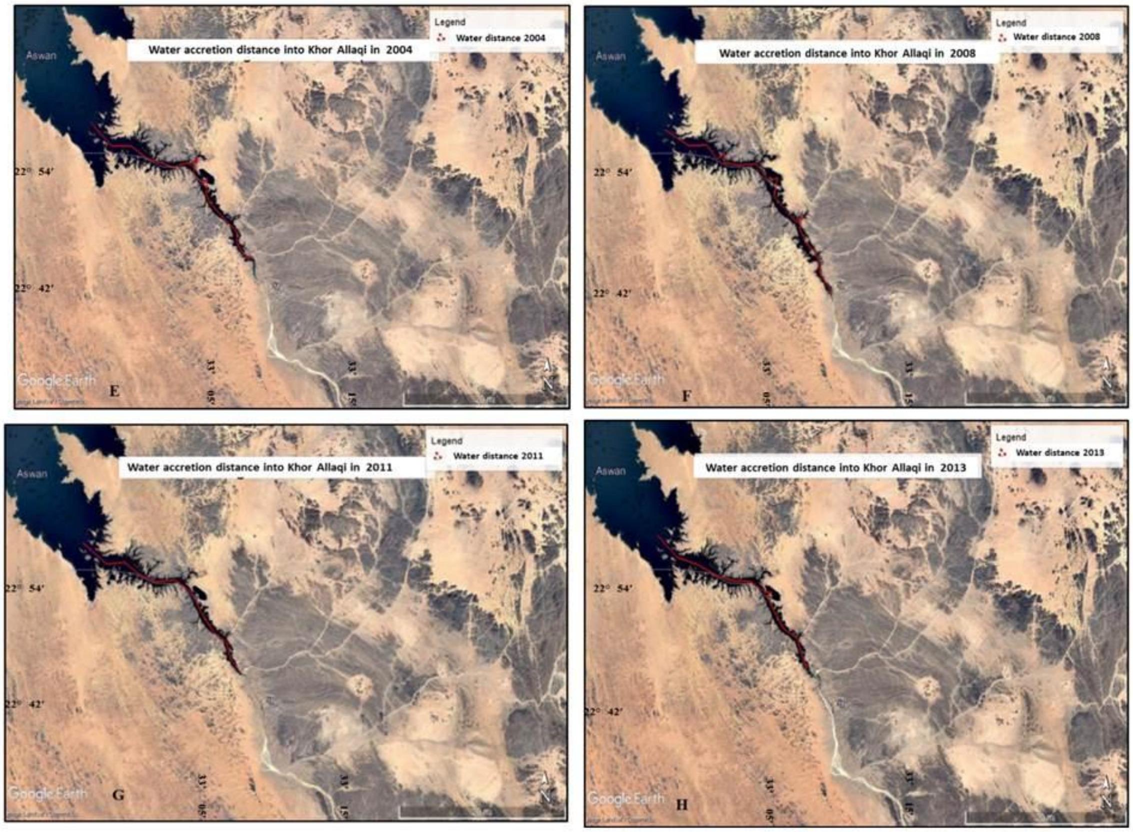

Fig. 5. Satellite images exhibiting the development of water accretion length distance (red line) into Khor Allaqi from 2004 till 2013 **(E)** 2004 **(F)** 2008 **(G)** 2011 and **(H)** 2013.

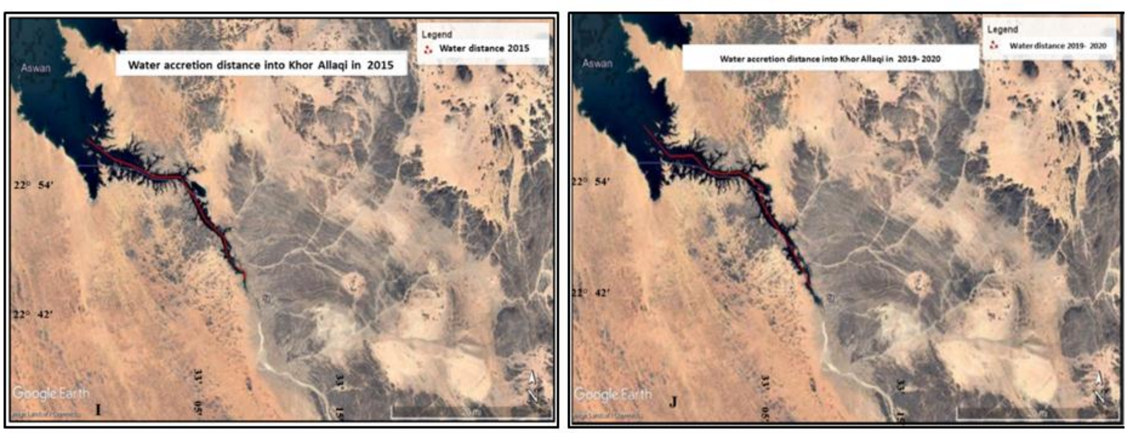

Fig. 6. Satellite images exhibiting the development of water accretion length distance (red line) into Khor Allaqi **(I)** 2015 and **(J)** which exhibits the flood year 2019/2020.

Table 2. The values of water accretion length distances inside Khor Allaqi during the flood seasons (1984 – 2019/2020)

Year	Water accretion distance inside Khor Allaqi (km)
1984	30
1989	40.5
1994	41.4
1999	55.4
2004	51
2008	53.2
2011	42
2013	42.7
2015	48
2019/2020	54.5

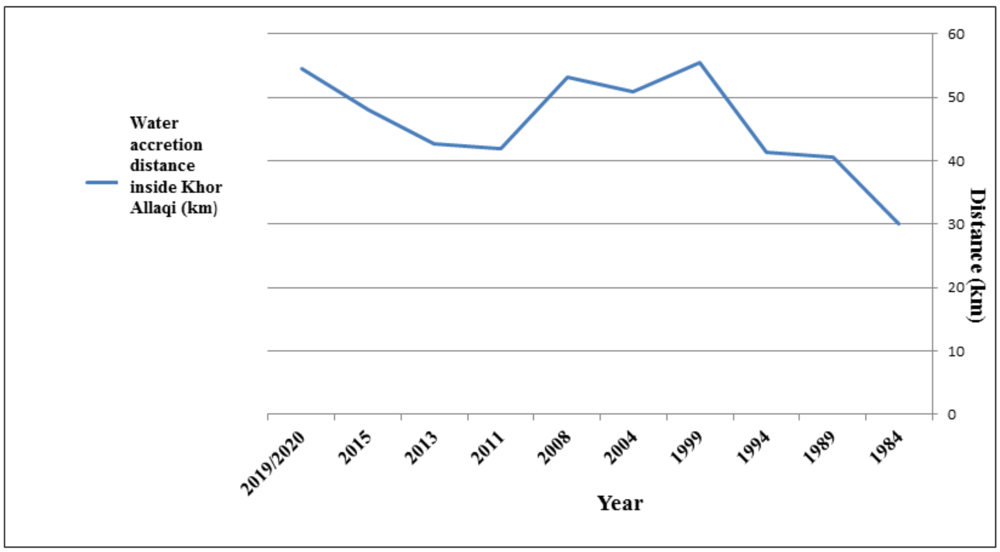

Fig. 7. A diagram showing the relationship between the accretion length distances of water inside Khor Allaqi and the corresponding flood years (1984 – 2020)

It can be recognized that the flood years (1999, 2008 and 2019) had witnessed the highest values of water accretion distances inside Khor Allaqi, recording 55.4 m, 53.2 m and 54.5 m, respectively.

4. Changes detection of the woody vegetation cover at the downstream of Wadi Allaqi Biosphere Reserve during the last fifty years

The CORONA satellite image for the 1960s decade extracted from USGS archive and LANDSAT ETM + image represents the flood year (2019/ 2020) were exported to Arc GIS 10.2 software in order to determine the discrepancies of the woody vegetation cover after conducting colour classification. It was noticed that, no considerable cluster of the vegetation cover was recorded for the 1960s period alongside the old downstream region of Wadi Allaqi. The sedimentological cover was very thin, which did not permit the ability of the roots of the woody shrubs of the vegetation cover to penetrate the shallow basement rocks. Only scattered perennial plants existed in the 1960s (Fig. 3A). On the other hand, the overall clusters area of the recent dominating woody vegetation cover, which were calculated throughout the supervised LANDSAT ETM$^+$ satellite image, expanded and reached 17.5 km^2 in the flood year (2019/ 2020) (Fig. 8).

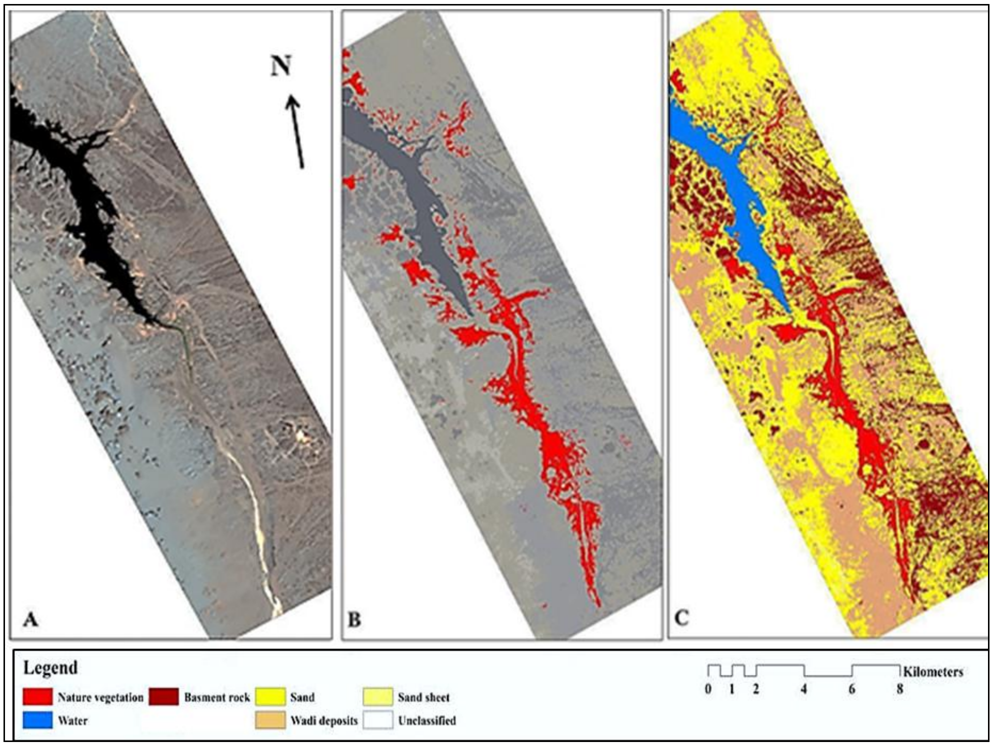

Fig. 8. Land cover classification of LANDSAT ETM + image representing the flood year 2019/2020, exported to (Arc GIS 10.2) software to calculate the corresponding vegetation areas The red colour class represents the expanded vegetation colour
(A) Unclassified image **(B)** Classified image and **(C)** Colour classified image

CONCLUSION

The study area and its vicinity comprise diverse topographic features and geomorphologic units. Sand sheets, desert plains and plateaus are considered the major three geomorphologic units. The accretion of water inside Khor Allaqi permitted the increment of the water saturated soil cover overlying the basement rocks distinguishing Wadi Allaqi. The roots of the woody vegetation cover experienced better conditions to grow in the last decade because of the increments of the water accretion distances inside Khor Allaqi, which is accompanied with considerable friable silty soil providing favorable conditions for the floristic species distinguishing Wadi Allaqi.

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