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GEO-ENVIRONMENTAL STUDIES ON WADI QENA, EASTERN DESERT, EGYPT. BY USING REMOTE SENSING DATA AND GIS.

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Abstract

Geographic information system (GIS) and remote sensing data confirmed by field checks have been used to investigate the geoenvironmental characteristics at Wadi Qena area. The study area is mainly covered by sedimentary rock units (Paleozoic to Cenozoic) and a small basement exposure in its northeastern corner. It exhibits different types of structural elements represented by anticlines (Wadi Qena and Wadi Hamama) and synclines (El Serai and Abu Had) and four main fault trends (NE-SW, NW-SE, ENE-WSW and N-S). The basin analysis studies show that the most dangerous risk area is located at the southern part of the wadi drained by Wadi El-Jurdi and Wadi Shahdeen. Quantify the hydrogeologic situation, land-use map and a plane for flood risk protection of the investigated area are delivered to support the decision-making processes. However, many locations are suggested for new cities along Wadi Qena which accommodates the residential and the industrial activities required for developments. The most dangerous zones are located at the downstream of Wadi El-Jurdi and Wadi Shahdeen. So, the entire development plan should avoid this buffer zone.

1. Introduction:

Wadi Qena is considered as one of the largest wadis in the Eastern Desert area, and it lies to the northeast of Qena City between Latitudes 26° 00' and 28° 20' N and Longitudes 32° 00' and 33° 00' E (Fig. 1). It is bordered in the east by the igneous and metamorphic rocks of the Red Sea Mountains and in the west by cliffs of the Upper Cretaceous-Lower Tertiary succession which extend westward to the Nile Valley. It reaches to more than 270 km in length and its general course trends in North-South direction. The surface area of Wadi Qena covers about 16.000 km^2 and occupied by Upper Cretaceous, Lower Tertiary, Quaternary and Recent sediments. The area under investigation is 6 km far from Qena City along Qena-Safaga road which was the main accessible road to the area. Recently, different roads have been constructed such as El Sheikh Fadl-Ras Gharib road at the north of Wadi Qena, as well as the new road that joins the Nile Valley with the Red Sea (Fig. 1). This road starts from Sohag or Assiut and passes through Wadi El Sheih until Wadi Jurdi. The length of the road from Assiut to Wadi Qena is 177.550 km, while the length of the road from Sohag to Wadi Qena is 121.570 km. These two roads cross Wadi Qena from west to east and finally connect with Qena-Safaga road at the sign of 40 km. Also the length of the road from Qena to connect with the main road is 47 km. The geological and environmental resources are now undergoing tremendous changes due to urban, environmental, and industrial development, associated the commercial and residential growth in the study area. As the different roads and new urban areas have been developed; these changes draw more public attention, and sustainable development becomes a goal for the community, the continuing change associated with accelerated growth becomes a critical issue.

The present study aims at investigating the structural, geoenvironmental and geomorphological characteristics of the recent stream sediments in Wadi Qena based on the analysis of the available satellite image, field check, geological maps and environmentally data. The geomorphologic study is important to assess the flash flood risk zones, distinguish the suitable land-use sites, define high-risk basins and suggest flood precautionary measures.Throughout the building up of a Geo-data-base for all geologic rock units, and dominant structural elements in the study area

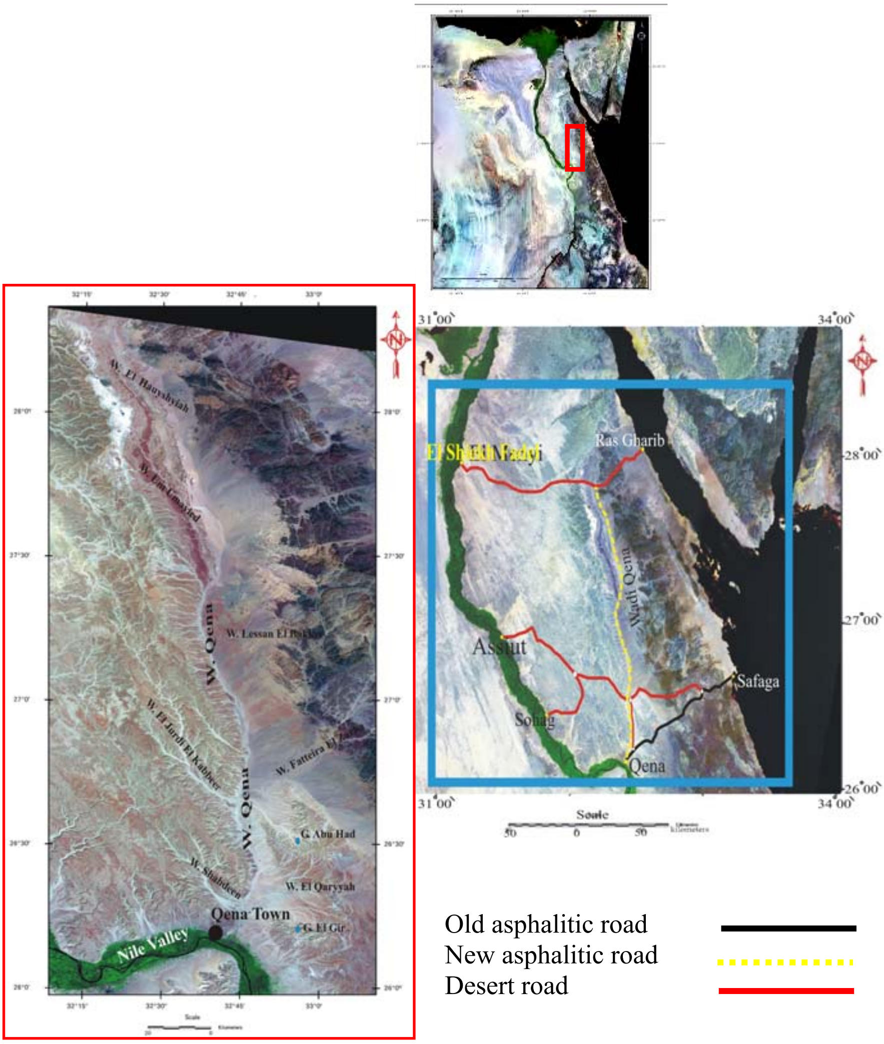

Fig. (1): Enhanced Thematic Mapper Landsat ETM+ 7, 5 and 1 in RGB image showing location of the study area and the main accessible roads.

using all available data in form of digital maps, published and unpublished authorized reports and remote sensing data in Geographic Information System (GIS) environment. Also the present study aims to create a detailed land-use map for Wadi Qena district using GIS tools that will help the decision makers in finding out the pattern and extent of land-use changes in the area for any future development and assessment.

The hydrographic basin of Wadi Qena occupies a portion of the arid belt of Egypt, where the annual rainfall is very limited. However, occasional precipitation occurs as heavy showers with short duration results in flash floods during winter season between October and February. The area under investigation is characterized by extreme aridity with very low and erratic rainfall, high evaporation rates, high summer temperature and generally vigorous winds. The prevailing arid to semi-arid climate has a distinct influence on the hydrogeologic regime of both surface and groundwater systems. The available meteorological data presented in this studying which cover the years from 1913 to 2000 for different stations and include the average value of air temperature (maximum and minimum), evaporation, relative humidity, rainfall and wind velocity and direction are recorded by the Egyptian Authority of Meteorology. Generally, the climatic data recorded by Qena meteorological station revealed that the average maximum temperature reneging from 33°C in to 42°C whereas the average minimum reneging from 5°C to 14°C (Table 1).

Table (1): Total annual rainfall, temperature and degree of the aridity of the study area (After the Meteorological Authority of Egypt, 1996).

Station	Total annual rainfall	Maximum temperature	Minimum temperature	Degree of Aridity
Hurghada	4.38	33.41	10.92	0.44
Sohag	1.18	39.2	7.2	0.08
Assuit	1.2	37.3	5.9	0.09
Nag Hammadi	0.7	38.4	5.8	0.05
Quseir	4	35.6	14.04	0.40
Qena	3.47	41.7	7.2	0.20
Luxor	2.13	41.3	5.6	0.12

The total annual rainfall in (mm/year) reneging from 0.7 to 4.38 (Table 1), recorded by the different stations to estimate the degree of aridity reneging from 0.05 to 0.44 (Table 1) of the study area based on the aridity scale of Emberger (1951).

Wind is considered as one of the geomorphological factors that obviously participate in forming the geomorphological features in the area but may be less than flowing water. Mostly the north winds with its types are usually of prevailing matter except in winter when the west wind is of the prevailing. It is noticed also that the wind speed increases in the spring and summer (table 2).

Table (2): Monthly rates of the wind direction in some cities surrounding the study area (After the Meteorological Authority of Egypt, 1996).

Month and Year	Mina (Airport)			Quseir		
	Aver. Speed (km/hr)	Prev. direction	Calm %	Aver. Speed (km/hr)	Prev. direction	Calm %
January	6.4	N	23.9	18.0	W	4.2
February	6.8	N	20.8	18.0	W	5.3
March	9.4	N	11.0	18.0	N	6.1
April	9.6	N	13.7	18.0	N	9.3
May	10.7	N	11.1	18.0	N	9.4
June	12.7	N	7.1	14.4	N	7.2
July	9.5	N	16.8	14.4	N	10.9
August	7.7	N	23.2	18.0	N	13.2
September	8.3	N	17.1	14.4	N	8.9
October	6.9	N	23.6	18.0	N	7.2
November	7.1	N	27.3	14.4	N/W	2.8
December	5.6	N	21.5	14.4	W	2.1

The evaporation plays a principal role in the groundwater regime. Evaporation value is a function of air temperature, air humidity and wind velocity. It affects both the surface and groundwater particularly when the level of the latter is close to the ground surface. Table (3) shows the average maximum monthly mean value of the evaporation (23.5 mm) during June at Assiut station, while the minimum value is (3.1 mm) in December at Sohag and Nag Hammadi stations.

Table (3): Average value of (degree of evaporation, rainfall and relative humidity) in some cities surrounding the area under study and given by metrological stations.

Months	Luxor 1948---1994			Qena 1913-1994			Nag Hammadi 1942-1975			Assiut 1946-2000		
	E	R	H	E	R	H	E	R	H	E	R	H
January	4.32	0.09	56.27	5.1	0.17	50.67	3.2	0.1	-	6.3	<0.1	-
February	5.82	0.26	47.34	6.87	0.2	42.97	4.5	0.1	-	7.7	0.3	-
March	7.87	0.44	39.04	9.41	0.59	37.1	6.7	0.1	-	12.2	0.2	-
April	11.23	0.3	30.62	13.43	0.07	26.89	9.2	0	-	15.8	<0.1	-
May	13.36	0.55	27.8	16.08	0.18	24.06	10.5	0	-	20.6	<0.1	-
June	14.4	0	27.8	17.63	0	24.81	8.6	0	-	23.5	0	-
July	13.65	0	31.02	16.08	0	28.77	8.9	0	-	20.6	0	-
August	13.14	0	33.04	15.18	0	31.87	8.4	0	-	18.2	0	-
September	11.35	0	37.17	13.46	0	35.53	7.3	0	-	16.1	0	-
October	8.62	0.26	42.16	10.43	0.23	38.21	5.4	0.1	-	12.1	0	-
November	5.57	0.17	51.81	6.33	0.43	47.09	3.8	0.1	-	7.9	0.7	-
December	4.44	0.06	57.8	4.54	1.6	51.45	3.1	0.2	-	5.8	<0.1	-

Months	Quseir 1978-1994			Sohag 1942-1993			Hurghada 1978--1994			
	E	R	H	E	R	H	E	R	H	Evaporation (E) Rainfall (R) Humidity (H)
January	6.06	0.84	50	3.2	0.05	51.53	7.94	0.58	51	
February	6.68	0.01	45.3	4.5	0.05	48.11	8.82	0.03	43	
March	6.97	0.13	46.52	6.7	0.05	51.28	9.55	0.65	36	
April	8.29	0.07	45.12	9.2	0	50.62	11.88	0.04	27	
May	8.76	0.62	41.77	10.5	0	48.99	14.18	0.38	25	
June	8.3	0	41.25	8.6	0	47.85	14.86	0	28	
July	9.01	0	44.77	8.9	0	50.37	16.12	0	34	
August	8.94	0	46.53	8.4	0	51.73	15.34	0	37	
September	8.33	0	49.63	7.3	0	54.45	14.03	0.01	41	
October	6.81	0.82	53.94	5.4	0.79	58.33	10.37	0.41	43	
November	6.94	0.41	51.47	3.8	0.14	54.45	9.03	0.34	50	
December	5.94	1.1	51.77	3.1	0.1	52.55	7.68	1.94	52	

Rainfall forms an important factor, for helping and knowing the prevailing conditions of the area. Rainfall in the area under investigation is extremely rare; which reaches less than 1.94 mm/year (table 3). Actually Wadi Qena basin lies in Upper Egypt, which is characterized by arid conditions and generally negligible rainfall. Sometimes, during the winter season occasional short rainy storms take place over the scattered locations. Generally the rainfall is rare or trace all over the year except three months (February, March and November). The maximum monthly mean value of the rainfall is 1.94 and 1.60 mm during December at Hurghada and Qena stations respectively (table 3).

Annual rainy days are very few (about 3 days per year). Relative heavy rainfall (cloudburst) takes place only accidentally. It is usually of short duration (few hours) and causes flash flooding. The recurrence of cloudbursts is irregular and statistically takes place only once every 5 to 15 years with a daily rainfall up to 24 mm. According to the Egyptian Authority of Meteorology, the last thunderstorm took place in November 1st and 2nd in 1994, with a daily rainfall of 24 and 13 mm respectively.

The relative humidity is the ratio of the amount of the actual water vapor in the air compared to the maximum amount of water vapor air can hold at that particular temperature and pressure. It plays an important role in determining the rate of evaporation, and condensation. Generally, the values of relative humidity in winter are higher and the opportunity of cloud formation reaches its maximum range in November, December and January. It is higher along the Red Sea coast than that along the Nile Valley. The average maximum monthly mean value of the relative humidity is 57.8 and 56.27 % at Luxor Station during December and January respectively, while the minimum is 24.06 % at Qena Station in May along the Nile Valley. While in the Red Sea coast the average maximum monthly mean value of the relative humidity is 58.33 % at Quseir Station during October, while the minimum is 41.25 % at Hurghada Station in May (table 3).

2. Stratigraphic setting:

The sedimentary cover of Wadi Qena ranges in age from Paleozoic to Quaternary (Fig. 2). The distribution of the Paleozoic sediments was more or less controlled by older Pre-Cenomanian structural events (Said, 1990; Issawi et al., 1999). The Nubian Sandstone facies unconformably overlies the basement rocks in the central and southern parts (El-Shami, 1988) and unconformably underlies the Paleocene, Eocene and Pliocene rocks forming the downstream hills and the western calcareous plateau. The Quaternary sediments exist as alluvial fillings and alluvial terraces (Abdel Moneim, et al., 2004). Accordingly, the following is a brief description of the different rock units exposed in the study area from older to younger.

2.1. Precambrian rocks:

The Pan-African basement rocks exposed in the eastern part of the study area, it comprises igneous and metamorphic rocks uncomfortably overlain by the Paleozoic sedimentary cover.

2.2. Paleozoic rocks:

The Paleozoic sedimentary rocks are represented by massive, cross-bedded sandstone of fluvial origin at the base; uncomfortably overlie the basement rocks. The middle part of this unit is thick, massive with calcareous content. The topmost part of the Paleozoic rocks (Naqus Formation) consists mainly of thin fluvial sandstone with minor intercalation of marine sandstone with few siltstone content (Fig. 3A).

2.3. Mesozoic rocks:

2.3.1. Malha Formation (Albian – Cenomanian):

Malha Formation overlies the Paleozoic rocks in some parts and basement rocks in others.

As specific position of Wadi Um Umayied, Malha Formation rests uncomfortably on the Precambrian basement rocks and is conformably overlain, in most places, by marine strata of the Galala Formation (Fig. 3B). Malha Formation consists of white and yellow fluvial sandstone with local conglomerate. Therefore, it is sometimes confused with the other parts of the older sediments. This confusion can be solved by the characteristic position of Malha Formation under the fossiliferous marine Galala Formation. Malha Formation forms a distinct escarpment on the western side of Wadi Qena to the area of Somr EI Qaa and between there and the Wadi Dakhal area, this sandstone is underlain by Paleozoic strata (Klitzsch et al., 1990).

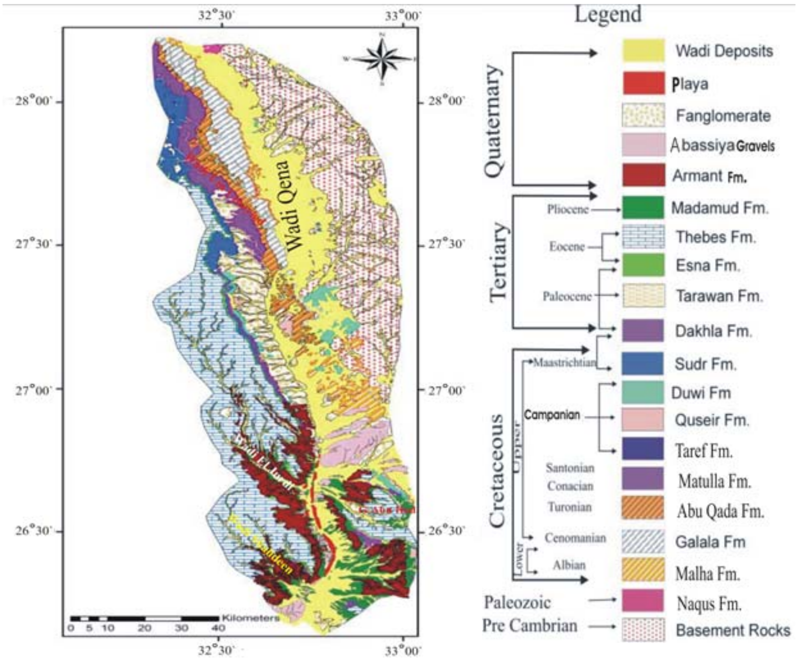

Figure (2): Complied geologic map of Wadi Qena area. (After EGSMA 1983 and Conoco 1987).

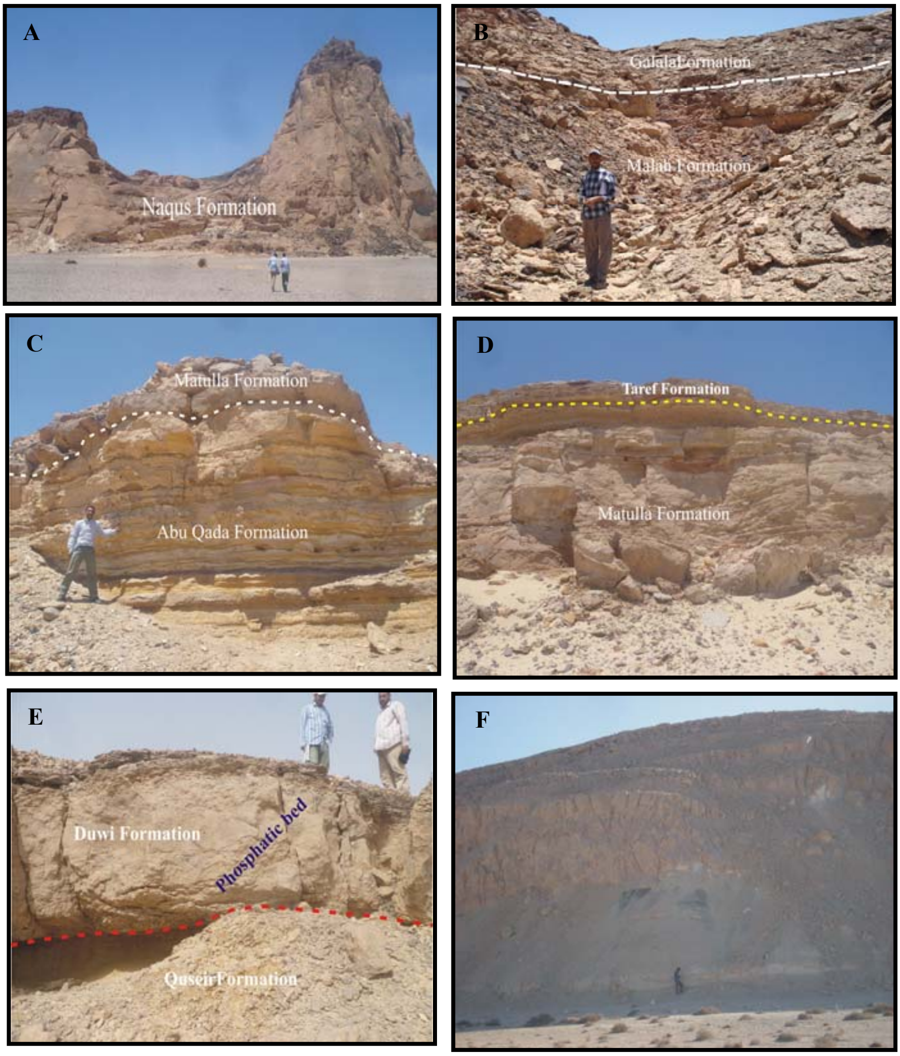

Figure (3): **Field Photograph showing Naqus Formation (A), Malha Formation conformably underlying Galala Formation (B) Abu Qada Formation directly overlaying by Matulla Formation (C) Matulla Formation underlying Taref Formation (D), Duwi Formation (E) and massif limestone of Sudr Formation (F) at the study area.**

2.3.2. Galala Formation (Late Cenomanian–Early Turonian):

The marine sediments of the Galala Formation at Wadi Qena represent the first transgression event of the southern Tethyan Sea. It overlies fluvial sandstones of the Malha Formation (Klitzsch, 1986 and Hendriks et al., 1987). The Galala Formation consists mainly of silty shale, sandy marl and fossiliferous limestone (Fig. 3B). The thickness of the Galala Formation at the study area ranges from 20 to 30 m.

2.3.3. Abu Qada Formation (Middle-Late Turonian):

At Wadi Um Umayied, northern part of Wadi Qena, the Galala Formation underlies unconformably Abu Qada Formation. On the other hand, Abu Qada Formation is overlend by Matulla Formation (Fig. 3C) that is made up of a lower and upper tabular cross-bedded sandstone units (15 to 20 m thick) and a middle unit of shale, silt, marl and marly sandstone (25 to 30 m thick). The sandstone units represent fluvial fans with a northwest and north (locally also east and southeast) directions of transportation (Klitzsch et al., 1990).

2.3.4. Matulla Formation (Coniacian–Santonian):

The upper sandstone of Abu Qada Formation is overlend by an approximately 55 m thick sequence, named as Matulla Formation. This formation consists of lagoonal marine carbonate and shale, locally intercalated with thin sandstone beds and minor silty shale, marl, and sandy marl. Less carbonate towards the south is noted (Figs. 3C and D).

2.3.5. Taref Formation (Early Campanian):

At the end of Wadi Um Umayied, the marine strata of the Matulla Formation are overlend by phosphatic, calcareous, partially silicified conglomerates and marls of Taref Formation. Further to northernwest (Hermina et al. 1989), the facies of the Taref Formation changes into marginal marine shale and sandstone with marine carbonate and occasional phosphate beds (Fig. 3D).

2.3.6. Quseir Formation (Middle Campanian):

Quseir Formation was firstly introduced by Ghorab (1956) who described it as variegated shale that consists of multicolored shale with blackish alternating yellowish sandstone at Gabal Duwi. Quseir Formation is represented by two parts. The lower part of the formation is represented by coarsening upward sandstone-shale unit intercalated with calcareous and trough cross-bedded sandstone beds (Fig. 3E). The upper part of the Quseir Formation is very similar to the shale lithofacies of the Duwi Formation. The basal shale and sandstones of the formation provides evidence of a terrestrial and brackish palaeoenvironment (Hermina, 1990).

2.3.7. Duwi Formation (Late Campanian):

Ghorab (1956) introduced the term Duwi Formation for the Phosphate unit overlying the Quseir Formation and underlying the Sudr and or Dakhla Formations. In the study area, the Duwi Formation is composed of a succession (15-30 m in thickness) of phosphatic marl and sandstone beds intercalated with marls, calcareous shales, sandstones and siltstones with oysters (Fig. 3E).

2.3.8. Sudr Formation (Maastrichtian):

The chalky deposits are widely distributed within the northern part of Wadi Qena particularly at Wadi Um Umayied, and are named as the Sudr Formation. This Formation is made up of chalk, marls, fossiliferous limestone and massive limestone (Fig. 3F). The Sudr Formation, with a reduced thickness, is also present in the northern part of the study area as a 15 m thick sequence overlying the Campanian Duwi Formation.

2.3.9. Dakhla Formation (Maastrichtian–Paleocene):

Dakhla Formation overlies the Duwi Formation in some parts and Sudr Formation in others, while it underlies the Tarawan Formation in all exposures. In the study area Dakhla Formation consists of a series of marls and shales which vary in thickness from one place to another (Fig. 4A).

2.4. Cenozoic rocks:

2.4.1. Tarawan Formation (Paleocene):

The Tarawan Formation is mainly built up of marl and marly limestone beds. It is conformably underlend by the Dakhla Formation (Fig. 4A). Its presence denotes its stratigraphic importance as a marker between the Dakhla and Esna Formations. Marzouk (1985) measured a thickness of about 11 m of the Tarawan Formation as a separate unit in Gabals Abu Had and El Serai.

2.4.2. Esna Formation (Paleocene–Eocene):

Only 6 m thick calcareous shale of Esna Formation is recorded at Um Umayied area underlying the limestone sequences of the Thebes Formation. The thickness of the Esna Formation increases southward to reach up to 10 m at Wadi El Jurdi (Fig. 4B).

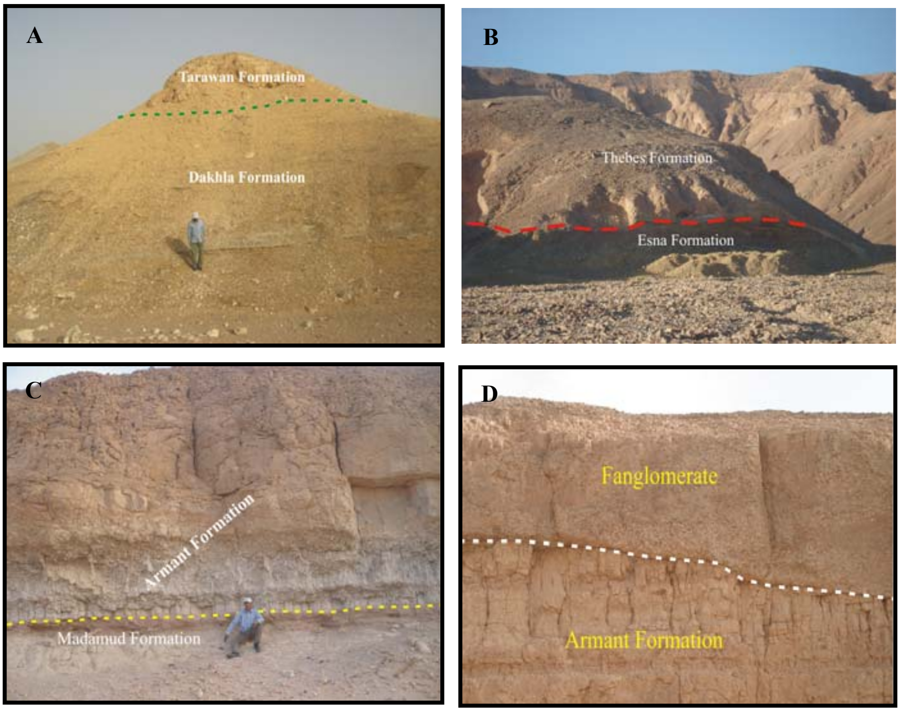

Figure (4): Field Photograph showing Tarawan Formation conformably underlay by Dakhla Formation (A), Esna–Thebes boundary (B), Madamud-Armant Formation boundary (C) and Armant Formation-Fanglomerate disconformities boundary (D) at the study area.

2.4.3. Thebes Formation (Eocene):

Said (1960) described the flint-bearing chalk sequence of Nile Valley near Luxor and called it as Thebes Formation. Similar chalks and well bedded marly chalks with flint layers are recorded in the upper escarpment along the whole western flank of the mouth of Wadi Jurdi El Kabbir, Gabal Ras Um Umayied and in north of Wadi Qena. It is observed that the Thebes Formation overlies the Esna Formation and forms the western escarpment boundary of the Wadi Qena (Fig. 4B).

2.4.4. Madamud Formation (Late Pliocene):

The Madamud Formation consists of chocolate brown marls and rhythmically banded fine sand and silt laminae, and fluviatile siltstone, sandstone and claystone. It overlies older bed rocks and underlies the Armant Formation. The Madamud Formation is displayed in the southern part of Wadi Qena at Gabal Abu Had, Wadi Shahdeen and Wadi El Jurdi. The maximum exposed thickness of this formation is about 15 m. The section is non-fossiliferous and is topped unconformably by beds of the Armant Formation, a poorly sorted torrential deposit (Fig. 4C).

2.4.5. Quaternary deposits:

Quaternary deposits are well represented and distributed in the study area, where they cover large parts of Wadi Qena. The Quaternary sediments are represented by the wadi fill deposits which are composed of conglomerate, sand and gravels. These deposits are represented in the study area by four different sedimentary units, from base to top, the Armant Formation, Abbassiya Gravels, fanglomerate, and recent wadi deposits (Fig. 4D).

3. Geomorphology:

The landscape of some localities at the investigated area has been treated by a number of authors. Among them are Abu El Izz (1971), El Shami (1985, 1988 and 1992a and b), El Rakaiby (1989) and Ashmawy (1994). Based on the available Landsat TM and ETM+ images (scales 1:100,000), topographic maps (scales 1:250,000 and 1:50,000), and the geologic maps (scales 1:500,000 and 1:250,000), the geomorphologic features have discussed of the investigated area. Actually it was geomorphologically subdivided into four units.

3.1. The eastern terrain of the Red Sea Mountains.

Red Sea mountainous terrain forms the main watershed in the investigated area. It is cut by two deep drainage systems. One of them drains eastwards into the mountains of the Red Sea, forming up the eastern sub-basins of Wadi Qena basin, Wadi Umm Sulimate, Wadi El Qaryyah, Wadi Fattiera, Wadi Zubir, Wadi Abu Hammad, Wadi Lessan El Bakker and Wadi Mudsar. The other system drains westwards to debauch finally into the River Nile, forming up the western sub-basins of Wadi Qena basin, Wadi Shahdeen, Wadi El Jurdi, Wadi Um Jalwa, Wadi Um Umayied and Wadi Hawayshiyah. The Red Sea mountainous terrain represents the most important groundwater supplies in the Eastern Desert due to its great extension, high altitudes and dense fracture systems.

3.2. Forelands.

A foreland basin is a depression that develops adjacent and parallel to a mountain belt. Foreland basins form because the immense mass created by crustal thickening associated with the evolution of a mountain belt causes the lithosphere to bend, by a process known as lithospheric flexure. The width and depth of the foreland basin is determined by the flexural rigidity of the underlying lithosphere, and the characteristics of the mountain belt. The foreland basin receives sediment that is eroded off the adjacent mountain belt, filling with thick sedimentary successions that thin away from the mountain belt. Foreland basins represent an endmember basin type, the other being rift basins. Space for sediments, accommodation space, is provided by loading and downflexure to form foreland basins, in contrast to rift basins, where accommodation space is generated by lithospheric extension.

3.3. Residual hills.

Wadi Qena forms a very wide dry valley, strewn by a large amount of detritus deposits drived from Quaternary. These deposits form a low lying plateau overlying the foot slopes of Gabal Abu Had and Gabal El Serai at the east and the foot slopes of El Maaza Limestone Plateau at the west. It extends about 80km from the downstream portion of Wadi Qena basin. It is dissected by drainage lines with precipitous marked cliffs of 50 to 150 m in height.

3.4. The western limestone (El Maaza) plateau.

El Maaza Limestone Plateau separated from the Red Sea mountainous terrain by Wadi Qena depression. The plateau is bounded westerly and southerly by the River Nile as well as it is overlooking easterly the Wadi Qena main channel. El Maaza Plateau is bounded by numerous cliffs rising up to 250 m above the channel floor and extends northward for about 440 km. Its surface slopes towards the west and it is formed of hard, massive and ledge forming up the Eocene limestone. It is dissected by numbers of valleys of steeply sloping sides whereas the water often falls and the neck points are usually of pronounced land features along the valley channels. The eastern side of El Maaza Plateau is joined at the main channel with Wadi Qena and it is represented by Wadi Shahdeen, Wadi El Jurdi and Wadi Um Jalwa. The surface water runoff and the fracture systems played an important role for weathering of the limestones and developing the drainage patterns. As a result, the streams cut down through the hard limestone beds which forming up the summit of the plateau and the nodular white limestone next below them.

3.5. Drainage Analysis Procedures:

The watershed of Wadi Qena basin is delineated for quantitative geomorphometric analysis. The concerned area consists of the main Qena trunk and its tributaries (Figs. 5 and 6). Software packages ArcView (version 9.2) and Eardas (version 8.5, 8.6 and 9.2) are used for spatial data analyses and satellite images displaying. Overlying the networks digitized from topographic maps on the available satellite images increases the accuracy of the output networks. A drainage pattern is an arrangement of channels determined by slope, different rock resistance, climatic and hydrologic variability, and structural controls imposed by the landscape. A stream pattern is the design formed by a single drainage way (Drury, 1993). Basin morphometry is the measurement and description of the geometric characteristics of the drainage basin. The purpose here is to introduce a few morphometric properties that are germane to discussion of surface water potentialities and channel flow. According to Horton (1945) many parameters have been calculated for the area under investigation and listed in (table 4); area of drainage basin (A), length of the water divide of the watershed area (P), drainage basin length (L), stream order (O), stream number (Nu), stream length (Lu), bifurcation ratio (Rb), drainage frequency (F), drainage density (D), constant of channel maintenance (C), texture ratio (Rt), basin shape lemniscate Ratio (K), compactness ratio (Co), form factor (Rf), channel gradient (So), slope index (Si), time of concentration (Tc), relief ratio, elongation ratio and ruggedness number are calculated using GIS software (table 4).

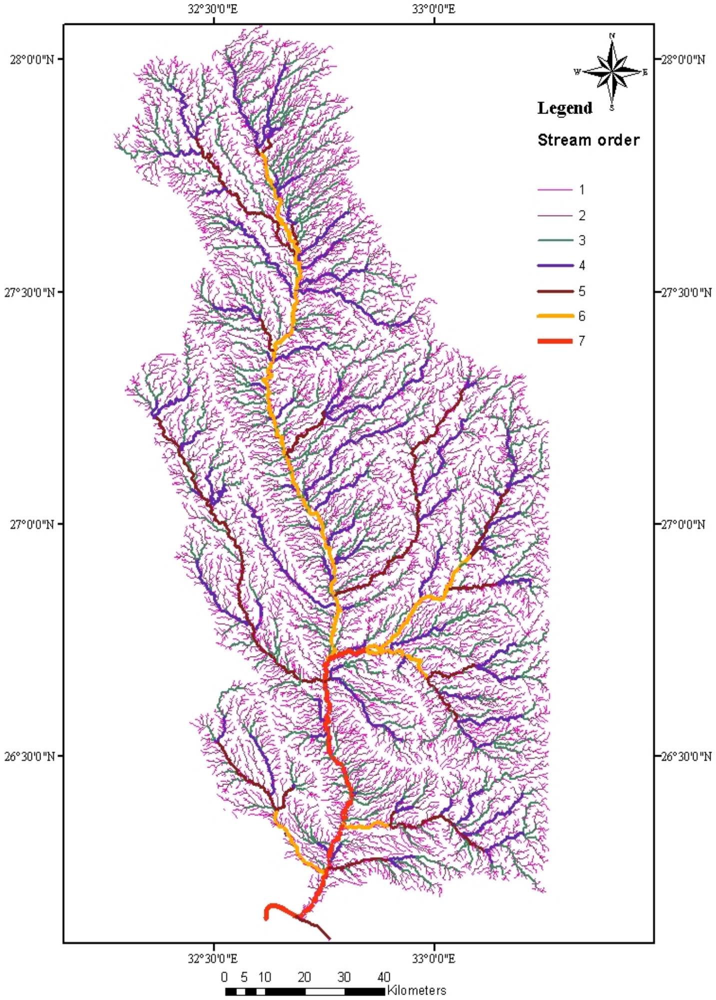

Figure (5): Automated drainage networks extracted from Landsat ETM+ images of Wadi Qena.

The quantitative morphometric analysis, which is considered as the most satisfactory method to clarify the relationship among different aspects of the drainage pattern, to compare the different drainage basins developed in various geologic and climatic conditions and to define certain useful variables in numerical terms. This analysis pursued to assess the hydrologic response, and to determine the runoff, flood potential and peak discharge, which is considered one of recharge sources of the potential groundwater aquifers of the basins. Also one of the most important advantages of quantitative analysis is that many of the basin variables are derived in the form of ratios or dimensionless numbers thus providing an effective comparison regardless of scale (Krishnamurthy et al., 1996). Linear, aerial and relief

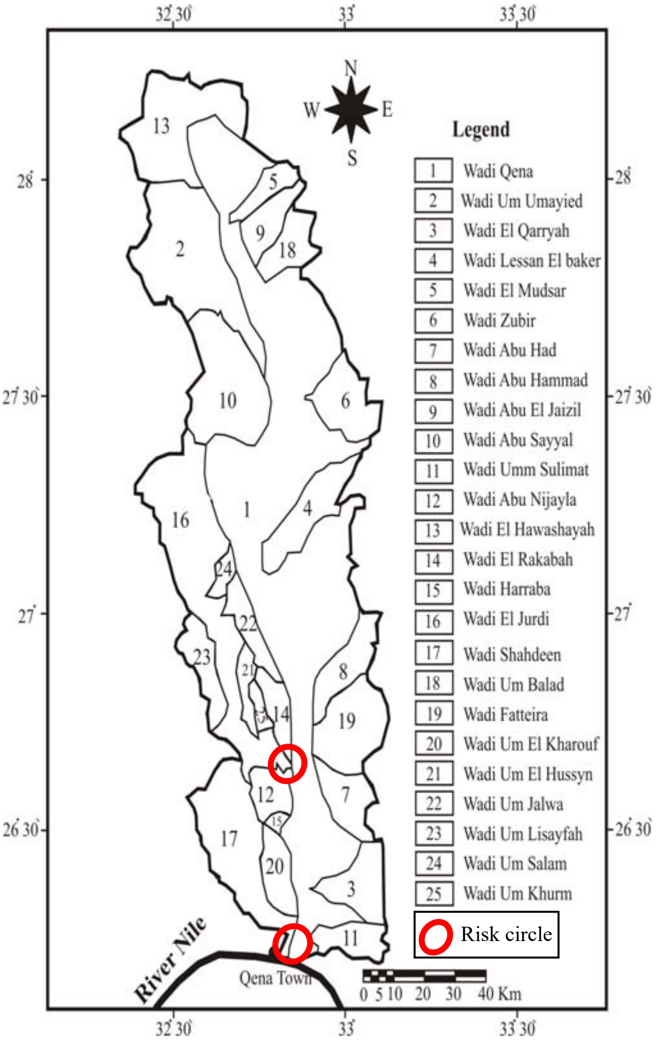

Figure (6): Sub-basins and risk map for the study area.

Table (4): The calculated parameters for the area under investigation.

Wadi name	R_b	A.	P.	O.	Lu	L	D	F	R_e	R_r	R_n	R_c.	Cir.	L_o	Si	Rb	D	F
Abu Had	3.7	240	79.5	863	6932503	30.96	3.59	8.97	0.56	0.013	0.04	10.85	0.476	0.317	0.0013	3.7	3.59	8.97
Abu Hammad	4.5	290	90.6	1152	943139	37.83	3.97	10.95	0.50	0.007	0.02	12.715	0.4437	0.257	0.0007	4.5	3.97	10.95
Abu Jizil	5	210	69	792	646037	28.7	3.77	9.871	0.56	0.014	0.05	11.471	0.554	0.323	0.0146	5	3.77	9.871
Abu Nijila	3.4	141	57	538	4378715	18.5	3.81	10.1	0.72	0.02	0.07	9.438	0.545	0.523	0.0219	3.4	3.81	10.1
Hawayshiyah	4.2	642.5	128	1683	1668569	36.5	2.61	4.76	0.78	0.007	0.01	13.148	0.492	0.612	0.0073	4.2	2.61	4.76
El-Qaryyah	3.4	241.7	72.1	567	676164	22	2.34	3.81	0.79	0.007	0.01	7.864	0.583	0.634	0.0072	3.4	2.34	3.81
Abu Harraba	3.6	31	27	118	97121.7	11.1	3.80	10.05	0.56	0.031	0.11	4.37	0.534	0.319	0.0319	3.6	3.80	10.05
El-Jurdi	4.3	1190.8	279	7390	4327426	100.5	6.20	26.72	0.38	0.003	0.01	26.48	0.192	0.15	0.0035	4.3	6.20	26.72
Lessan- El	5.4	293	95	380	565527	39.5	1.29	1.16	0.48	0.012	0.01	4	0.407	0.238	0.0129	5.4	1.29	1.16
Zubir	3.5	346	92	706	749383	31.5	2.04	2.88	0.66	0.015	0.03	7.673	0.513	0.442	0.0158	3.5	2.04	2.88
El-Musdar	4.2	105	53.2	396	299132	23.2	3.77	9.87	0.49	0.016	0.06	7.443	0.465	0.247	0.0163	4.2	3.77	9.87
Shahdeen	4.6	615	152	2187	1734074	52.7	3.55	8.77	0.53	0.0079	0.02	14.388	0.334	0.281	0.0073	4.6	3.55	8.77
Um_Khurm	4.3	55	43.3	216	4978965	17.5	3.92	10.7	0.47	0.015	0.05	4.99	0.368	0.228	0.0154	4.3	3.92	10.7
Um El kharouf	3.5	180	67	628	547577	25.4	3.48	8.44	0.59	0.016	0.05	9.373	0.503	0.354	0.0165	3.5	3.48	8.44
Um Jalwa	4.9	157	93	761	5448924	39	4.84	16.3	0.36	0.01	0.04	8.182	0.227	0.131	0.01	4.9	4.84	16.3
Qena	4.4	1650	610	6983	7765314	216.3	4.23	12.43	0.21	0.0024	0.01	11.448	0.557	0.044	0.0025	4.4	4.23	12.43
Um lisayfah	4.1	208	82.5	1426	754847	29.1	6.85	32.61	0.55	0.01	0.06	17.285	0.383	0.311	0.0106	4.1	6.85	32.61
Um Balad	3.6	220	73.5	753	6629085	26	3.42	8.13	0.64	0.018	0.06	10.244	0.511	0.413	0.0182	3.6	3.42	8.13
Um-Umayried	3.9	883	160	3729	2746112	60	4.22	12.37	0.55	0.007	0.02	23.306	0.433	0.311	0.0078	3.9	4.22	12.37
Fattiera	3.7	400	80.3	897	921409.7	85	2.24	3.48	0.85	0.003	0.006	11.17	0.78	0.728	0.0034	3.7	2.24	3.48
Umm Sulimat	3.5	182	67	641	556673.8	25.4	3.52	8.6	0.59	0.01	0.03	9.567	0.509	0.358	0.0135	3.5	3.52	8.6
Abu Sayyal	3.8	595	111.3	2275	1958265	38.5	3.82	10.14	0.71	0.04	0.03	20.44	0.603	0.51	0.0122	3.8	3.82	10.14
Ar-Rakabah	4.8	170	60	685	411174	21.2	4.02	11.26	0.69	0.01	0.03	11.416	0.593	0.48	0.0124	4.8	4.02	11.26

characteristics of the drainage basins are measured. The networks of drainage basins were traced from topographic map at scale 1:50,000. The authors evaluated the morphometric parameters of the studied drainage basins and emphasized on the relation between these parameters and the climatologically factors (especially rainfall) as controlling factor for the runoff events in the area of study. These parameters may also give a better understanding for determining the surface water potentialities in the hydrographic basins. Another goal is to evaluate the relationship between the morphometric parameters and flash floods that frequently occur.

4. Structural setting:

The area under investigation has a set of surface lineaments with different trends. These structural lineaments were delineated and subjected to some sort of statistical analysis to get an idea about the major and minor directions of such structural features by which one can conclude the major direction of the lineaments**.** The total number of such lineaments for the area under study is about 3301 fracture lines; displaying two main sets of NE-SW and NW-SE major trends. Surface structure depends on feature analysis which is a term applied to any study involving natural linear feature of which at least 70 % are known to be of structural origin. In this respect, the feature analysis techniques have been achieved for the study area by using the Conco's maps (1987) of scale 1:500,000, EGSMA`s maps (1983) of scales 1:250,000 and 1:100,000 and a series of Landsat images of different scales; as well as the field investigations. The studied area shows three different types of structures explain as follow:

4.1. Folds:

Hume (1929) recognizes these rolls and visualizes Egypt as cut across by two anticlines (Kharga Oasis and Wadi Qena) separated by a syncline (is occupied by the Nile north of Luxor). The Stable Shelf areas of Egypt of Said (1962) are mildly flexure, and folding seems to play a minor role in the structure of these areas. Two or possibly three sets of folds may be noted. The first, and perhaps the oldest, series may be rolls rather than folds; they have great amplitude and usually gentle dips. Their trend is almost north to south (Said, 1962). The limestone plateau is highly affected by the structures of Wadi Qena. These structures are represented by an anticline fold, which is disturbed by different fault systems especially those bounded Wadi Qena depression from the west (Aggur, 1997). In the study area there are two different types of folds (anticlines and synclines, Fig. 7); they are discussed in details as follows:

4.1.1. Wadi Qena anticline:

Wadi Qena anticline (Fig. 7) is one of the main resulted folds and subsequently affected by the later displaced faults subsequently. To this uplifting more faulting and folding took place. This ultimately led to the formation of Wadi Qena beside the action of erosion by water flow. It has a great amplitude, gentle dip and plunging southward. Its axis runs a mostly in North-South direction and coincided with Wadi Qena main trunk (Said, 1962). Wadi Qena is shown to be an anticline plunging trends mostly of NNW-SSE (El Shami 1988). The core of this anticline lies at the outlet of Wadi Um Umayied, where the basement rocks are exposed on the surface and surrounded by Paleozoic and Mesozoic rocks. The western flank is gently dipping (3°to5°) and occupied by El Maaza Plateau (Aggur, 1997) while the eastern flank is highly disturbed by the uplifting of the basement. The deformations accelerate the erosion of the exposed rocks except the area of Gabal Abu Had, where the concerned flank is clearly recognized.

4.1.2. Wadi Hamama anticline:

Wadi Hamama anticline lies between two synclines (El Serai to the south and Abu Had to the north; Fig. 7). The axis of the concerned anticline runs in WNW-ESE direction for about 30 km. Its core consists of the Nubian Sandstones (Naqus Formation). Its eastern and western flanks are disturbed by NNW-SSE fault system, parallel to its axial trend. At the eastern border of limestone plateau, an asymmetrical anticline was detected in Wadi Jurdi, west Wadi Qena. Both limbs of the anticline are steeply dipping (35° to 40°), the crest of this fold was affected by erosion factors forming the Wadi Hamama.

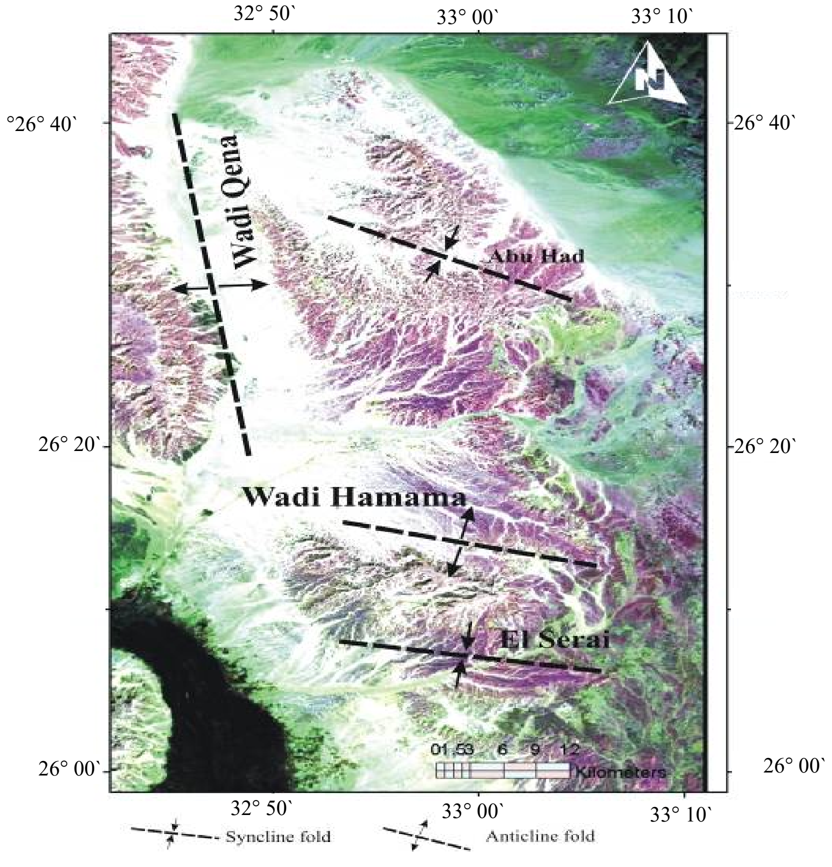

Figure (7): Landsat image showing the recorded folds at the study area.

4.1.3. El Serai syncline:

El Serai syncline lies to the east of Qena City and occupies Gabal El Serai. The axis of the concerned syncline runs in a WNW-ESE direction for a distance of about 30 km. It is built up of Upper Cretaceous sandstone interbedded with shale, Paleocene shale and Lower Eocene limestone, while the Pliocene deposits cover a part of its western and eastern flanks. It has gentle dips (3° to 8°) toward the axial plane (Aggur, 1997). It is worth mentioning that the Upper Cretaceous sandstones are exposed on the surface at both the southeastern and southwestern portions of this syncline due to faulting processes. The old strata are well preserved from the weathering activities by a cover of thick hard Lower Eocene limestone of about 250 m thick (Fig. 7). The different fold axis trends at the area under investigation can be interpreted as two different deformation events in the two different ages.

4.1.4. Abu Had syncline:

Abu Had syncline is recognized at Gabal Abu Had. Its axial trend runs in a NW-SE direction for a distance of about 40 km. It is built up of a sedimentary succession ranges from the Upper Cretaceous Quseir variegated shale at the base to the Lower Eocene hard limestone at the top (Fig. 7). The limestone covers protects the tilted succession in the syncline from the erosion processes. The two flanks of this syncline were affected by fault systems having parallel trend with the axial plane. The syncline has a gentle dip (2° to 4°), while the dip increases up to 23° at the faulted parts (Aggur, 1997).

4.2. Unconformity surfaces:

Three different main types of unconformities have been recorded in the study area, the first one is the disconformities between the Armant Formation (Early Pleistocene) and the overlying fanglomerate (Late Pleistocene) in Wadi Jurdi (Fig. 4D). The second type is the angular unconformity between the Lower Cretaceous rocks (Malha Formation) and the Upper Cretaceous rocks (Taref Formation) at Wadi Um Umayied (Fig. 8A). Finally, The nonconformity between the basement rocks and the overlying sedimentary Paleozoic rocks (Naqus Formation) at the western side of the Red Sea mountainous terrain at the northern part of Wadi Qena (Fig. 8B).

4.3. Structural lineaments analysis:

Structural lineaments analysis of the study area is carried out to throw more light and bring up a better understanding for the major structural trends. This study is based mainly on field check and detailed investigation of the digitally enhanced Landsat-7 ETM+ imagery with scales (1:100 000), as well as the geological maps at scales of 1:100,000, 1:250,000 and 1:500 000. The structural lineaments of the study area comprise several structural elements, which have different styles, sizes and deformational magnitudes, as a complex tectonic history (Fig. 9 A). The study area is influenced by the tectonics in the Gulf of Aqaba and Gulf of Suez provinces and it is crossed by two fault systems (NW-SE and NE-SW) cutting each other (Fig. 9 B). The structural lineaments of the study area are related to Middle and Late Pan-African orogney; related to the formation of Red Sea and Gulf of Suez in the Oligo-Miocene time and the structural lineaments related to Pliocene Aqaba trend. Most of the post-Precambrian structures were developed along old fractures of Precambrian age and later rejuvenated and reactivated during the successive geological times (El Khashab, 2007).The analysis of the data shows that most fault trends are NE-SW, NW-SE, ENE-WSW and N-S (Fig. 9B).

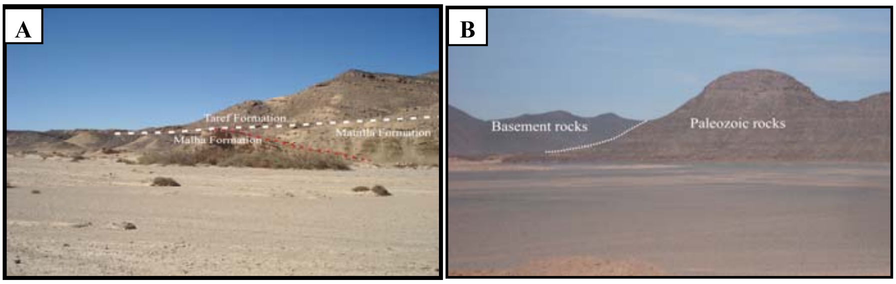

Figure (8): Field photograph showing the angular unconformity between the Lower Cretaceous (Wadi Qena Fm. A) and Upper Cretaceous (Rakhyat Fm.) at Wadi Um Umayied, and nonconformity between the Precambrian basement rocks and the overlying sedimentary rocks in the northern part of Wadi Qena (B).

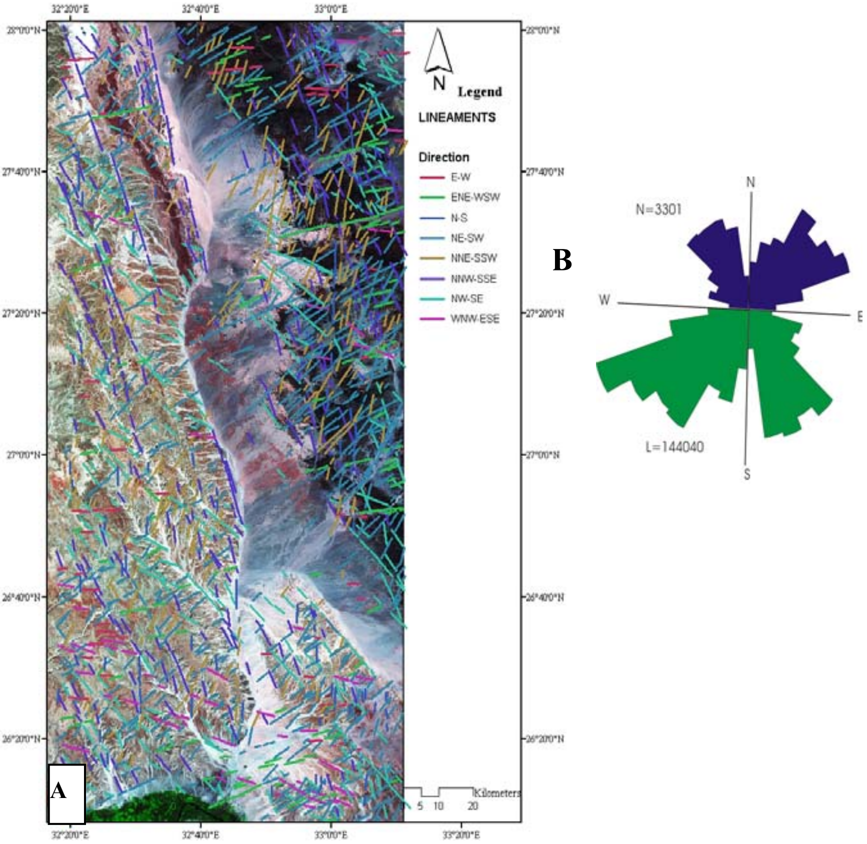

Fig. (9): Structural lineaments map (A) with azimuth frequency of rose diagram (B) of the study area.

4.3.1. NE-SW faults.

The NE-SW fault trend is the most predominate in the study area and it has short lengths, small throws and small throw length ratios. The Cross Fault System (NE-SW) is clear in the study area as in the eastern part of Wadi Qena in the core of Wadi Abu Hammad, Wadi Um Balad, Wadi El Musdar and Wadi Abu Jizil. Also at Gabal Abu Had there is normal faulting between the fanglomerate (Late Pleistocene) in the downthrown side and Dakhla Formation (Late Cretaceous) and Tarawan Formation (Paleocene) in the upthrown side of the fault. The direction of this fault is N40°E (Fig. 10A). In addition, the study area has been affected by several NE-SE faults especially in its northern part and Wadi Um Umayied (Fig. 10B).

4.3.2. NW-SE faults.

The NW-SE trend represents the third predominates faults in the study area, and it seem to dissect the area particularly in the western part of Wadi Qena. These faults are recorded in the Cretaceous, Eocene, Pliocene and Quaternary rocks. The Northwestern–Southeastern oriented faults have relatively small angles of dip; large throws and moderate throw length ratios. They mainly control the major wadis of the study area (e.g. Wadi El Jurdi El Kabeer, Wadi Shahdeen, and Wadi Um Umayied) and affect the Eocene limestone plateau. Moreover, there is also one normal fault at Gabal Abu Had which separates the Tarawan, Esna Formations (Paleocene-Early Eocene) and Thebes Formation (Eocene) in the downthrown side and Dakhla Formation (Late Cretaceous), Tarawan Formation (Paleocene) and fanglomerate (Late Pleistocene) in the upthrown side of the fault (Figs. 10C, D and E).

4.3.3. ENE- WSW faults.

The ENE- WSW oriented faults represent the most predominant trends forming about 34 % of the detected faults in the study area. These faults are mainly normal, and they are present as step faults. Faults belong to this trend were recorded in the Precambrian, Cretaceous, Paleocene and Pliocene rocks. The ENE-WSW faults represent the major trend and have relatively small angles of dip. Also, these faults play an important role in the present of some main wadis trending N 60°-70° E in the study area (Figs. 11A and B).

4.3.4. N-S faults.

The North-South Fault System has limited number and represents the oldest system in the Eastern Desert of Egypt together with the East-West fault trend (Ammar, 1973). This fault system had been originated by deviating the N 10° W compression force by about 10° towards the west which are responsible of forming the fold structure (Youssef, 1968) and developed after the emplacement of the late orogenic plutonites (Ghanem, 1968). These faults extend from south of Luxor in Gabal Rakhamiya northward past the shattered little hill of El Qurn at the mouth of Wadi Matuli and further through Gabal Serai to Gabal Abu Had at the mouth of Wadi Qena. Toward the north, at Southern Galala, the northern part of the study area North-South faults dissect this mountain into a complex pattern of grabens and horsts along the planes of which many basalt dikes and volcanic flows have been observed. The area separated the Southern Galala and that of Luxor-Gabal Abu Had is occupied mainly by Wadi Qena, (Picard, 1939, Tromp, 1947 and Henson, 1951). N-S faulting is considered as the most minor fault trends and its orientation varies from N 05°-15° E to N 10°-15° W. In the central part of Wadi Qena, and in its western boundary, there is a major fault between the Thebes Formation (Eocene) and the Duwi Formation (Campanian). This fault has N 10° W trend (Fig. 11C). Also in Wadi Um Umayied, several N-S oriented faults have been detected. Two N 13° E oriented normal faults have been observed forming a graben structure (Fig. 11C).

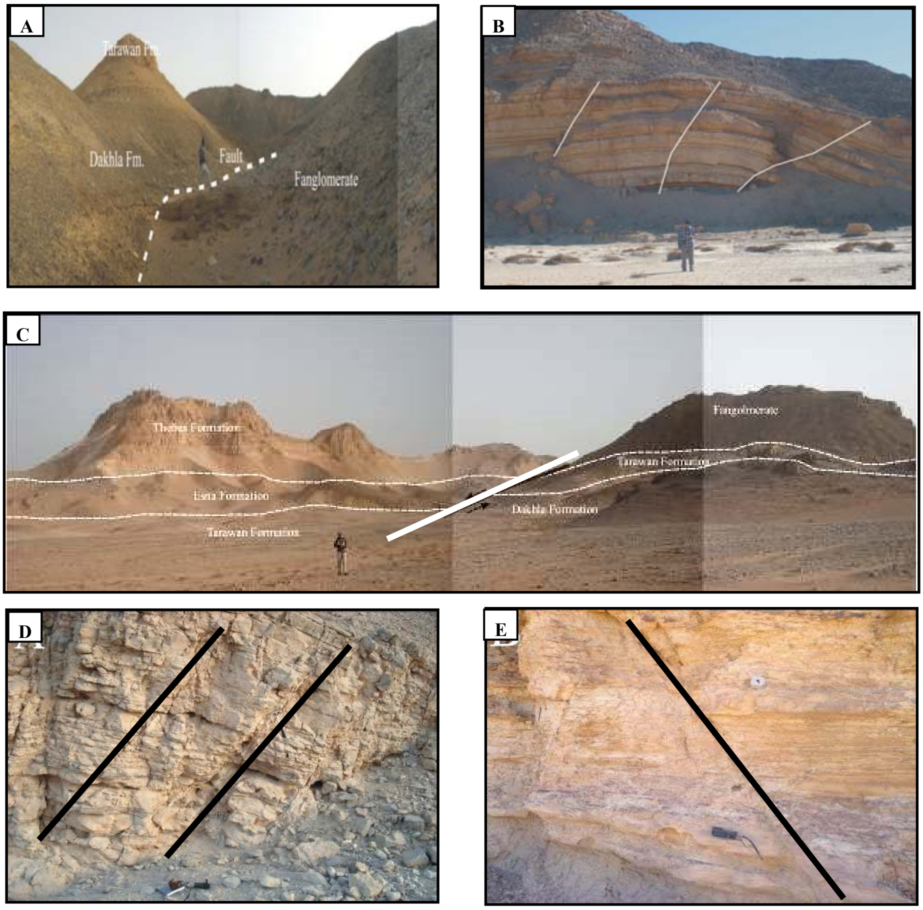

Figure (10): Field photograph showing the N 50° E oriented fault up throwing the Tarawan and Dakhla Formations and down throwing the Fanglomerate in Gabal Abu Had (A), N50°E and N55E oriented step faults dissecting the Matulla Formation in Wadi Um Umayied (B), N25°E oriented normal fault in Wadi Abu Had (C), N20°W oriented normal fault dissecting the Thebes Formation in Wadi Qena (D) and N25°W reverse fault cross cutting Malha Formation in Wadi Um Umayied (E).

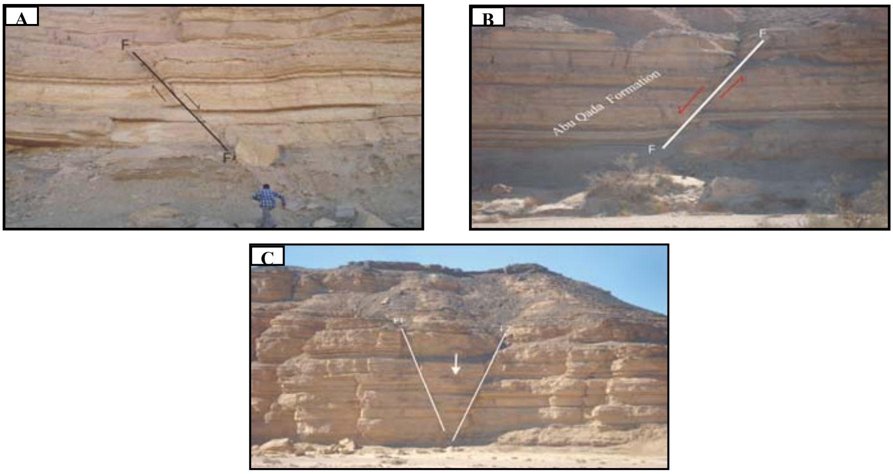

Figure (11): Filed photograph showing the N 70° E oriented normal fault cross dissecting Abu Qada Formation (A), N55°E and N60°E oriented normal fault dissecting the Abu Qada Formation (B) and N13°E oriented graben forming faults dissecting the Matulla Formation (C) in Wadi Umm Umayied area (C).

4.4. Strike-slip faults:

The strike-slip faults are easily recognized on the digital enhanced images. On the ETM+ images, direct observations of strike-slip offset, as well as correlation of marker beds is attempted to identify the horizontal movement along these faults. The most dominant strike-slip faults in the present study are trending NE-SW, ENE-WSW and NW-SE, while the nearly N-S and E-W fault trends are less common. These faults are mainly characterized by left-lateral (Sinistral) displacement, although some faults have right-lateral (Dextral) displacement. The best example for the right-lateral (Dextral) displacement is recorded at Wadi El Mudsar in the northern and eastern limits of Wadi Qena. It runs in a NE-SW direction from Red Sea Mountain to Wadi Qena (Fig. 12A). Another ENE-WSW oriented right-lateral (Dextral) fault runs along Wadi Fattiera in the southern part of Wadi Qena (Fig. 12B). The best example for the left-lateral (Sinistral) fault is noted in Wadi Um Umayied in the northern and western limits of Wadi Qena. It runs in a NW-SE direction from El Maaza plateau to Wadi Qena dissecting the Cretaceous rocks (Fig. 12C). Another left-lateral fault along El Sheikh Fadl-Ras Gharib in the northern limit of Wadi Qena (Fig. 12D).

5. Wadi Qena risk hazards:

5.1. Flash flood:

Estimation of flooding and feeding probabilities for drainage basins within the study area are studied according to EI-Shami method, (1992), which depends on some hydrological parameters as the bifurcation ratio (Rb), stream frequency (F) and drainage density (D). According to these parameters (table 4) the basins can be classified into three classes.

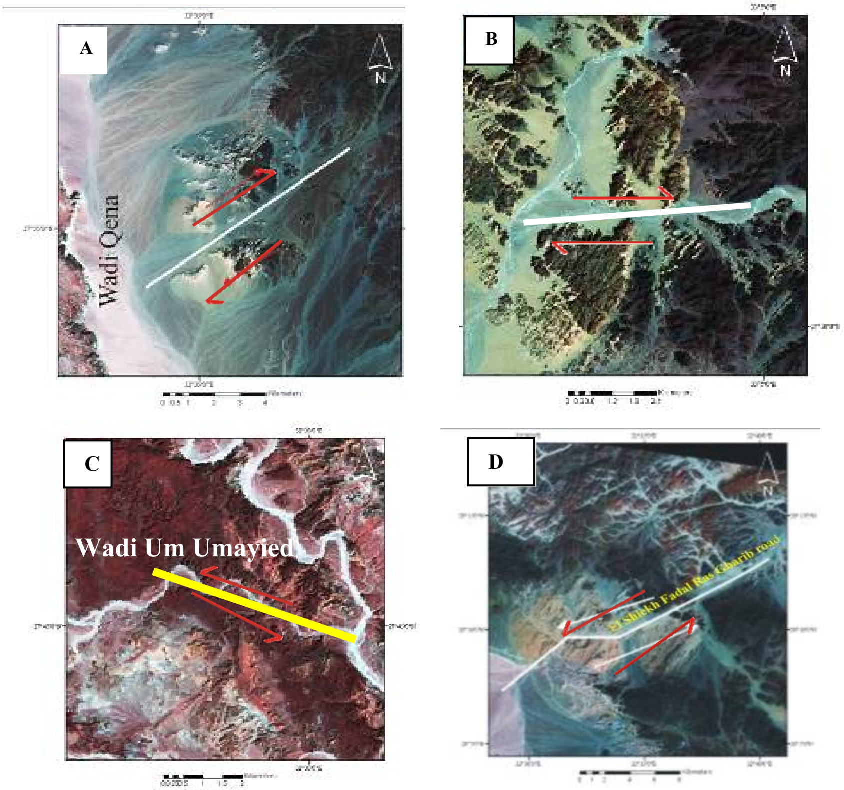

Figure (12): Landsat images showing NE-SW oriented (A), and ENE-WSW oriented faults (B) right-lateral (Dextral) faults, NW-SE oriented (C) and NE-SW oriented faults (D) left-lateral (Sinistral) faults in study area.

Class A: basins of high Rb and low F and D may represent ideal areas for feeding the pervious units with the least chance for flash flooding. Class B: basins of low Rb and high F and D may indicate areas of high flooding probabilities with the least feeding chance to the exposed units even when pervious in the second set of basins, the bridling of flash floods and increasing the recharge possibilities require constructing suitable controlling systems. Class C: includes all basins that disobey one or two of the boundary conditions (El-Shami, 1992a). By applying this method on the studied basins, it is clear that five basins (Wadi Lessan El Bakker, Wadi Fattiera, Wadi Zubir, Wadi Hawayshiyah and Wadi El Qaryyah) belong to Class A which may reflect appropriate geologic and geomorphologic setting with good chances of downward recharge to the existing shallow aquifers that may form important water resource in such remote areas. Class B includes four basins (Wadi Um Lisayfah, Wadi El Jurdi, Wadi Harrabah and Wadi Um Jalwa). Areas of these basins may reflect the highest flooding probability and the least groundwater potentiality. Class C includes the remains of the Wadis in the study area, which may involve areas of moderate groundwater potentialities and flooding probabilities as well.

5.2. Evaluation of flash flood hazard:

Depending on the studied morphometric parameters of Wadi Qena drainage basin an assessment for the degree of hazard due to flooding has been estimated. Nine parameters have direct impact on the flooding processes have been analyzed. Eight of these parameters are directly proportional to the hazard degree, including watershed area (A), drainage density (D), stream frequency (F), shape index (Tsh), ruggedness number (Rn) and texture ratio (Rt), slope index (SI) and relief ratio (Rr). On the other hand, one parameter has an inverse relation with the hazard degree. This is the weighted mean bifurcation ratio (WMRb). A scale number for the hazard degree starting with (1) lowest to (5) highest, has been calculated by (Davis, 1972). Estimated degree of hazards ranging from moderately hazardous (Wadi Harraba and Wadi Um Lisayfah), slightly hazardous (it is represents most of sub basins at the study area) and weakly hazardous (Wadi El Qarreiyah and Wadi Ar-Rakabah). The values of actual hazard degrees of each morphometric parameter of the studied basin have been tabulated in Table (5).

5.3. Flood prediction:

Flood prediction represents an attempt to say whether a flood of particular magnitude will occur during a specified future time span. There are three different methods used to predict the floods. It is based on the study of reoccurrence intervals (return periods) of foods which have been recorded in the past. Table (6) shows the floods that happened in the area during the last 50 years (Kariem, 2000).

The hazardous probability of the different basins in the area was determined using El-Shami's model (1992a) considering the relation between bifurcation ratio, drainage density, and drainage frequency. In the current study the hazard probability method was used. Two different diagrams were used to determine the hazard degree for each basin in the area (El-Shami, 1992b). Figures 13a and b show the relation between bifurcation ratio with drainage density and drainage frequency respectively. Both diagrams include three fields A, B, and C; high, moderate and low possibility for floods respectively. If the same basin has two different fields most conservative situation were chosen. The hazard degree according to basin number is summarized in Table (7).

By applying this method on the studied of sub-basins at the studied area, show class A included 2 basins (Wadi Um Lisayfah and Wadi El Jurdi). The area of these basins may reflect the highest flooding probability and the least groundwater potentiality. 9 basins in the study area (Wadi Abu Sayyal, Wadi Abu Had, Wadi Harrabah, Wadi Um Balad, Wadi Abu Sulimat, Wadi Fattiera El Zarka, Wadi Zubir, Wadi Abu Nijila and Wadi El Qaryyah) are belonging to class B, which may involve areas of moderate groundwater potentialities and flooding probabilities as well. Class C included the remain wadies in the study area, which may reflect appropriate geologic and geomorphologic setting with good chances of downward recharge to the existing shallow aquifers that may form important water resource in such remote areas.

Table (5): Summary of the morphometric parameters, hazard degrees and types of the studied basins

Wadi name	Area (km^2)	Density	Frequency	Relief Ratio	Ruggedness	Texture Ratio	Shape Index	slope index	WMBR	Average of Evaluation	Hazard Degree	Type of hazard
Abu Had	240	2.73	1.93	2.48	2.41	2.21	2.6	1.07	3.47	20.41	2.26	Slightly hazardous
Abu Hammad	290	3.02	2.24	1.64	1.73	2.55	2.24	1	3.53	19.58	2.17	Slightly hazardous
Abu Jizil	230	2.87	2.1	2.62	2.63	2.32	2.63	2.78	5	24.39	2.71	Slightly hazardous
Abu Nijila	87	2.9	2.1	3.46	3.5	1.97	3.8	3.71	3.87	26.51	2.94	Slightly hazardous
Hawayshiyah	642	2	1.45	1.62	1.4	2.62	4.32	1.84	3.29	21.05	2.33	Slightly hazardous
El -Qaryyah	241	1.8	1.33	1.64	1.33	1.68	4.45	1.83	1.41	16.99	1.88	Weakly hazardous
Abu Harraba	40	2.9	2.13	5	5	1.06	2.6	5	2.4	27.09	3.01	Moderately hazardous
El -Jurdi	1191	4.71	4.25	1.08	1.42	5	1.62	1.36	1.67	24.97	2.77	Slightly hazardous
Lessan- El baker	293	1	1	2.34	1.31	1	2.13	2.56	4.76	18.04	2	Slightly hazardous
Zubir	290	1.56	1.2	2.76	1.86	1.65	3.32	2.93	2.6	19.66	2.18	Slightly hazardous
El-Mudsar	105	2.87	2.1	2.77	3.04	1.61	2.18	3	5	23.75	2.63	Slightly hazardous
Shahdeen	615	2.7	2	1.77	1.77	2.08	2.4	1.84	4.78	21.78	2.42	Slightly hazardous
Um_Khurm	50	3	2.21	2.76	2.88	1.17	2.07	2.88	0	18.03	2	Slightly hazardous
Um El kharouf	180	2.65	1.92	2.77	2.74	1.95	2.81	3.02	2.23	21.46	2.38	Slightly hazardous
Um Jalwa	55	3.6	2.92	2.06	2.5	1.74	1.5	2.19	4.75	22.57	2.5	Slightly hazardous
Um lisayfah	140	5	5	2.06	3.22	3.36	2.56	2.27	4.72	29.62	3.29	Moderately hazardous
Um Balad	240	2.61	1.9	3.13	3	2.11	3.15	3.24	3.43	24.04	2.67	Slightly hazardous
Um-Umayied	883	3.21	2.42	1.64	1.82	4.47	2.56	1.91	4.15	25.28	2.8	Slightly hazardous
Fattiera	400	1.71	1.3	1.08	1	2.27	5	1.35	2.94	18.56	2.06	Slightly hazardous
Umm Sulimat	160	2.68	1.94	2.06	2.02	1.99	2.83	2.64	1.03	18.56	2.06	Slightly hazardous
Abu Sayyal	595	2.91	2.14	0	0	3.92	3.72	2.47	2.6	20.16	2.24	Slightly hazardous
Ar-Rakabah	110	3.07	2.28	0	0	2.31	3.54	0	3.58	16.12	1.79	Weakly hazardous

Table (6): Frequency of the floods of Upper Egypt and Red Sea areas.

Area	Flood date	Number	Period range
Sohag	1950, 1966, 1967, 1968, 1969, 1975, 1980, 1985, 1994	9	2 – 9 years
Assiut, Luxor, Aswan, Hurghada and El Quseir	15-20/10/1979, 15-16/10/1987, 12-13/10/1991, 1-2/11/1994, 17-18/10/1997, 19-21-1-2010	6	2 - 13 years

Table (7): Hazard degree assessment for each drainage basin in the area (based on El-Shami, 1992b).

Wadi Name	Rb vs F and Rb vs D	Total
Abu Hammad, Um Umayied, Ar-Rakabah, El Musdar, Lessan El Bakker, Shahdeen, Um Khurm, Um El kharouf, Hawayshiyah, Um Jalwa and Abu Jizil.	L	L
Abu Sayyal, Abu Had, Harrabah, Um Balad, Umm Sulimat, Fattiera El Zarka, Sabir, Abu Nijila and El Qaryyah	M	M
Um Lisayfah, El Jurdi, and Qena	H	H

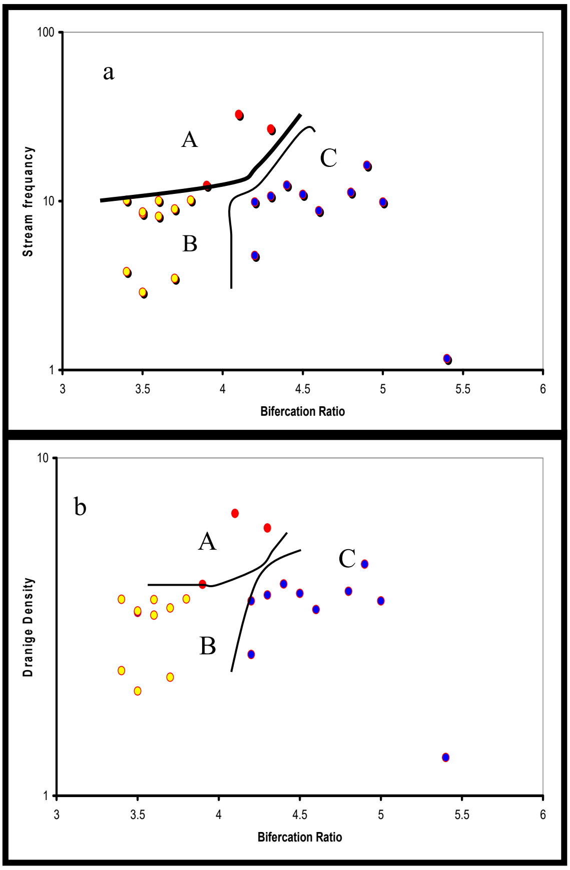

Figure (13): Bifurcation ratio vs. drainage frequency (a) and drainage density (b).

By applying this method on the studied of sub-basins at the studied area, show class A included 2 basins (Wadi Um Lisayfah and Wadi El Jurdi). The area of these basins may reflect the highest flooding probability and the least groundwater potentiality. 9 basins in the study area (Wadi Abu Sayyal, Wadi Abu Had, Wadi Harrabah, Wadi Um Balad, Wadi Abu Sulimat, Wadi Fattiera El Zarka, Wadi Zubir, Wadi Abu Nijila and Wadi El Qaryyah) are belonging to class B, which may involve areas of moderate groundwater potentialities and flooding probabilities as well. Class C included the remain wadies in the study area, which may reflect appropriate geologic and geomorphologic setting with good chances of downward recharge to the existing shallow aquifers that may form important water resource in such remote areas.

Flash flood prone wadies (dry channels cut into the terrain) can be assessed and delineated through the use of GIS. As a part of the research project, this methodology was used to determine the hazard of flash floods in each basin in Qena area, for the analysis and creation the hazards map. The attribute table for the drainage basins was added to the GIS database in building the drainage basin hazard map and is classified into high, moderate, and low hazard basins. The risk map of the study area after analyzing the results of El Shami method of hazard degree assessment and the results of the morphometric analyses for each drainage basin in the area are applied in GIS layers. The two circles in figure 6 represent the most dangerous zones in the study area, so the entire development plan should avoid these buffer zones. It is found that the flash flood which runs along Wadi Shahdeen and Wadi El Jurdi has high risk on the different projects at the study area. Consequently, there are many cities and future projects will be affected by flash flood and a protect policy should be taken at this zones for human safety, development a new residentional areas, constructed roads, cultivated land and other projects.

6. Change detection and land-use map predication for the study area:

The change detection of images provides information about the change that occurs at Qena City for the same location during different times (Fig. 14A and B). The aim of the land-use map at the study area is for the increasing of the population there and developing the low land zone at the wadi such as agriculture, reclamation, urbanization and build up some safari area along the eastern side of the study (Fig. 15). Soil in this area is mainly composed of silt, sand and limestone gravels with a thickness ranging from 1.5 to 2m which it is suitable for agricultural activates. More than 220000 feddans, can be used for agricultural activity if the Egyptians Government develop the water sources for this area by drilling wells from quaternary aquifer. Beside the agricultural activities the study area is rich with many economic rocks which are useful for developing and building the new cities such as sandstone, limestone and gravels as well as the exporting materials such as phosphates and talc which are used for many industry manners. The authors suggest many locations for new cities along Wadi Qena which accommodates the residential and the industrial activities as shown in (Fig. 15) which required for developments.

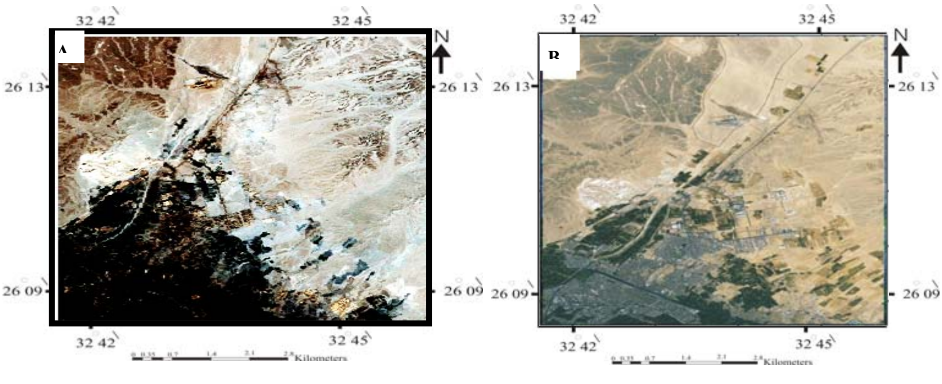

Figure (14): Land-use changes in the southern part of Wadi Qena using Landsat (ETM+) images in the year 2000 (A) and in 2010 (B).

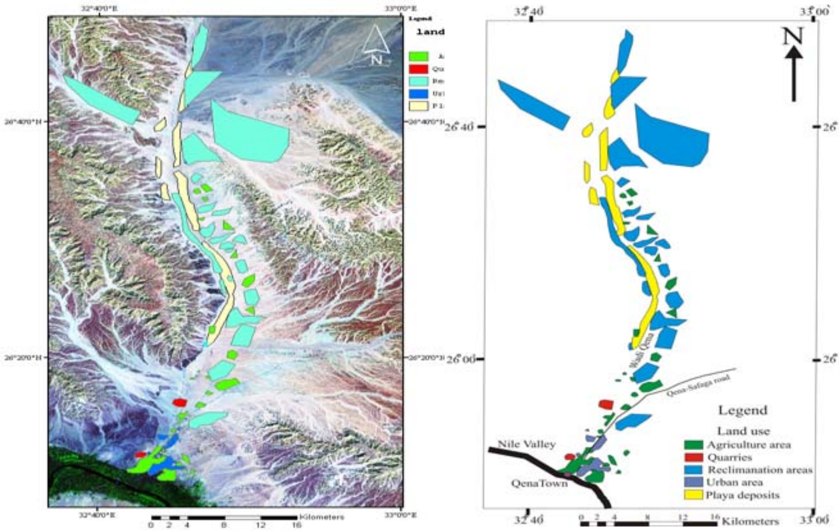

Figure (15): Landsat Image overlies the vector layer of the land-use areas at Wadi Qena.

7. Conclusion:

The area under investigation shows that Wadi Qena is affected by folding and main predominant fault trends (NE-SW, NW-SE, ENE-WSW and N-S). The authors notice that Wadi Qena is located between two different drainage basins which come from the Nile River at the west, and the Red Sea Mountains at the east and it is suitable for agricultural development. The natural risk located at Wadi El-Jurdi and Wadi Shahdeen can be decreased by building some dams at the downstream parts. The presence of some economic materials such as sand, limestone, and gravels can be very useful for the developing and building up the future cities.

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