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Using Remote Sensing Techniques to Determine New Route for the Nile Valley

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Using Remote Sensing Techniques to Determine New Route for the Nile Valley

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Abstract: The collapse of dam structure leads to serious disasters for surrounding areas along the waterway. The objective of this research is to determine a new route for the waterway by using remote sensing techniques.
Drainage patterns were determined from Digital Elevation Model (DEM) of Shuttle Topographic Radar Mission (STRM) by using the ARC-GIS software. The most appropriate route for the new valley is determined by using DEM and assisted by topographic maps of scale 1:500000 starting from Toshka lake until Qattara downrange and passing through the depressions of El Kharga oasis, El-Dakhla, El-Farafra and El-Baharia Oases.
The route selection is matched with the expected new valley that proposed by Prof. Dr. Farouk El-Baz in his project " The Development Project / Corridor of Development Project [1].

Keyword: DEM **,** ARC-GIS, Remote sensing, Drainage pattern, Route selection.

1. Introduction

Most dams have a spillway or weir over through which water flows, either discontinuously or continuously and some dams have hydroelectric power generation systems installed.
Dam failures can cause enormous damage and loss of souls when they occur. The most common reason behind the failure of dam is overtopping. Overtopping could be a major failure because of significant floods.
Drainage patterns were used to delineate the appropriate route selection for the flooded water that yielded from dam failure. These patterns were determined from Digital Elevation Model (DEM) of Shuttle Topographic Radar Mission (STRM) by the aid of ARC-GIS software.
Topographic maps of scale 1:500000 for the Western desert starting from Toshka lake until Qattara downrange were used to clarify and assist the recommended route that been selected by drainage patterns inspection.
To transfer water from the Toshka spillway to the Qattara downrange, some hydrological constructions are needed. In order to justify these constructions, the mentioned topographic maps were used. The route selection is matched with the expected new valley that proposed by Prof.

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Dr. Farouk El-Baz in his project "The Development Project / Corridor of Development Project [1].

2. Reasons and causes of dam failures

There are many reasons of dam failure that face most countries all over the world and well known to the hydrologists, engineers and scientists who works in this field. The most common reason behind the failure of dam is overtopping which caused by water spilling over the top of a dam and usually a precursor of dam failure. Foundation issues and defects, including slope instability, is the root cause behind about 30% of all dam failures. Moreover, cracking caused by movements like the natural settling of a dam is one of important reason of dam failure. On the other hand, inadequate maintenance and upkeep is of the same effect of dam failure. Another reason of dam failure is piping, when seepage through a dam is not properly filtered and soil particles continue to progress and form sink holes in the dam, see Figure (1).
There are many causes of dam's failure. These causes can be summarized as follows: (I) Human error, error in design of the spillway and poor maintenance; (II) Natural disasters, earthquakes, extreme inflow, earth's instability etc.; (III) construction materials & techniques used.

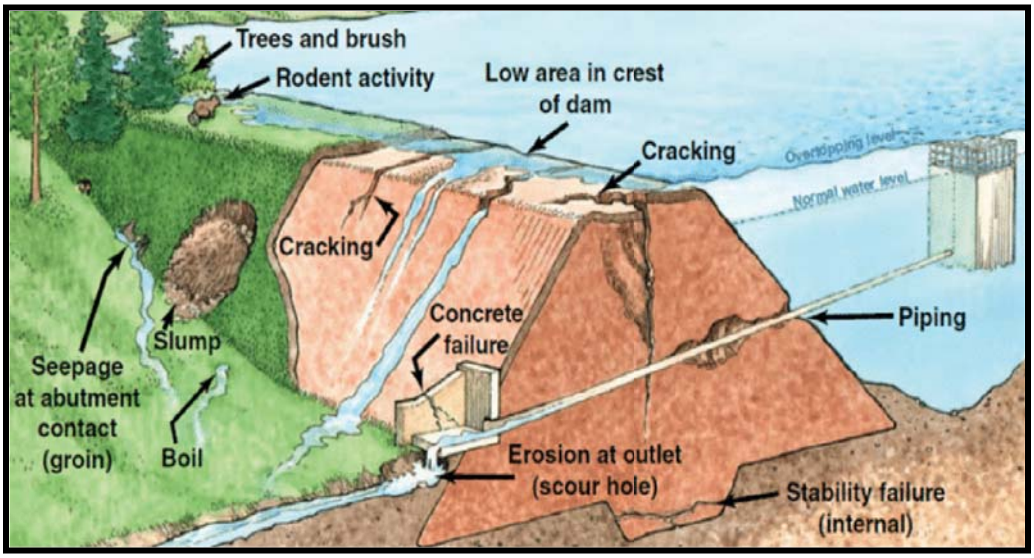

Figure (1) Various Reasons of Earth dam's Failure [8].

3. Study Area

The study area extended from the Aswan high dam (AHD) reservoir in upper Egypt and ended by El- Qattara downrange, north part of Egypt (Close to the Mediterranean Sea).
The study area includes the western dessert starting from the Toshka Lake and passing through El Kharga, El-Dakhla, El-Farafra, El-Baharia and ended by the El-Qattara downrange.

3.1 Aswan High Dam

The Aswan High Dam is an embankment dam that was built across the Nile in Aswan, Egypt between 1960 and 1970, see Figure (2). The dam, completed in 1968 at a distance of 7 km south of Aswan City, is a rock fill dam made of granite rocks, sands, and provided with a vertical cutoff wall consisting of impermeable clay [2]. The Aswan High Dam is 3,830 Meter (12,570 ft) long, 40 m (130 ft) wide at the crest, 980 m (3,220 ft) wide at the base and 111m (364ft) tall. It contains 43,000,000 cubic Meter (56,000,000 cu yd) of material. At maximum, 11,000 cubic Meter per second (390,000 cu ft/s) of water can pass through the dam [2].

Figure (2) satellite image of Aswan High Dam [2].

3.2 Aswan High Dam Reservoir (AHDR).

Aswan High Dam Reservoir, see Figure (3) extends for 500 km along the Nile River and covers an area of 6,000 km^2, it holds 132 km^3 of water of which northern two-thirds (known as Lake Nasser) is in Egypt and tierce (called Lake Nubia) in Sudan. [3]

The reservoir has 100 side arms called khors. The total capacity of the reservoir (163.3 km^3) consists of the dead storage of 31.6 km^3 (85 - 147 m) of lake water amount, the active saved storage of 90.7 km^3 (147 - 174 m) and the emergency saved storage for flood protection of 41 km^3 (175 - 182 m). [4]

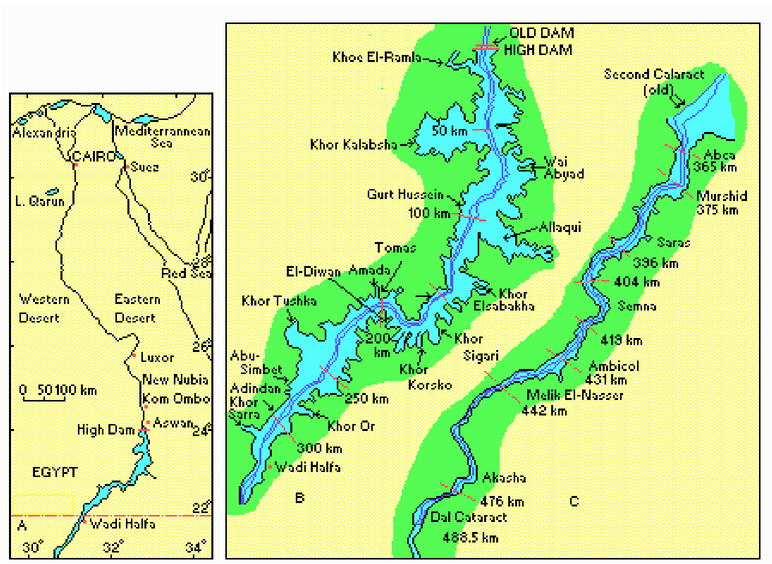

Figure (3) Aswan High Dam Reseviour [5]

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3.3 Toshka Depression

NASA satellite image (October2000) of Lake Nasser and the Western Desert of Egypt. Shows the four lakes, known as the Toshka Lakes which lie west of Lake Nasser. In 1978, the Egyptians constructed a canal known as the Toshka Spillway or Sadat Canal from Lake Nasser into a low area to the west to allow spill over of Lake Nasser water if the reservoir filled above 178m. Despite the fact that the spillway was created in 1978, It was not until the late1990 that Lake Nasser actually filled up to the level of the spillway canal and the overflow lakes began to form. In November of 1998, US astronauts orbiting within the space craft detected the lakes filling for the primary time, and that they have had water in them ever since. Figure (4) close-up views of the Toshka Depression in 2004.

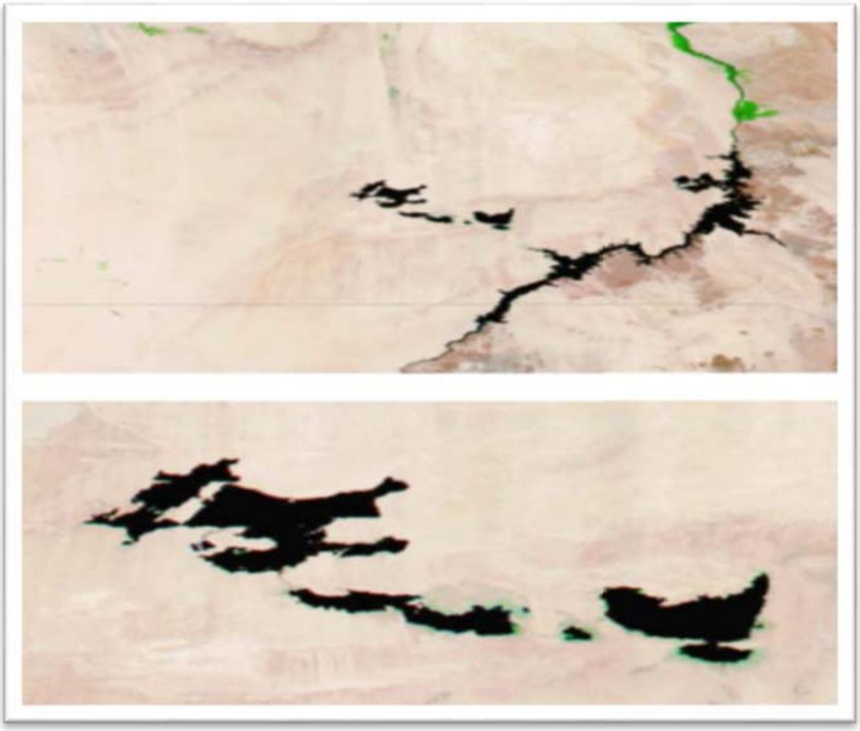

Figure (4) Toshka Lakes in 2004 [6]

3.4 Western Desert.

The area is characterized by a hot and dry summer with rare winter rainfall and bright sunshine through the year. The average annual temperature is 26.4 °C, while the average of evaporation is 7.76 mm.

El Kharga oasis is the nearest oasis to Luxor city and it is the capital of the New Valley. The Kharga depression is hemmed in by 300 m high cliffs, with belts of dunes advancing across the oasis. Many desert routes converged on the oasis, noted by the Forty Days Road.

El Dakhla oasis lies in the Nile Valley governorate, 350 Km from the Nile and lie between El Farafra and El Kharga oases. It is extended about 80 Km from East to West and 25 Km from North to South and covers an area of 2000 Km^2.
EL Farafra oasis lies at a distance of 170 Km South el Bahria oases. It belongs to the New Valley governorate and lies at level of 76 m above mean sea level. EL Farafra Formation tops with clear slopes are made out of independent bowls, which differ in size. Al Gunnah playa, which is situated at the upper east foot incline of Al Quss Abu Said level, covers region of more than 100 km^2 and It is one of the most established agrarian and settlement zones in the Farafra.
El Bahariya oasis is approximately 370 Km away from Cairo. The roughly oval valley extends from North East to South West, has a length of 94 Km with maximum width of 42 Km and covers an area of 2000 Km^2; with an average width of 21.28 Km. It is located in El Giza governorate.

3.5 Qattara Depression.
The Qattara Depression is the largest underground depression below the sea level in the world. This depression extends about 300 km from the Oasis of Mugra, south of El Alamein, with a distance of about 53 km to Siwa Oasis in the west. While its maximum width is about 137 km. The area of Qattara depression is about 19516 km^2. Several sub depressions were attached to this depression with a total area of about 1572 km^2. Thus, the total area of the main depression and its attachments from the sub depressions is 21088 km^2. An area of 20695 km^2 is under sea level with a maximum of -139.0 meters below sea level and average of 50m.

4. Methodology
DEM was constructed from shuttle Topographic Rader Mission (STRM), then using Geographic Information System (Arc-GIS) version 10.3 to construct watershed for each depression along the route of the study area.
The available data is 30m Digital Elevation Model (DEM) for the study area, extracted from Shuttle Topographic Rader Mission (STRM).
The SRTM (Shuttle Radar Topography Mission) database is a remarkable worldwide digital elevation data set for about 80% of the Earth's land surface. It took 10 days to collect all of the data. The data set covers all land areas between 60°N and 56°S latitude, higher latitudes were excluded because of the inclination of the Shuttle orbit which was 56°S. The resolution of SRTM knowledge is thirty meter per pixel for the best resolution knowledge.
Digital Elevation Model (DEM) represents ground surface and permit computer software direct extraction of hydrological options, thus it gives advantages in terms of processing efficiency, cost effectiveness and accuracy assessment, compared with traditional methods based on topographic maps, field surveys or photographic interpretations [7]. For the last few decades, DEMs are widely used for resource management, urban planning, transportation planning, earth sciences, and environmental assessments and Geographic Information System (GIS) applications. In this study the raster DEM is used as a base map layer to derive the topographic phenomenon of the watershed such as area, slope and field slope length. Resolution of pixel represents the horizontal accuracy of DEM. The topography of the hydrologic modeling is based on spatial resolution of the model that perform optimally.

5. Expected Route Selection using ARC – GIS
In order to avoid flow disaster that’s caused from dam failure, it’s obligatory to select a new route of water far away from the old river valley. Primary inspection for route selection was carried out by reviewing the topographic maps of scale 1:500,000 and satellite images which cover the western desert of Egypt.

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The expected route is started from the western side of Lake Nasser, the long arm of Lake Nasser that focuses at the Toshka Lakes as shown in the satellite image, see Figure (4). It extends over the Toshka Depression, and broadens north along the old Drab el-Arba'in through the desert springs of Baris and El-Kharga. This route extends through El-Farafra Oasis, passing by El-Baharia Oasis and ends to the Qattara downrange.

DEM for western desert from Toshka spillway to el-Qattara downrange is obtained from Shuttle Topographic Rader Mission STRM as shown in Figure (5.1). Then Geographic Information System (Arc-GIS) was utilized for watershed display activities.

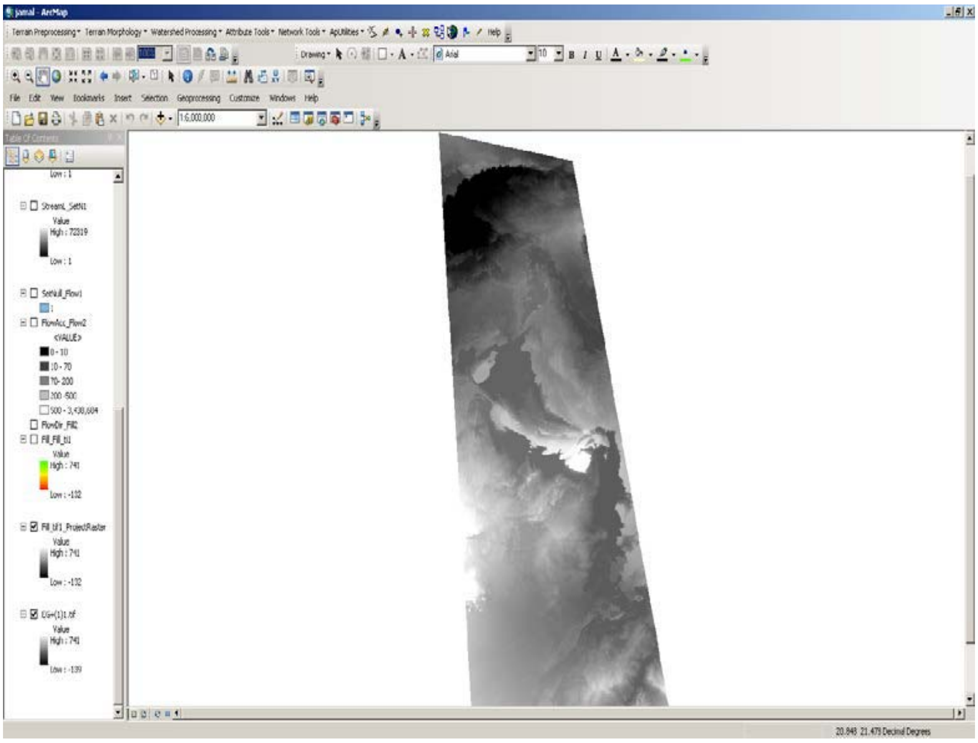

Figure 5.1 DEM of western desert

Image of western desert was embedded in Arc-GIS model and the dataset were transformed from (Latitude, longitude) projection to WGS_1984_UTM projection framework (N, E) Coordinates.

Hydrology selected from spatial analysis tool. This subroutine consists of the following steps, subtitles **5.1** through **5.8**, until the drainage pattern of each basin clarified.

5.1 Fill (Spatial Analyst):

Fills and sinks in a surface raster is used to remove small imperfections of the data as shown in Figure (5.2).

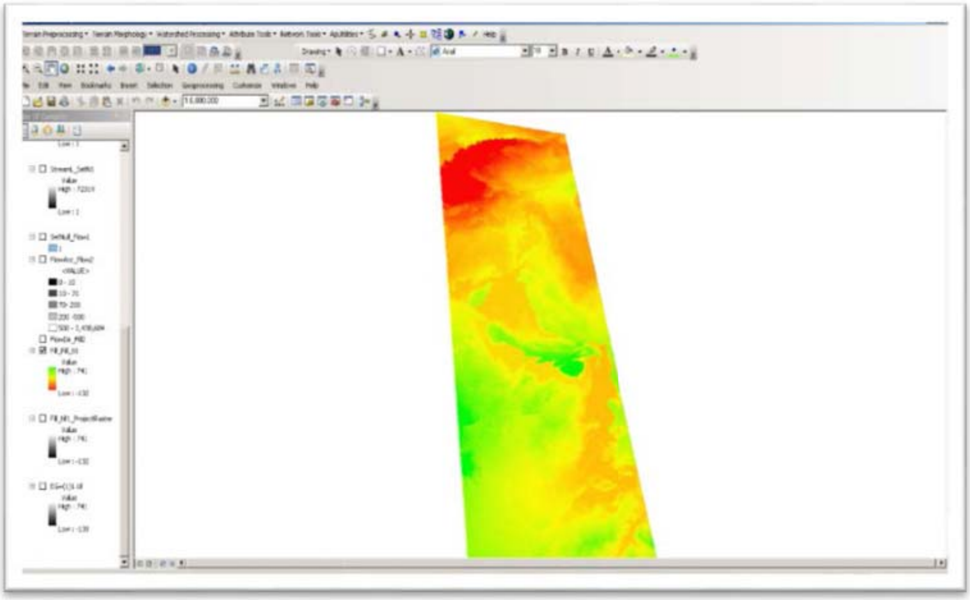

Figure 5.2 fill (Spatial Analyst)

5.2 Flow direction:

This creates a raster of flow direction from each cell to the steepest down slope neighbor as shown in Figure (5.3).

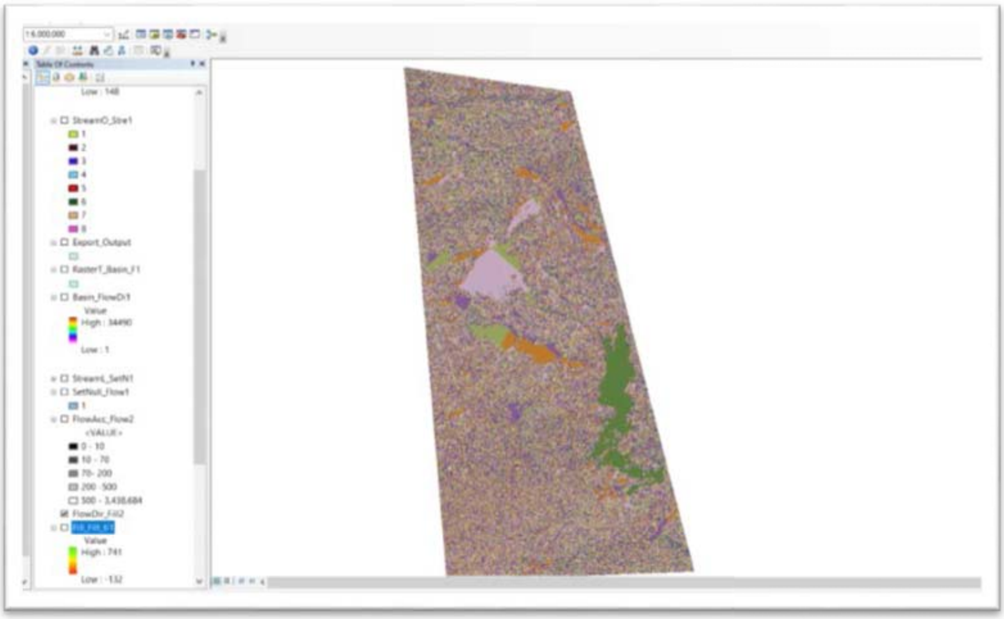

Figure 5.3 flow direction

5.3 Flow Accumulation:

This creates a raster of accumulated flow into each cell. A weight factor can optionally be applied see Figure (5.4).

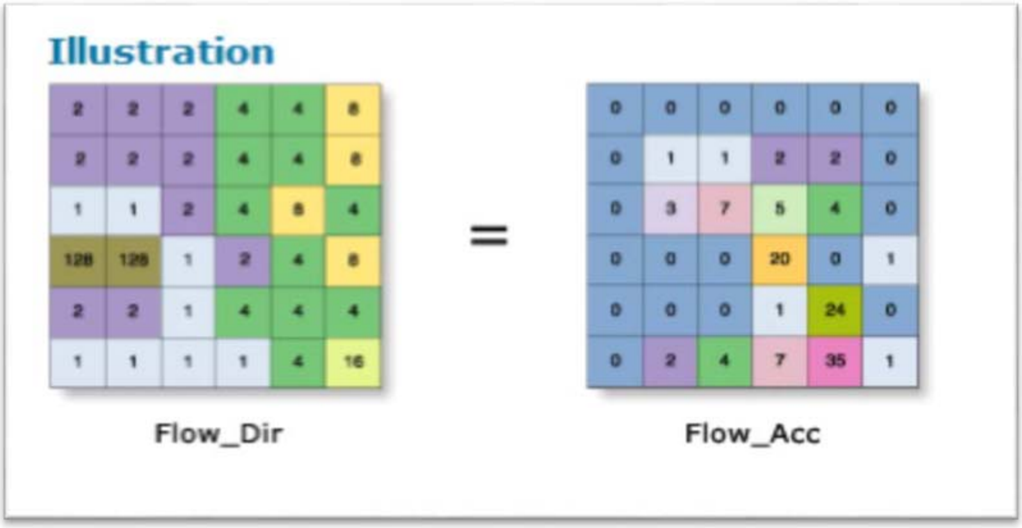

Figure 5.4 flow dir. & flow acc.

5.4 Stream link:
This step assigns unique values to sections of a raster linear network between intersections.

5.5 Stream Order:
This assigns a numeric order to segments of a raster representing branches of a linear network as shown in Figures (5.5 & 5.6).

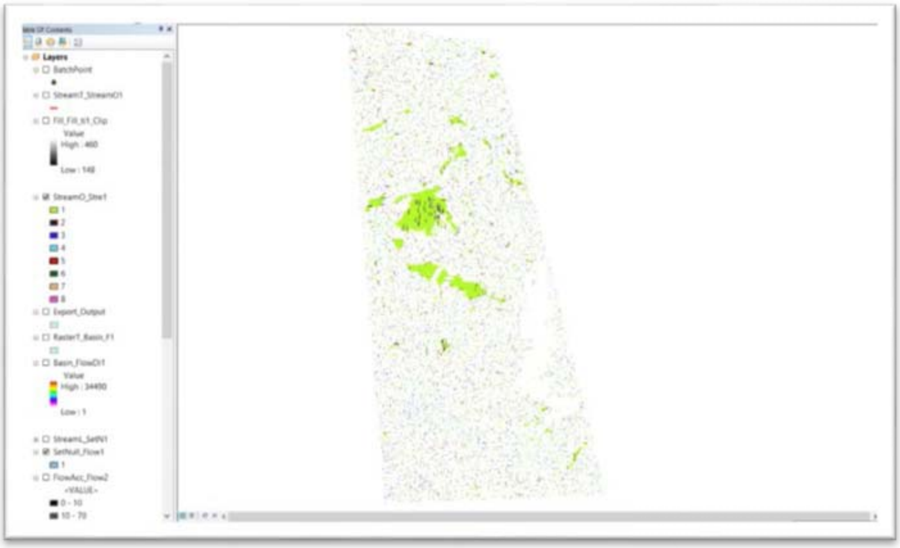

Figure 5.5 Stream Order

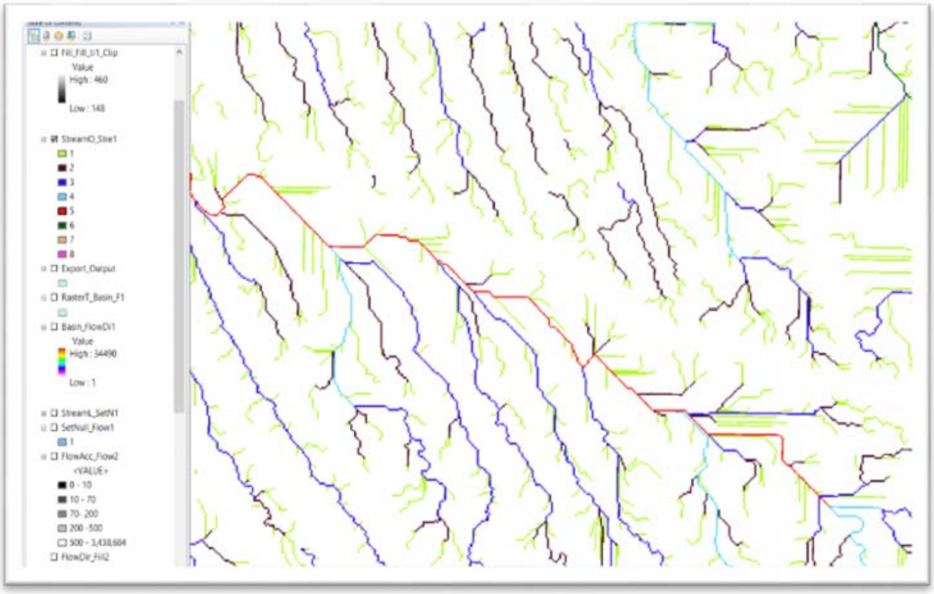

Figure 5.6 Stream Order (drainage pattern)

Stream order of the drainage pattern is divided into eight colored elevation levels from high to low order which can follow the direction of water related to the slope of drainage pattern orders as shown in Figure (5.6), then we can follow the red one which describe the slope in the study area.

5.6 Stream to feature:

This step converts a raster of linear network to features representing the linear network, see Figure (5.7).

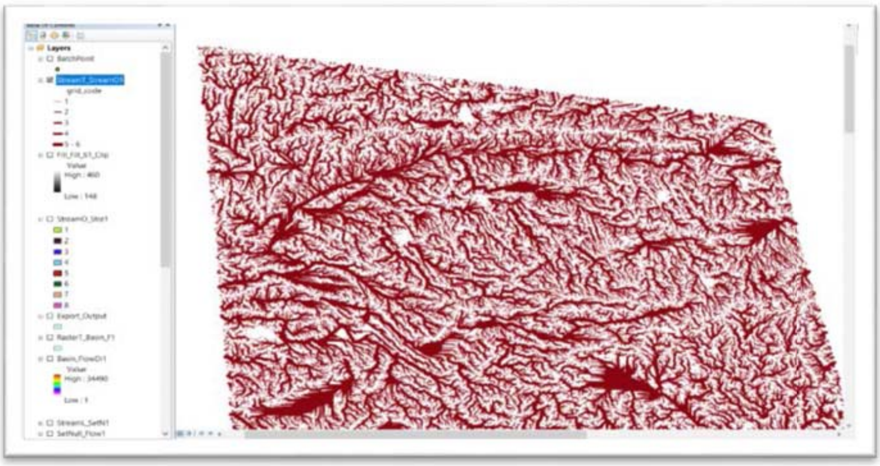

Figure 5.7 Stream to future

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5.7 Define Basin:
Which Creates a raster delineating all drainage basins, see Figure (5.8).

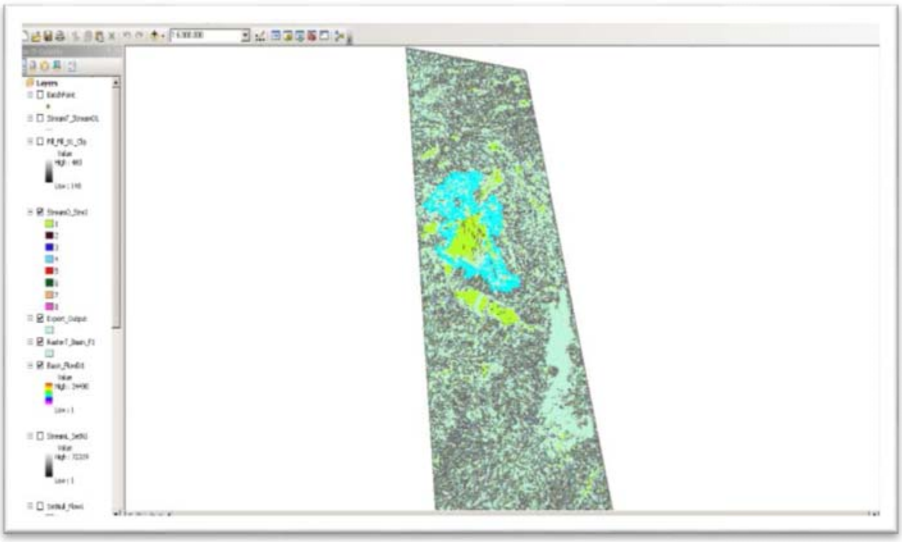

Figure 5.8 Define basin

5.8 Basin flow direction:
The drainage basins are delineated within the analysis window by identifying ridgelines between basins. The flow direction raster is analyzed to find all sets of connected cells that belong to the same drainage basin. The drainage basins are created by locating the pour points at the edges of the analysis window (where water would pour out of the raster), as well as sinks, then identifying the contributing area above each pour point. This results in a raster of drainage basins, see Figure (5.9).

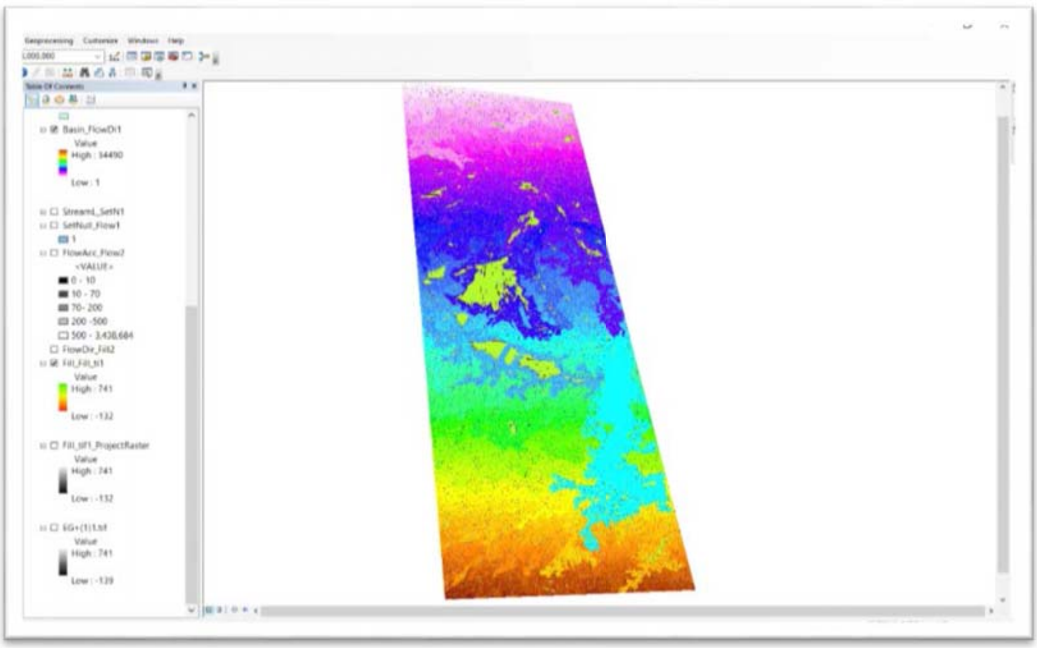

Figure 5.9 Basin Flow directions

Drainage pattern from Toshka to El-Qattaea downrange:

The Arc-GIS model is delineating the boundary of the watershed to collect the water flooded from Aswan reservoir.

a- From Toshka to El_Dakhla:

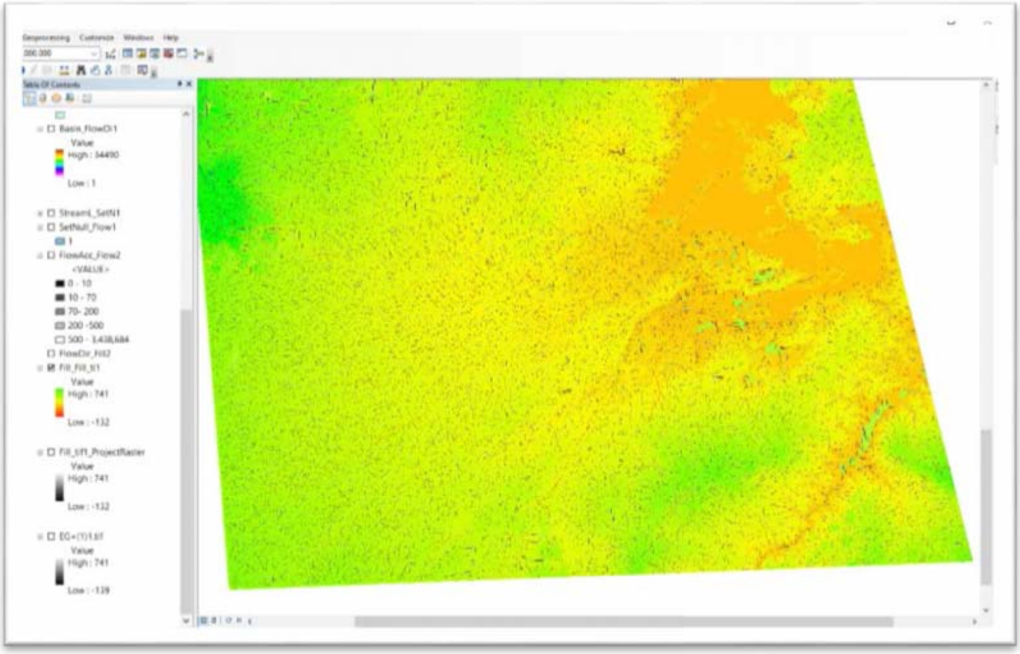

Figure 5.10 drainage pattern from Toshka to El_Dakhla

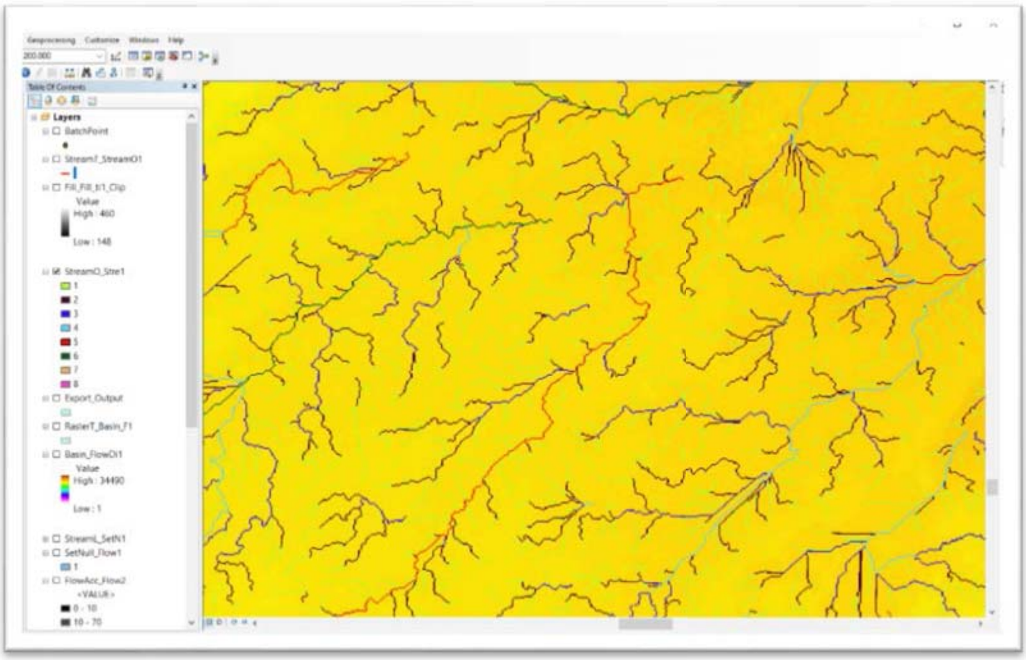

Figure 5.11 drainage pattern from Toshka to El_Dakhla.

b- From Farafra to Elbaharea:

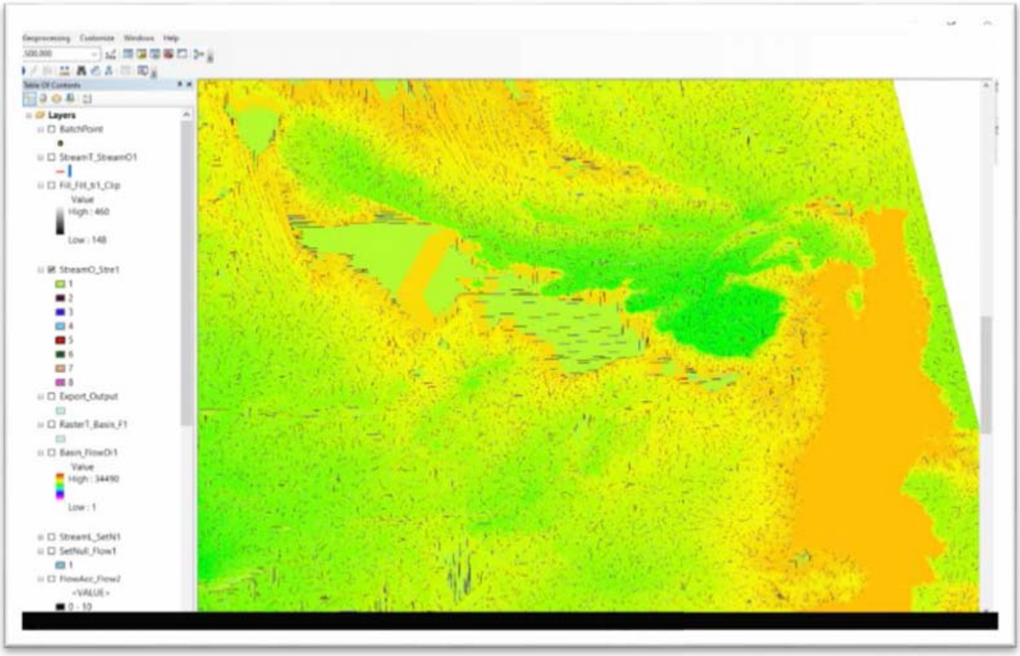

Figure 5.12 drainage pattern from Farafra to Elbaharea

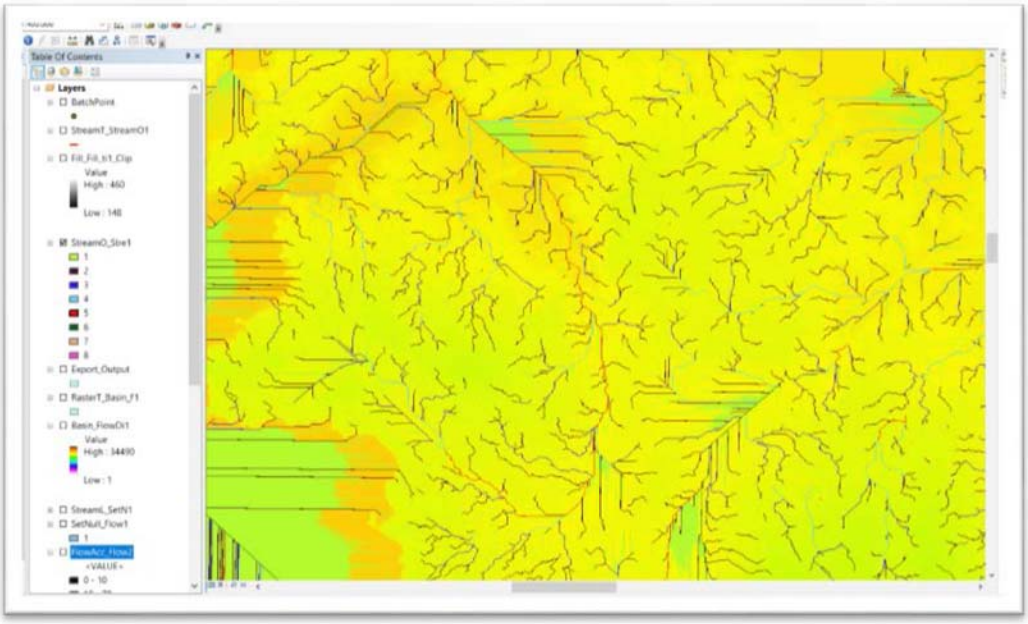

Figure 5.13 drainage pattern from Farafra to Elbaharea.

c- From Elbaharea to El-Qattara downrange:

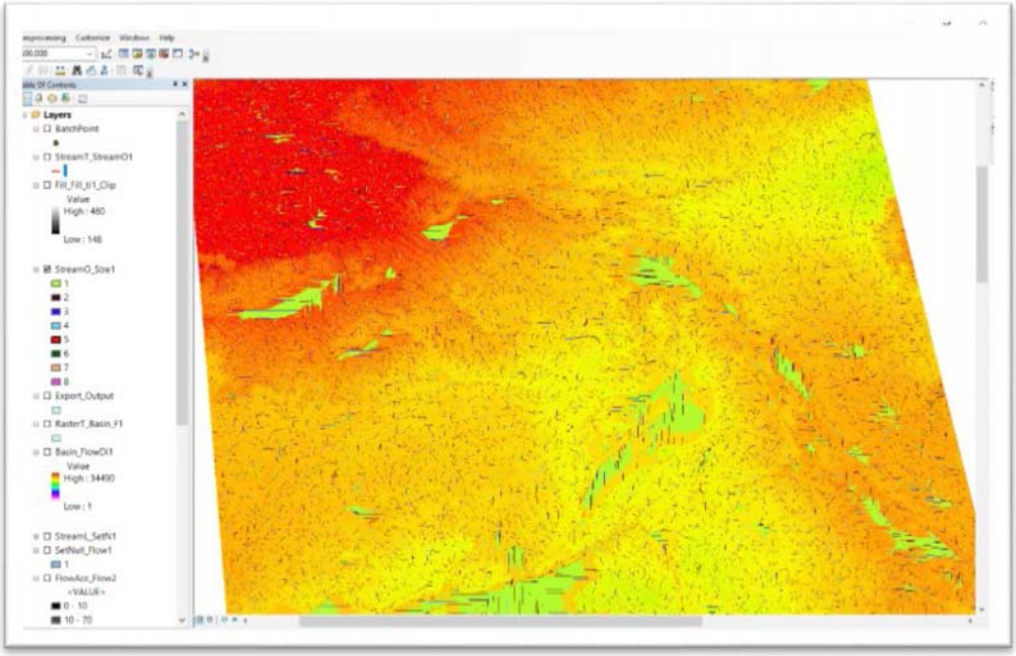

Figure 5.14 drainage pattern from Elbaharea to El-Qattara downrange

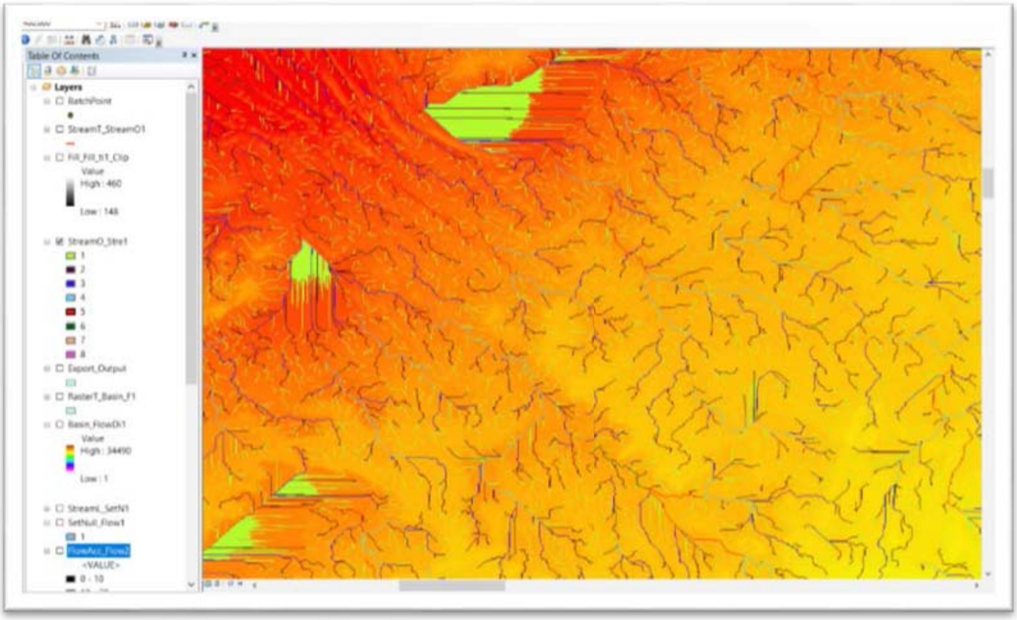

Figure 5.15 drainage pattern from Elbaharea to El-Qattara downrange

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6. Topographic Maps usage for route construction projects.

New Valley route selection can be determined from hydrological study of the region in order to choose the most appropriate path for the construction to transfer water from the Toshka spillway to the Qattara downrange and to reduce the budget of industrial works to be carried out at that distance, estimated at 800 km, topographic maps of the scale (1: 500000) were used to justify these works.

1- Luxor map
   Constructing a tunnel corridor at coordinate 30° 38′ E & 24° 27′ N through the Darb al-Arba'een road, see Figure (6.1)

Figure 6.1 Construction works in Luxor

2- Dakhla map
   a-Construct bridge at coordinate 28° 58′ E & 25° 28′ N or made tunnel in the same valley path and pass down the road.
   b- Construct tunnel at coordinate 29° 38′ E & 25° 15′ N for a distance 1km then another tunnel at coordinate 29° 30′ E & 25° 20′ N for a distance 2km, see Figure (6.2).

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Figure 6.2 Construction works in Dakhla

3- Farafra map

a-Construct industrial work (bridge or tunnel) at coordinate 27° 50′ E & 26° 41′ N.

b- Construct industrial work (bridge or tunnel) at coordinate 28° 12′ E & 27° 28′ N.

c-Digging a distance of about 17.5km from point 27° 31′ E & 26° 33′N to point 27° 42′ E & 26° 38′ N, see Figure (6.3).

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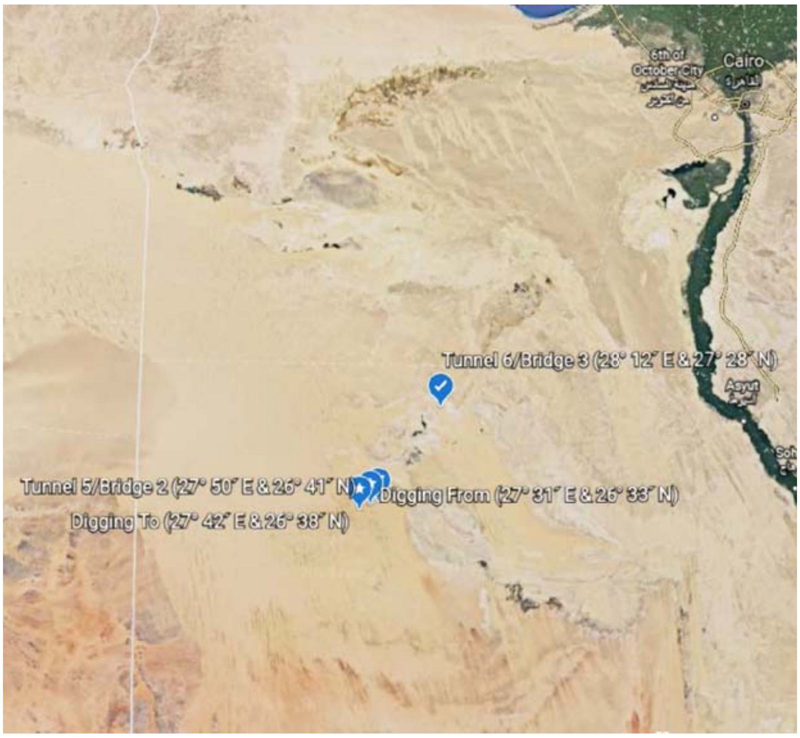

Figure 6.3 Construction works in Farafra

4- Baharia Map
Construct industrial work (bridge or tunnel) at coordinate 27° 40′ E & 28° 41′ N, see Figure (6.4).

Figure 6.4 Construction works in Baharia

Figure 6.5 Construction works from Luxor to El Baharia Oasis

The route selection shown in Figure (6.6) is matched with the expected new valley that Dr. Farouk El Baz Proposed in his project (The Development Project/Corridor of Development Project) as shown in Figure (6.7).

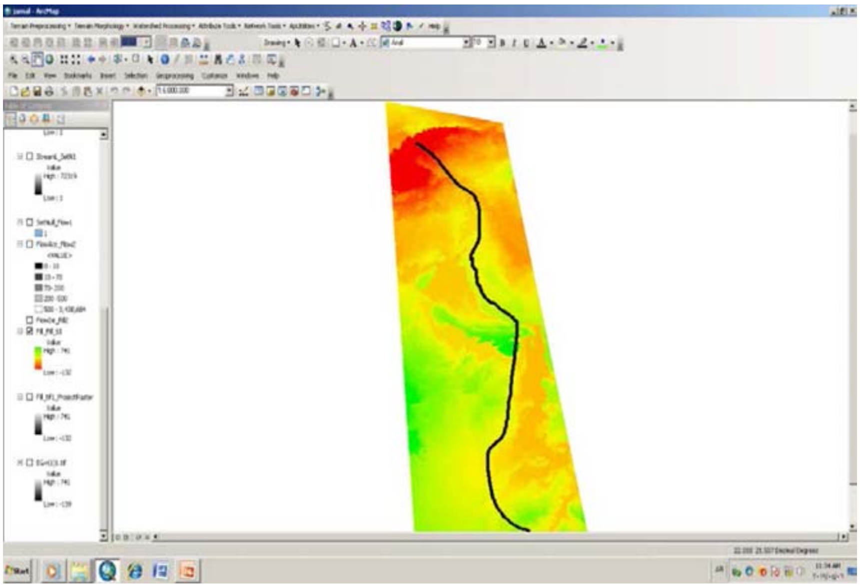

Figure 6.6 Final route selection

Figure 6.7 Final route selection [8]

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7. Conclusion & Recommendations for future work.

The following statements are concluded:

1- The DEM is an effective way to represent the surface of the earth and extract hydrological characteristics.
2- Route selection for a new valley in western desert is carried out by using ARC-GIS to protect many cities from tremendous flood.
3- The volume of El-Qattara downrange (1054.4 km^3) is about 6.5 times the water volume of AHDR (131.7km^3), without any losses that contain evaporation, infiltration, etc.
4- Outlet stations of different watersheds or basins in each oasis delineate the path of the new route of the Nile River.

It is recommended to determine the new route by matching the outlet station of each neighbor watershed or basin consequently for each oasis in order to obtain the best route for the new valley. It is also recommended to determine the volume of construction works to be carried out (digging - pipelines - tunnels - bridges) on the new valley.

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