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CHARACTERISTICS OF WATER AND SOIL RESOURCES IN WADI WATIR BASIN, SINAI, EGYPT.

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ABSTRACT: The goal of this work is evaluating the hydrological characteristics and soil resources of Wadi Watir basin, Sinai, Egypt. Thirty morphometric parameters were calculated relying on SRTM data of digital elevation model (DEM). The drainage area of the basin is 3493.2 km^2. It is divided into thirteen sub-basins of various areas. The morphometric analysis suggests that, the basin is of seven stream order via in most cases dendritic drainage pattern and homogeneous nature.

Based totally on the morphometric parameters that have right away impacts on flood susceptible region, the flash flood hazards of Wadi Watir basin are categorized into medium and high hazard degree. For mitigation measure, some dams and dikes are important to construct at the crossing point of the highest stream order.

Consequences indicated that, the peak discharge values for Watir basin were 12203.9, 8103.1, 5366.2, 2977.5, and 1884.7 m^3/s for the 100-, 50-, 25-, 10-, and 5-year return periods, respectively. The runoff volumes for Wadi Watir basin have been 880195.88×10^3 m^3, 585256.89 ×10^3 m^3, 387778.05×10^3 m^3, 214802.10×10^3 m^3 and 135858.1×10^3 m^3 for the 100-, 50-, 25-, 10-, and 5- year return periods, respectively. The groundwater map was categorized into five potential classes; e.g., very poor, poor, intermediate, good and very good potential.

In step with the physiochemical characteristics of the geomorphological units of the study basin, the theme layer of those units become reclassified into marginal and non-suitability classes for agriculture use. Marginal suitability class is represented through wadi channel, alluvial plains and delta deposits (230.9 km^2). Non suitability class is represented with the aid of all other geomorphic units which characterized by high relief, steep slope, and impervious rocks or very shallow soil depth.

Key words: Hydrological characteristics, morphometric parameters, soils, Wadi Watir basin, WMS, Arc-GIS.

INTRODUCTION

The Sinai Peninsula lies in an extraordinary role, both politically and geographically and is interested by special assets. As a result, its miles decided on to play a vital function inside the Egyptian grasp plans to create new settlements (MWRI, 2005). Depths of the flood water within the principal channel of Wadi Watir increase from 2 m at 58 km from Neweiba city to 3 meters at 46 km and reaches 5 m at 37 km (WRRI, 1987). Flash floods arise, inflicting losses of infrastructure and lives (Cools, *et al.*, 2012). Excellent management can turn a flash flood from a danger right into a valuable water aid.

The Wadi Watir susceptible to flash floods approximately every 2-3 years. Those intense storm activities which produce flash floods are the primary recharge activities for aquifers of the Wadi Watir watershed (El-Sammany, 2011). The pinnacle catchments and slopes composed of uncovered impermeable rock, but the wadi bottom is permeable as consists of gravel and coarse sand. Mount Saint Catherine (2629 m asl), the tallest top in Sinai, is just south of the catchment limits. More than 60 km distance, the Wadi falls from the mountain to sea stage thru a steep canyon. The upstream a part of the wadi is in particular includes fractured rocks and has a terrace structure with repeated steep and flat slopes. At Wadi Watir outlet inside the Gulf of Aqaba, a delta of an area about 40 km^2 has formed. Nuweiba town lies in this delta which vital as an exchange port to different Arabic countries and for tourism. The Wadi Watir basin

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is located in the South Sinai governorate of Egypt (Fig.1). It is one of the maximum lively wadis at Sinai with regard to flash floods. The wadi outlet is Nuweiba city; it's a visitor hub and has a global harbor. Further, Nuweiba metropolis becomes flooded because of its geographical area by the flash flood. Disasters were reported at the Nuweiba-Dahab highway (Cools, et al., 2012).

The study area lies in an arid to semi-arid weather region, where in summers are very warm and dry, and winters are slight with excessive rainfall. The suggest temperature in the Wadi Watir levels between 22 and 24°C in July and 12° C in January (Greenwood, 1997). Relative humidity is decrease at the south Sinai station of Saint Cathrine (15-40 %) (Greenwood, 1997). Common annual rainfall is 35 mm year^{-1}, ranging from 10 mm yr^{-1} within the lowland coastal areas to 50 mm yr^{-1} inside the highland areas. Evapotranspiration is 1750 mm year^{-1}.

Geologically, the Wadi Watir vicinity lies within the Arabian-Nubian Massif which extends via western Saudi Arabia to Southern Sinai. Numerous formations are present with one-of-a-kind hydrological traits. The basin downstream is covered by igneous and metamorphic rocks of the Precambrian Basement complicated, but the rest of the basin is including Phanerozoic sedimentary rocks. The dry streams are filled with Quaternary sediments (Geological Survey of Egypt, 1994), Fig (2). The basement rock, overlaying 34% of the basin, represents the steep hills along the main wadis, and the steep slope makes runoff accumulation into the wadis. Moreover, the sedimentary succession of the Phanerozoic become divided into three kinds with the decrease clastic of Lower Cretaceous overlaying 16% of the basin, the center calcareous of Cenomanian to Eocene covering 24 %, and the upper clastic of the Neogene to Holocene age overlaying 26 %. The decrease and higher types are incredibly permeable, separated by lower permeable center department (Said, 1962).

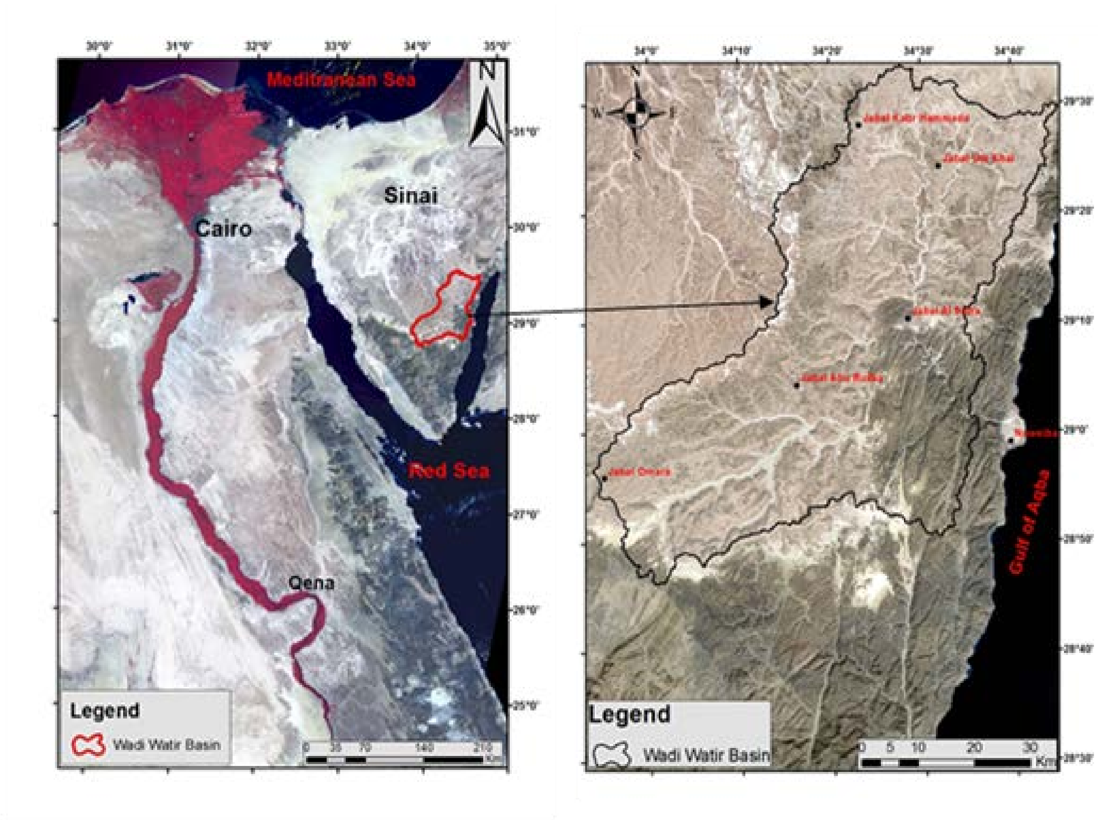


Fig (1): Location of Wadi Watir Basin on satellite images.

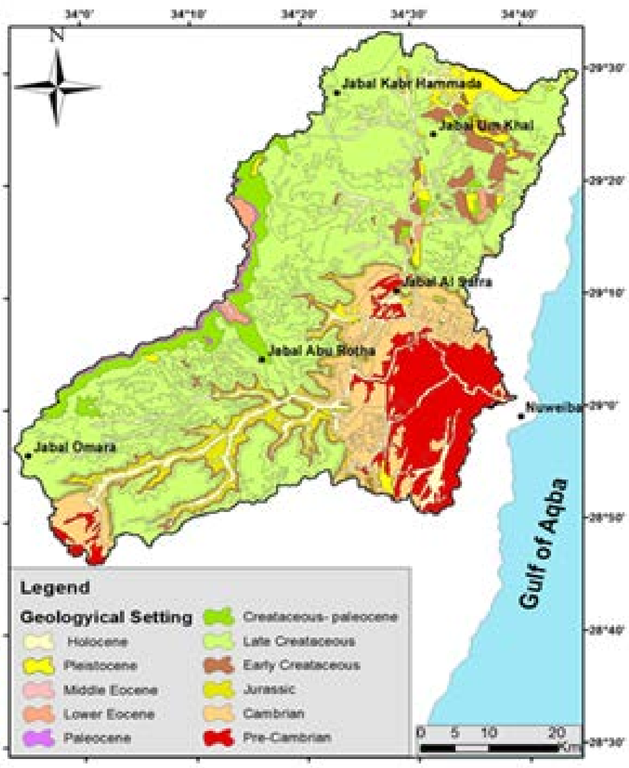


Fig (2): Geological map of study area. (After Geological Survey of Egypt, 1994).

Structurally, the basin is an uplifted Horst bordered by the grabbing device of the Gulfs of Aqaba and Suez. Strike-slip faults are the essential fault kind which slicing in the Precambrian rocks and the overlying sedimentary-phase in addition to en-echelon folds (Abdel-Rahman *et al.*, 2009). The left-lateral shear motion, principally formed the Aqaba-Levant structure (Freund *et al.*, 1970). The strike-slip movement affected essentially within the introduction of the pull-apart basins with N-S to NNE -SSW fault trend (Lyberis 1988). Consequently, Wadi Watir basin have become the extraordinarily uncovered to danger traits.

Geomorphologically, the basin has an awesome morphological feature and also has unique drainage pattern (Doornkamp and Cuchlaine, 1971). It is categorized into seven fundamental units particularly; Wadi channel, alluvial plains, delta, alluvial terraces, high sedimentary terraces, sedimentary plateaus and Basement Mountains (Fig. 3). The high catchments and slopes composed of exposed impermeable rock, whereas the wadi bottom is surprisingly permeable as it's far encompassed gravel and coarse sand. The upstream of the basin composed of fractured granite and has a terrace shape with alternating steep and flat slopes fluctuated from 2 to 6 %. At Wadi Watir outlet inside the Gulf of Aqaba, a delta of forty km^2 has formed. Nuweiba city lies in this delta, as a trade port to other Arabic countries and crucial for tourism.

The morphometric analyses of drainage basin are a critical object of watersheds characterization (Strahler, 1964). These analyses can be achieved as dimension of linear, aerial and relief factors of the basin and the slope contribution (Nag and Chakraborty, 2003). Amee and Dhiman (2007) used GIS techniques for morphometric analyses and watersheds prioritization.

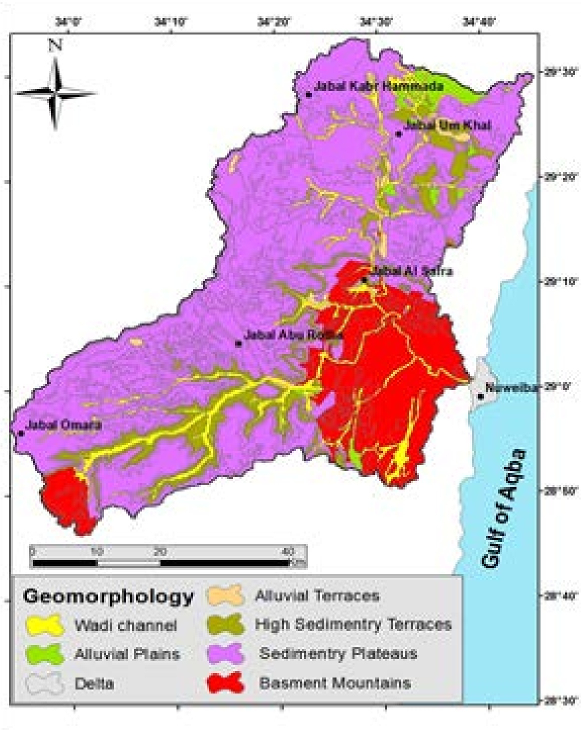


Fig (3): Geomorphological map of study area. (After Geological Survey of Egypt, 1994).

This work is aimed to assess the morphometric parameters (e.g. linear, areal and relief factors) in addition to the watershed potentiality including water and soil resources. A GIS method has been used to predict the approximate behavior of Wadi Watir basin to evaluate their flash flood danger degree at some stage in durations of heavy rainfall.

METHODOLGY

Digital Elevation Model (DEM) with 12.5 m resolution has been obtained from the SRTM (Shuttle Radar Topography Mission data) for the year 2010 (which finally improved by way of the topographic spot heights, contours and streams of topographic sheet 1:50.000; EGACS, 1989) become exported to a GIS environment (Arc GIS 10.4 software program; ESRI, 2015) to calculate all morphological parameters of the basin. By way of the use of HEC-Geo HMS and Arc hydro tool in Arc GIS 10.4 software, the drainage basin is assessed into numbers of sub-basins based on the water divide concept for morphometric evaluation.

The drainage lines digitization become done in GIS environment (hydrology tool in Arc toolbox). The essential parameters, specifically; area, perimeter, number of streams, stream length and basin length had been extracted from the drainage basin and drainage patterns. Thirty morphometric parameters for the study basin were computed relying at the formula proposed by many authors as proven in Table (1).

Estimation of surface runoff:

Daily rainfall data from the observe area have been used to deduce the maximal annual rainfall quintessential statistics for the estimation of the rainfall depth for numerous return periods by using HYFRAN-PLUS software.

The DEM became exported in WMS 10.0 (Watershed Modeling System) software program (EMSI, 2018) to offer equipment for all stages of watershed modeling consisting of automatic watershed delineation, morphometric parameter computation, hydraulic parameter computation (e.g., Time of concentration and Lag-Time) and result visualization (EMRL, 2015). The study used the curve number which turned into delivered through USDA (1986) to the soil and land use of the studied basins.

The HEC-1 model additives in WMS 10.0 software program are used to simulate the rainfall-runoff manner as it takes place in an actual river basin. The model components are based totally on simple mathematical relationships which are supposed to represent character meteorologic, hydrologic and hydraulic approaches which contain the precipitation-runoff method.

Field investigations:

The soil profiles are taken only from wadi channel, alluvial plains and delta units where the other units don't have any soils. Soil profiles have been defined using GPS (global Positioning System) and Landsat ETM+ image. Fourteen representing soil profiles were allotted, exposed and morphologically described (FAO, 2006). Forty-four soil samples were taken from the different profile layers for laboratory analyses.

Table (1): Formulas of morphometric parameters.

No.	Morphometric Parameters		Formula	Reference
1	Watershed Area (A)	Basin Geometry	GIS software Analysis	
2	The basin length (Lb)		GIS software Analysis	
3	The basin perimeter (P)		GIS software Analysis	
4	Basin Width (W)		GIS software Analysis	
5	Stream Number (Nu)	Linear Aspect	Nu= N1+N2+…….Nn	Horton (1945)
6	Stream Order (U)		Hierarchical rank	Strahler (1964)
7	Stream Length (Lu)		Length of the stream	Horton (1945)
8	Mean Stream Length (Lsm)		Lsm = Lu/Nu	Strahler (1964)
9	Bifurcation Ratio (Rb)		$Rb = Nu/N_{u+1}$	Schumn (1956)
10	Mean Bifurcation Ratio (Rbm)		Rbm=Average of bifurcation ratio	Strahler (1964)
11	Drainage Density (Dd)	Areal Aspect	Dd=Lu/A	Horton (1945)
12	Stream Frequency (Fs)		.Fs= Nu/A	Horton (1945)
13	Infiltration Number (FN)		FN = Dd*Fs	Faniran (1968)
14	Texture Ratio (Rt)		Rt= Nu/P	Horton (1945)
15	Form Factor (Ff)		$Ff = A/Lb^2$	Horton (1945)
16	Basin Shape (Bs)		$Bs = Lb^2/A$	Horton (1945)
17	Basin shape Index (Ish)		$Ish = 1.27\ A/Lb^2$	Hagget (1965)
18	Circularity Ratio (Rc)		$Rc = 4\pi A/P^2$	Miller (1953)
19	Elongation Ratio (Re)		$Re = (2/Lb)\ X\ (A/\pi)^{0.5}$	Schumn (1956)
20	Length of overland flow (Lo)		Lo=1/Dd*2	Horton (1945)
21	Fitness Ratio (Fr)		Fr = Lb / P	Melton (1957)
22	Drainage pattern (Dp)		Stream network using GIS software Analysis	Horton (1932)
23	Compactness Constant (Cc)		$Cc = 0.2821\ P/A^{0.5}$	Horton (1945)
24	Maximum elevation (H_{max})	Relief Aspect	GIS software Analysis using DEM	
25	Minimum elevation (H_{min})		GIS software Analysis using DEM	
26	Relief (R)		R =Highest elevation-Lowest elevation	Strahler (1952)
27	Relief ratio (Rr)		Rr = Rf / Lb	Schumm(1956)
28	Slope (So)		GIS software Analysis using DEM	
29	Mean basin slope (Sm)		GIS software Analysis using DEM	
30	Ruggedness number (Rn)		Rn = Rf *Dd	Melton (1957)

Laboratory analyses:

The soil samples were analyzed for particle size distribution, pH (in the soil paste), ECe (in the soil paste extract), $CaCO_3$ and gypsum (Burt, 2004).

Land evaluation:

The land evaluation has been assessed based totally on Sys *et al.* (1991) and Sys and Verheye (1978).

RESULTS AND DISSCUSSIONS

Hydro-morphometric Analysis:

The Wadi Watir basin has an area of about 3493.2 km^2. The wadi morphology is distinguished with the aid of high relief in most of the basin area, lowering whilst coming near the Aqaba Gulf at the Wadi delta (Fig, 4). Wadi Watir drainage basin includes a number of streams and the basin is assessed into thirteen sub-basins depending at the water divide (Fig, 5). The drainage network development in a location is relying at the lithology, structure, topography, rainfall, apart from endogenetic and exogenic influences. Morphometric analysis may be explained hydrological characteristic and the geomorphic strategies of the watersheds under observe. The linear, relief and areal components of Wadi Watir watershed and sub-basins had been analyzed as proven in Tables (2) and (3). The morphometric evaluation shows that, the basin is of seven stream orders by frequently dendritic drainage pattern and homogeneous nature (Fig, 6).

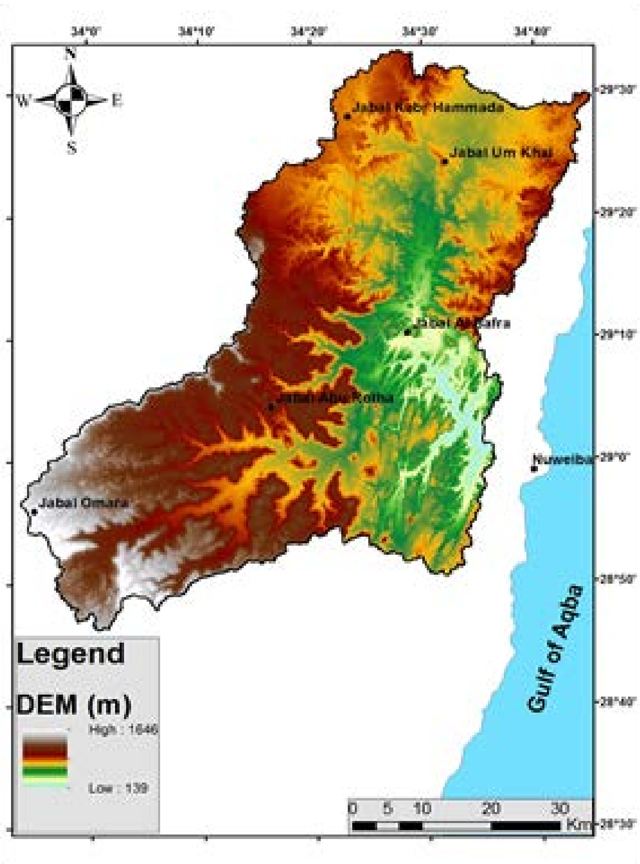


Fig (4): Digital Elevation Model (DEM) of Wadi Watir Basin.

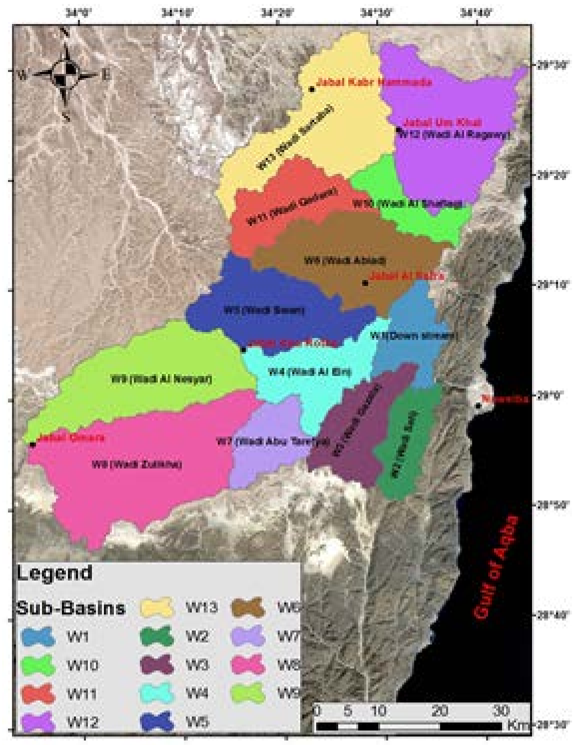


Fig. (5): Wadi Watir Sub-basins.

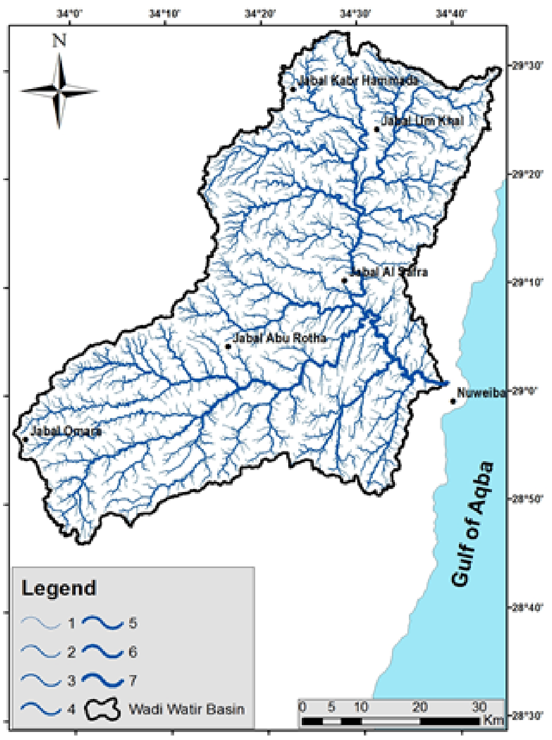


Fig (6): Stream orders and drainage pattern of Wadi Watir Basin.

Table (2): The linear morphological analyses of Wadi Watir Basin and its sub-basins.

a) Stream numbers and lengths in different orders

Basin\ Sub-Basin	Name	Stream Number (N) in Different Orders (1-7)								Length of Streams (Km)							
		N1	N2	N3	N4	N5	N6	N7	Total	N1	N2	N3	N4	N5	N6	N7	Total
W1	Downstream	189.0	132.0	39.0	0.0	0.0	3.0	57.0	420.0	69.1	39.11	13.35	0.01	0.01	0.1	23.4	145.1
W2	Wadi Safi	201.0	73.0	45.0	92.0	0.0	0.0	0.0	411.0	71.9	33.64	20.66	15.30	0.00	0.0	0.0	141.5
W3	Wadi Gazala	259.0	111.0	47.0	26.0	22.0	0.0	0.0	465.0	100.0	43.87	23.27	16.33	16.44	0.0	0.0	199.9
W4	Wadi El-Ain	375.0	236.0	57.0	0.0	0.0	191.0	0.0	859.0	122.3	45.49	17.95	0.00	0.00	39.1	0.0	224.9
W5	Wadi Swan	478.0	265.0	86.0	61.0	61.0	1.0	0.0	952.0	158.0	77.01	25.94	25.88	17.06	0.02	0.0	303.9
W6	Wadi Abiad	485.0	206.0	178.0	1.0	3.0	77.0	0.0	950.0	173.2	83.24	56.25	0.79	0.04	25.8	0.0	339.3
W7	Wadi Abu Tarifiya	298.0	95.0	132.0	32.0	0.0	2.0	0.0	559.0	68.8	29.34	25.61	8.43	0.00	0.1	0.0	132.3
W8	Wadi Zulikha	920.0	339.0	242.0	161.0	47.0	1.0	0.0	1710.0	274.0	131.56	98.85	38.96	11.35	0.4	0.0	555.1
W9	Wadi Al Nesyar	604.0	321.0	201.0	103.0	50.0	0.0	0.0	1279.0	213.9	86.00	69.89	34.62	9.76	0.0	0.0	414.2
W10	Wadi Al Shaflag	298.0	105.0	13.0	33.0	147.0	13.0	0.0	609.0	60.96	21.04	8.87	14.92	12.81	5.2	0.0	123.8
W11	Wadi Qadera	280.0	137.0	65.0	50.0	18.0	0.0	0.0	550.0	102.98	58.84	24.12	18.01	15.34	0.0	0.0	219.3
W12	Wadi Al Ragawy	854.0	361.0	150.0	133.0	15.0	0.0	0.0	1513.0	251.71	126.13	47.00	44.95	13.11	0.0	0.0	482.9
W13	Wadi Sartaba	544.0	293.0	179.0	201.0	12.0	0.0	0.0	1229.0	208.81	110.12	63.41	50.80	9.85	0.0	0.0	443.0
Watir		5814.0	2691.0	1434.0	891.0	375.0	284.0	90.0	11579.0	1891.33	893.44	495.16	269.04	105.79	70.7	32.1	3757.5

b) Mean Stream length, stream length ratio and Bifurcation ratio

Basin\	Mean Stream Length								Stream Length Ratio						Bifurcation Ratio						
Sub-Basin	N1	N2	N3	N4	N5	N6	N7	Total	2\1	3\2	4\3	5\4	6\5	7\6	1\2	2\3	3\4	4\5	5\6	6\7	mean
W1	0.37	0.30	0.34	0.00	0.00	0.00	0.41	1.41	0.81	1.16	0.00	0.00	0.00	0.00	1.43	3.38	0.00	0.00	0.00	0.05	0.81
W2	0.36	0.46	0.46	0.17	0.00	0.00	0.00	1.44	1.29	1.00	0.36	0.00	0.00	0.00	2.75	1.62	0.49	0.00	0.00	0	0.81
W3	0.39	0.93	0.90	0.63	0.75	0.00	0.00	3.59	2.42	0.96	0.70	1.19	0.00	0.00	5.51	1.81	1.81	1.18	0.00	0.00	1.72
W4	0.33	0.19	0.31	0.00	0.00	0.00	0.00	0.83	0.59	1.63	0.00	0.00	0.00	0.00	1.59	4.14	0.00	0.00	0.00	0.00	0.95
W5	0.33	0.29	0.30	0.42	0.28	0.02	0.00	1.65	0.88	1.04	1.41	0.66	0.07	0.00	1.80	3.08	1.41	1.00	61.00	0.00	11.38
W6	0.36	0.40	0.32	0.79	0.00	0.00	0.00	1.87	1.13	0.78	2.50	0.00	0.00	0.00	2.35	1.16	178.0	0.33	0.04	0.00	30.31
W7	0.23	0.31	0.19	0.26	0.00	0.06	0.00	1.05	1.34	0.63	1.36	0.00	0.00	0.00	3.14	0.72	4.13	0.00	0.00	0.00	1.33
W8	0.30	0.39	0.41	0.24	0.24	0.41	0.00	1.99	1.30	1.05	0.59	1.00	1.70	0.00	2.71	1.40	1.50	3.43	47.00	0.00	9.34
W9	0.35	0.27	0.35	0.34	0.00	0.00	0.00	1.31	0.76	1.30	0.97	0.00	0.00	0.00	1.88	1.60	1.95	2.06	0.00	0.00	1.25
W10	0.20	0.20	0.68	0.45	0.09	0.40	0.00	2.02	0.98	3.41	0.66	0.19	4.55	0.00	2.84	8.08	0.39	0.22	11.31	0.00	3.81
W11	0.37	0.43	0.37	0.36	0.85	0.00	0.00	2.38	1.17	0.86	0.97	2.37	0.00	0.00	2.04	2.11	1.30	2.78	0.00	0.00	1.37
W12	0.29	0.35	0.31	0.34	0.87	0.00	0.00	2.17	1.19	0.90	1.08	2.59	0.00	0.00	2.37	2.41	1.13	8.87	0.00	0.00	2.46
W13	0.38	0.38	0.35	0.25	0.82	0.00	0.00	2.19	0.98	0.94	0.71	3.25	0.00	0.00	1.86	1.64	0.89	16.75	0.00	0.00	3.52
Watir	0.33	0.33	0.35	0.30	0.28	0.25	0.36	2.19	1.02	1.04	0.87	0.93	0.88	1.43	2.16	1.88	1.61	2.38	1.32	3.16	2.08

Table (3): Areal and Relief morphometric analyses of wadi Watir Basin and its sub-basins.

Basin\ Sub-Basin	Area (Km^2)	Perimeter (Km)	Basin Length (Km)	Basin Width (Km)	Drainage Density (km/Km^2)	Stream Frequency	Infiltration Number	Texture Ratio Km^{-1}	Circulatory Ratio	Elongation Ratio	Compactness constant	Form Factor	Basin shape	Basin Shape index	Length of overland flow	Fitness Ratio	Mean Slope	Relative Relief in (m)	Relief Ratio	Ruggedness value
W1	130.6	99.2	19.5	6.70	1.11	3.22	3.57	4.23	0.17	0.66	2.45	0.34	2.91	0.44	0.45	0.20	19.24	919.0	47.1	1020.9
W2	127.1	94.6	21.3	5.97	1.11	3.23	3.60	4.35	0.18	0.45	2.37	0.28	3.57	0.36	0.45	0.23	14.64	830.0	39.0	923.9
W3	183.3	112.2	22.3	8.22	1.09	2.54	2.77	4.15	0.18	0.69	2.34	0.37	2.71	0.47	0.46	0.20	16.27	1013.0	45.4	1104.9
W4	208.7	133.8	25.6	8.15	1.08	4.12	4.43	6.42	0.15	0.64	2.61	0.32	3.14	0.40	0.46	0.19	14.13	824.0	32.2	887.7
W5	292.2	143.7	30.9	9.46	1.04	3.26	3.39	6.63	0.18	0.62	2.37	0.31	3.27	0.39	0.48	0.22	13.51	1008.0	32.6	1048.3
W6	324.5	151.9	20.3	15.99	1.05	2.93	3.06	6.45	0.18	1.00	2.38	0.79	1.27	1.00	0.48	0.13	12.88	768.0	37.8	802.9
W7	131.4	82.1	19.4	6.77	1.01	4.25	4.28	6.81	0.24	0.67	2.02	0.35	2.86	0.44	0.50	0.24	11.5	557.0	28.7	560.9
W8	553.9	189.5	39.2	14.13	1.00	3.09	3.09	9.03	0.19	0.68	2.27	0.36	2.77	0.46	0.50	0.21	10.61	825.0	21.0	826.7
W9	390.9	156.0	39.5	9.90	1.06	3.27	3.47	8.20	0.20	0.56	2.23	0.25	3.99	0.32	0.47	0.25	11.23	861.0	21.8	912.4
W10	116.8	99.8	15.1	7.73	1.06	5.22	5.53	6.41	0.15	0.81	2.60	0.51	1.95	0.65	0.47	0.15	10.6	568.0	37.6	602.0
W11	196.5	122.9	24	8.19	1.12	2.80	3.12	4.48	0.16	0.66	2.47	0.34	2.93	0.43	0.45	0.20	10.63	759.0	31.6	846.8
W12	423.5	166.2	28.2	15.02	1.14	3.57	4.07	9.10	0.19	0.82	2.28	0.53	1.88	0.68	0.44	0.17	6.79	399.0	14.1	454.9
W13	400.3	191.0	34.8	11.50	1.11	3.07	3.40	6.43	0.14	0.65	2.69	0.33	3.03	0.42	0.45	0.18	7.06	665.0	19.1	735.9
Watir	3493.2	542.3	67.8	51.52	1.08	3.31	3.57	21.35	0.15	0.98	2.59	0.76	1.32	0.97	0.46	0.13	11.28	1507.0	22.2	1621.0

The greatest streams numbers of maximum sub-basins are covered in most cases sedimentary rocks. Whereas, sub-basins, that received the least streams number is included ordinarily Basement rocks. There's a right away dating between the area, length and perimeter of study sub-basins.

The ruggedness number, relief ratio, slope, and the digital elevation model (DEM) suggest the variable topography and slope with late mature level of geomorphological improvement. On the alternative aspect, the drainage density, texture, basin shape, elongation ratio, circularity ratio and fitness ratio indicate that the Wadi Watir basin and maximum of sub-basins are semi-circular indicating that, they vulnerable to flash flood hazards and has a less chance for groundwater recharge.

Flash Flood hazard evaluation:

Throughout flash floods, a high flood wave velocity with excessive sediment is channeled alongside the wadi with flood wave that can reach a peak of 1-2 m. This commonly is outcomes in extensive damage to the road, which in some elements is absolutely washed away.

For evaluation of the sub-basins flash flood hazard, nine affected morphometric parameters (i.e: A, Dd, Fs, Ish, Sm, Rr, Rn, Rat and Rbm) were selected and their relation with the flash flood had been analyzed. Most of these parameters have a directly proportional relationship with the hazard morphometric parameters except for the Rbm which shows an inverse share. A scale quantity of hazard starting with 1 (minimum) to 5 (maximum) has been detected to all parameters. The hazard degrees for the study sub-basins were accomplished as follows:

- Dedication of the minimal and maximum values of every morphometric parameter for the study sub-basins.
- Exams of the real hazard degree for all parameters which might be offered among the maximum and minimum values had been based totally on a trial to derive the empirical courting between the relative hazard degree of a basin with regard to the morphometric parameters and flash floods, the simple linear interpolation or identical spacing between statistics factors manner turned into selected.
- Assuming an instantly linear relation occurs among the samples points; the intermediate values can be anticipated from the geometric dating (Davis, 1975).

$$\text{Hazard degree} = \frac{4\,(X - X\text{min})}{(X\text{max} - X\text{min})} + 1 \qquad (1)$$

For the mean bifurcation ratio (Rbm) which shows an inverse proportion, the hazard degree was calculated using the following formula (Davis 1975).

$$\text{Hazard degree} = \frac{4\ (X - X\text{max})}{(X\text{min} - X\text{max})} + 1 \qquad (2)$$

Where X is the morphometric parameters value to be estimated for the hazard degree of each basin and X_{min} & X_{max} are the minimum and maximum values of the morphometric parameters of all basins respectively.

The hazard degrees of studied sub-basins are calculated with the aid of the equations (1) and (2). The summation of the hazard degrees for every basin represents the final flash flood hazard of that basin (Table, 4). These values variety between 22.48 (W7: Wadi Abu Tarifiya) and 29.44 (W1: Downstream). The real hazard degrees for all observe basins are tabulated in Table (5). From the calculated values and according to their hazard's degree, the studied sub-basins could be classified into two groups; sub basins of medium hazard degree (W5, W6, W7, W8, W11 and 13) and sub basins of high hazard degree (W1, W2, W3, W4, W9, W10 and W12) as shown in Fig (7).

For mitigation the flash flood hazards, some dams and dikes need to be assembled on the crossing point of the highest stream order to reduce the flow volume of flash flood that is predictable to reach the downstream regions (Fig, 7). To maintain Nuweiba city, on its susceptible position on the canyon mouth, large finances are made. at the delta of Wadi Watir, flood diversion dikes had been performed at the same time as upstream 5 dams, 1 artificial lake and 2 underground reservoirs had been built. The dams are designed to sluggish the flash floods power and not to dam the floodwater absolutely. The synthetic lake is an open detention basin, which in normal conditions is completely dry. The underground reservoirs are covered, concrete constructions intended to seize floodwater and store it for later use.

Water/ land use promising units for sustainable development:

The Wadi Watir sustainable development based mainly on the water and soil resources for agriculture and other purposes.

1- Water resources:

A- Estimation of predicted rainfall-runoff values for different return periods:

Basin boundaries and drainage lines of the study area have been extracted through the use of the digital elevation model (DEM, 12.5 m resolution) and the WMS 10.0 software program. Additionally, the morphometric and geometric parameters (e.g. area, basin slope, basin length, maximum stream length, centroid stream distance, perimeter, shape factor and sinuosity factor) were routinely calculated for every basin (Fig. 8).

Table (4): Hazard degree of the study sub-basins.

Sub - Basin	Area (A)	Drainage Density (Dd)	Stream Frequency (Fs)	Shape Index (Ish)	Mean Slope (Sm)	Relief Ratio (Rr)	Ruggedness Ratio (Rn)	Texture Ratio (Rt)	Mean Bifurcation Ratio (Rbm)	Summation of Hazard degree	Hazard degree
W1	1.03	4.15	2.02	1.69	5.0	5.0	4.48	1.07	5.0	29.44	1
W2	1.0	4.22	2.04	1.22	3.52	4.01	3.89	1.16	5.0	26.06	7
W3	1.5	3.57	1.0	1.88	4.05	4.79	5.0	1.0	4.88	27.67	3
W4	1.8	3.18	3.36	1.51	3.36	3.19	3.66	2.83	4.98	27.87	2
W5	2.5	2.1	2.08	1.41	3.16	3.24	4.68	3.0	3.57	25.74	9
W6	2.8	2.25	1.58	5.0	2.96	3.87	3.14	2.7	1.0	25.3	10
W7	1.04	1.14	3.56	1.73	2.51	2.77	1.65	3.15	4.93	22.48	13
W8	5.0	1.0	1.82	1.82	2.23	1.84	3.29	4.94	3.84	25.78	8
W9	3.47	2.67	2.10	1.0	2.43	1.93	3.82	4.27	4.94	26.63	6
W10	0.9	2.67	5.0	2.95	2.22	3.85	1.91	2.58	4.59	26.67	5
W11	1.65	4.29	1.39	1.68	2.23	3.12	3.41	1.27	4.92	23.96	12
W12	3.78	5.0	2.55	3.10	1.0	1.0	1.0	5.0	4.78	27.21	4
W13	3.56	4.3	1.8	1.60	1.09	1.6	2.73	2.85	4.63	24.16	11

Table (5): Rainfall-Runoff data of Watir basin.

Return Period (years)	Rainfall Intensity I (mm)	Peak Discharge Q (m^3 /sec)	Peak Time (min)	Runoff Water volume (m^3)
5	19	12203.9	1530	880195879.4
10	30	8103.1	1530	585256893.3
25	53	5366.2	1530	387778051.8
50	78	2977.5	1515	214802096.8
100	115	1884.7	1515	135858104.1

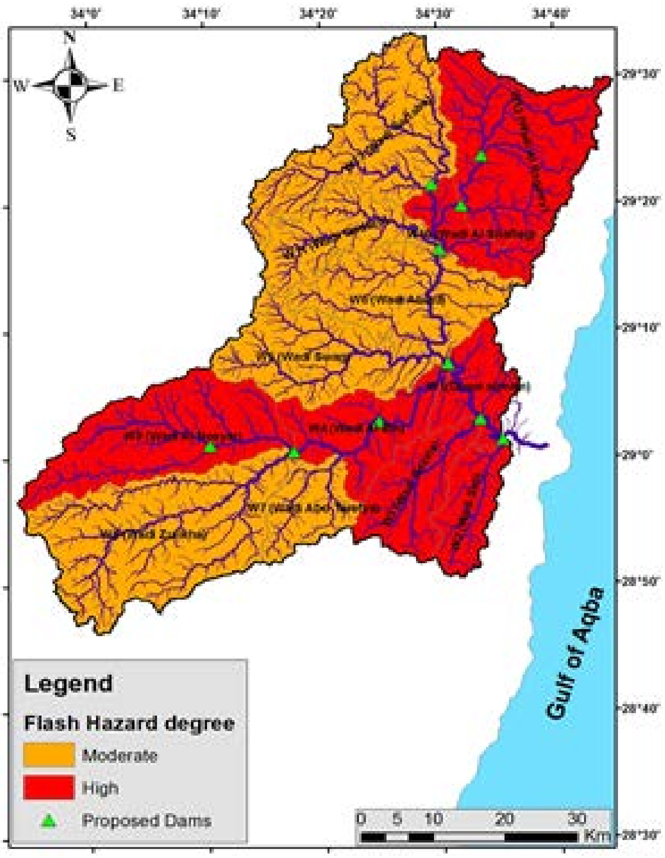
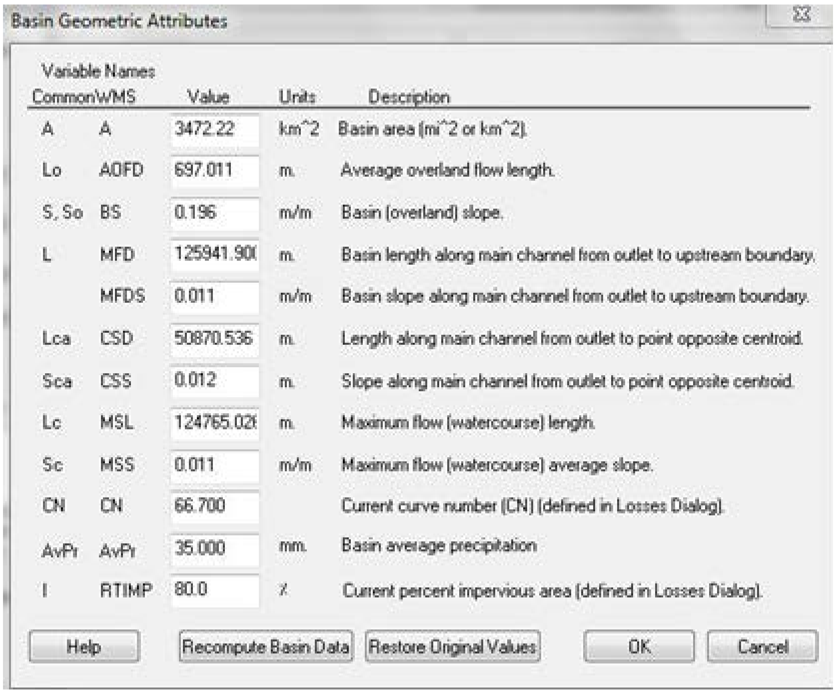


Fig (7): Flash flood hazard degree and Proposed dams in Wadi Watir basin.



Basin Geometric Attributes

Variable Names Common	WMS	Value	Units	Description
A	A	3472.22	km^2	Basin area (mi^2 or km^2).
Lo	AOFD	697.011	m.	Average overland flow length.
S, So	BS	0.196	m/m	Basin (overland) slope.
L	MFD	125941.90(	m.	Basin length along main channel from outlet to upstream boundary.
	MFDS	0.011	m/m	Basin slope along main channel from outlet to upstream boundary.
Lca	CSD	50870.536	m.	Length along main channel from outlet to point opposite centroid.
Sca	CSS	0.012	m.	Slope along main channel from outlet to point opposite centroid.
Lc	MSL	124765.02(	m.	Maximum flow (watercourse) length.
Sc	MSS	0.011	m/m	Maximum flow (watercourse) average slope.
CN	CN	66.700		Current curve number (CN) (defined in Losses Dialog).
AvPr	AvPr	35.000	mm.	Basin average precipitation
I	RTIMP	80.0	%	Current percent impervious area (defined in Losses Dialog).

Help | Recompute Basin Data | Restore Original Values | OK | Cancel

Fig (8): Basin geometric attributes calculated and introduced in WMS software.

Estimation of the surface runoff (Q) was achieved thru the SCS-CN method (SCS, 1993). The curve number (CN) is a hydrologic parameter used to explicit approximately surface water runoff capability for an area. In line with worldwide Hydrologic Soil groups (Ross *et al.*, 2018), the soil hydrologic group of the studied basin became labeled as HSG-B (moderately low runoff potential where the texture of soil is in general sandy). In keeping with the curve number method, the hydrologic soil characteristics are the principal thing affecting the surface runoff value. Consequently, it become expected for the areas which are covered with the aid of alluvial deposits in which the alternative areas are occupied by way of sedimentary and basement rocks. The precipitation falls over these rocks is mainly spread and disbursed due to the high fracture's density of the rocks. The curve number 66.7 is used for sandy soil in arid lands that carries desert shrubs.

Annual rainfall data received from the study area for a time period about 27 years (1980-2007) have been analyzed so that you can decide the layout rainfall amount. Statistical analytical checks regarding the rainfall values have been completed using HYFRAN PLUS software. The designed precipitation for estimating the rainfall intensity values at different returned periods (5, 10, 25, 50 and 100 years) primarily based on the assumption of Generalized Extreme Value (GEV) distribution maximum probability, was computed. The maximum annual values of every day rainfall for the selected observation period were used to determine long-term discharge series (Table 5).

The HEC-1 model (Hydrologic Engineering center's Hydrologic Modeling system; Feldman, 1995) run within WMS v10.0 software, become applied after introducing the input data, e.g., curve number for each basin, rainfall intensity for each return period and the concentration time via SCS method for each basin. results confirmed that, the SCS-24 storm type II represents the satisfactory distribution to simulate the rainfall-runoff event for various return periods. Results indicated that, the peak discharge values for Watir basin had been 12203.9, 8103.1, 5366.2, 2977.5, and 1884.7 m^3/s for the 100-, 50-, 25-, 10-, and 5-year return periods, respectively. The runoff volumes for Watir basin have been 880195.88×103 m^3, 585256.89 ×103 m3, 387778.05×103 m3, 214802.10×103 m3 and 135858.1×103 m3 for the 100-, 50-, 25-, 10-, and 5- yr return periods, respectively (Table, 5 and Fig, 9). Results showed also that, the runoff in the study watershed, anticipated via the SCS-CN model, will increase progressively as the rainfall will increase.

B-groundwater:

The reconnaissance of recent places for groundwater potentiality is wanted to guide the needs of agricultural and urban functions in arid areas including Wadi Watir basin. Abuzied (2016) discover new groundwater wells which could help triumph over the water scarcity. Many predominant factors contributing to groundwater potentiality have been identified. These elements include lithological units, textural class of alluvial sediments, surface and subsurface structures, geomorphological features, morphometric parameters specifically the drainage density (Fig, 10) and land use/land cover. For a final groundwater ability map, all elements had been transformed to raster data to integrate spatially as vital thematic layers rely on weighted analysis. The potential map of groundwater became classified into five classes, comprising very poor to very good ability (Fig, 11).

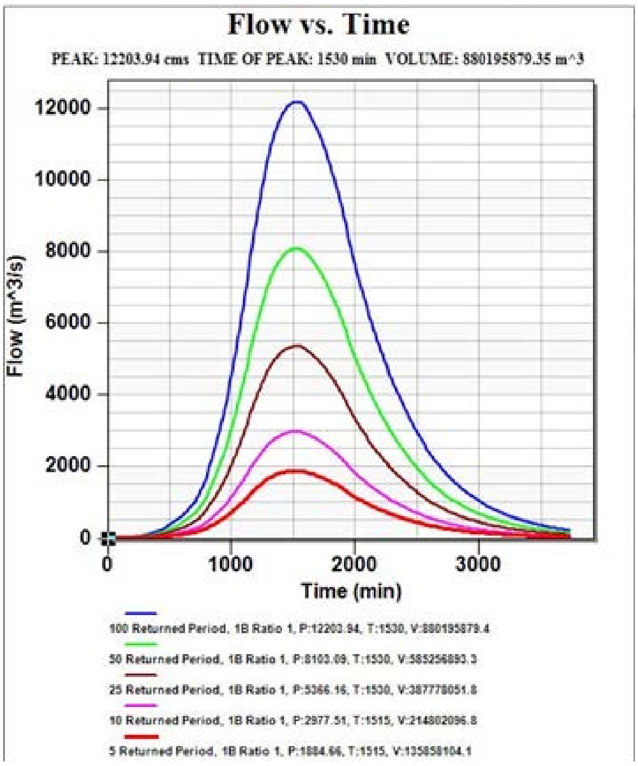


Fig (9): The predicted rainfall-runoff values of different return periods for Watir basin.

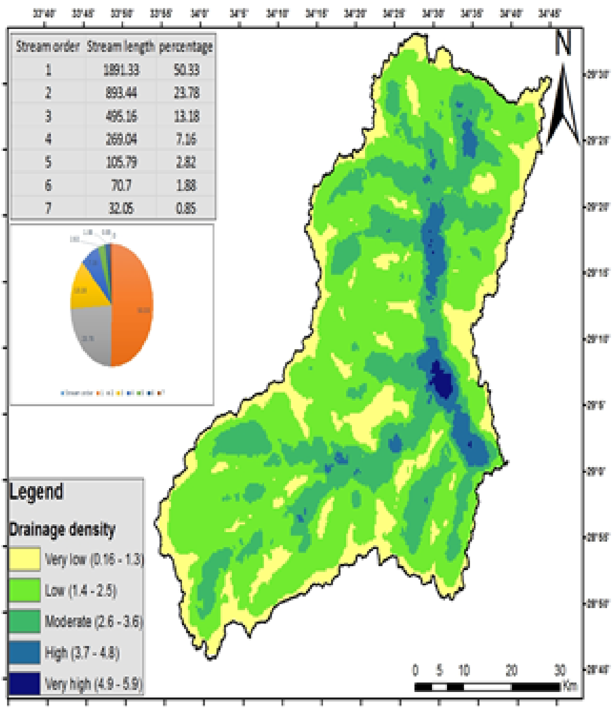


Fig (10): Drainage density classes of Wadi Watir basin.

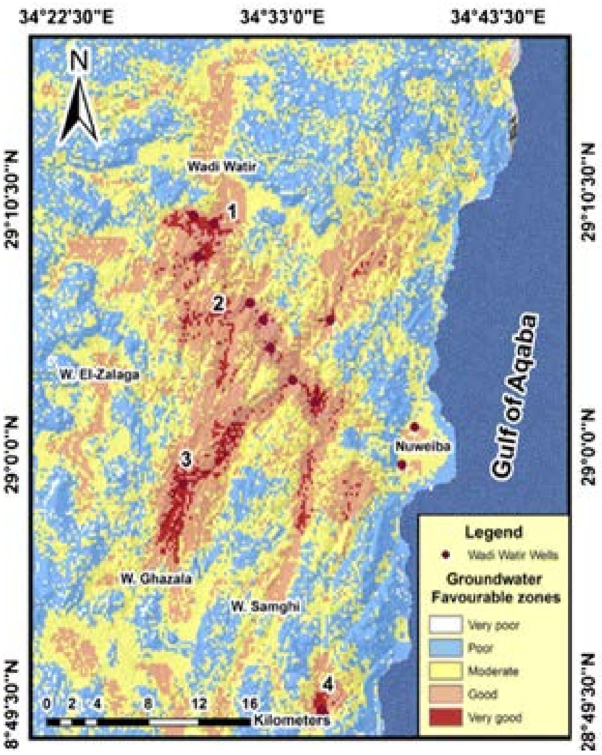


Fig (11): Groundwater potentiality and Wells in Wadi Watir basin (after Abuzied, 2016).

2- Soil resources:

The soils of Wadi Watir geomorphological units are reclassified depending on their physical and chemical characteristics (Table, 6) into marginal- (S3) and non-suitable (N) classes for agriculture use (Fig.12 and Table 7) as follows:

- Marginal suitable class is represented via wadi channel, alluvial plains and delta deposits (230.9 km^2) mainly in the north and middle of the Watir basin. This reflects their functionality for agricultural use and might contribute to the storage of flood waters to boom the soil moisture necessary for agriculture which particular through the natural vegetation distribution through the wadis. These soils are prominent via gently sloping surface, very deep soil profile (>120 cm), loamy sand to gravelly sand texture and commonly non saline soils having < 4 ds/m (Table 6). These soil limiting factors are texture (s1), calcium carbonate (s3) and topography (t) with slight to severe and very severe intensity for soil limitations.
- Non suitability class is represented by all other geomorphic units (3262.3 km^2) which prominent with the aid of high relief, steep slope, and impervious rocks or very shallow soil intensity.

In conclusion, the water harvesting of runoff water as well as the available groundwater in Wadi Watir basin are adequate for agriculture of marginally suitable soils in wadi channel, alluvial plains and delta geomorphological units. Further land improvements are required to correct or reduce the severity of limitation exiting within the studied vicinity, along with a) continuous application of organic compost to enhance soil characteristics and fertility status, and b) utility of sprinkler and drip irrigation device.

Table (6): Some physicochemical characteristics of the studied soils.

Profile No.	Depth, cm	Gravel %	Coarse sand %	Fine sand %	Silt %	Clay %	Textural class	$CaCO_3$ %	$CaSO_4$ %	pHe	EC dS m^{-1}
1	0-10	10	76	9.8	11.2	10.2	Sl. Gr. Sandy loam	37.7	0.24	7.5	1.32
	10-50	50	80.8	8.7	4.55	5.85	V. gr. Sand	41.3	0.2	7.7	1.06
	50-100	40	71.4	10.78	4.8	13	Gr. Sandy loam	38.5	0.06	7.8	0.65
2	0-20	50	73.1	17.16	7.7	2	V. Gr. sand	40.3	0.16	7.5	7.55
	20-90	60	58.4	29.3	2.45	9.8	V. Gr. Loamy sand	35.6	2.4	7.3	11.75
	90-120	80	49.1	37	6.69	6.5	V. Gr. Loamy sand	38	3.7	7.2	18.5
3	0-10	5	91.8	1.23	2.4	4.2	Sl. Gr. Sand	19.8	0.3	7.7	0.81
	10-75	30	90.5	2.52	2.3	4.3	Gr. Sand	18.6	0.62	7.8	0.64
	75-100	30	81.2	2.1	6.1	10.5	Gr. Loamy sand	15.7	1.4	7.7	0.85
4	0-20	50	74.9	15.45	4.5	5	V. Gr. Sand	25.2	0.61	7.7	1.37
	20-40	50	86.1	9.96	2.4	1.4	V. Gr. Sand	30.8	0.93	7.9	0.73
	40-80	70	87.7	9.76	1.29	1.21	V. Gr. Sand	21.2	0.61	7.9	0.65
	80-120	40	85.4	6.93	0.65	6.95	Gr. Sand	28.4	1.2	7.9	0.83
5	0-20	10	82.58	10.2	3.4	3.8	Sl. Gr. Sand	3.2	0.61	7.7	0.9
	20-40	50	85.26	10.6	2.04	2.06	V. Gr. Sand	2.8	0.62	7.7	0.4
	40-70	60	88.1	7.8	1.6	2.4	V. Gr. Sand	4	0.62	7.7	0.4
	70-120	40	94.76	2.51	1.42	1.28	Gr. Sand	2.8	0.78	7.5	0.32
6	0-25	5	80.24	15.7	1.85	2.2	Sl. Gr. Sand	6.4	0.62	7.7	0.61
	25-75	10	89.1	6.5	1.75	2.55	Sl. Gr. Sand	5.6	0.78	7.6	0.46
	75-110	40	78.3	17.3	1.6	2.7	Gr. Sand	7.2	0.78	7.4	0.38
7	0-30	10	81.48	14.30	0.30	3.80	Sl. Gr. Sand	13.50	0.94	7.50	1.15
	30-55	20	91.31	4.30	0.70	3.70	Gr. Sand	10.70	0.61	7.60	1.30
	55-90	30	90.38	4.38	0.90	4.30	Gr. Sand	10.30	0.38	7.60	1.13
8	0-30	10	81.48	14.30	0.30	3.80	Sl. Gr. Sand	13.50	0.94	7.50	1.15
	30-60	20	91.31	4.30	0.70	3.70	Gr. Sand	10.70	0.61	7.60	1.30
	60-120	20	88.20	5.90	1.60	4.20	Gr. Sand	10.10	0.61	7.70	1.26
9	0-30	30	90.75	3.38	1.50	4.30	Gr. Sand	13.70	0.61	7.40	1.59
	30-70	10	77.00	16.80	1.70	4.40	Sl. Gr. Sand	15.30	0.88	7.20	6.77
	70-120	30	83.80	11.00	1.20	3.90	Gr Sand	13.30	0.56	7.40	5.40
10	0-40	40	88.30	2.80	5.30	3.40	Gr. Sand	13.00	0.33	7.80	1.48
	40-80	50	85.10	9.60	2.00	3.20	Gr. Sand	10.80	0.21	8.00	0.85
	80-120	10	86.00	8.51	2.50	2.95	Sl. Gr. Sand	10.50	0.29	7.60	1.54
11	0-30	50	73.1	17.16	7.7	2	V. Gr. sand	40.3	0.16	7.5	7.55
	30-80	60	58.4	29.3	2.45	9.8	V. Gr. Loamy sand	35.6	2.4	7.3	11.75
	80-120	80	49.1	37	6.69	6.5	V. Gr. Loamy sand	38	3.7	7.2	18.5
12	0-25	50	74.9	15.45	4.5	5	V. Gr. Sand	25.2	0.61	7.7	1.37
	25-75	70	87.7	9.76	1.29	1.21	V. Gr. Sand	21.2	0.61	7.9	0.65
	75-120	40	85.4	6.93	0.65	6.95	Gr. Sand	28.4	1.2	7.9	0.83
13	0-20	5	80.24	15.7	1.85	2.2	Sl. Gr. Sand	6.4	0.62	7.7	0.61
	20-70	10	89.1	6.5	1.75	2.55	Sl. Gr. Sand	5.6	0.78	7.6	0.46
	70-115	40	78.3	17.3	1.6	2.7	Gr. Sand	7.2	0.78	7.4	0.38
14	0-25	10	81.48	14.30	0.30	3.80	Sl. Gr. Sand	13.50	0.94	7.50	1.15
	25-60	20	91.31	4.30	0.70	3.70	Gr. Sand	10.70	0.61	7.60	1.30
	60-120	20	88.20	5.90	1.60	4.20	Gr. Sand	10.10	0.61	7.70	1.26

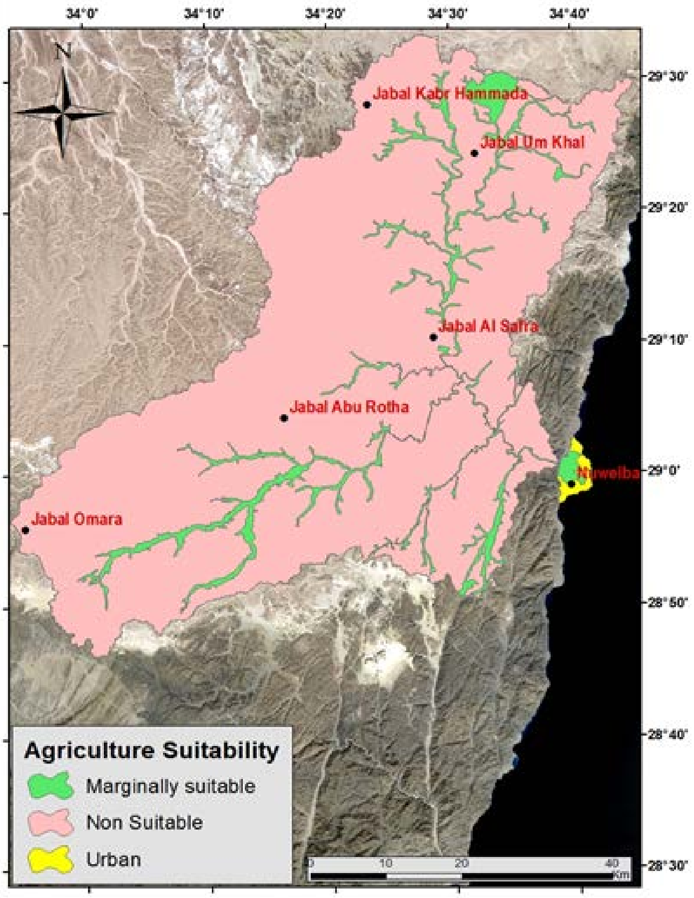


Fig. (12): Current soil suitability for agriculture land use in Wadi Watir basin.

Table (7): Degree of soil limitations and suitability classes* of the studied soil profiles in the selective geomorphological units.

Profile No.	t		w		Soil Physical characteristics (s)					n		Ci		Suitability classes	
	c	p	c	p	s1		s2	s3	s4	c	p	c	p	c	p
					c	p									
1	90	100	100	100	60	70	100	80	100	96	100	41.47	50.4	S3	S2
2	100	100	100	100	50	60	100	80	100	90	100	36.00	48.0	S3	S3
3	90	100	100	100	55	65	100	90	100	96	100	42.77	52.65	S3	S2
4	100	100	100	100	50	60	100	90	100	96	100	43.20	54.0	S3	S2
5	100	100	100	100	30	50	100	100	100	96	100	28.80	50.0	S3	S2
6	90	100	100	100	30	50	100	100	100	96	100	25.92	45.0	S3	S3
7	100	100	100	100	30	50	100	90	100	96	100	25.92	45.0	S3	S3
8	100	100	100	100	30	50	100	100	100	96	100	28.8	50.0	S3	S2
9	100	100	100	100	30	50	100	100	100	90	100	27.0	50.0	S3	S2
10	100	100	100	100	30	50	100	100	100	96	100	28.8	50.0	S3	S2
11	100	100	100	100	50	60	100	80	100	90	100	36.00	48.0	S3	S3
12	100	100	100	100	50	60	100	90	100	96	100	43.20	54.0	S3	S2
13	90	100	100	100	30	50	100	100	100	96	100	25.92	45.0	S3	S3
14	90	100	100	100	30	50	100	100	100	96	100	28.8	50.0	S3	S2

* t = Topography, w= wetness, s1= texture, s2 = soil depth, s3= $CaCO_3$, s4= $CaSO_4.2H_2O$ n= salinity & alkalinity, c= current, p=potential, Ci=Capability index, no hazards (95-100), slight (85-95), moderate (60-85) severe (45-60), very severe hazards (<45).

REFERENCES

Abdel-Rahman, K.; Al-Amri, A.M. and Abdel-Moneim, E. (2009). Seismicity of Sinai Peninsula, Egypt. Arab J. Geosci. 2:103–118.

Abuzied, S.M. (2016). Groundwater potential zone assessment in Wadi Watir area, Egypt using radar data and GIS. Arab J. Geosci. 9: 501.

Amee, K. T. and Dhiman, S.D. (2007). Morphometric analysis and prioritization of mini-watersheds in Mohar watershed, Gujarat using remote sensing and GIS techniques, J. Indian Soc. Remote Sensing, 35: 313-321.

Burt, Rebecca, Ed. (2004). Soil Survey Laboratory Methods Manual, Soil Survey Investigations Report No. 42, Version 4.0, USDA-NRCS, Lincoln, Nebraska.

Cools, J.; Vanderkimpen, P.; El Afandi, G.; Abdelkhalek, A.; Fockedey, S.; El Sammany, M.; Abdallah, G.; El Bihery, M.; Bauwens, W. and Huygens, M. (2012). An early warning system for flash floods in hyper-arid Egypt. Nat. Hazards Earth Syst. Sci., 12: 443-457.

Davis, J.C. (1975). Statics and data analysis in geology. Wiley, New York.

Doornkamp, J.C. and Cuchlaine, A.M.K. (1971). Numerical Analysis in Geomorphology-An Introduction, Edward Arnold, London. Edn., San Jose State University, pp: 86.

EGACS (1989). Egyptian General Authority for Civil Survey. Topographic sheets, scales 1:500000.

El-Sammany, M.S. (2011). Forecasting of flash floods over Wadi Watier–Sinai Peninsula using the weather research and forecasting (WRF) model. World Acad. Sci. Eng. Technol. 46: 996–1000.

EMRL. (2015). Environmental Modeling Research Laboratory. Watershed modeling system (WMS) version 10.0 tutorial. Utah: Brigham Young University.

EMSI. (2018). Watershed Modeling System (WMS). Available from Environmental Modeling Systems

ESRI (2015). ArcGIS 10.4 Software and user manual. Environmental Systems Research Institute, Redlands, California, USA. HTTP://www.esri.com.

Faniran, A. (1968): The Index of Drainage Intensity - A Provisional New Drainage Factor", Australian Journal of Science, 31:328-330.

FAO (2006). Guidelines for soil profile description. Third Edition. Soil resources management and conservation service, land and water development division, FAO, Rome.

Feldman, A.D. (1995). HEC-1 flood hydrograph package. In: Singh VP, editor. Computer models of watershed hydrology. Highlands Ranch, Colorado: Water Resources Publications.

Freund, R.; Garfunkel, Z.; Zak, I.; Goldberg, M.; Weissbrod, T. and Derin, B. (1970). The shear along the Dead Sea Rift. Phil. Trans. R. Soc., London A Math. Phys. Eng. Sci. 267(1181): 107–130. doi:10.1098/rsta.1970.0027.

Geological Survey of Egypt (1994). Geological maps of Sinai (four sheets), Scale 1: 250.000. Geosci 2(2):103-118. doi:10.1007/s12517-008-0014-0.

Greenwood, N.H. (1997). The Sinai: a physical geography. University of Texas Press, Austin, TX.

Haggett, P. (1965). Locational Analysis in Human Geography, Arnold, London.

Horton, R. E. (1932). Drainage Basin Characteristics, Transactions-American Geophysical Union, Vol. 13, pp. 350-361.

Horton, R. E. (1945): Erosional Development of Streams and Their Drainage Basins: Hydro physical Approach to Quantitative Morphology," Bulletin Geological Society of America, 56 :275-370.

Lyberis, N. (1988): Tectonic evolution of the Gulf of Suez and the Gulf of Aqaba. Tectonophysics 153(1): 209–220.

Melton, M. N. (1957). An analysis of the relations among elements of climate surface properties and geomorphology. Project NR

389-042 Tech. Rept. II, Columbia Univ., and Dept. of geology, On Geog., R., Branch, New York, 34.

Miller, V.C. (1953). A quantitative geomorphic study of drainage basin characteristics in the Clinch Mountain area, Virginia and Tennessee, Project NR 389042, Tech. Rept.3., Columbia University, Department of Geology, ONR, Geography Branch, New York.

MWRI (Ministry of Water Resources and Irrigation) (2005). Water for the Future: National Water Resources Plan for Egypt. Imbaba-Giza, Egypt. UNESCO-IHE publishing.

Nag, S. K. and Chakraborty, S. (2003). Influence of Rock Types and Structures in the Development of Drainage Network in Hard Rock Area, J. Indian Soc. Remote Sensing, 31(1): 25-35.

Ross, C.W.; Prihodko, L.; Anchang, J.; Kumar, S.; Ji, W. and Hanan, N.P. (2018). Global hydrologic soil groups (HYSOGs250m) for curve number-based runoff modeling. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1566.

Said, R. (1962). The geology of Egypt. Elsevier, New York 377.

Schumn, S. A. (1956). Evolution of Drainage Systems and Slopes in Bad Lands at Perth Amboy, New Jersey, Bul- letin Geological Society of America, 67 (5): 597-646.

SCS (1993). National Engineering Handbook, "Section 4: hydrology", Soil Conservation Service, USDA, Washington, DC.

Strahler, A.N. (1952). Hypsometric Analysis of Erosional Topography, Bulletin of the Geological Society of America, 63: 1117-1142.

Strahler, A.N. (1964). Quantitative geomorphology of drainage basins and channel networks, Handbook of Applied Hydrology, (New York, Mc. Graw Hill Book Company): 411.

Sys, C. and Verheye, W. (1978). An attempt to the evaluation of physical land characteristics for irrigation according to the FAO framework for land evaluation. Int. Train. Center for post Grade. Soil Sci., Ghent, Belgium.

Sys, C.; Van Ramst, E.; Debaveye, J. and Beernaert, F. (1991). Land Evaluation. Parts I, II and III. Agric. Public. No. 7, GADC, Brussels, Belgium.

USDA (1986). Urban hydrology for small watersheds. Technical Release 55 (TR-55), United States Department of Agriculture, Natura Resources Conservation Service, Conservation Engineering Division, Office of Civil Rights, Room 326W, Whitten Building, 14th and Independence Avenue, SW, Washington, DC 20250-9410.

WRR1 (1987). Wadi Watir Internal. Report. Ministry of Public Works and Water Resources in Arabic.

خصائص الموارد المائية والأرضية في حوض وادي وتير، سيناء، مصر

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الملخص العربي

تهدف هذه الدراسة إلى محاولة تقييم الخصائص الهيدرولوجية والأرضية لوادي وتير، سيناء، مصر باستخدام تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية، ولقد تم قياس وحساب 30 خاصية مورفومترية (مثل عدد ورتب واطوال المجاري بالإضافة إلى خواص أخرى مثل معدل التشعب وكثافة التصريف وتكرار المجاري ونمط التصريف بالإضافة الى خواص شكل حوض التصريف) وذلك اعتمادا على بيانات نموذج الارتفاعات الرقمية (SRTM) ذات دقة 12.5 م بعد تحسينها باستخدام خرائط طبوغرافية ذات مقياس رسم ١:٥٠,٠٠٠،واعتمادا على الخصائص المورفومترية المؤثرة تم حساب مخاطر الفيضان الفجائي لتحت احواض وادى وتير، كذلك تم انشاء خريطة لملاءمة استخدام الحوض في الزراعة من الوحدات الجيومورفولوجية والدراسات الحقلية والمعملية.

تبين ان مساحة حوض وادى وتير هي ٣٤٩٣,٢ كم٢، وتم تقسيمه الى ١٣ تحت حوض ذات مساحات مختلفة، ودللت التحليلات المورفومترية على أن حوض وادى وتير به ٧ رتب للوديان وذات نمط شجيري وتسير غالبا في طبيعة متجانسة، وباستخدام درجات التضاريس ودرجة الوعورة والتفسير المرئي لنموذج الارتفاعات الرقمية تبين أن منطقة الدراسة تتميز باختلاف فى التضاريس والميول وفى مرحلة متأخرة من مراحل عملية التطور الجيومورفولوجي، على الجانب الآخر فان كثافة التصريف المائي ونسيج الوديان وكذلك نسب كل من الاستدارة والاستطالة، تبين أن نسيج الأودية لتحت الأحواض يتراوح من متوسط الى خشن وشكل الحوض الرئيسي ومعظم تحت الأحواض شبه دائري، وهذا يدل على أنها معرضه لمخاطر الفيضان بدرجه كبيره ولها سعة تصريف ضعيفة لتغذية الخزان الجوفي.

اعتمادا على خواص سطح الأرض التي لها تأثير على الخواص الهيدرولوجية للأحواض، تم تقدير درجة مخاطر الفيضان الفجائي بالنسبة لتحت أحواض وادي وتير، وقسمت درجات مخاطر الفيضان في منطقة الدراسة الى قسمين (متوسطة وعالية المخاطر)، وتم انشاء خريطة تبين مواقع السدود المقترحة لمنع مخاطر الفيضان ولتغذية الخزان الجوفي وذلك عند اماكن التقاء الرتب الأعلى للوديان مع الرتب الأقل.

ولقد تم انشاء خريطة لتقييم درجة استخدام حوض وادي وتير في الزراعة، وأمكن تقسيمه الى رتبتين من حيث صلاحيته للزراعة (هامشية الصلاحية وغير ملائمة للاستخدام الزراعي)، كذلك دلت خريطة امكانيات المياه الجوفية فى منطقة الدراسة على أن مختلف الاماكن في الحوض بها مياه جوفية تختلف في كميتها من فقيره جدا الى جيده جدا.