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Flash Flood Risk in West- Central Sinai, Egypt

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FOUR drainage basins of the unique watershed regions of west-central Sinai have been decided on to look at the flash flood hazards. Using the latest topographic maps, the drainage basins, the hydrologic, topographic and morpho-tectonic parameters have been generated from the elevation thematic layer namely; the virtual elevation model (DEM) turned into appropriately decided and analyzed. The carried-out technique discovered that the hydrologic and morphometric parameters play essential roles in flash flood contributing factors. The low slopes regions are related to low runoff linked and excessive sediment accumulation.

Integration of hydrologic indices, sediment transport, and topographic wetness indices with morpho-tectonic parameters to provide sedimentation related to flash floods are the principle objectives.

This working illustrated the remote sensing data are important tools in flood assessment and management,helping the city the urban planner for destiny development.

Keywords: Topographic parameters, Hydrologic indices, Morpho-tectonic, model of digital elevation, Flash flood, Gulf of Suez.

Introduction

The water scarcity is a number one socio-monetary disaster in Sinai Peninsula of Egypt. Lack of sources of water making plans brought about the drastic dropdown in the Sinai populace improvement. Drought management, sustainable agricultural production in the regions of semiarid arid and arid of Sinai deserts will rely on meticulous making plans in the water sources exploration for human requirements.

The hydrogeological situations improvement of west-central Sinai of Egypt has a great wonderful precedence of the Egyptian authorities concerns. So, unique and big efforts are committed on this aspect.

The west-central basin is taken into consideration because the promising areas of the Egyptian coasts for likely improvement. The groundwater represents the backbone of any development sports on this region. The groundwater occurrences in west-central Sinai are in particular controlled through managed by the climatic situations, geomorphologic functions, landforms and the geologic placing of the water-bearing formations.

In west-central Sinai basin, the groundwater is to be had from exclusive water-bearing formations under different hydrogeologic situations. These unique situations replicate reported variations neighborhood morphologic, topographic, lithologic and structural functions. These functions manage the groundwater occurrence, motion and quality.

An arid weather and missing adequate flood control structures are the principle caustic flash flood activities in semi-arid and arid region. This

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working is numerous flooded activities at some point of beyond decades.

The towns or lodges and connecting roads are seasonally subjected to flash hazards. The flood precipitated screw ups at the structures have been constructed at the side of caused disasters on the constructions which have been built along with their ways. Avoiding such screw ups calls for placing a few measures primarily based totally on quantitative research of the disasters requires putting some measures based on quantitative studies of the hydrographic basins.

The goals of this work are to set up maps incorporating hydrologic indices and morpho-tectonic parameters to pick out the capacity sediment accumulation. Integration of hydrologic indices, topographic wetness and sediment transport indices with morpho-tectonic parameters to supply and hit upon sedimentation related to flash floods.

Study of Physiography

This vicinity of examine occupied the western side of the Gulf of Suez alongside Sudr-Gharandal Stretch (Fig. 1). The worried area attains approximately fifty-five Km from north to south, at the same time as from west to east, it averages 60 Km. Thus; the vicinity covers of about 3240 Km^2. The present area is bounded through Longitudes 32° 40’ and 33° 20’ East and Latitudes 29° 10’ and 29° 52’ North.

The Sinai Peninsula is part of the Arabo-Nubian shield foreland and regularly dips northward (Said, 1962). The structural placing of the west Sinai area indicates that the faulting system is device is a great deal mentioned extra than folding (Abdallah et al., 1992).

Generally, the Sinai area is prominent through very arid weather with most important seasons. The wintry weather months are from November to March. However, the midnight temperature can drop to about 12°C. According to Penman’s formula (Ayyad and Ghabbour, 1986), Sinai lies in an exceedingly arid belt of North Africa and belongs to the Saharan-Mediterranean weather region. The Sinai area is classed as extraordinarily arid (P/EP< 0.03), in which P is the once a year precipitation and EP is the ability evapotranspiration.

Meteorological aspects

The weather of the pilot area is characterized with the aid of using excessive aridity with lengthy warm long hot and rainless summer time season, excessive, usually energetic winds.

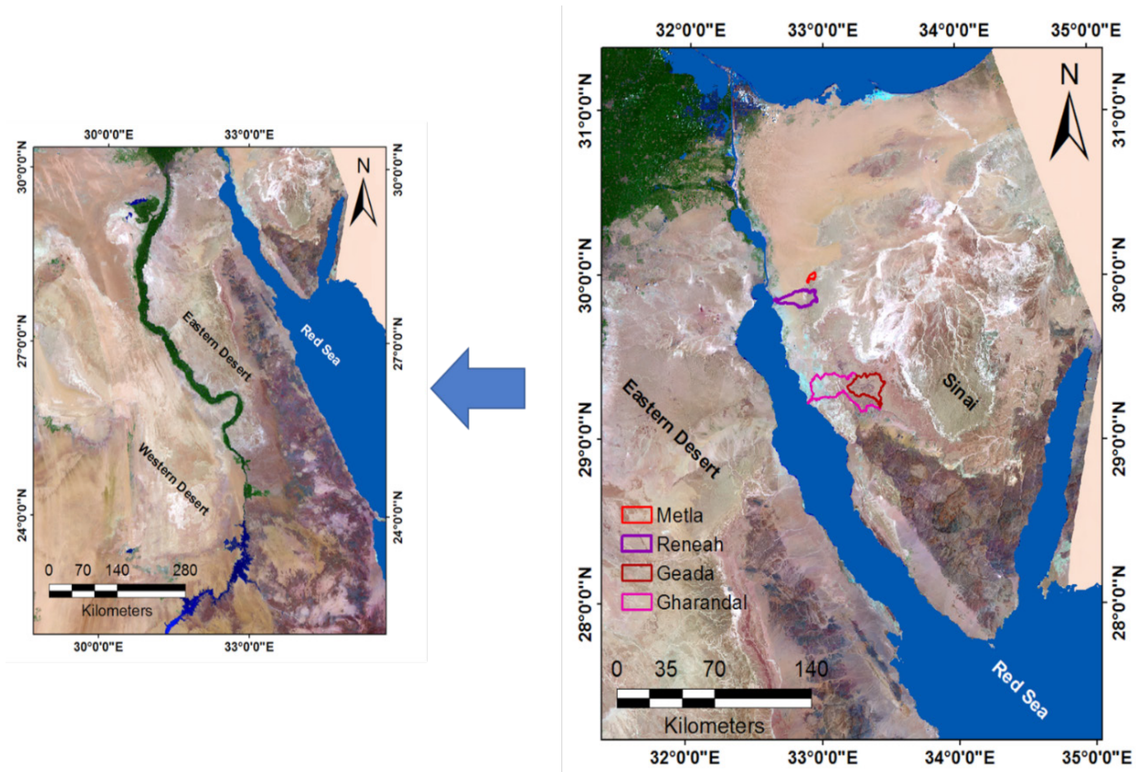


Fig. 1. Location map of the studied area.

The rainfall intensities lower from north to south, wherein the suggest rainfall is ready mean is ready 1.97 mm/year at Suez and 0.78 mm/year at El Tor. The intensity of rainfall reaches its most price in November-February. Figure 2 suggests the 100-years maximum daily storm height of Sinai.

The air temperature at Suez reaches its maximum value of 36.5 ºC in July and its minimum value of 8.7 ºC in January, wherein the suggest annual temperature ranging between 22.5 ºC at Suez and 22.8 ºC at El Tor. The intensities of evaporation boom from north to south and variety among 14mm/month and 4.8mm/month at Suez.

The wind in southern Sinai is variable directions wherein in summer time season north winds be successful with a pace of, where in summer north winds prevail with a velocity of 25m/sec. In winter, southern winds with a velocity of 830m/sec. The most relative humidity percentage recorded at Suez is 59% even as the minimum value is 61%. At El Tor it reaches 64% and 58% respectively.

Materials and Methods

The drainage community became delineated through the Arc Hydro tool, the information of Shuttle Radar Topography Mission (SRTM), with 90 m spatial resolution, Landsat ETM+ information with 30 m spatial resolution (band 1, 2, 3 and 4). The topographic and geological maps with a scale of 1:250,000 and 1:50,000, were used to illustrated the distribution of different units. The Arc Hydro device of ArcGIS 10.4 became used to differentiate a basis for acquiring a deeper know-how the drainage and watershed system. Terrain pre-processing used for developing watershed basin. The digital elevation model (DEM) strategies for extracting the drainage community have been following the literature of Morris and Heerdegen (1988), Tarboton et al. (1991), Gurnell and Montgomery (2000), Maidment (2002) and Ghoneim and El-Baz (2007).

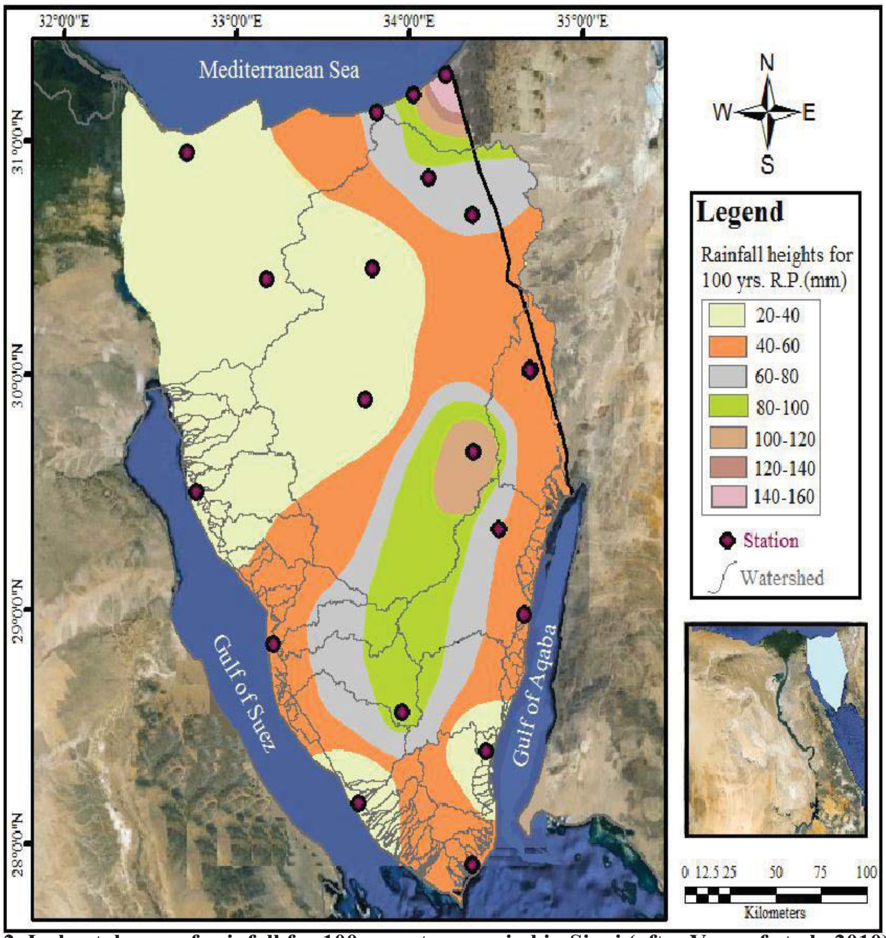


Fig. 2. Isohyetal map of rainfall for 100-yr. return period in Sinai (after Youssef et al., 2010).

The following features are involved with terrain pre-processing:

(1) The 'Fill Sinks' function eliminates sinks in a DEM grid. The characteristic takes SRTM as enter records and produces a grid 'Hydro DEM' as an output. The maximum complicated steps in the drainage extraction method is filling the pits.

(2) The Flow Direction characteristic function takes 'Hydro DEM' records, and computes the corresponding go with the drift path grid. This grid values in the cells suggest the steepest descent from that cell, which making use of the 8-go with the drift path set of rules of Fairfield and Leymarie (1991).

(3) The creates a Stream Grid depends on the Stream Definition function, which takes a flow accumulation grid as input. The stream grid could have a price of '1' for all of the cells in the input which have a price extra than the given threshold.

Geomorphic Units

Shata (1955) divided the Sinai Peninsula into 5 primary geomorphologic units. The Southern mountainous unit, the Tih-Egma unit, the conspicuous hilly unit, the Northern Mediterranean undeniable unit and the Gulf of Suez coastal undeniable unit. The later coastal plain unit became subdivided into two subunits; the northern and southern respectively.

The southern part of Sinai is occupied via way of means of the excessive mountains complex, which incorporates Gebel Catherina (2,641 m amsl), Um Shomar (2,586 m amsl) and Serbal (2,070 m amsl). The notable Egma limestone plateau takes place to the north of this mountain mass, which slopes from greater than 1,000 m downwards to the Mediterranean Sea. The southern mountainous is tremendously dissected via way of means of watersheds draining both to the gulfs of Suez or Aqaba, whilst the most drainage basins of the northern plateau are debouching northwards to the Mediterranean Sea.

Landforms

The subject investigations, topographic and geologic maps to be had aerial pictures photographs it turned into determined the subsequent landforms are triumphing in the pilot area; 1) The uplands (watershed areas), which blanketed the dissected tableland and the hilly terrain, 2) The hydrographic basins (water collectors), which blanketed the drainage basins and the open plains and 3) The Gulf of Suez coastal plain.

Due to their significance regarding groundwater potentialities, the essential basins are qualitative. They are represented with the aid of using Wadi Gharandal, Geada, Metla and Reneah. that have the subsequent not unusual place which have the following common characteristics; 1) Topographically excessive watershed region, starting at the extreme eastern portion of the dissected tableland, at an elevation exceeding seven hundred m above sea level, 2) Long consequents trunk channels (exceeding 50 Km in length) of the northeast and east-west directions, with a few deflection especially on the meanders. Angularity takes area in limestone terrains because of fracturing influence, 3) High degree of integration and bifurcation, with next and re-sequent tributaries of the northeast and east-west trends.

Piedmont

This is the vicinity of carbonate rocks at the foot of the elevated plateau which attains 600m above sea level. The piedmont has a confined volume and is managed via way of means of vintage structures, which might be chargeable for many geomorphic capabilities and additionally the form of the aquifer.

Flood Plains

These are the areas of mild slope which might be included via way of means of clays and sands. They encompass suitable soils suitable for cultivation. The pilot place has a narrow coastal strip parallel to the Gulf of Suez and included by the following; 1) Calcareous dune sands in the northern component and quartzes in the eastern part and stabilized by of means of vegetation, 2) Dry salt marsh, which incorporates salty gypsum, sandy clay which included via way of means of skinny salt crust and has tolerant plant life and 3) Cracked muddy plain: It made from very coarse sand and clay which paperwork a cracked crust.

Characteristics of drainage basin

The place is split into four wadis namely, Wadi Gharandal, Geada, Metla and Reneah. The virtual elevation version indicates elevation model shows the Wadi Gharandal ranges from zero m to 1200 m amsl (Fig. 3), Wadi Geada altitudes variety from three hundred m amsl. (Fig. 4), in Wadi Metla levels from 250 m to six hundred m amsl (Fig. 5) and Wadi Reneah levels from zero to 750 m amsl (Fig. 6).

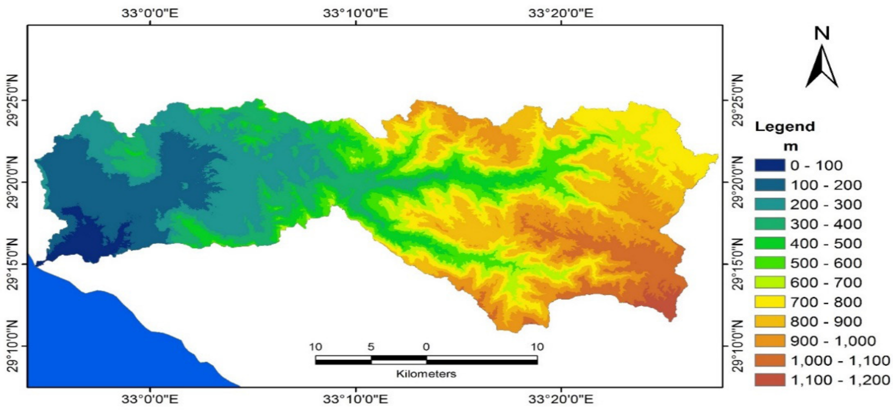


Fig. 3. Digital elevation model of Wadi Gharandal.

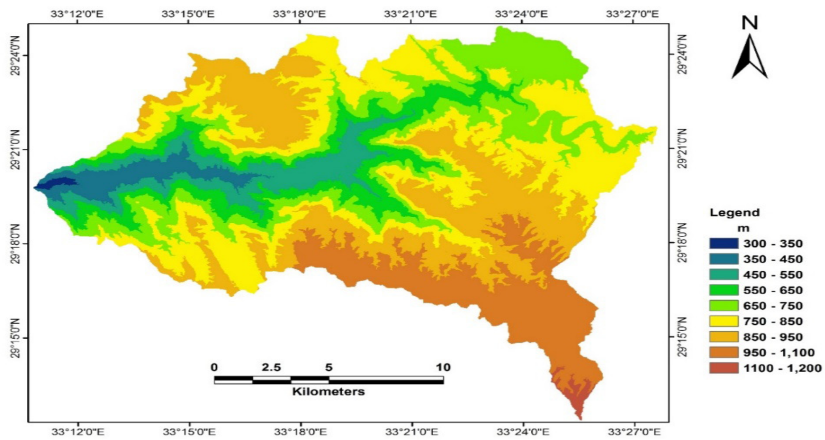


Fig. 4. Digital elevation model of Wadi Geada.

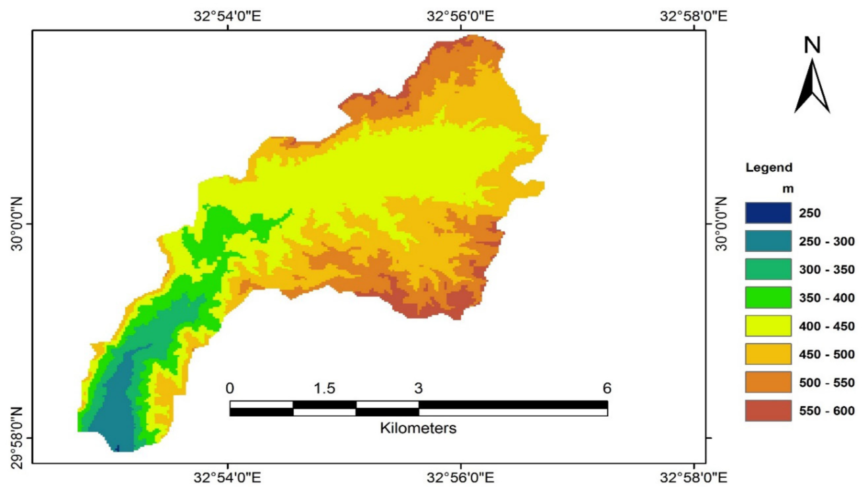


Fig. 5. Digital elevation model of Wadi Metla.

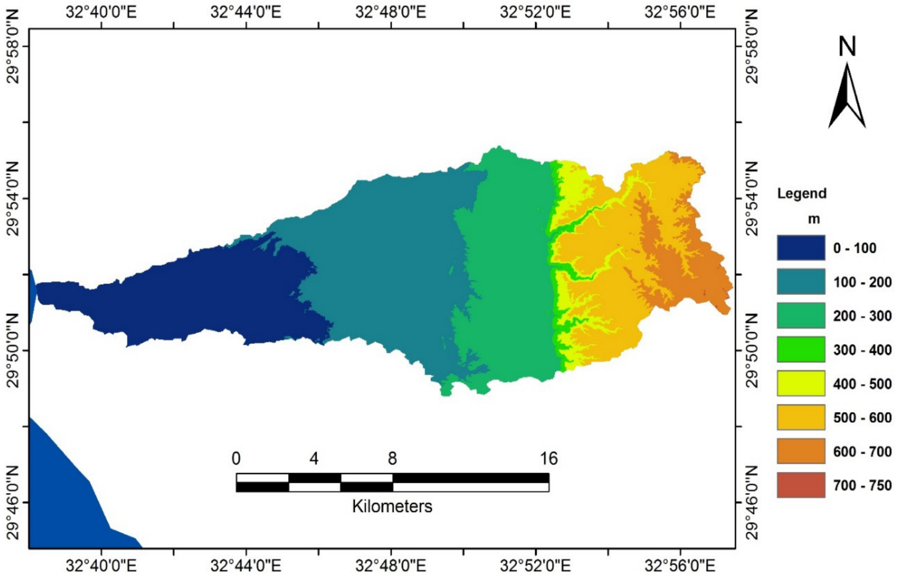


Fig. 6. Digital elevation model of Wadi Reneah.

The anticipated linear drainage basin traits encompass circulation ordering (Strahler, 1952), mean of the bifurcation ratio, total drainage length, drainage frequency (Horton, 1945) and drainage density (Melton, 1957). The gift location traits encompass basin location, length, width, and perimeter as proven of means of Horton (1945) (Table 1 and 2).

Basin place

This place is decided through the watershed and is critical detail that influences the circulate numbers, lengths, the water gathered and runoff in the wadis (Ahmed, 1997).

Basin perimeter

The perimeter represents the water divide among basins. The versions in basin perimeters are managed through the place, period and width (Ahmed, 1997).

Stream order

It is a numbering gadget for the floor drainage segments which could help the definition of hydrographs. Strahler (1952), offered a gadget of circulate orders wherein unbranched fingertip tributaries (smallest conduit) order 1 (first order), while first-order conduits join, a conduit of order 2 is formed.

Stream number

Horton 1945; Strahler (1952), Ahmed (1997) referred to that the stream numbers for character orders are counted for the taken into consideration basin. The total stream numbers of all orders are determined to be ranged some of small basins to thousands for massive basins.

Stream lengths

The lengths of tributaries of individual orders are measured using Arc GIS, where these measurements indicate that the length of character order is greater than of the next lower order.

Drainage Basin network analysis

Geographic information systems the use of (GIS) wherein the ones measurements mean that of a given order is more than the following lower order. The drainage internet analysis (Figs. 7-10), and resolution of move orders, move number, bifurcation ratios, channel lengths, move frequencies, texture ratios and drainage densities. Moreover, the correlation and interrelationships among those factors have been considered. DBAP has been designed as efficient as required, however has a person interface very simple (Youssef and Hegab, 2005, Youssef et al., 2005).

TABLE 1. Drainage basin of the study area.

Basin	Gharandal	Geada	Metla	Reneah
Stream Order	5	4	4	5
Stream Number	565	185	118	256
Stream orders Length (Km)	760	262.15	46.29	286.36
Basin Area (Km2)	862	312.6	18.6	203.1
Basin Width (Km)	24	17	3.9	10.9
Perimeter (km)	210	110.7	26.2	93.2

TABLE 2. Stream order length and count in the study area.

Orders	Length (m)	Count	Length	Count	Length	Count	Length	Count
1st	378.762	282	129.60	91	26.78	60	136.86	130
2nd	202.529.	139	80.67	44	8.85	23	67.78	62
3rd	92.825.	64	37.22	29	2.62	24	62.72	51
4th	46.591	44	14.66	21	8.04	7	10.07	8
5th	39.468	35	0.00	0	0.00	0	8.93	5

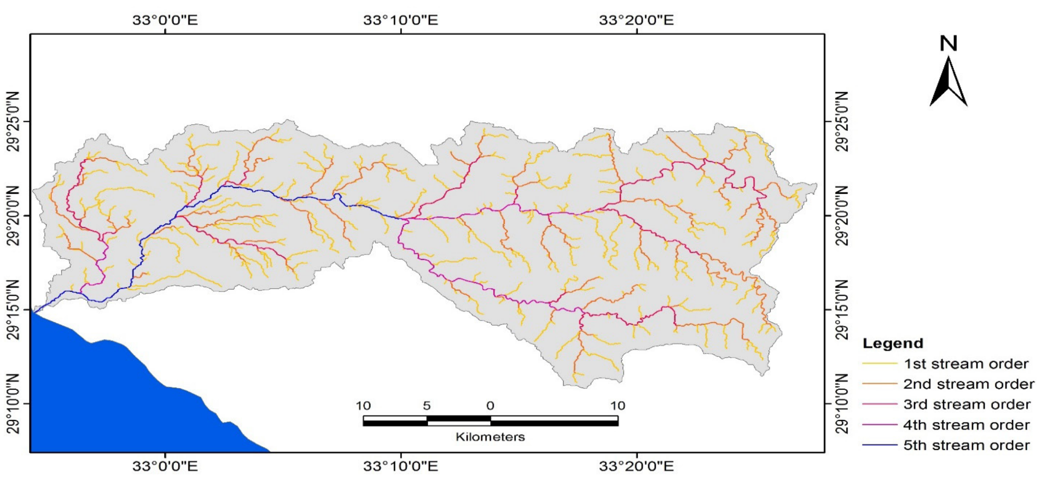


Fig. 7. Drainage network map of Wadi Gharandal.

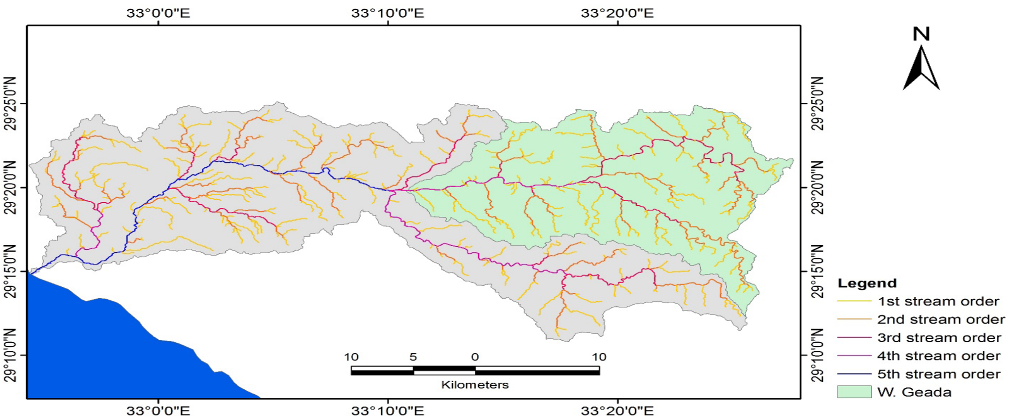


Fig. 8. Drainage network map of Wadi Geada of green color.

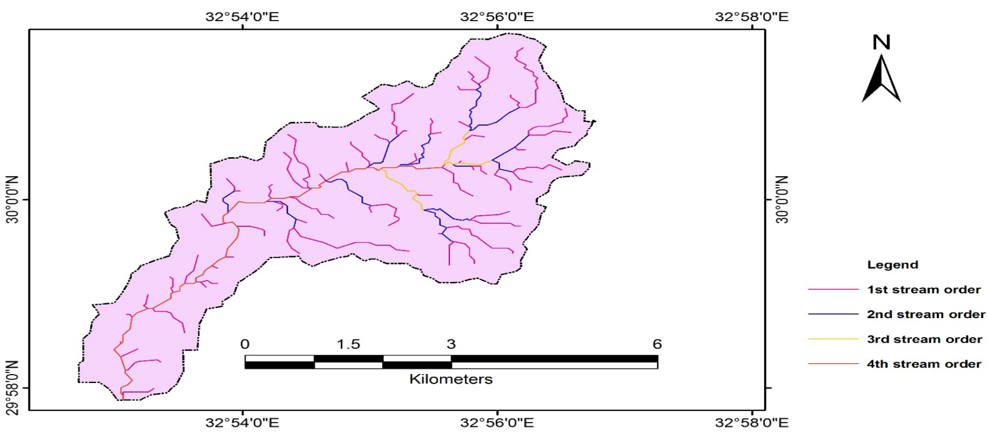


Fig. 9. Drainage basin characteristics of Wadi Metla.

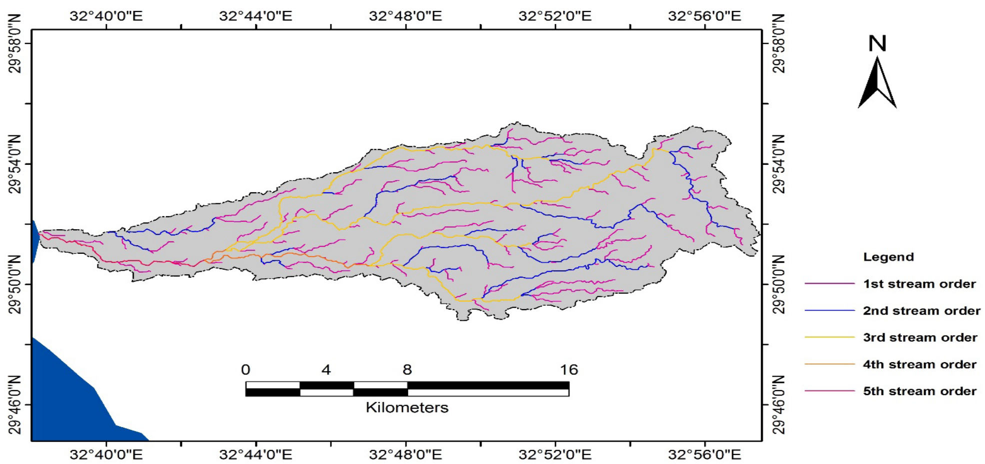


Fig. 10. Drainage basin characteristics of Wadi Reneah.

Bifurcation ratio (RP)

The bifurcation ratios for the studied basins are proven in (Table 3), wherein the bifurcation ratio is ranging among 1.66 and 2.82. The small values of the bifurcation ratios suggest the distinction among movement numbers from one order to every other isn't always large (Strahler, 1954). The comparable values of the calculated bifurcation ratios suggest the genetic situations of the movement orders are equal for every basin. Moreover, the same values of basin bifurcation ratios suggest the evolution situations for the studied basins are the equal.

Drainage frequency (F)

The small values of drainage frequencies are attributed to the small vicinity of those basins, while the better values are rather large regions of those basins. High value of has a tendency to provide extra to runoff. Moreover, the drainage frequency tiers from 0.59 to 6.18, indicating excessive for wadi Metla displays extra runoff because of a steeper slope.

Drainage density (D)

Areas of excessive drainage density are attributed to massive large flood flows and a low percentage of groundwater contribution with growing drainage density, the path length of overland glide decreases, therefore the rate of runoff increase (El-Rakaiby, 1989). Table 3 confirmed that the drainage density is ranging between 0.84 and 2.49. Wadi Metla is taken into consideration as the best drainage density as Wadi Geada indicates the bottom drainage density values.

Strahler (1964) stated that a low drainage density occurs in a region of high resistant or high permeable strata, while a high drainage density happens in area of excessive resistant or excessive permeable strata, at the same time as excessive drainage density consequences from area of vulnerable or impermeable rocks below sparse plant life and mountainous relief.

TABLE 3. Morphometric characteristic of the study area.

	Gharandal	Geada	Metla	Reneah
ER elongation ratio	0.49	0.73	0.47	0.38
CR circulation ratio	0.25	0.32	0.34	0.29
SF shape factor	0.18	0.42	0.18	0.11
LWR length width ratio	2.85	1.60	2.64	3.93
F frequency	0.65	0.59	6.18	1.26
D density	0.88	0.84	2.49	1.41
SR stream retaining	1.13	1.19	0.40	0.71
BR bifurcation ratio	1.73	1.66	2.26	2.82
SlopD slope degree	0.99	1.84	3.96	0.46
SlopR slope ratio	1.73	3.21	6.90	0.79
RugD ruggedness degree	1.04	0.73	1.77	0.48
R Relf	1184.00	874.00	711.00	340.00
ReRe relative relief	0.56	0.79	2.71	0.36
ReRa (relief ratio	0.02	0.03	0.07	0.01
TSN total stream number	564.00	185.00	115.00	256.00
TSL total stream length	760.18	262.15	46.25	286.36
TEX texture ratio	2.69	1.67	4.39	2.75
GN geometry number	1.05	0.40	0.45	1.05

Elongation ratio (Er)

This issue helps in giving idea approximately about the hydrological character of drainage in a basin. The values of this ratio range vary from 0.6 to 1.0 (Strahler, 1964), so the values near to 1.0 are traditional of very low alleviation, while values among 0.6 to 0.8 are normally associated with excessive alleviation related to high relief and steep ground slope. The values variety from 0.38 to 0.73 (Table 3).

Form factor (Ff)

As the length of the basin increases, the height runoff decreases. Thus, the form factor (Ff) indicates an inverse relation with the length of the basin and direct relation with the height runoff. If the form factor is zero, it suggests the form of the basin is exceedingly elongated, with flat peak flows for an extended duration; if it is one, it indicates a really perfect circular shape of the basin, with excessive peak, flows for a quick duration (Horton, 1932). Elongated watershed suggests low shape issue keeps flat peak flows for an extended longer duration. In the study site, the values variety from 0.11 to 0.42 (Table 3).

Flood hazard using hazardous probability

El-Shamy (1992) paid strain on three hydro morphometric drainage parameters simplest i.e. drainage frequency, drainage density, and bifurcation ratio, at the same time as he overlooked different powerful parameters, which include slope index, alleviation, he disregarded other effective parameters, such as slope index, relief, elongation ratio and circularity ratio. Nevertheless, the authors carried out the unsafe possibility of the distinct basins the usage of El-Shamy's model (1992). Table 4 indicates distinct two different diagrams have been used to determine the hazard degree, the study areas are of moderate hazards, even as Wadi Metla excessive danger.

Flood risk and vulnerability

A dependable version of the flood risk evaluation is crucial to know-how the effects of any destiny floods in the isolate regions which have excessive opportunity of hazards. Some of the geomorphometric parameters have been used to assess the dangerous impact of the specific sub-basins. The levels of hazardousness have been decided the usage of El-Shamy's diagram (Fig. 11). Two techniques have been used, the primary one makes use of the connection among bifurcation ratio and drainage density and the second one makes use of the connection to suggest the proper situations for infiltration.

Figure 5 suggests three fields; (C) represents a low possibility for floods and excessive groundwater recharge, field (B) with slight opportunity for floods and slight groundwater recharge, and (A) of excessive floods and low potential of groundwater recharge. Figure (10) suggests the plotting of the sub-basin's bifurcation ratio as opposed to drainage density and drainage frequency and suggests that Metla basin exceedingly liable to flash floods, even as others are of slight flood risk vulnerability on west-central Sinai. The identity of the degree of risk because of flooding decided in keeping with density, frequency, shape factor, and elongation parameters, that have at once a directly proportional relationships with the risk.

TABLE 4. Relation between bifurcation ratio, drainage density, and drainage frequency.

Wadi Number	Rb vs F	Wadi Number	Rb vs D	Wadi Number	Total
Wadi Gharandal Wadi Geada Wadi Reneah	M	Wadi Gharandal Wadi Geada Wadi Reneah	M	Wadi Metla	M
Wadi Metla	H	Wadi Metla	H	Wadi Metla	H

Rb-F = Hazard Degree (due to Rb vs. F), Rb-D = Hazard Degree (due to Rb vs. D), and Total = Final Hazard Degree. (Rb = Bifurcation ratio, F= drainage frequency, and D = drainage density).

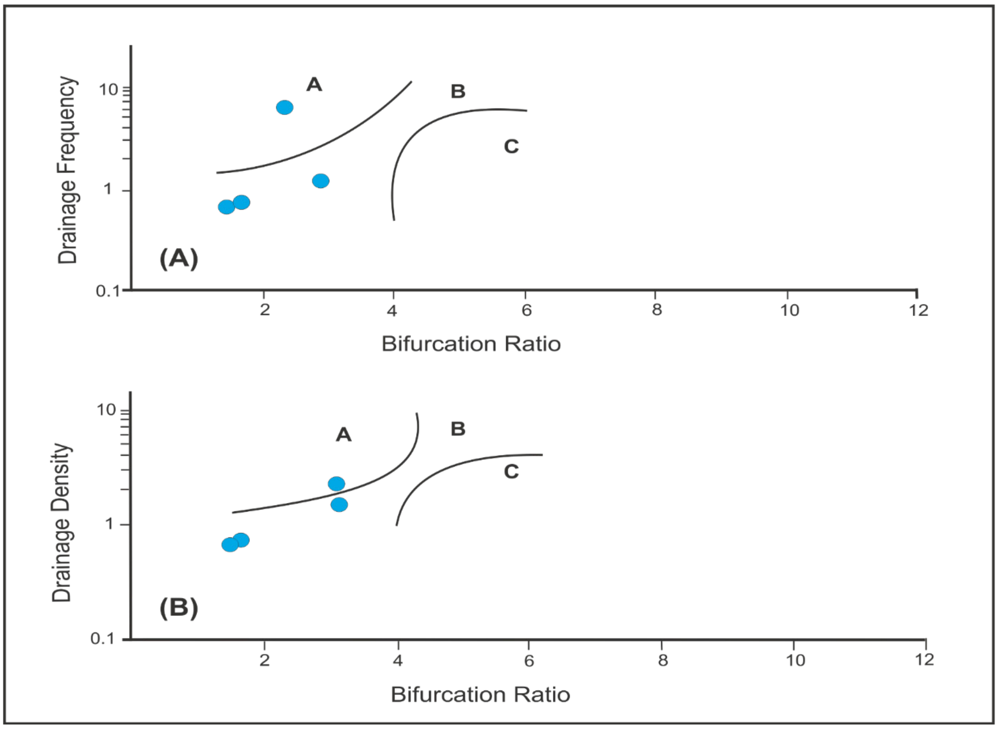


Fig. 11. El-Shami's model (1992).

Groundwater Occurrence

Five water-bearing formations are prominent in the region. Figure 12 indicates a generalized stratigraphic column for the Gulf of Suez that turned into changed after Pivnik et al., 2003, the water-bearing formations are mentioned from the more youthful to the older as following:

The Quaternary Aquifer

This aquifer occupied the downstream components of Wadi Sudr, Wadi Wardan, and Wadi Gharandal, and consists of alluvial deposits (Hassanein, 1989; Misak et al., 1995). Westwards of the outcrops of the Neogene beds in Wadi Gharandal, the Gharandal Formation alongside an NW-SE fault, wherein groundwater is encountered at shallow depths. The Quaternary extraordinarily effective one and its groundwater is used specially for irrigation (Fig. 13).

The Neogene Aquifer

In the middle and upper parts of Wadi Gharandal, the Neogene water-bearing formation is represented through the Gharandal Formation, dipping closer to the west and southwest with a dip angle attitude ranging among 30 and 35^{o} (Abdel-Mogheeth et al., 1985). The Gharandal Formation bureaucracy the principle aquifer the higher and middle components of Wadi Gharandal.

The Miocene sediments in the Gulf of Suez are represented through specific in step with the National Stratigraphic Sub-Committee(1976). The first facies are deep marine and divided into; a) The decrease particularly clastic Gharandal Group consists of Nukhul, Rudeis and Kareem formations; in the east Sudr area, and b) the upper Ras Malaab Group is particularly evaporite with the Belayim, South Gharib and Zeit formations. The second facies; 2) A non-marine (coastal) facies includes the Abu Gerfan, Gharamul, Gemsa and Sarbut El Gamal formations (Ghorab and Marzouk 1967).

The Upper Cretaceous-Eocene Aquifer

This aquifer is positioned on the upstream components of Wadi Sudr, Wadi Wardan and Wadi Geada. It constitutes the maximum vital and efficient aquifer important and productive aquifer at the eastern parts of the dissected tableland (El-Tih Plateau). The Cretaceous aquifer is represented through the lower unit Cretaceous Nubian sandstone, which includes sandstone overlaid through the Cenomanian sandstone of the upper unit of the Nubian sandstone (Dames and Moore, 1985; Sultan et al., 2011). This aquifer is recharged constantly through rainfall, and through the fractured and karstified nature of limestone (Abdel Mogheeth et al., 1985; Misak et al., 1995).

The Lower Cretaceous Sandstone Aquifer

This aquifer is such as the sandstone of the African shield that underlies Egypt, Libya and extends westward through the Sahara Desert (Melloul, 1995). The aquifer includes of alternating beds of sandstone and shale in the central and southern Sinai (Water Resources Research Institute and Japan International Cooperation Agency 1999). In the piolet area, this water-bearing formation is represented through the Malha Formation (Aptian-Albian) consists of sandstone with subordinate interbeds of sandy siltstone. It is uncovered exposed at the eastern part of Wadi Abu Gada, where it is occasionally exposed on its ground and will become overlain by younger formations to the west.

The Paleozoic Water-Aquifer

These formations belong to the Nubian facies and are uncovered to the east of Abu Zenima alongside the scarp of Gebel El-Tih and are represented with the aid of using the Abu Thora Formation (Lower Carboniferous) and the Araba Formation of Cambrian age. The Abu Thora Formation which includes sandstone intercalated with carbonaceous clay, while the Araba Formation which includes sandstone with sandy clay bands.

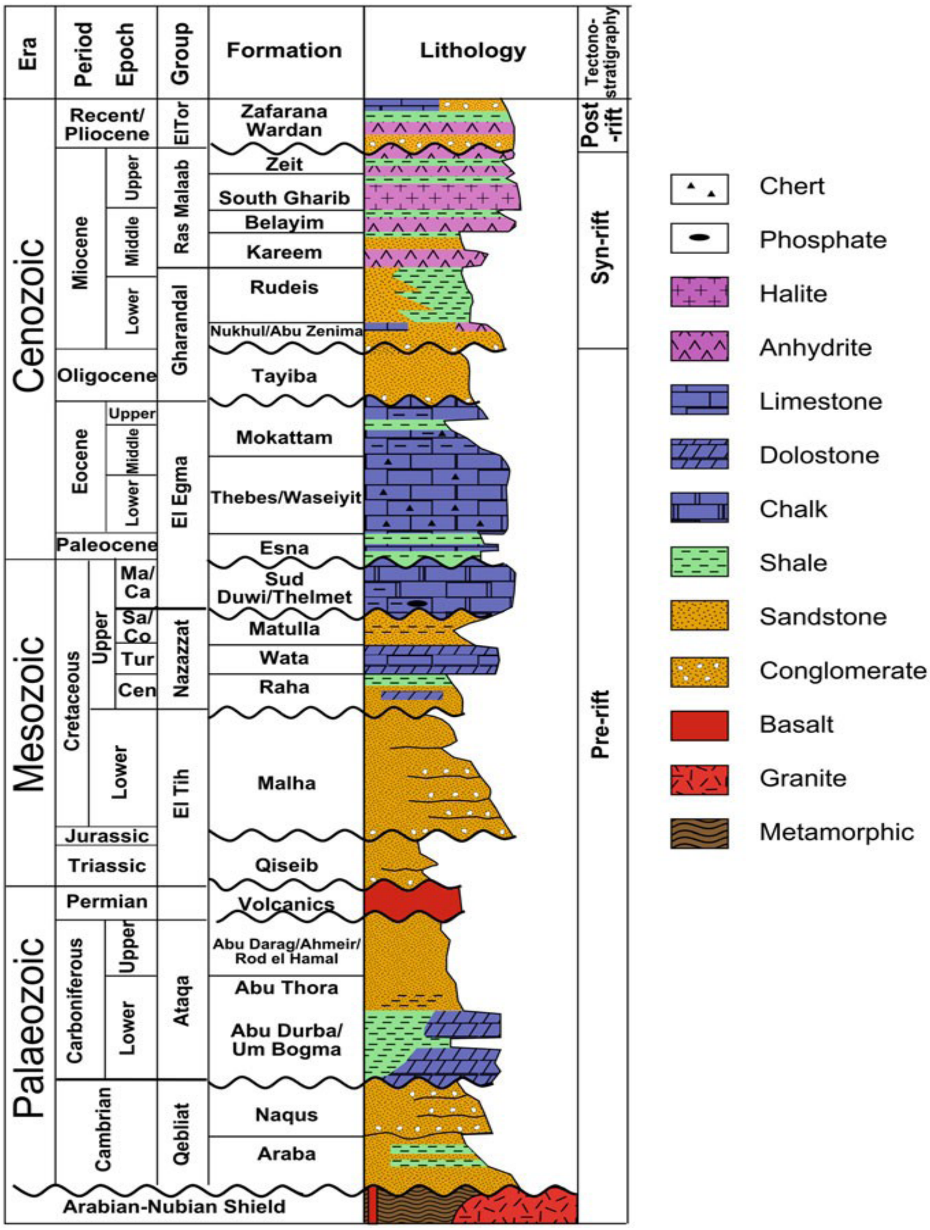
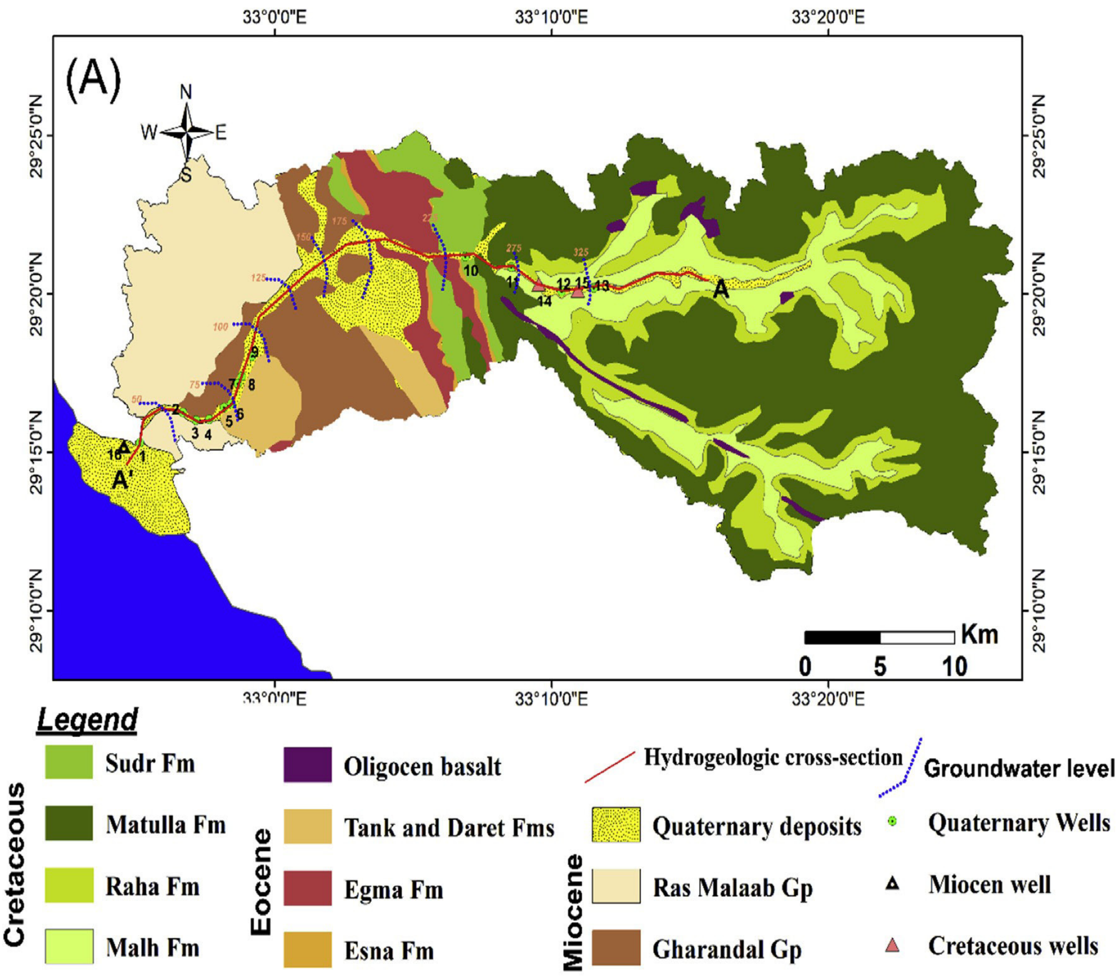


Fig. 12. Stratigraphic column of the Gulf of Suez (modified after Pivnik *et al.*, 2003).



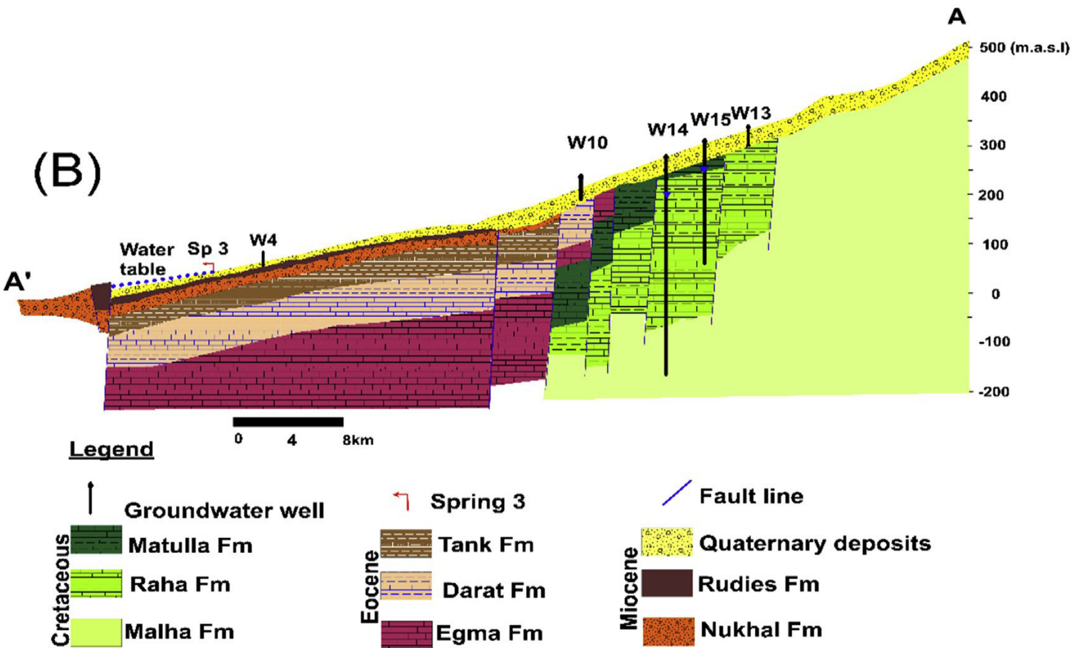


Fig. 13. (A) Geologic map of Gharandal watershed showing watershed, groundwater well's location of Quaternary aquifer. (B) hydrogeological cross-section (A-A′, Fig. 13A) along Gharandal watershed based on the geophysical data (modified after Al Temamy, 2000).

Discussion

Flood Hazard Potentiality Assessment

Flash floods are herbal risks hazards that threaten many cites in the world. Alexander (1993) illustrated that the effect of floods is extreme at the financial system and agriculture. The risk refers back to the opportunity of a probably risky phenomenon happening in a given location inside a particular time. probability of a potentially dangerous phenomenon occurring in a given area within a specific time.

Several research posted regarding using GIS tools in geological study (Salvi et al., 1999; Masoud and Koike, 2005; Khalil, 2006, 2013; Abbas et al., 2018; Hegazy et al., 2020), in seismological study (Ganas and Papoulia, 2000), volcanological (Kauahikaua et al., 1995; Pareschi et al., 2000; Pareschi, 2002), Groundwater potentiality (El Bastawesy, 2005; Armanuos and Negm, 2016; Megahed and Farrag, 2019; Paul et al., 2019) and landslides information (Carrara et al., 1991; Carrara et al., 1995; Carrara et al., 1999; VanWesten et al., 1999; Jibson et al., 2000). Two decades, information was used efficaciously for tracking and studying distinctive forms of phenomena and risks (Mason et al., 2010; Elbialy et al., 2013; Pradhan et al., 2014; Youssef et al., 2010, 2014a, b, c, 2015; 2020 and Youssef, 2015).

The following characteristics (Table1 and 2) used to explain every each of the sub-basin. (1) Linear drainage basin (Horton, 1945; Strahler, 1952), bifurcation ratio of overall drainage community duration (Pradhan, 2009; Carlston and Langhein, 1960), drainage frequency (Horton, 1945; Pradhan, 2009; Pradhan et al., 2006), and drainage density (Melton, 1957; Pradhan et al., 2006; Pradhan, 2009). Aerial drainage basin has been determined (Pradhan et al., 2006). They consist of drainage basin area, location, duration, width, perimeter, and the duration of overland flow (Horton, 1945; Strahler, 1991), basin form (circularity and elongation ratio) (Miller, 1953; Schumn, 1956), shape index (Haggett and Chorley, 1969), alleviation and relief ratio (Schumn 1956); relative relief (Maner, 1958); ruggedness quantity (Melton, 1957), compactness coefficient, lemniscate ratio, and length/width ratio (Miller, 1974), and hypsometric integral, geometry quantity, and texture ratio (Chorley and Kennday, 1971).

The studied vicinity is split into four wadis namely; Wadi Gharandal, Geada, Metla and Reneah. The version indicates that the elevation in Wadi Gharandal stages from zero m to 1200 m amsl (Fig. 2), Wadi Geada altitudes variety from three hundred m to 1200 m amsl. (Fig. 3), in Wadi Metla elevation stages from 250 m to six hundred m amsl (Fig. 4) and Wadi Reneah elevation stages from zero m to 750 m amsl (Fig. 5). The extreme of hazard because of flooding is expected in line with density, frequency, form factor, and elongation parameters that have a right away proportional relation with the hazard.

Conclusion and recommendations

Protecting the roadside because of floods via way of means of the use of rock fabric beside the roads to decrease their hazard and digging reservoirs on the shops of the tributaries in the extraordinarily excessive and high hazard degrees basins which include Metla basin.

This take a look at demonstrates that the software of remote sensing records related with morpho-tectonic and hydrologic records is a good device for knowledge flash floods, and their control techniques. Flash flood danger estimation is crucial for watershed control, mainly handling, water resources for sustainable improvement in arid and semi-arid areas and defensive inclined zones.

Proper evaluation of flash flood danger regions and suitable managemental techniques can reduce the rate of hazard degree. It is suggested to assemble enough quantity of dams downstream of flash flood danger regions. This control exercise can erect the surface runoff which brought about recharge groundwater. Additionally, this approach also can be considered for making plans rainwater harvesting and watershed control to sustainable makes use of floodwater and decrease land erosion in the area under consideration.

References

Abbas A., Majid R., Amir H.M., Ramin N., Mahmood Y., Hamed S., Mahmood A. 2018. Groundwater quality assessment for irrigation purposes based on irrigation water quality index and it's zoning with GIS in the villages of Chabahar, Sistan and Baluchistan, Iran. *Data Brief* **19**: 623–631. https:// doi. org/10.1016/j.dib.2018.05.061.

Abdallah A. M., Darwish M., El Aref M., Helba A. A. 1992. Lithostratigraphy of the Pre-Cenomanian clastics of north Wadi Qena, Eastern Desert, Egypt. *Proceedings of the First International Conference on Geology of the Arab World, Cairo University, Cairo*. 255-282.

Abdel-Mogheeth S.M., Hammad F.A., Abdel-Daiem A.A. 1985. hydrogeological remarks on Gharandal Basin, southwest Sinai Peninsula. *Desert Inst. Bull., Egypt,* **5** (2): 309-329

Ahmed A. A. 1997. Geophysical and hydrological studies in the area southeast Sohag, Egypt. *M. Sc. Thesis, Geol. Dep., Fac. Sci., Sohag, South Valley Uni., Egypt.* 214.

Alexander D. 1993. Natural Disasters. UCL Press, London.

Al Temamy A. M. 2000. Geophysical studies on the groundwater occurrence in Wadi Gharandal and its tributaries, southwest Sinai, Egypt. *M. Sc. Thesis, Faculty of Science, Ain Shams University.* 204.

Armanuos A.M., Negm A.M. 2016. GIS-based spatial distribution of groundwater quality in the Western Nile Delta, Egypt. In: Negm A (ed) The Nile Delta. The handbook of environmental chemistry, **55**. *Springer, Cham*, 89–119. https://doi.org/10.1007/698_2016_66.

Ayyad M.A., Ghabbour. S.I. 1986. Hot deserts of Egypt and the Sudan. In M. Evenari et al. (eds.), Ecosystems of the World, Hot deserts and arid shrublands. *Elsevier, Amsterdam* **12B**: 149-202

Carlston C.W., Langhein W.B. 1960. Rapid approximation of drainage density. Line intersection for hydrological assessment of method. U.S. *Geol. Surv, Bull*., 11: 31.

Carrara A., Cardinali M., Detti R., Guzzetti F., Pasqui V., Reichenbach P. 1991. GIS techniques and statistical models in evaluating landslide hazard. Earth Surface Processes and Landforms, *Bergamo, Italy, ISMES S.P.A*., **16**, 5, 427–445.

Carrara A., Cardinali M., Guzzetti F., Reichenbach P. 1995. GIS technology in mapping landslide hazard. Geographical Information Systems in Assessing Natural Hazards, Dordrecht, *The Netherlands, Kluwer Academic Publishers*, 135–175.

Carrara A., Guzzetti F., Cardinali M., Reichenbach P. 1999. Use of GIS technology in the prediction and monitoring of landslide hazard. Natural Hazards, Dordrecht, *The Netherlands, Kluwer Academic Publishers*, **20**, 117–135.

Chorley R. J., Kennedy B. A. 1971. Physical geography: a systems approach, London: Prentice Hall. Dames, Moore 1985. Sinai development study, phase 1, final report, water supplies and cost. **5**. *Rep. submitted to the Advisory Committee for Reconstruction Ministry of Development*, Cairo.

El Bastawesy M. 2005. Development of a Gis-Based Hydrological Model for the Dryland Catchment of Wadi Haymour, Egypt. *University of Reading,* England.

Elbialy S., Mahmoud A., Pradhan B., Buchroithner M. 2013. Application of spaceborne SAR data for extraction of soil moisture and its use in hydrological modelling at Gottleuba Catchment, Saxony, Germany. *J. Flood Risk Manage.* (Article online first available). doi.org/ 10.1111/jfr3.12037.

El- Rakaiby M.L. 1989. Drainage basins and flash flood hazard in selected parts of Egypt. *Egypt. Journ. Geol*. **33**, 307–323.

El-Shamy I. Z. 1992. New approach for hydrological assessment of hydrographic basins of recent recharge and flooding possibilities – *10th Symp. Quaternary and Development, Egypt, Mansoura Univ.*, 15 (Abstract).

Fairfield J., Leymarie P. 1991. Drainage networks from grid digital elevation models. *Water Resources Research*, **27**(5): 709-717

Ganas A., Papoulia, I. 2000. High-resolution, digital mapping of seismic hazard within the Gulf of Evia Rift, central Greece using normal fault segments as line sources, Natural Hazards, Dordrecht, *The Netherlands, Kluwer Academic Publishers,* **22**, 203–223.

Ghoneim E., El-Baz F. 2007. The application of radar topographic data to mapping of a mega-paleodrainage in the Eastern Sahara. *Journal of Arid Environments*, **69**: 658- 675.

Ghorab A., Marzouk M. 1967. A summary report on the rock stratigraphic classification of the Miocene non-marine and coastal facies in the Gulf of Suez and Sea Coast. Unpublished Report. *Egyptian General Petroleum Co-operation* Egypt, 1-601.

Gurnell A. M., Montgomery D. R. (editors) 2000. *Hydrological Applications of GIS,* Advances in Hydrological Processes Series, John Wiley and Sons, *Chichester*, 176.

Haggett P., *Chorley* R. J. *1969.* Network Analysis in. Geography. *Edward Arnold*, 348.

Hassanein A. H. 1989. Geology of water resources in Wadi Sudr-Wadi Gharandal area, Gulf of Suez region, Sinai Peninsula, Egypt. *M. Sc. Thesis, Fac. Sc., Ain Shams Univ.,* Cairo.

Hegazy D., Abotalib Z., El-Bastaweesy M., Al-Said M., Melegy A., Garamoon H., 2020. Geo-environmental impacts of hydrogeological setting and anthropogenic activities on water quality in the Quaternary aquifer southeast of the Nile Delta, Egypt. *African. Earth Sci*. https://doi.org/10.1016/j.jafrearsci.2020.103947.

Horton R. E. 1932. Drainage basin characteristics, *Amer. Geophys. Union Trans*. **13**, 350-361.

Horton R.E. 1945. Erosional development of streams and their drainage basins: hydro physical approach to quantitative morphology. *Bull Geol. Soc. Am*. **56**, 275-370.

Jibson R. W., Harp E. L., Michael J. A. 2000. A method for producing digital probabilistic seismic landslide hazard maps, Engineering Geology, *The Netherlands, Elsevier*, **58**, 271–289.

Kauahikaua J., Margriter S., Moore R. B. 1995. GIS-aided volcanic activity hazard analysis for the Hawaii geothermal project environmental impact statement, Natural Hazards, Dordrecht, *The Netherlands: Kluwer Academic Publishers*, 235–257.

Khalil M.H. 2006. Geoelectric Resistivity Sounding for Delineating Salt Water Intrusion in the Abu Zenima Area, West Sinai, Egypt. *Journal of Geophysics and Engineering,* **3**, 243-251.

Khalil M.H. 2013. Detection of Magnetically Susceptible Dyke Swarms in a Fresh Coastal Aquifer. *Pure and Applied Geophysics*, **170**, 1-17. http://dx.doi.org/10.1007/s00024-013-0696-4.

Maner S. B. 1958. Factors affecting sediment delivery rates in the Red Hills physiographic area. *Transactions of the American Geophysical Union* **39**, 669-75

Maidment D. R. ArcHydro 2002. GIS for water resources. Redland: ESRI Press.

Mason V., Andrews H, Upton D. 2010. The psychological impact of exposure to floods. *Psychol Health Med*. **15**, 61-73.

Masoud A., Koike K. 2005. Remote Sensing and GIS Integration for Groundwater Potential Mapping in Sinai Peninsula, Egypt. Proceedings of International Association for Mathematical Geology (IAMG'05): GIS and Spatial Analysis, **1**, *Toronto*, 440-445.

Megahed H.A., Farrag A.E.A. 2019. Groundwater potentiality and evaluation in the Egyptian Nile Valley: case study from Assiut Governorate using hydrochemical, bacteriological approach, and GIS techniques. *Bull Natl. Res. Centre* 43-48. https://doi.org/10.1186/s42269-019-0091-0

Melloul A. 1995. Use of principal components analysis for studying deep aquifers with scarce data-application to the Nubian Sandstone aquifer, Egypt and Israel. Hydrogeology Journ. **3** (2), 19–39

Melton M.A. 1957. An analysis of the relations among elements of climate, surface properties, and geomorphology Ibid. *Technical Report* No. 1 **1**, 102.

Miller N. C. 1953. A quantitative geomorphic study of drainage basins characteristics in Clinish mountain area, Verginia and Tenssesse: Columbia University, Geology Dept., *Technical Report* No. 3, 30.

Miller R.A. 1974. The geologic history of Tennessee: *Tennessee Division of Geology Bulletin* **74**, 63.

Misak R.F., Atwa S.M., Sallouma M.K., Hassanein A.H. 1995. Geology and water quality of the groundwater supplies in Sudr Gharandal area, Gulf of Suez, Egypt. *Bull. Fac. Sci., Assiut Univ*., **24** (2-F), 1-21.

Morris D. G., Heerdegen R. G. 1988. Automatically drained catchment boundaries and channel networks and their hydrological applications, *Geomorphology*, **1**, 131-141.

National Committee of Geological Sciences (N. C. G. S.). 1976. Miocene rock stratigraphy of Egypt. *Egyptian Journal of Geology*, **18**, 1–69.

Pareschi M. T. 2002. Evaluation of volcanic fallout impact from Vesuvius using GIS, in: GIS for emergency preparedness and health risk reduction, edited by Briggs, D. J., et al., Dordrecht, *The Netherlands, Kluwer Academic Publishers*, 101-114.

Pareschi M. T., Cavarra L., Favalli M., Giannini F., Meriggi A. 2000. GIS and volcanic risk management, Natural Hazards, Dordrecht, *The Netherlands, Kluwer Academic Publishers,* **21**, 361–379.

Pivnik D.A., Ramzy M., Steer B.L., Thorseth J., El Sisi Z., Gaafar I., Garing J.D., Tucker R.S. 2003. Episodic growth of normal faults as recorded by syntectonic sediments, July oil field, Suez rift, Egypt. *AAPG Bull* **87**, 1015–1030.

Pradhan B. 2009. Ground water potential zonation for basaltic watersheds using satellite remote sensing data and GIS techniques. *Cent. Eur. Journ. Geosci*. **1**(1), 120-129.

Pradhan B., Hagemann U., Shafapour Tehrany M., Prechtel N. 2014. An easy to use ArcMap based texture analysis program for extraction of flooded areas from Terresa-X satellite image. *Comput. Geosci*. **63**, 34-43.

Paul R., Brindha K., Gowrisankar G. et al. 2019. Identifcation of hydrogeochemical processes controlling groundwater quality in Tripura, Northeast India using evaluation indices, GIS, and multivariate statistical methods. *Environ. Earth Sci*. **78**:470. https://doi.org/10.1007/s12665-019-8479-6.

Said R. 1962. The Geology of Egypt. Elsevier, Amsterdam, 377.

Salvi S., Quattrocchi F., Brunori C. A., Doumaz F., Angelone M., Billi A., Buongiorno F., Funiciello R., Guerra M., Mele G., Pizzino L., Salvini F. 1999. A multidisciplinary approach to earthquake research: implementation of a geochemical geographical information system for the Gargano site, southern Italy, Natural Hazards, Dordrecht, *The Netherlands, Kluwer Academic Publishers*, **20**, 255–278.

Schumn S.A. 1956. Evolution of drainage systems and slopes in Badlands at Perth Amboy. New Jersey. *Geological Society of America Bulletin*, **67**, 597–646.

Shata A. A. 1955. An introductory note on the geology of northern portion of the Western Desert of Egypt. *Bull. Inst. Desert d' Egypte*, T. **3**, 96-106

Strahler A. 1964. Quantitative geomorphology of drainage basins and channel networks. In: Chow VT (ed) *Handbook of applied hydrology*. McGraw-Hill, New York

Strahler A. N. 1952. Dynamic basis of geomorphology, *Bull. Geol. Soc., Amer*., **63**, 923-938.

Strahler A. N. 1954. Quantitative geomorphology of erosional landscapes. C. R. *19th Intern. Geol. Cont. Algiers, sec*. 13, pt. **3**, 341-354.

Strahler A. N. 1964. Quantitative geomorphology of drainage basin and channel networks. In: Chow VT (Ed) *Handbook of applied hydrology*. McGraw Hill Book Co., New York: 4-76.

Sultan M., Metwally S., Milewski A., Becker D., Ahmed W., Sauck F., Soliman N., Sturchio E., Yan M., Rashed A., Wagdy R., Becker R. and Welton B. (2011) Modern re-charge to fossil aquifers: geochemical, geophysical, and modeling constraints. *Journal of Hydrology,* **403**, 14-24.

Tarboton D. G., Bras R. L. and Rodriguez-Iturbe I. (1991) On the extraction of channel networks from digital elevation data, *Hydrol. Process*., **5,** (1): 81-100,

VanWesten C. J., Seijmonsbergen A. C. and Mantovani F. (1999) Comparing landslide hazard maps, Natural Hazards, Dordrecht, *The Netherlands, Kluwer Academic Publishers*, **20**: 137-158.

Water Resources Research Institute and Japan International Cooperation Agency 1999. South Sinai Groundwater Resources Study in the Arab Republic of Egypt. *Main Rep, WRRI*, El-Kanater El Khayria.

Youssef A.M. 2015. Landslide susceptibility delineation in the ArRayth Area, Jizan, Kingdom of Saudi Arabia, by using analytical hierarchy process, frequency ratio, and logistic regression models. *Environ Earth Sci*. doi:10.1007/s12665-014-4008-9

Youssef A. M. Hegab M. A. 2005. Using geographic information systems and statistics for developing a database management system of the flood hazard of Ras Gharib area, Eastern Desert, Egypt. *The Fourth International Conference on The Geology of Africa*, **2**, 1-15, Assiut –Egypt.

Youssef A.M., Abdel Moneim A.A., Abu El-Maged S.A. 2005. Flood hazard assessment and its associated problems using geographic information systems, Sohag Governorate, Egypt. In: *The fourth international conference on the geology of Africa,* Assiut*,* Egypt, **1**, 1–17.

Youssef M.A., Pradhan B., Hassan M.A. 2010. Flash flood risk estimation along the St. Katherine road, southern Sinai, Egypt using GIS based morphometry and satellite imagery. *Environ Earth Sci*., **62**, 611-623.

Youssef A.M., Al-kathery M., Pradhan B. 2014a. Landslide susceptibility mapping at A l Hasher Area, Jizan (Saudi Arabia) using GIS-based frequency ratio and index of entropy models. *Geosci. Journ*. https://doi.org/10.1007/s12303-014-0032-8.

Youssef A.M., Pradhan B., Jebur M.N., El-Harbi H.M. (2014b) Landslide susceptibility mapping using ensemble bivariate and multivariate statistical models in Fayfa area, Saudi Arabia. *Environ Earth Sci*. doi:10.1007/s12665-014-3661-3.

Youssef A.M., Al-kathery M., Pradhan B., Elsahly T. 2014c. Debris flow impact assessment along the Al-Raith Road, Kingdom of Saudi Arabia, using remote sensing data and field investigations. *Geomat Nat Hazards Risk*. doi:10.1080/19475705.2014.933130.

Youssef M., Hussien H.M. and Abotalib A.Z. (2020) The respective roles of modern and paleo recharge to alluvium aquifers in continental rift basins: a case study from El Qaa plain, Sinai, Egypt. *Sci. Total Environ*. **739**:139927

المؤشرات الهيدرولوجية والمعاملات التكتونية المورفولوجية لتقييم مخاطر الفيضانات في غرب، وسط سيناء، مصر

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تم اختيار أربعة أحواض صرف بمختلف مناطق متجمعات المياه غرب- وسط سيناء لدراسة مخاطر السيول. باستخدام الخرائط الطبوغرافية الحديثة ، تم إنشاء أحواض الصرف والمعايير الهيدرولوجية والطبوغرافية والتكتونية المورفولوجية من الطبقة الموضوعية للارتفاع وقد تم تحديد وتحليل نموذج الارتفاع الرقمي ب (DEM) بدقه وأظهرت المنهجية التطبيقة أن المعاملات الهيدرولوجية والقياسية الشكلية تلعب دورًا رئيسيًا في العوامل المساهمة في الفيضانات حيث ترتبط مناطق المنحدرات المنخفضة بانخفاض الجريان السطحي المرتبط بتراكم الرواسب.

تتمثل الأهداف الرئيسية في تكامل المؤشرات الهيدرولوجية ، ونقل الرواسب ، ومؤشرات الرطوبة الطبوغرافية مع المعاملات التكتونية الشكلية لإستنتاج واكتشاف الترسبات المرتبطة بالفيضانات السريعة.

توضح الدراسة الحالية أن المعاملات الهيدرولوجية والتكتونية المورفولوجية مع مجموعة بيانات الاستشعار عن بعد هي أدوات فعالة في تقييم وإدارة الفيضانات ، ودعم المخطط للتنمية المستقبلية.