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The Dynamics of Sedimentation in the Nile River and Its Effect on the coalescence of Shaybah and Ash-Shaykh Timay Islands in the Flood Plain, Minya Governorate By Using Geographical Information Systems and Remote Sensing

Dr/ Manal Samir Shalapy Metwaly
Lecturer of Geomorphology and Geographical Information Systems
Faculty of Arts- Port Said University
E-mail: Manal.samir@arts.psu.edu.eg
Dr.manal.samir16@gmail.com

ABSTRACT

The sedimentation process plays a major role in the geomorphological changes in the Nile River, especially the alluvial islands from the beginning of its formation until their coalescence with the flood plain. Such process is applied to the islands of Shaybah and Ash-Sheikh Timay through studying the physical and human factors affecting the dynamics of sedimentation through establishing geographical database containing hydrological, morphological, geomorphological and human variables in the study area. Geographic information systems (GIS) and remote sensing (RS) are used to determine the areas and rates of sedimentation during the comparison periods and their role in the coalescence of the two islands.

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Keywords

Sedimentation, alluvial islands, flood plain, geomorphological changes, geographic information systems, remote sensing.

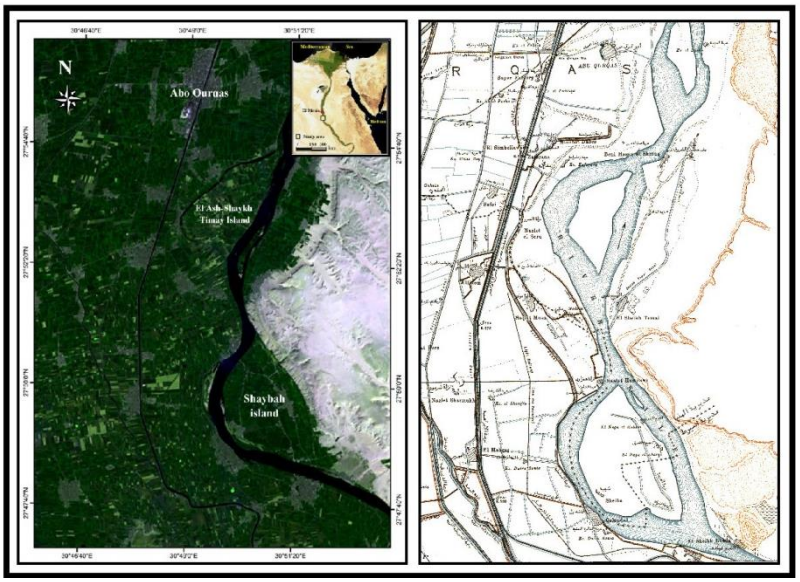
Introduction:

Sedimentation is the process by which the river deposits the substances it carries when its velocity is reduced or completely stops as a result of the reduction in its ability of carrying more than the necessary limit to move the load of water. When the river loses the required velocity to move its load of sediments, it rapidly loses a part of its load. In the first stage of sedimentation, the river deposits the coarse sediments, and with the reduction in velocity, it has to deposit the smaller substances followed by the minute ones whenever the current slows down more and more (Abo Rady, 1998).

Alluvial islands are the most noticeable geomorphological phenomena in the Nile River that is related to the dynamics of sedimentation. This is because the river deposits its load of sediments to form sand bars as a result of the water's sedimentation of its load. As a result of this frequent process, these bars gradually grow to form small islands that quickly grow and finally coalesce with the flood plain (Saber, 2012).

The study aims at monitoring and analyzing the dynamics of horizontal and vertical sedimentation and the effect of the geomorphological changes in the Nile River, especially alluvial islands. Besides the monitoring and comparison of the effect of the physical and human factors on the dynamics of sedimentation and their role in the coalescence of the islands with the flood plain; through establishing a Geographical database that contains Hydrological, Morphological, and Geomorphological variables in the Nile River in the study area.

To achieve the purpose of this study, it has been applied to the Nile River in the area of Shaybah and Ash-Shaykh Timay islands, which are located between Malawy and Abu Qurqas in Minya Governorate, from 1905 to 2019 (Figure1).



Source:Topographical maps 1:50000, 1905 and Land Sat TM 2019.

Figure (1): The Location of the study area

Geographical Information Systems as well as Remote Sensing have been used in locating sedimentation areas and rates during the comparison periods; through the processing of the Satellite image relying on the program, ERDAS IMAGINE 14, to clarify the border line between the river banks, the river water and the islands through using the measurement model of the Threshold level, in the zone of the near-infrared rays to show and highlight the variation between water and the adjacent lands through the zone of the nearby infrared rays Band 4 as water absorbs most of the infrared wave rays, and the application of the improvement process using enhancement in the equation: T=2(RW+Ric) (Al Gaber,2000).

The Previous Studies: such as (Shawer, 1966), (Taha, 1988), (El houssini 1988), (El houssini, 1991), (Akl, 1992), (Desoky, 1997), (Hafez, et al, 2005), (Saber, 2012), (Saber, 2016), (Saber, 2017).

This research has been divided into several subjects as follows:

First: The factors affecting the sedimentation process in the Nile River in the study area.

There are several factors and processes that affect the sedimentation process and the geomorphology of the Nile River especially the alluvial islands. These can be summed up as follows:

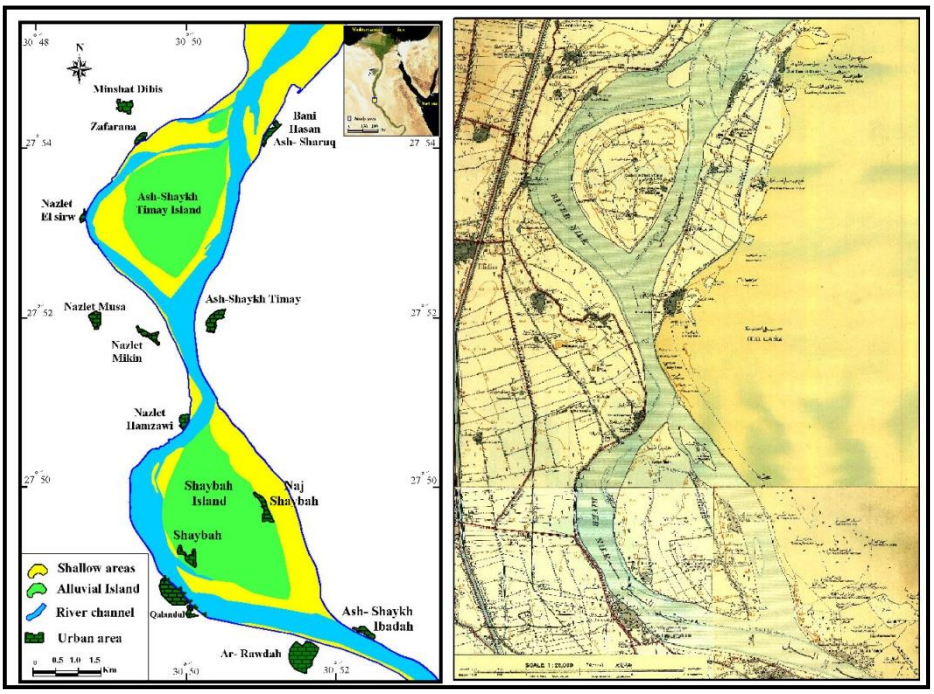
1- The discharge volume and the water levels:

The volume of water discharge whether increasing or decreasing and its variation in the water levels are the most effective hydrological factors in the sedimentation process. The discharge volume in the Nile River in the study section has been influenced by essential changes after the construction of the High Dam. The decrease in the volume of discharge was from 66.6mm^3 per day before the construction of the Dam to 35.3mm^3 per day; that is almost the half (El setiha, 2019). After the construction of the High Dam, there was a variation in the amount of water discharge. The discharge volume ranged between the minimum discharge 29.2mm^3 per day in 1996 and 75.23 mm^3 per day in 2000, and the maximum discharge 157.0mm^3 per day in 1993 and 184.28mm^3 per day in 2001. This resulted in the decrease in the water levels in the study section as the average of the minimum water level was 38.10 m in January and the average of the maximum water level was 40.75m in July in 2019 (The Nile Research Institute, 2019). That refers to the existence of a positive relation between the water levels and the volume of discharge.

The reduced amount of discharge after the construction of the High Dam led to a decrease in the river's energy in the study section, and therefore a decrease in the erosion rates and an increase in sedimentation rates. In addition, the decrease in water levels after the construction of the High Dam caused the emergence of the shallow areas in the study section, which had a great effect on the geomorphology of Shaybah and Ash-Sheikh Timay Islands (Figure 2). In 1953 the shallow areas in the study area reached 3.3 km^2(1), and they were distributed as follows: some between the eastern bank and

(1) Measured using ArcMap10.5 .

Shaybah Island (sub-channel), 0.24 km^2 on the western side of Shaybah island, 0.03 km^2 on the southern side of the west bank, 0.04 km^2 on the northwestern side of Shaybah island, and 0.11 km^2 on the west bank between the two islands. Ash-Sheikh Timy Island is also surrounded by shallow areas on all sides, especially the south and the west, at 1.97 km^2, and the northern side of the eastern bank of the Nile River at 1.86 km^2 while the west bank is 0.8 km^2. The reduced amount of discharge and water levels after the construction of the High Dam led to the full emergence of these areas, which played a major role in the coalescence of Shaybah Island. Despite of the existence of shallow areas in Ash-Sheikh Timy Island, the reason for the obstruction of the coalescence process is the existence of low areas in the sub-channel associated with the scour holes which remained even after the construction of the High Dam.



Source Topographical maps 1:25000 in 1953 using the ArcMap10.5

Figure (2): The shallow areas in the Nile River in the study area in 1953

2- The Velocity of the water Currents:

The velocity of water is directly related to the volume of discharge and water levels. The decrease of both of them leads to the reduction of the river energy and then the increase of the sedimentation process. The analysis of (Table 1) shows that the average velocity of water currents ranges from 0.65 m/sec. in the north of the study area at 653.7 Km of Aswan Nilometer to 0.47 m/sec. in the south at 651.2 of Aswan Nilometer with a general average of 0.56 m/sec. Moreover, the velocity of water reaches its highest level from the water surface to the depth of 0.5 m, and it decreases towards the riverbed. The lowest velocity of water current in the study area on the western side of the stream has reached 0.21 m/sec. at the depth of 2m in the first location. In the second location, the highest velocity was recordered from the water surface level to the depth of zero and the depth of 0.5 meters. The variation in the velocity of water currents is due to the shape of the stream as the velocity reaches its maximum rate in the east and the middle of the stream and it obviously decreases in the west of the stream. In addition, the rise of the riverbed level led to the increase of friction between the water and the riverbed; and then the reduction of the water current velocity. This variation in the velocity of the water current led to the variation in the degree of river erosion. Generally, the velocity of water in the study area is low so that the river energy has been decreased and therefore became unable to carry the sediments to eventually deposit them.

Table (1): The velocity of the Water Currents in the Nile River in the Study Area.

Location	Distance from Aswan Nilometer (Km)	Depth from water surface (m)	Velocity of water currents (m/sec)		
			East of stream	Mid-stream	West of stream
The first	651.200	0	0.46	0.68	0.44
		0.5	0.46	0.68	0.43
		1.0	0.38	0.62	0.32
		2.0	0.29	0.6	0.21
		Average	0.4	0.65	0.35
		General Average	0.47		
The second	653.700	0	0.86	0.74	0.46
		0.5	0.86	0.74	0.46
		1.0	0.75	0.62	0.35
		2.0	0.71	0.6	0.33
		Average	0.82	0.7	0.42
		General Average	0.65		

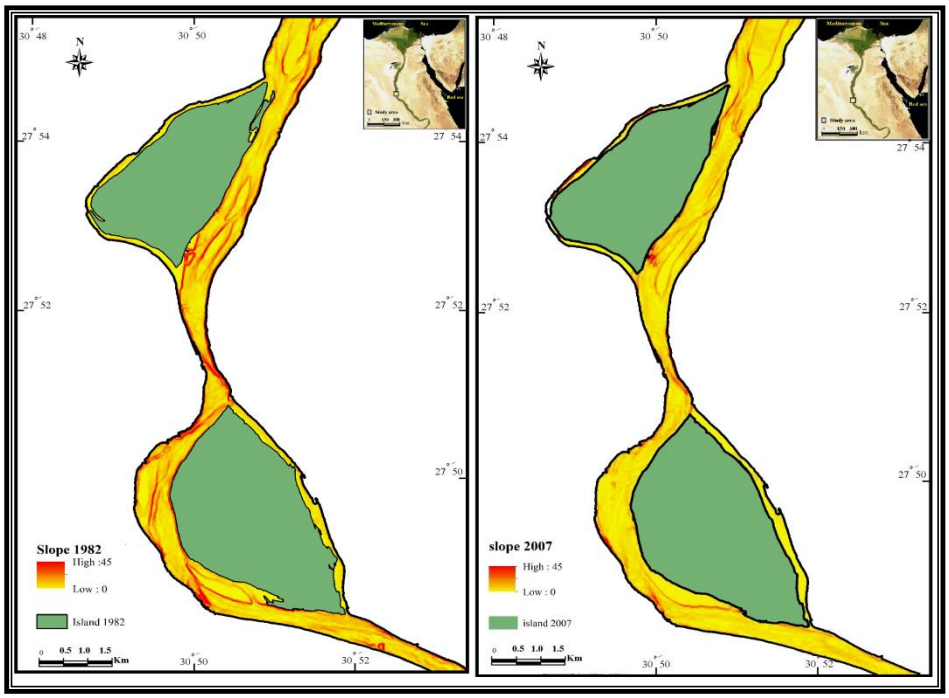
Source: The Nile Research Institute, unpublished data, 2019.

3- The Relief Characteristics:

A- Riverbed Slope:

The sloping degree of the Riverbed is one of the most important means used in the study of the sedimentation process. The flat areas and those with low slop help in decreasing the river energy and then the current loses a part of its power to carry and entrain its riverbed load so that the river tends to deposit it. The analysis of both figure (3) and Table (2) reveal the following:

The areas with a sloping degree less than 2.0 by 79.7% in 1982 have been decreased to 61.8% in 2007; however, the category of sloping that ranged from 3 to 5 increased from 14.2 % in 1982 to 29.6% in 2007. Generally, both the first and the second categories (gentle and very gentle) exceed 90% of the total study area whether in 1982 or 2007.This refers to the decrease of the river energy and accordingly the rise of the sedimentation rates more than the erosion rates; as a result of the decrease of the water velocity especially on the eastern side of shaybah Island and the northern and south western side of Ash-Shaykh Timay Island.



Source: Hydro Topographical Maps 1:5000 in 1982 and 2007 using ArcMap10.5

Figure (3): The Sloping Degrees in the Riverbed 1982 and 2007

Table (2): The Slope Degree in the Riverbed in the Study Area in 1982 and 2007.

Categories	1982	2007
0-2	79.7	61.8
3-5	11.2	29.6
6-10	5.3	3.7
11-18	3.1	3.0
19-30	0.2	0.4
31-45	0.4	0.4
< 45	0.1	1.1
Total	100	100

Source: It is prepared by the researcher relying on Figure (3).

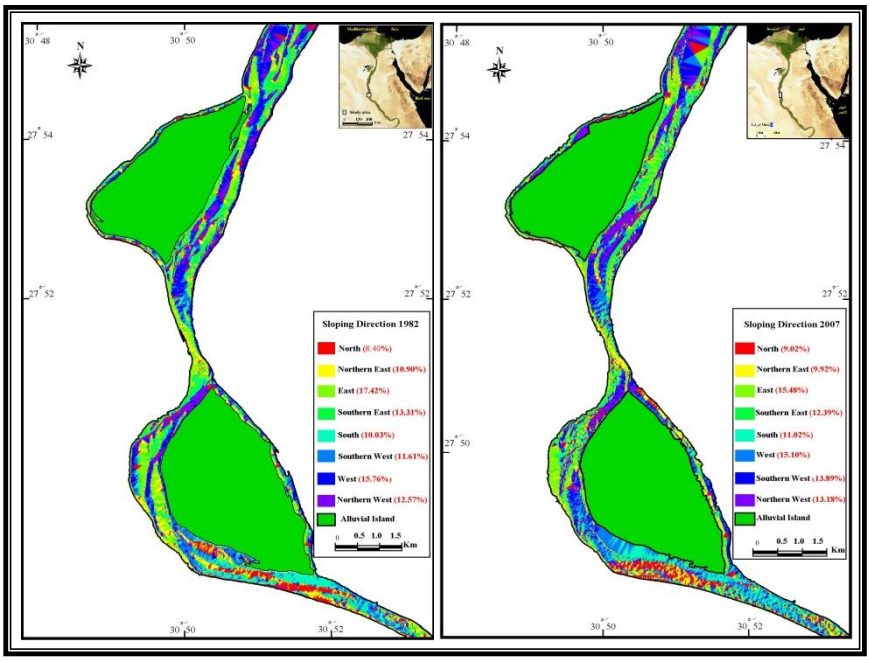
B- The Slope Direction:

The study of the bed slope direction aims at knowing the water movement direction and its effect upon the velocity whether increased or decreased and therefore being acquainted with the common geomorphological processes in the bed of the stream especially the

sedimentation process. The analysis of figure (4) shows the following about the slope direction of the riverbed in the study area:

The eastern direction represents the highest percentage in 1982 which is the common direction by 17.42% which was reduced to 15.48% in 2007 followed by the western direction by 15.76% in 1982 which was decreased to15.10% in 2007 while the Northern direction has registered the lowest percentage that reached 8.40% in 1982 and 9.2% in 2007.Although it is the general direction of the Riverbed in the study area.

This refers to the prevalence of the sedimentation processes in the study area according to the rule that implies the following: The higher the rate of the directions that do not match with the trend of the river profile is, the more the friction between the riverbed and water becomes, and hence the velocity of water lowers. Accordingly, sedimentation rates become more than those of erosion (Saber, 2016).



Source: Hydro topography maps 1: 5000 for 1982 and 2007, using Arc Map 10.5.

Figure (4): The Sloping Directions in the Riverbed in the Years 1982 and 2007.

4- The River Load:

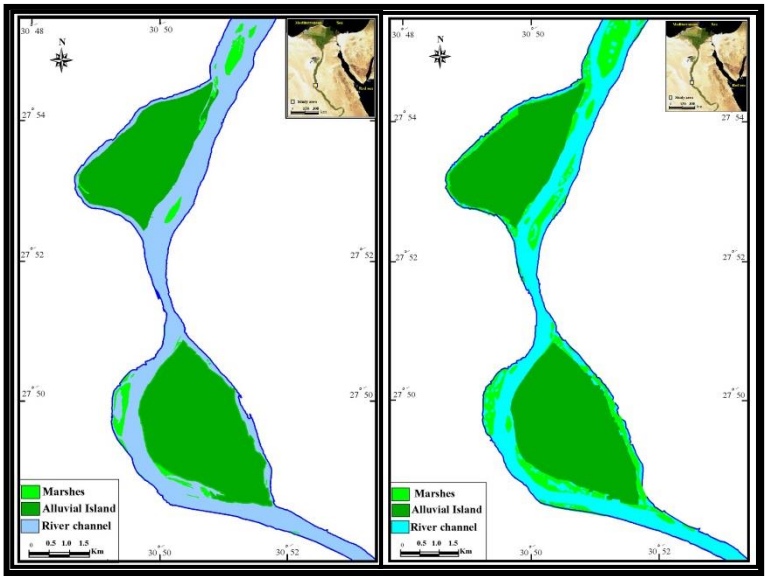
The construction of the High Dam led to the decrease of the suspended solids due to sediments retention. The annual average of the suspended solids behind Assiut Barrage has decreased from 105 million t/year before the construction of the High Dam to 3.51 million t/year after its construction; which decreased by 97% (Hassan, 2014 p.67). The pre-construction period was characterized with the great variation in the monthly rates of the suspended solids concentration throughout the year. It ranged from 43 ppm in April to 2580 ppm in August. Therefore, it is in line with the monthly discharge quantity before the construction of the High Dam which reached its peak in the flood period. The average of the suspended load after the construction of the High Dam was 43 ppm (Nile Research Institute, 2019). Generally, there is an observable reduction in the average of the suspended load concentrations of the level of the study area section. Its main source is the drift pits which result in whirlpool and the sediments of floods and some of the erosion parts of the banks. Their effect is obvious on the areas near to the source since the sand bars are formed near to the pools and the floods burrs especially wadi Abbadi and the areas in which marshes are spread and which are considered traps for this load. Accordingly, their effect is obvious in the sub-channels through the increase in the bed level more than the main channel which had a great role in the channel morphology changes especially in the rapid of coalescence of two islands in the flood plain.

5- Natural Vegetation:

Natural vegetation is considered an effective factor in the characteristics of the river channel as plants contribute directly in fixing and improving the islands. The decrease of the current velocity forms an obstacle to the river load so that it contributes in deposing this load and spurring the river to make new islands.

The analysis of Figure (5) shows that marshes are spread in the Nile River section in the study area, with a great increase in its area between 1982 and 2007 from 1.02 km² to 3.4 km². The figure shows that they are spread in the areas close to the two islands especially the island of Shaybah in 1982 while their spread increased obviously in 2007 especially in both sub-channels. This led to an intense decrease in the current velocity in them, and they have become an obstacle to the

river load. In 2019, the field study shows that the people utilize the marsh plants (reeds) to construct several dust dams between Ash-Shaykh Timay Island and the flood plain. In addition, the process of backfilling has facilitated the increase of the agricultural area. This has led to the increase in the coalescence process of the two islands in the flood plain.



Source Hydro topographical maps 1:5000 for two years 1982 and 2007 using ArcMap10.5

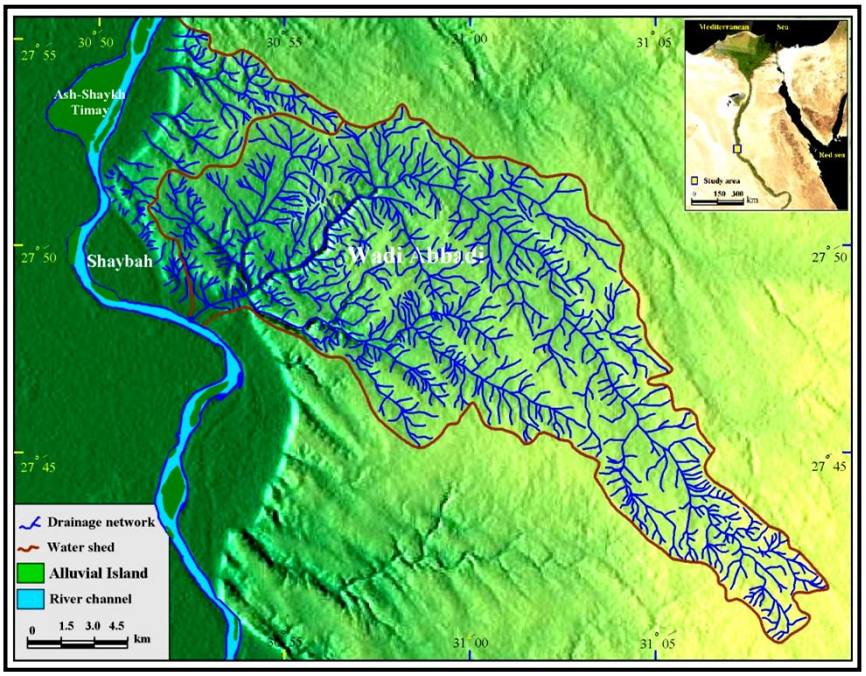
Figure (5) Marshes in the Study Area for Years 1982 and 2007.

6- Floods:

The Floods rushing from the Eastern Desert valleys bring coarse sediments. These valleys drain into the Nile directly. Despite of the rareness of floods, their occurrence is considered a very important issue as it contains great quantities of varied and different size sediments that find their way towards the Nile (El houssini, 1991).

(Figure 6) shows the concentration on the drainage network that flows into the study area on the eastern side, the most important of which is wadi Abbadi with an area of 270.1 km^2, a speed of 7.41 km/h, a flow of 3.1 million m^3. It pours directly into the Nile River south of Shaybah island along with sediments carried, which helped create the sand bars that resulted in closing the sub-channel and raising its level to

reach the level of the flood plain. This has been confirmed by the field study, which found out the difference of the soil texture, the spread of coarse sediments and the steep gravel. This, in turn, reflects their association with floods (Figure 7), and this has helped in coalescing Shaybah Island with the eastern flood plain.



Source: Topographical maps 1:50000 in 1990, (land sat TM) of 2019, and Dem 30m using the ArcMap10.5.

Figure (6): The drainage network which drains into the Nile River in the study area.

Source: Field study 2019.

Figure (7): The effect of floods on the spread of coarse sediments and steep gravels in the flood plain east of Shaybah Island.

7- Protection Methods (Revetment- Stone Cladding)

Stone heads are a major obstacle to the movement of the current and its speed, aiming to reduce the activity of erosion processes and the force of water flow. The field study identified 12 stone heads in the study area on the western bank of the Nile River across from Sheba Island, one on the western bank of the island, two on the eastern bank of the Nile River between the two islands, six on the eastern side of the Nile River in front of Ash-Sheikh Timy island, and five on the west bank of the island. Stone heads in the study area helped the sedimentation activity in general (Figure 8). Although its existence is a protection for the banks from erosion, it caused the formation of whirlpool, which has a role in the riverbed erosion of the Nile River (Ahmed, 2005). This, in turn, increased the river's load of fragments that it could not carry, and consequently made them become sediments on the riverbed at a close distance to the erosion areas, forming sand bars.

The cladding is also one of the most important ways to protect the banks from geomorphological processes, and it has proven effective and worthy in facing the danger of the banks and islands erosion in the study area. They are distributed on the eastern side of Ash-Sheikh Timy Island, in the far northeast and southeastern part of the island; on the eastern side of Shaybah Island, in the middle and southwestern part; on the western side of the Nile River at Qalandul and Nazlet Hamzawi village. This helped lower the rates of erosion than the rates of sedimentation.

Source: Field study 2019.

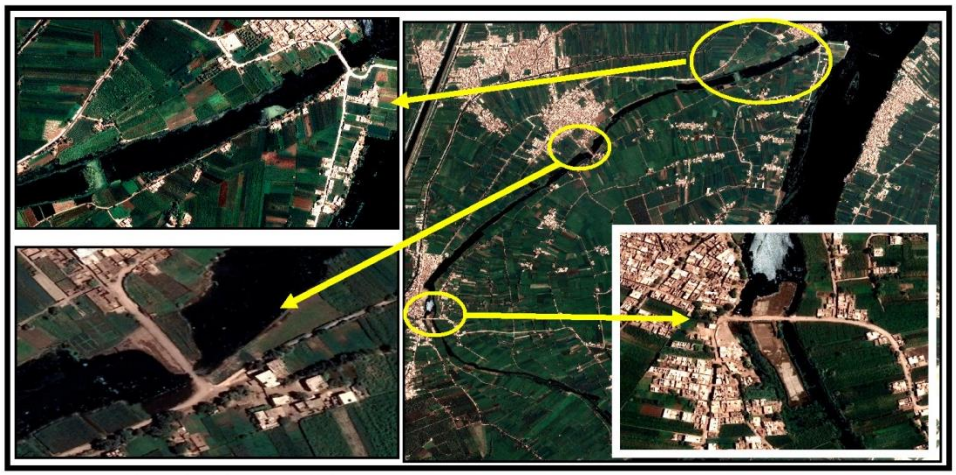
Figure (8) Revetment and Stone Cladding in study area

8- Backfill:

There are many human activities in the study area, which have a major role in increasing the area of the two islands and their migration to end up coalescing them with the flood plain. In addition, it was found from the field study that the most important of these activities is the process of filling the sub channels for the purpose of cultivating them, or using them as roads and earthen pestles to connect the two islands with the flood plain (Figure 9). These channels thus turned into bays and then separate channels, which contributed to rapid the coalescence process, especially Ash-Sheikh Timy Island. The field study observed many earthen dams: 4 earthen dams to connect Ash-Sheikh Timy Island to the west bank, and 3 earthen dams to connect Shaybah Island to the eastern bank, beside a bridge in the southeast of Shaybah Island (Figure10).

Source: Field study 2019.

Figure (9) The expansion of backfill with sediments in sub channel to be used in agriculture, and the establishment of dust dams linking two islands to the flood plain in study area



Source: Google Earth 2019

Figure (10) The spread of the dusty dam between Ash-Shaykh Timay Island and the Western flood plain

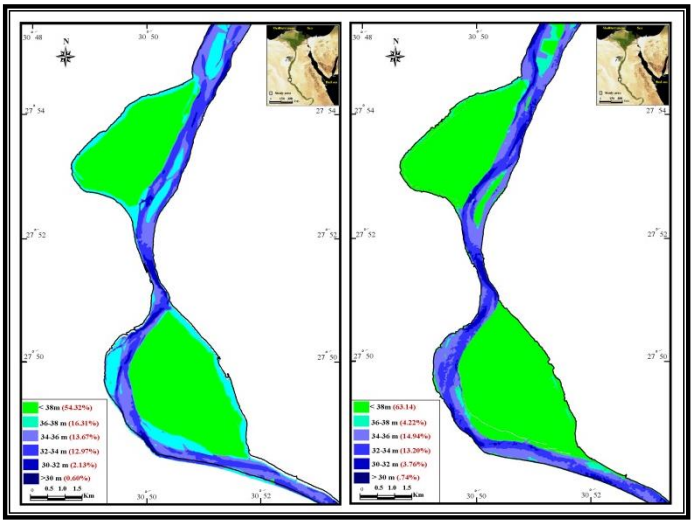
Second: The Dynamics of the Sedimentation Process.

1- The Dynamics of the Vertical Sedimentation Process:

The study and analysis of DEM are among the most important methods used in the evaluation of the vertical sedimentation process and which relies on comparing two DEM for different years to explain the relation between several morphological processes related to water especially sedimentation. Figure (11) shows the rate of the digital elevation categories of the Nile River in the study area between the two years 1982 and 2007 where the following is obvious:

There is a rise for nearly all the categories in their percentage during the period from 1982 to 2007. This shows the prevalence of the sedimentation process especially in the last categories of the elevation where the category of 34-36m has increased by 1.2% which means that there is an increase of the sand bars and a decrease in the category of 36-38m with a percentage that exceeded 12%; this shows that large parts of marshes have been converted into alluvial islands that are obviously spread in the two sub-channels and the close areas to the two islands. This assures the prevalence of the sedimentation process in the study area. It is a logical result because of the decrease in the river energy because of the physical factors or the human interferences previously mentioned. This led to the rise in the percentage of the last category related to alluvial islands so that the area of the two islands,

Shaybah and Ash-Shaykh Timay has increased and it was one of the causes that led to the coalescence of Shaybah Island afterwards.



Source: Hydro topographic maps 1:5000 in 1982 and 2007 using ArcMap10.5.

Figure (11): DEM in the Nile River in the study area in 1982 and 2007.

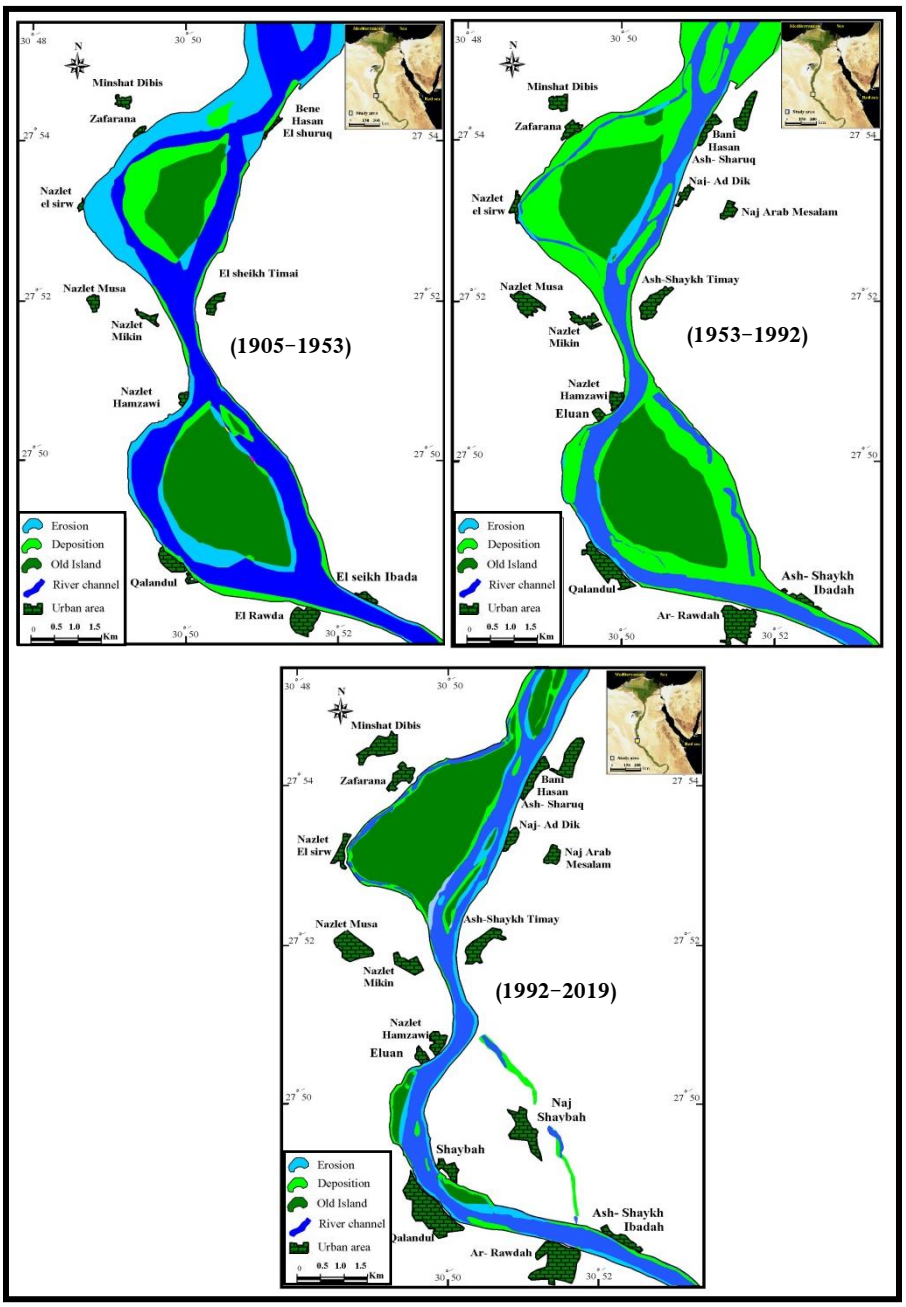
2- The Dynamics of the Horizontal Sedimentation Process:

Changes in the vertical sedimentation process have resulted in horizontal changes which can be shown as follows in figure (12) and Table (3):

Table (3): The Geomorphological Changes of the Nile River in the Study Area from 1905 to 2019

Year	Erosion	Deposition	The Difference
1905-1953	5.39	2.65	2.74
1953-1992	0.54	6.51	-5.98
1992-2019	1.35	1.43	-0.08

Source: Prepared by the researcher relying on the figure (12) using ArcMap10.5



Source: Topographical maps 1:50000 in 1905 and 1922 and 1:25000 in 1953, Land sat TM 2019 and Dem 30m, using ArcMap10.5.

Figure (12): The Geomorphological Changes of the Nile River in the Study Area

A-The period 1905-1953:

The analysis of figure (12) shows that the southern area is balanced to a certain extent between both the erosion and the sedimentation rates with a decrease in their percentage in general. In Shaybah Island, erosion was prevalent while in the banks, sedimentation was prevalent. In the southern part of the western bank, sedimentation was prevalent which the contrary to the northern part is. As to the northern area related to Ash-Shaykh Timay, there was an increase in the erosion and sedimentation rates so that the sedimentation rates were prevalent ones in Ash-Shaykh Timay Island as the increased part was about the area of the island itself.

Sedimentation rates were obviously prevalent on the western bank of the island. This change has resulted in a decrease in the area of Shaybah Island and in an increase in the area of Ash-Shaykh Timay Island during the period of comparison. We deduct from this the existence of a balance between the two processes of erosion and sedimentation in the northern part with high increase in the area of erosion in the northern part where the total sedimentation in the study section has reached 2.65 km² with a decrease of 2.74km² from the total erosion area (5.39km²).

B- The period 1953-1992:

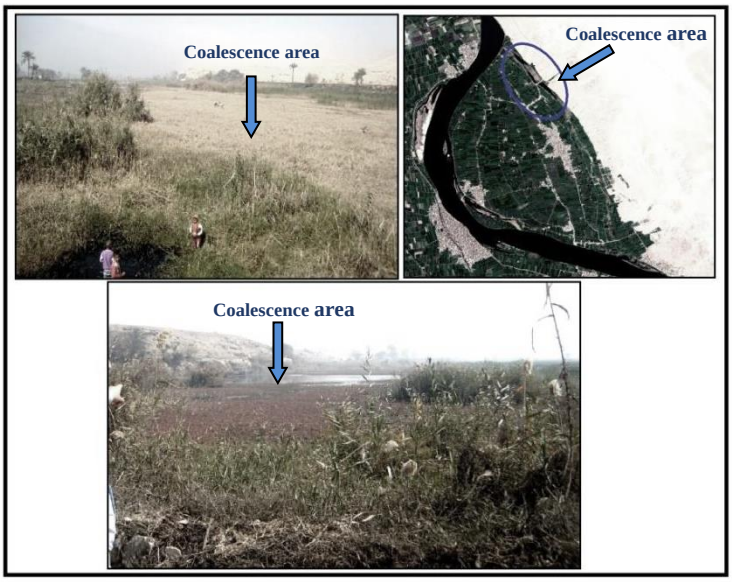
The discharge volume and the water level have decreased during this period which is a logical result of the construction of the High Dam. Therefore, all the shallow areas have been exposed including the areas that were eroded during the period before the construction of the High Dam. These shallow areas had not been deepened since the process had stopped after the construction of the High Dam to be among the areas where sedimentation took place (Figure12). Total sedimentation had been 6.512 km² with an increase of 5.98km² from the total erosion area (0.535km²). Because of their shallowness, all the places that were eroded during the previous period and which were close to Shaybah Island after the construction of the High Dam emerged. This led to a big increase in the area of the island. The eastern

bank of the island was shallow because of the accumulation of the floods sediments in it. The field study confirmed that there is an increase in the coarse and gravel sediments in this area. When the water level decreased, these areas appeared on the surface to coalesce with the eroded shallow areas in the period prior to the conversion of the sub-channel to a deserted one. Shaybah Island has become a part of the eastern flood plain Figure (13). Accordingly, the physical factors represented in floods and the human factors represented in the construction of the High Dam, during this time, have contributed in coalescence of Shaybah Island.

Ash-Shaykh Timay Island resembles Shaybah Island in one phenomenon which is that the eroded areas, during the previous period on the western bank became on the surface with the domination of the sedimentation process on the western side of the island; this has resulted in the conversion of a water channel with average width 443m in 1953 into a sub-channel similar to a water arm whose average width is 85m; there is a prediction that it will convert into an dried - up channel soon. We deduct from all this that the main factor behind the increase in the sedimentation process and the approaching coalescence between Ash-Shaykh Timay Island and the flood plain during this period is the construction of the High Dam.

c- The period 1992-2019:

It is the duration of the balance or equality between the erosion and sedimentation rates where total sedimentation was 1.43km² with increasing difference of 0.08km² of a total erosion area (1.35km²). However, Ash-Shaykh Timay Island coalesced with the western bank where the sub-channel converted into a bay, then into a dried- up channel (Figure 14). The field study shows that the main factor behind this is the human factor represented in the process of constructing dust dams on the sub-channel whose number has been 4 dams for connecting the island to the flood plain (Figure 10). Therefore, the channel has become a group of separate channels in addition to the continuous filling processes as mentioned before to end in coalescence with the western rather than the eastern side.



Source: Field study 2019.

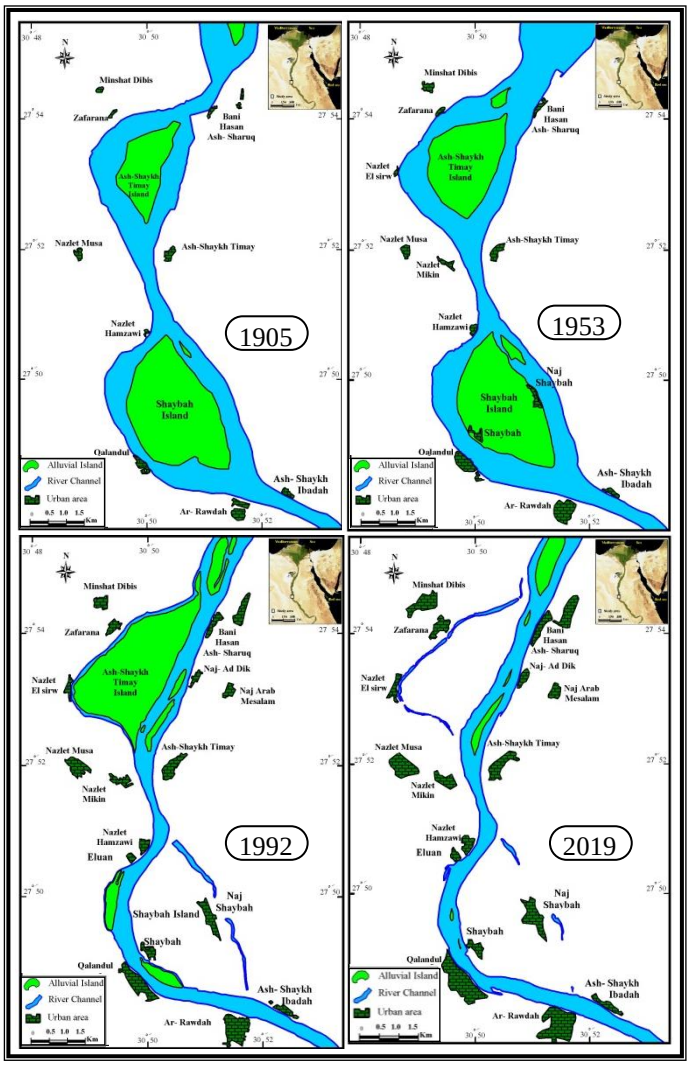
Figure (13) The coalescence of Shaybah Island in the eastern flood plain with traces of the dried - up channel.

Source: Field study 2019.

Figure (14) The coalescence of Ash-Shaykh Timay Island in the eastern flood plain with traces of the dried - up channel.

Third: The effect of the Sedimentation Dynamics on the Shaybah and Ash-Shaykh Timay islands in the study area:

Sedimentation process plays a prominent role not only in the morphological properties of the water stream but also in the formation and development of the alluvial islands. Figure (15) and Table (4) show that there is an observable change in the morphological properties of the Nile River in the period from 1905 to 2019 especially after the construction of the High Dam. This, consequently, has led to the decrease in the area of both the water area surface and Nile River from 16.79 km² to 8.53 km² and from 26.64 km² to 9.63km² respectively; this led to the decrease in the average of River width from 1.5 to 0.9 km. This decrease led to the sinuosity of the stream and to the increase in its length in the different years as it became 17.6 km in 1905 and 17.8 in 1953. Its length has increased after the construction of the High Dam where it became 19.14 km in 1990 with a very slight decrease in 2019 where there was a balance in the river between the erosion and sedimentation processes as occurred before the construction of the High Dam.



Source: Topographical maps 1:50000 for the years 1905 and 1992, and 1: 25000 for 1953 and Land Sat TM 2019, using ArcMap10.5.

Figure (15) The morphological changes of the Nile River in the study area in the (1905-2019).

Table (4): The morphological properties of the Nile River in the study area in the period (1905-2019)

Year	Stream Length (km)	Stream Area (km^3)	Stream Average Width (km)	Water Area Surface (km^2)
1905	17.6	26.64	1.51	16.79
1953	17.8	29.99	1.68	19.02
1992	19.2	17.13	0.90	8.82
2019	19.1	9.63	0.50	8.53

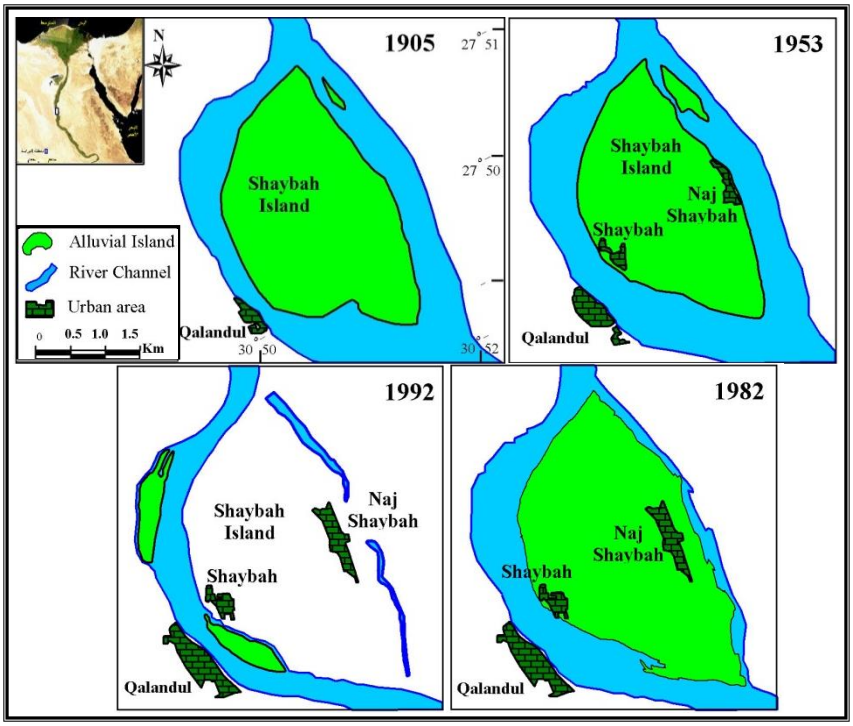
Source: Prepared by the researcher relying on figure (15).

As to the explanation of the existence of these changes in the morphologic properties of the Nile River, it is in the first place due to the decrease in the water income after the construction of the High Dam and the conversion of the Hydrological properties of the Nile River and the increase of the sedimentation rates as mentioned before. This is beside the conversion of the sub-channels into water arm whether through physical factors (flood sediments) or through human factors (people filling some parts and exploiting them in agriculture and road construction).These changes caused the existence of morphologic changes in the two Islands, Shaybah and Ash-Shaykh Timay where the following became obvious in Figure (16) and Table (5):

1- Shaybah Island:

The area of Shaybah Island ranged from 6.28 to 8.49 km² in the period from 1905 to 1982 by average of 7.29 km² and a standard deviation of 1.12 and coefficient of variation of 15.34%. This point to the variation in the island areas in their different growth stages where the area has decreased with the value of 11.42% in the period from 1905 to 1953 and increased with the value of 35.19% in the period from 1953 to 1982. It is observable that the increase in the island area was after the construction of the High Dam.

The lengths of the island were about 4.33km and 5.10 km by average of 4.60 km. The value of the standard deviation for the island lengths is 0.43 the value of the coefficient of variation is 9.42; this refers to the island approximate lengths along the different periods of their development since the percentage of change between the highest length and the lowest one has not exceeded 0.77km from 1905 to 1982. The major increase in length can as a result of the construction of the High Dam and the decrease of the water level; and then submerged parts were exposed. The width of the island during its different development periods has ranged from 1.44 to 1.66 km , by average of 1.58 km and standard deviation of 0.12 and relative coefficient of variation 7.70% which refers to a slight change in the width of the island during the period of measurement.



Source: Topographic maps 1: 50000 for the years 1905 and 1992, and 1: 25000 for 1953, and the hydro topographic maps of 1:5000 in 1982 using ArcMap10.5.

Figure (16): The morphological development of Shaybah Island from 1905 to 1992.

Table (5): The morphological properties of Shaybah Island in the period from 1905 to 1992.

Year	Area (km^2)	Length (km)	Average Width (km)	Perimeter (km)	Area of the water surface in the island area (km^2)	Area of the water surface of the eastern channel (km^2)	Average width of the water surface of the eastern channel (km)	Area of the water surface in the western channel (km^2)	Average width of the water surface of the western channel (km)
1905	7.09	4.33	1.64	10.89	4.77	2.31	0.53	2.46	0.46
1953	6.28	4.37	1.44	10.36	5.66	2.29	0.48	3.37	0.63
1982	8.49	5.1	1.66	14.91	4.34	0.73	0.14	3.61	0.52
1992	**Coalesced**	**Coalesced**	**Coalesced**	**Coalesced**	**Coalesced**	**Coalesced**	**Coalesced**	**Coalesced**	**Coalesced**
Average	7.29	4.60	1.58	12.05	4.92	1.78	0.38	3.15	0.54
Standard Deviation	1.12	0.43	0.12	2.49	0.67	0.91	0.21	0.61	0.09
Coefficient of variation	15.34	9.42	7.70	20.64	13.67	51.02	55.36	19.28	16.07

Source: Relying on Figure (16).

The study of the associative array among some of the morphological variables in the island points to the existence of a strong

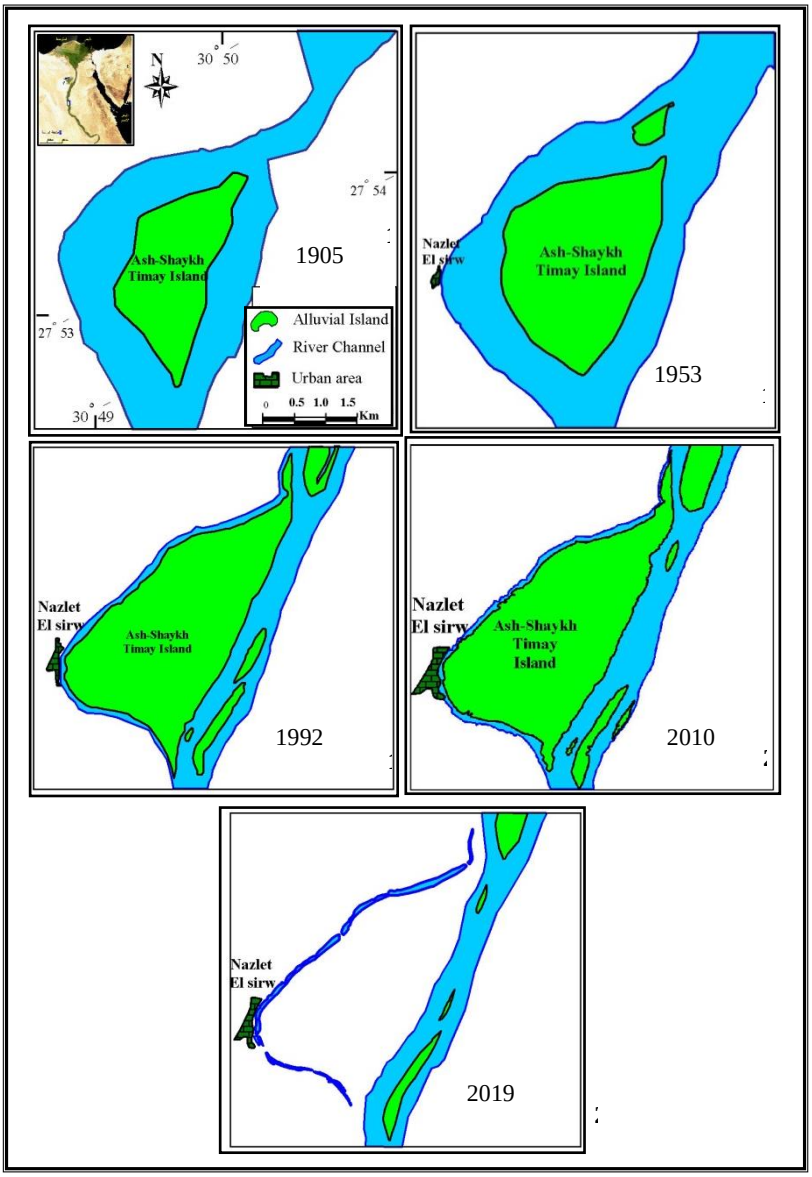
positive relationship between the area and length, width and perimeter where their values were 0.91, 0.83 and 0.97 respectively. There is an inverse relation between the area and the area of a water surface -0.94 because the expansion of the island is mostly on the expense of extracting areas from it that are to be added to its total area. Figure (16) and Table (5) show that Shaybah Island was nearly located amidst the stream in 1905 where the average width of the eastern water channel was 0.53 and the western channel was 0.46 km. Although the western channel was the least in area and average width, its area and width have increased as a result of the vertical sedimentation resulting from the sediments of Wadi Abbadi to the eastern water channel as mentioned before. This resulted in the formation of an island inside the channel to be converted actually into a sub-channel in 1953. Shallow areas have appeared in channels and the island has coalesced to Shaybah Island after building the High Dam so that Shaybah Island area was enlarged and the area of the sub-channel decreased into 0.73 km² so that it turns into an dried- up channel where Shaybah Island coalesced with the eastern flood plain as displayed in the topographical maps in 1992.

1- Ash-Shaykh Timay Island

The area of Ash-Shaykh Timay Island ranges from 2.50 to 6.72 km² in the period from 1905 to 2010 by average of 5.06 km², standard deviation of 2.04 and coefficient of variation of 40.37%; this points to the variation in the island areas in their different development stages where the area has increased to 73% in the period from 1905 to 1953 and to 55% in the period from 1953 to 2010 Table (6). It is obvious that Ash-Shaykh Timay island is characterized by the increase in the sedimentation rates whether before or after the construction of the High Dam; this increased its area with the percentage of 169% during the period from 1905 to 2010 Figure (17).

The lengths of the island ranged from 3.33 km to 5.14 km by average of 4.24 km. The standard deviation value of the island lengths 0.95, the coefficient of variation was 22.50%. In addition, the width of the island ranged from 0.75 to 1.34 km with an average of 1.16 and standard deviation 0.27 and relative coefficient of variation

23.71%.This points to the change in the length and width of the island during the measuring period with increasing values of 54% and 0.73% respectively during the comparison period.



Source: Topographical maps 1:50000, for 1905 and 1992 and 1:25000 in 1953, and Land Sat TM 2019, using ArcMap10.5

Figure (17): The morphological development of Ash-Sheikh Timay Island from 1905 to 2019.

Table (6) The morphological properties of Ash-Shaykh Timay island in the period (1905-2019)

Properties Year	Area (km^2)	Length (km)	Average Width (km)	Perimeter (km)	Area of the water surface in the island area (km^2)	Area of the water surface of the eastern channel (km^2)	Average width of the water surface of the eastern channel (km)	Area of the water surface in the western channel (km^2)	Average width of the water surface of the western channel (km)
1905	2.50	3.33	0.75	7.41	4.49	1.61	0.53	2.88	0.68
1953	4.33	3.51	1.23	8.35	4.41	3.04	0.67	1.37	0.44
1992	6.70	4.99	1.34	13.77	3.28	2.60	0.45	0.68	0.08
2010	6.72	5.14	1.30	13.65	3.21	2.71	0.50	0.50	0.06
2019	Coalesced	Coalesced	Coalesced	Coalesced	Coalesced	Coalesced	Coalesced	Coalesced	Coalesced
Average	5.06	4.24	1.16	10.80	3.85	2.49	0.54	1.36	0.32
Standard Deviation	2.04	0.95	0.27	3.39	0.70	0.62	0.09	1.08	0.30
Coefficient of variation	40.37	22.50	23.71	31.39	18.12	24.73	17.54	79.71	95.08

Source: Relying on figure (17).

The study of the associative array among some of the morphological variables in the island points to the existence of a strong positive relationship between the area and length, width and perimeter where their values exceeded 0.91. There is a contrastive relation between the area and the area of the water surface in the island that reached -0.95 where the area of the water surface in the island area has decreased from 4.49 km^2 to 3.21km^2 during the period from 1905 to 2010 noticing that the average width of the eastern channel had not nearly changed. Its area has changed from 1.61km^2 to 2.71km^2 during the period from 1905 to 2010. However, the increase in the area of Ash-Shaykh Timay Island was upon the expense of the western sub-channel whose area was decreased from 2.88km^2 to 0.5km^2 and from average width 0.68km^2 to 0.6km during the period of comparison. The sub-channel continued to shrink until it was converted into a bay where Ash-Shaykh Timay Island was coalesced from its southern side with the flood plain (figure 18) and the bay has changed into a group of disconnected channels because of the spread of the dust dams linking between the island and the flood plain leading finally to the coalescence of the island with the western bank of the Nile River.

Source: Google Earth 2015

Figure (18) The beginning of a coalescence of Ash-Sheikh Timay island to the flood plain from its southern side

Results:

The two islands Shaybah and Ash-Shaykh Timay have appeared nearly midstream; noting that Shaybah island was the nearest to the western bank and Ash-Shaykh Timay island was the nearest to the eastern bank according to the topographic maps in 1905. Shaybah Island was in continuous decrease due to the increase in the erosion rates more than the sedimentation rate which is the reverse to Ash-Shaykh Timay Island which was characterized with the increase in the sedimentation rates and area before the construction of the High Dam. Relying on the geomorphological properties of the Nile River and two islands during the period from 1905 to 1953, it was expected that Ash-Shaykh Timay Island would coalesce before Shaybah Island and its coalescence with the eastern bank and that if the sedimentation rates have increased in Shaybah Island, it would coalesce with the western bank. However, all that happened after the construction of the High Dam was unexpected. It can be said that there is a new stream with Hydrological and geomorphological properties that is completely different from the stream before the construction of the High Dam, as

the two islands have coalesced with the flood plain actually. This is natural due to the sedimentation processes as mentioned before. However, it is noticeable that Shaybah Island had coalesced with the eastern bank as well as Ash-Shaykh Timay Island had coalesced with the western bank. Unexpectedly, Shaybah Island had coalesced before Ash-Shaykh Timay Island more than fifteen years. The explanation of this is due to the reasons, locations and rates of sedimentation. In Shaybah Island, the physical factors are prevalent to the human ones represented in floods sediments which helped in increasing the level of the close areas to the eastern front and the prevalence of sedimentation on the eastern bank of the island and immigrating to the eastern direction. This helped in the fast conversion of the eastern channel into a sub-channel. In the study area, as floods continued and the Nile River was fed with the lost load after the construction of the High Dam, the sub-channel level had been raised quickly causing alleviation and the island coalesced at the end.

The cause behind the coalescence of Ash-Shaykh Timay Island is due to the human factors especially the construction of the High Dam and the decrease in the level of water so that the recently eroded areas become exposed (shallow areas). These areas were spread on the western bank of the stream with the prevalence of the sedimentation processes on the western bank of the island. They were one of the causes of the decrease of the width of the western water channel which approximately exceeded 80%. Here comes the human interference to exploit the reduction in the construction of dust dam to connect the island to the flood plain (The average width of the sub-channel is 85 meters) and start in filling the sub-channel to increase the cultivation area. However, due to the poor substances used in filling and the unavailability in several nearby areas, Ash-Shaykh Timay Island lasted more than Shaybah Island.

Finally, an important result to be mentioned is that physical factors were more influential than the human ones in the study area of the Nile River.

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