Journal of Nature, Life and Applied Sciences (JNSLAS) • Vol 8, Issue 4 (2024) • P: 28 – 13
https://journals.ajsrp.com/index.php/jnslas
ISSN: 2522-3356 (Online) • ISSN: 2522-3356 (Print)

Morphometric and hydrological characteristics of Abo-Habil Basin, western Sudan

Dr. Ummhani Idris Ahmed

Department of Geography | College of Language and Humanities | Qassim University | KSA

Received: 19/09/2024

Revised: 28/09/2024

Accepted: 15/10/2024

Published: 30/12/2024

* Corresponding author: U.IDRIS@qu.edu.sa

Citation: Ahmed, U. I. (2024). Morphometric and hydrological characteristics of Abo-Habil Basin, western Sudan. *Journal of natural sciences, life and applied sciences, 8*(4), 13 – 28. https://doi.org/10.26389/AJSRP.D210924

Abstract: Examining morphometric parameter is essential for understanding hydrological processes and watershed management, with the goal of utilizing water for various purposes. The primary objective of this research is to identify the morphometric characteristics of the Abo-Habil Basin in western Sudan, analyze the hydrological network of the basin and its significance, and focus on how natural elements have shaped the basin and their impact on flood-prone areas, which can lead to loss of life and property. Additionally, this study employs Geographic Information Systems (GIS) technology for data collection and analysis to establish a database of morphometric characteristics and their hydrological parameters in this region. The analytical descriptive method is utilized to describe the physical characteristics of the basin, including climatology and geology, while a quantitative approach is employed to develop a morphometric database. This includes quantitative analyses of the basin's characteristics, such as aerial, topographic, and drainage network data, using Digital Elevation Models (DEM) and Landsat 8 imagery to derive hydrological parameters. Findings indicate that the valley is situated in a desert climate zone, both arid and semi-arid. The morphometric analysis reveals that the valley trends toward a central location or an endpoint of the watershed, potentially leading to a primary river or drainage region. Additionally, the analysis shows the morphology and arial characteristics of the basin, , presented in Table(10) including an area of approximately (30211.8) km², a perimeter of (1356.4) km, a length of (374) km, width basin (233), an elongation ratio of (0.5), a circularity ratio of (0.2) and a form factor of (0.2). The drainage network analysis of the Abo-Habil basin, presented in Table(12), reveals five orders, ranging from 1st order (the smallest tributaries) to 5th order (the largest one), with a dendritic drainage pattern.The total Stream length of drainage network is (7271) km, with average bifurcation ratio of (5.13) and a hypsometric integral of (19.6%).Relief basin characteristics presented in Table (11). The Abo-Haibl basin has a total relief of (1082) m, a relief ratio of (2.9)m/km, a relative relief of (0.8) m/km, a ruggedness number of (277), and an average slope of (2.8) degrees. The research emphasizes the importance of addressing environmental risks in the region, such as floods and erosion, and recommends establishing water harvesting projects through dams and implementing soil conservation initiatives to protect vegetation and soil.

Keywords: Morphometric analysis, Geomorphological analysis, Abo-Habl Basin, hydrological parameters.

الخصائص المورفومترية والهيدرولوجية في حوض وادي ابوحبل بغرب السودان

د. أم هاني إدريس أحمد

قسم الجغرافيا | كلية اللغات والعلوم الإنسانية | جامعة القصيم | المملكة العربية السعودية

المستخلص: تعتبر دراسة الخصائص المورفومترية ضرورية لفهم العمليات الهيدرولوجية وإدارة الأحواض المائية بهدف استخدام مياهها لأغراض متعددة. يهدف هذا البحث إلى التعرف على الخصائص المورفومترية الرئيسية لحوض وادي أبو حبل في غرب السودان، وتحليل الشبكة الهيدرولوجية للحوض وأهميتها، مع التركيز على كيفية تشكيل العناصر الطبيعية للحوض وتأثيرها على المناطق المعرضة للفيضانات التي تؤدي إلى فقدان الحياة والممتلكات ، بالإضافة إلى ذلك، يستفيد البحث من تقنيات نظم المعلومات الجغرافية في جمع وتحليل البيانات لإنشاء قاعدة بيانات للخصائص المورفومترية ومؤشراتها الهيدرولوجية في هذه المنطقة. تم استخدام المنهج التحليلي الوصفي لوصف طبيعة الحوض وخصائصه المناخية والجيولوجية، بالإضافة إلى المنهج الكمي لبناء قاعدة بيانات جغرافية لمورفومترية حوض وادي أبو حبل. شمل ذلك تحليلاً كميًا لخصائص الحوض المورفومترية التي تتضمن الخصائص المساحية والشكلية والتضاريسية وشبكة التصريف المائي، من خلال استخلاص الشبكة الهيدرولوجية باستخدام نماذج الارتفاعات الرقمية والمرئيات الفضائية بغرض الوصول إلى مدلولاتها الهيدرولوجية ، أظهرت الدراسة أن حوض وادي أبو حبل يقع ضمن المناخ الصحراوي الجاف وشبه الجاف. كما بينت نتائج التحليل المورفومتري أن الوادي يتجه نحو موقع مركزي أو نقطة نهاية لمستجمع المياه، والتي يمكن أن تكون نهرًا رئيسيًا أو منطقة تصريف. ويوضح جدول (10) انه بلغت مساحة الحوض (30211.8 كم²) ومحيط الحوض (1356.4 كم) وطول الحوض (374 كم) وعرض الحوض (233) ونسبة الاستطالة (0.5) ونسبة الاستدارة (0.2) وعامل الشكل(0.2).

أما بالنسبة لتحليل شبكة التصريف، يوضح الجدول (12) فقد تم تقسيمها إلى خمسة رتب على الخريطة، تتراوح من الرتبة الأولى كأصغر الروافد إلى الرتبة الخامسة باعتبارها أكبر الرتب في الوادي وتمثل نهايته. بلغ إجمالي اطوال المجاري (7271 كم) مع معدل نسبة تشعب (5.13) وتكامل قياس هيبسومتري (19.6%). كما بلغ إجمالي تضاريس حوض أبو حبل (1082م) ومعامل التضرس (2.9م/كم) والتضاريس النسبية (0.8) ونسبة الوعورة (277) ومعدل الانحدار (2.8 درجة).

التوصيات: يوصي البحث بأهمية معالجة المخاطر البيئية في المنطقة، مثل الفيضانات، وذلك من خلال الاستفادة من مياه الأمطار والسيول، وإنشاء مشاريع لحصاد المياه مثل الخزانات أو السدود، ومبادرات للحفاظ على التربة لحماية الغطاء النباتي والتربة.

الكلمات المفتاحية: التحليل المورفومتري، التحليل الجيومورفولوجي، حوض أبو حبل، المعايير الهيدرولوجية.

1. Introduction:

Arid and semi-arid regions are characterized by drainage basins with low rainfall, significant runoff, and shallow flow depths (Jawdeha, 2003). Morphometry involves measuring and quantitatively analyzing the dimensions, area, shapes, and configurations of Earth's landforms. This analysis provides valuable information about the current climate, geology, and geomorphological characteristics of a catchment (Altaf, 2013). Morphometric analysis quantitatively measures and mathematically analyzes landforms, which is essential for understanding and determining the hydrological characteristics of water network basins. It provides quantitative data regarding topography and water flow behaviors (Starlher, 1964). According to (Horton (1932) and Soni (2017)), morphometric analysis, which includes basin shape, relief, and drainage network, serves as a key indicator of landform structure and hydrogeologic processes. Geographic Information Systems (GIS) is a comprehensive assembly of software, code, personnel, and digital tools used to manage, analyze, archive, access, and present spatial data related to geography, along with associated information used to define watershed boundaries and drainage basin features.

Previous Study:

Mani. et al. (2022) found that the Suswa River basin displays a sub-dendritic to dendritic drainage pattern, with an average drainage density of (2.84) km/km2. The ratio of elongation suggests that the basin is elongated in shape with a moderate relief.

Alvaro López-Ramos, (2022) this present study carried out a morphological analysis of the Sinú river basin, analyzing its geometric characteristics, drainage networks, and relief to develop integrated water resource management. The Sinú basin has a dendritic drainage pattern, and the results of the drainage network parameters make it possible for us to infer that the middle and lower Sinú areas are the ones mainly affected by floods.The basin geometry parameters indicate an elongated shape, implying a lesser probability of uniform and homogeneous rainfall.Additionally, the hypsometric curve shape indicates that active fluvial and alluvial sedimentary processes are present, allowing us to conclude that much of the material has been eroded and deposited in the basin's lower zones as it could be confirmed with the geological information available.

Al Daidi**.(**2021).This study is based on calculating and analyzing the topographic and morphometric variables directly from the data of the Digital Elevation Model of the Rahjan Valley Basin with a spatial clarity of (12.5) meters using the Spatial Analysis Applications. It also relied on the Strahler method in determining the hierarchical arrangement of the waterways of the network. The results of the study led to the effect of the hierarchical arrangement of the waterways of the network by the number of sewers, which helped not to develop the final rank of the streams of the Rahjan Valley basin to more than the sixth rank.

Alburki. Et al (2018) Morphometric analysis of watersheds: A comprehensive review of data sources, quality, and geospatial techniques, The study area is located in the Northern part of the Eastern Desert of Egypt.Morphology the area has been studied qualitatively and quantitatively, from geomorphologic point of view. qualitatively the drainage patterns tend to be radial reflecting the elongated elliptical antifoams , Four main geomorphologic units can proposed the coastal plain the western belt of mountainous terrain , the salient feature, of the study range and Wadi floor. Quantitative morphometric basin analyses include linear areal and relief characteristics of drainage basins Linear ,characteristics comprise stream number stream length bifurcation ratio and weighted mean bifurcation ratio, Areal characteristics of the drainage basin, include drainage area, stream frequency, drainage density channel maintenance length of overland flow shape index. The relief characteristics are: described in three terms relief ratio, elongation ratio and ruggedness number.

Al Dughairi. A.A, El Sharqawy. M.A. (2018) Characteristic of Wadi Al Rasha Basin Hydrological Network. Wadi Al-Rasha basin covers an area of 15,940 km^2 , in order to extract the hydrological network of Wadi Al-Rasha, remote sensing technique use & geographic information systems were applied to calculate all morphometric variables of the basin. The result reveals varied dimension of the main tributaries of the basin, which tend to have longitudinal shape mean that the basin has an intermediate level of risk in case of flash flood due to heavy rains. Also found the basin in mature stage according to Hypsometric integral value and Strahler classification which means it will take more time to complete it is erosion cycle.

Mustafa, Ahmed Suleiman, Ahmed, Ummhani Idris, et al. (2016). Drainage Basin Morphometric Analysis of Galagu Valley. The study describes the drainage characteristics of Galagu Valley area in Dinder district obtained through GIS based morphometric analysis. It is felt that the study will be useful to understand hydrological behavior of basin. This study depicts the process to evaluate the various morphometric parameters of Galagu Valley using Geographic Information Systems (GIS) techniques.Three major morphometric characteristics are utilized namely: basin shape, relief basin and drainage network are computed using standard methods and formulae for planning and development of the valley basin.

Mustafa. (2012) The Economic, Social and Environmental Impact of Abu Habil Agricultural Project in North Kordufan western Sudan. The research has adopted the method of descriptive , historical and inductive reasoning using rabid rural appraisal secondary and primary sources. The sample of the research used was 18 villages were selected through the scheme villages, representing 50%. And 225 farmer were selected by Simple random procedure among the scheme farmers representing 10%. Information and data were analyzed by the statistical package for social studies (SPSS).The resulted were pointed out poor economic, social and environmental impacts on the farmer.

Research problem:

This study aims to determine the hydrological and morphometric characteristics of the Wadi Abo-Habil Basin, specifically examining the role of natural features in shaping the basin. This area has been significantly impacted by floods, resulting in loss of lives and property, as illustrated in Photo 1. Three individuals were reported missing. https://www.altaghyeer.info

Photo (1) Wadi Abo-Habil Basin in flood stage, 3 people lost their life. Photo (2) Wadi Abo-Habil Basin in Summer Stage

Research objectives:

This research aimed to analyze the hydrological and morphometric characteristics of the Wadi Abo-Habl Basin, with a focus on how natural elements shape the basin and influence flood-prone areas, leading to loss of life and property. The specific objectives of the research are as follows:

1. identify the main Morphometric characteristics of Wadi Abo-Habil Basin.
2. Analysis Network characteristic of the basin & their hydrological significance.
3. Establish a Morphometrics data base of the basin.

Importance of research:

- Water Resources: The watershed is crucial for supplying water resources to the local population for domestic use, agriculture, and livestock.

- Ecology: It supports diverse ecosystems and habitats,which are vital for maintaining biodiversity in the region.
- Development:Understanding the hydrology and effectively managing the watershed is essential for sustainable development and for combating desertification and soil erosion in the area.

2. Materials and Methods:

Study Area:

Abo Habil is a significant watershed in the Kordofan region, Sudan, specifically within the South and north Kordofan states. The watershed plays vital role in the hydrolegy and agriculture sectore of the region. The approximate coordinates for the center of the Abo Habil watershed are around 12.5° to 13.5° North latitude and 29.5° to 31° East longitude.Fig.(1).The watershed is originated in the semi-arid zone of Sudan and is part of the larger Nile basin. It originates from the Dilling mountains in South Kordofan and flows through several of valleys, the most important of which it receives from Jabal al-Dayer in North Kordofan.

It converges with Khor Umm Takrqar, which originates near the city of Al-Abyad. These two waterways meet in Al-Rahad, close to the city of Al-Rahad, Abu Dekna. Abo Habil carries approximately 100 million cubic meters of water from Al-Rahad, moving east toward Samih to irrigate the Abu Habil agricultural project and surrounding areas, totaling about 100,000 acres. There are plans to construct a dam and water reservoir in this area to maximize the potential of these fertile lands and facilitate multiple agricultural cycles. Khor Abu Habil continues on to the White Nile State, reaching the city of Tindelti, where it empties into the White Nile during rainy years. The Al-Awaj Dam has been constructed in Tindelti to capture some of this water before it reaches the White Nile

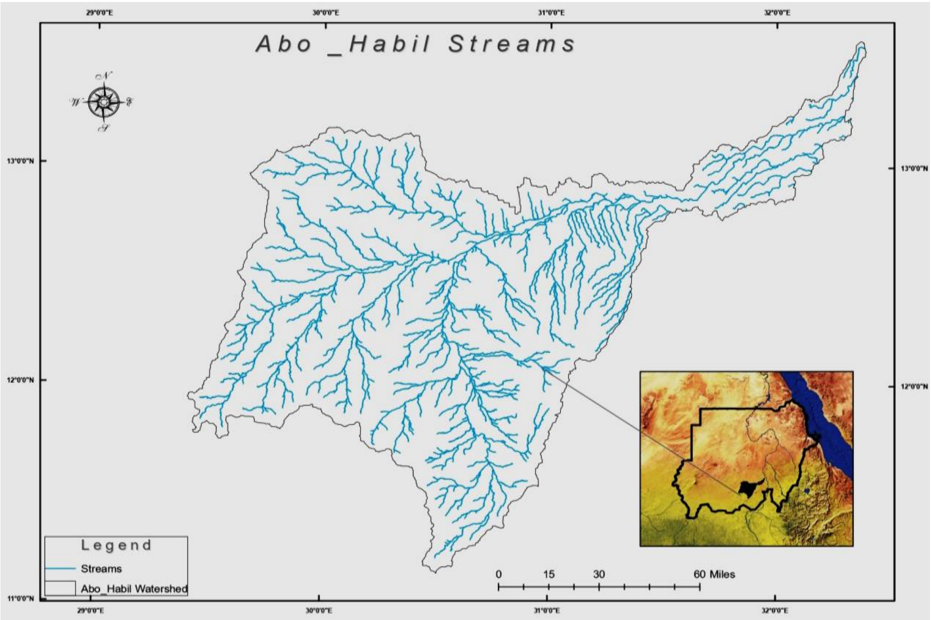


Fig. (1) Location Map of the study area Source:Researcher depend on landsat 8

Physicl characteristic of the study area:

Geologic Structure:

The geological map allows us to categorize the study area into four groups based on their geological history. Each group is further divided into different geological units according to their rock structures and mineral compositions (see Fig. 2).

1. Basement Rock :

This type of rock covers a large area of the basin and dates back to before 1800 million years (m/y). It consists of Pre-Cambrian metamorphic rocks (pCm), including gneisses, schist, marbles, and quartzite (GRAS International, 1995).

2. Nubian Sandstone formation:

This formation occupies a narrow area in the northwest of the basin and dates back to before 36 million years (M/Y). It belongs to the Mesozoic era, specifically the Cretaceous period (KC), and includes sedimentary formations such as chalk, limestone, sandstone, and shale (Eltom., A., 2007).

3. Quaternary deposits (Q) These deposits cover the central basin and represent modern deposition formed during the Pleistocene and Holocene epochs of the Cenozoic era, dating back to before 2.5 million years (M/Y) (GRAS International,1995).They consist of various sediments and volcanic rocks, which can be divided into two types.

3.1.Quaternary Tertiary (QT).) sediments surround the eastern part of the basin and consist of unconsolidated materials such as gravel, sand, and silt.

3.2.Quaternary Eolian (Qe) deposits cover a narrow area in the eastern part of the basin. These Eolian deposits, formed by wind action, typically include sand dunes and loess.

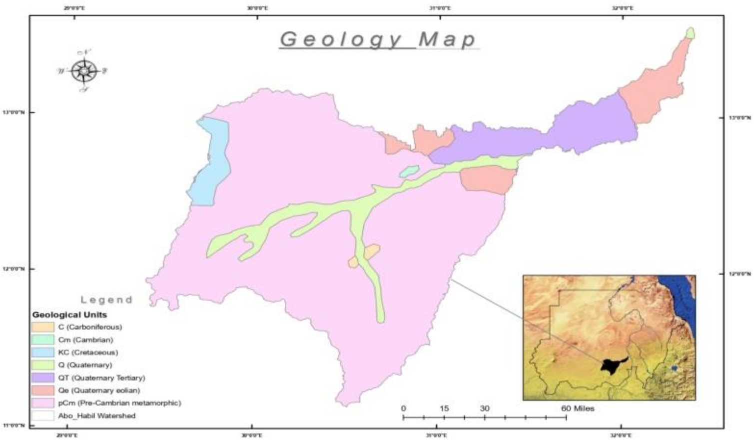


Fig. (2) Geological map of Abo Habil watershed Saurse: Ministry of Energy& Minning/ Geologic Research Authority.

Climate:Rain Quantity Ranges in the study area:

According to the climatic data analysis the annual average rainfall did not exceed (200) mm. The distribution of rainfall in the study area reveals that the southern region typically receives more rainfall, while the northwest and northeast regions tend to receive less compared to the central and southern areas. August displays the highest overall rainfall, with quantities ranging from (128.1–200) mm, making it the wettest month. In contrast, October shows lower rainfall ranges of (4.5 - 44.7) mm, while July and September have higher ranges of (59.5 - 138.8) mm and (68.5 - 82.4) mm, respectively. Although September shows a decrease in maximum rainfall compared to August, it still records higher amounts than July (General Meteorological Authority - Khartoum 2022).

Table (1) Quantity of rain fall in July

Minimum	Maximum
59.5	78.1
78.1	97.7
97.7	108.6
108.6	119.2
119.2	138.8

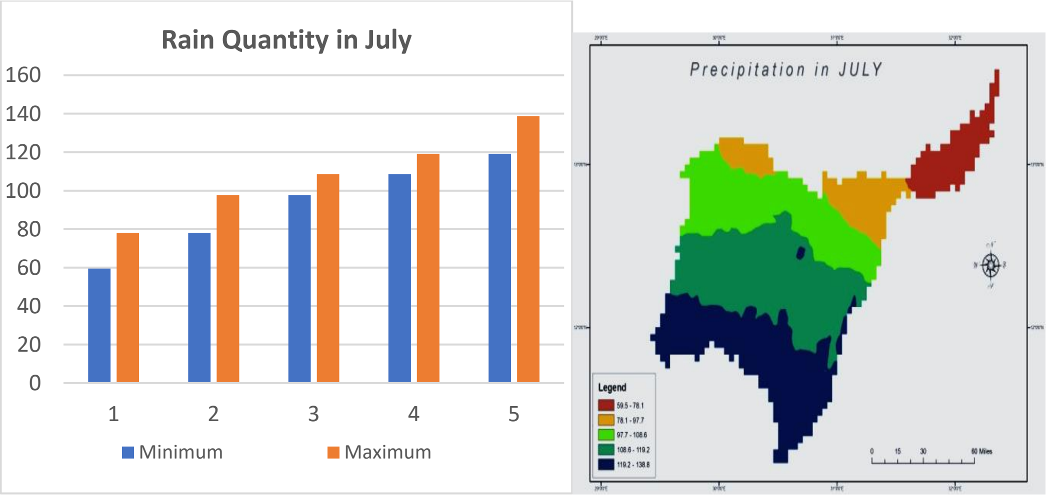


fig.(3) quantity of rain fall in July: Source: General Meteorological Authority - Khartoum 2022.

Table (2) quantity of rain fall in August

Minimum	Maximum
128.1	141
141	150.9
150.9	181.3
181.3	173.4
173.4	200

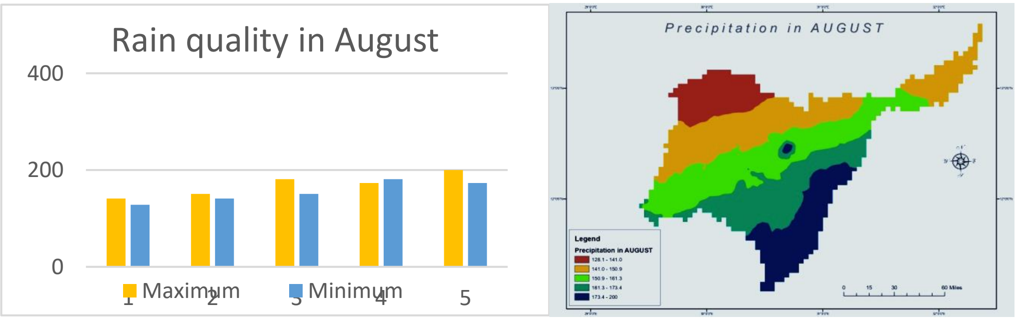
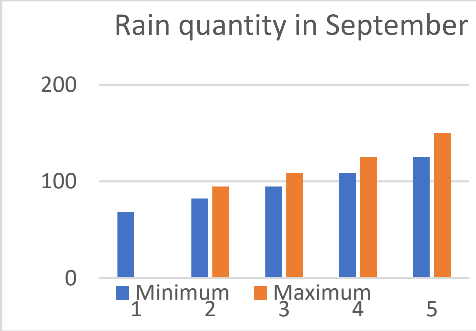


fig.(4) quantity of rain fall in August: Source: General Meteorological Authority – Khartoum2022

Table (3) quantity of rain fall in September

Minimum	Maximum
4.5	10.8
10.8	17.5
17.5	23.8
23.8	32.8
32.8	44.7



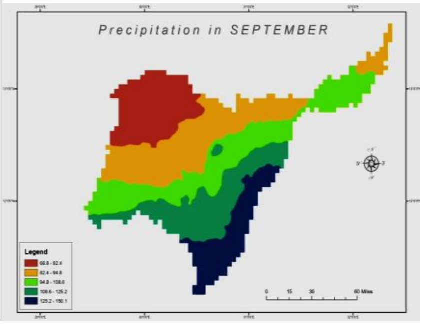
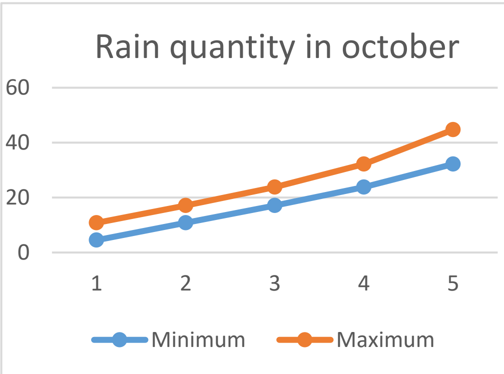


fig.(5) quantity of rain fall in septembe.r Source: General Meteorological Authority - Khartoum

Table (4) quantity of rain fall in October

Minimum	Maximum
68.5	82,4
82.4	94.8
94.8	108.6
108.6	125.2
125.2	150.1



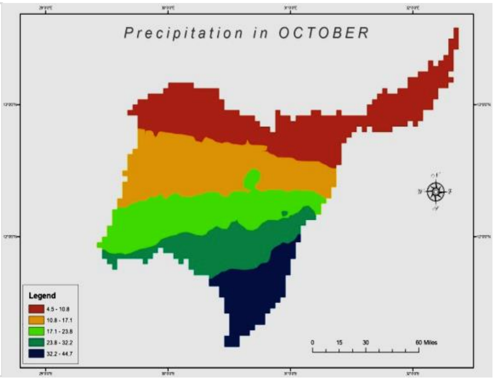


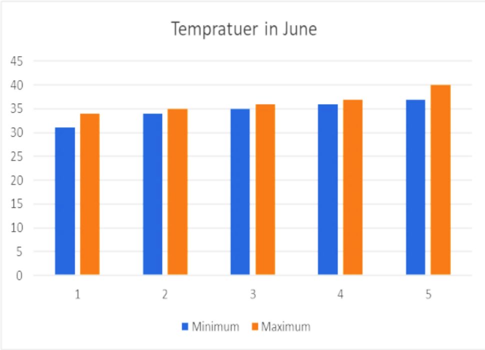
fig.(6) quantity of rain fall in September. Source: General Meteorological Authority - Khartoum 2022

Temperature degrees in the study area:

The temperature maps indicate a clear seasonal cooling trend from May to August range between (28^{O} - 42^{O}).The hottest areas remain consistent in the north and central regions, but the temperature overall decreases each month. The southern regions consistently experience the coolest temperatures.

Table (5) tempratuer degree in June

Minimum	Maximum
31	34
34	34.9
34.9	35.9
35.9	37
37	40



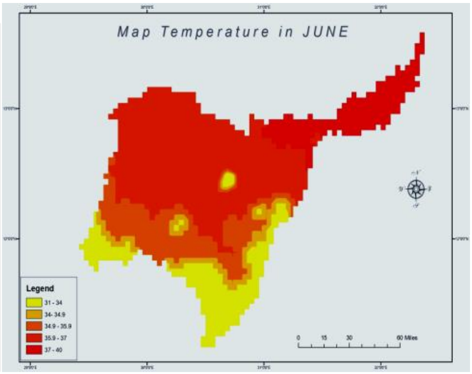
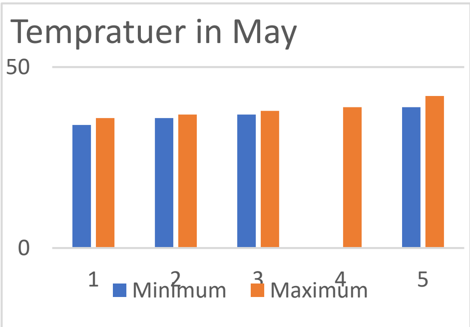
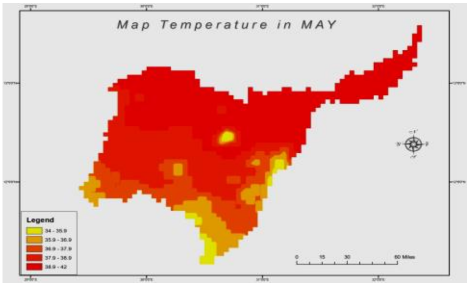


Fig. (7) map tempratuer degree in June. Source: General Meteorological Authority - Khartoum 2022

Minimum	Maximum
34	35.9
35.9	36.9
36.9	37.9
37,9	38.9
38.9	42

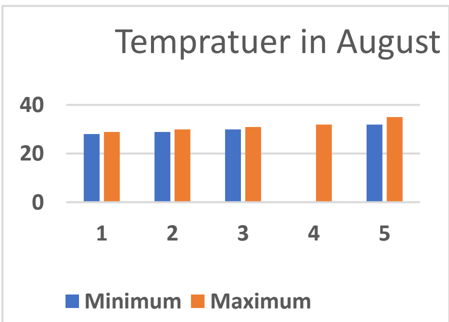
Fig.(6) Ttempratuer degree in May





Minimum	Maximum
28	28.9
28.9	29.9
29.9	30.9
30,9	31.9
31.9	35

Fig.(8) map tempratuer degree in May. Source: General Meteorological Authority – Khartoum 2022 Table (7) Tempratuer degree in August



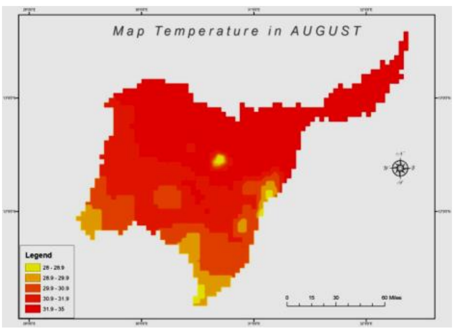


Fig. (9) map tempratuer degree in August.Source: General Meteorological Authority - Khartoum 2022

Table (8) Tempratuer degree in July

Minimum	Maximum
29	30.9
30.9	31.9
31.9	32.9
32,9	33.9
33.9	37

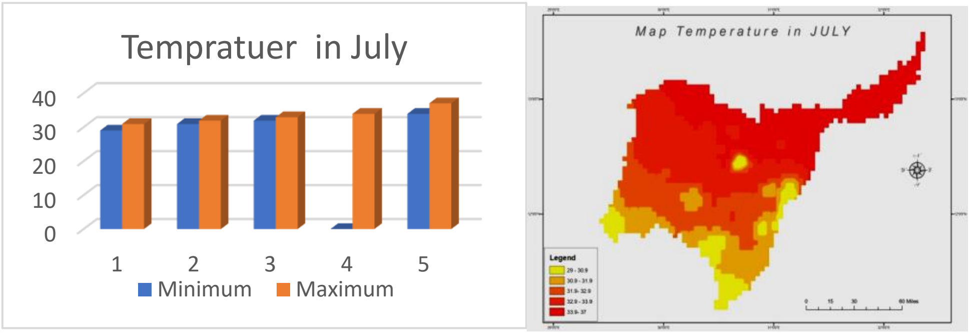
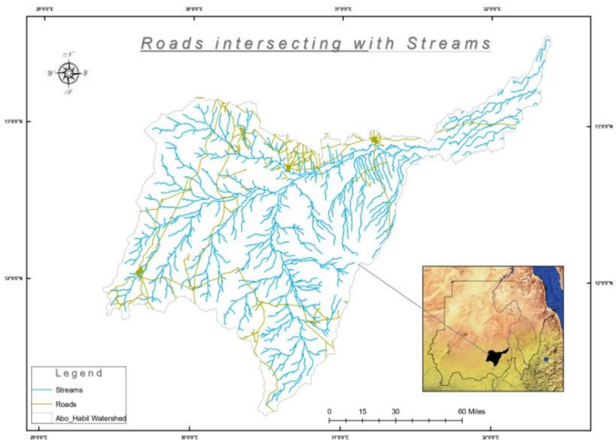


Fig.(10) Map Temperature degree in July. Source: General Meteorological Authority - Khartoum 2022



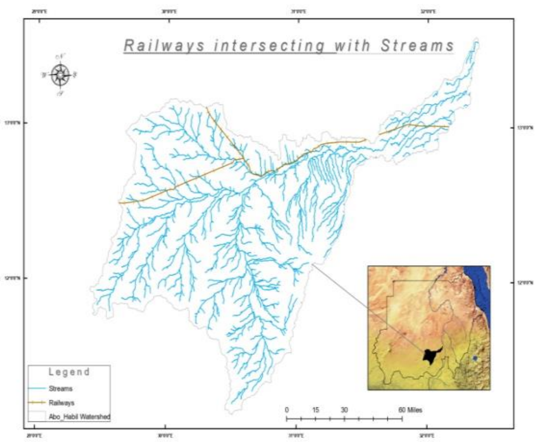


Fig. (11) map shows the intersection of Roads. fig (12) map railways within the Abo Habil watershed

3. Methods:

This study employs an analytical descriptive method to characterize the physical features of the basin, including climatology and geology (Sudan Geologic Map 2004 & GRAS International, 1995). A quantitative approach was utilized to develop a morphometric database, incorporating an analysis of basin characteristics such as area, topography, and the drainage network using Digital Elevation Model (DEM) and Landsat 8 imagery. Calculating morphometric parameters is essential for formulating hypotheses and strategies for water resource development planning. Morphometric analysis mean mathemetic quantitative description of study earth land form and dranige water system originated to (Horton (1945), Abu Elaineen.H.A. (1995). Accessing detailed and accurate topographic information-such as elevation, slope, is crucial for this analysis. These data facilitate the computation of various morphometric parameters, including catchment area, stream length, drainage density, and stream order, which provide valuable insights into the characteristics and behavior of catchment areas. Furthermore, integrating (DEM) with Geographic Information Systems (GIS) allows for the combination of morphometric data with other geospatial datasets, such as land cover, soil types, and rainfall, thereby enhancing our understanding of the complex interactions between landforms and hydrological processes. In this study, the morphometric data obtained were analyzed for the Abo Habil watershed, as indicated on the map, and several aspects can be considered.

Table (9) Morphometric parameters & Equations uses in the analysis:

Metric	Formula	Variables	Source
Elongation Ratio ©	E = {L}/{W}	L: Maximum basin length, W: Mean basin width	Schumm (1956)
Circularity Ratio ©	C = {4 π pi A}/{P^2}	A: Basin area, P: Basin perimeter, Pi: (3.14159)	Miller (1953)
Form Factor (F)	F = {A}/{L^2}	A: Basin area, L: Maximum basin length	Horton (1932)
Hypsometric Integral (HI)	HI = {A_h}/{A_t}	A_h: Area under the hypsometric curve, A_t : Total possible area under an ideal curve	Strahler (1952)
Stream Frequency (Fs)	F_s = {N_s}/{A}	N_s: Number of streams, A: Basin area	Horton (1945)
Ruggedness Number (Rn)	Rn = D_d *(H_m – H_{min})	D_d: Drainage density, H_m: Maximum elevation, H_{min}: Minimum elevation	Strahler (1956)
Drainage Density (Dd)	D_d = {L_t}/{A}	L_t: Total length of streams, A: Basin area	Horton (1945)
Total Relief (Rt)	R_t = H_m – H_{min}	H_m: Maximum elevation, H_{min}: Minimum elevation	Strahler (1952)
Relative Relief (Rr)	R_r = {H_m – H_{min}}/{L}	H_m: Maximum elevation, H_{min}: Minimum elevation, L: Maximum basin length	Melton (1957)
Rugosity Ratio (Rr)	Rr = {R_t}/{sqrt{A}	R_t: Total relief, A: Basin area	Strahler (1958)
Basin Slope (S)	S = {H_m – H_{min}}/{L}	H_m: Maximum elevation, H_{min}: Minimum elevation, L: Maximum basin length	Strahler (1958)
Bifurcation Ratio (Rb)	Rb = N{u}}/{N{u+1}}	N_u: Number of streams of a given order, N_{u+1}: Number of streams of the next higher order	Horton (1945)
Basin Width Ratio (Wb)	Wb = {A}/{L}	A: Basin area, L: Maximum basin length	Horton (1932)

Source: Resercher depend on Reference in above Table.

4. Analysis and Results:

Area and shape characteristics of a basin:

The text represents basin area, dimensions, and form, calculated using the formulae suggested by Horton (1945). The form factor is a dimensionless ratio of the square of the basin length to the basin area, commonly used to illustrate various basin shapes. Different ranges of form factor values exist, with round basins typically having a value around (1) and elongated basins exhibiting lower values (0 or low). A circular catchment experiences high peak flows for a shorter duration compared to an elongated basin, which has lower peak flows sustained over a longer period.

Based on these parameters, we can analyze and define the morphological characteristics of the Abo Habil watershed. As shown in Table (10), the Abo Habil watershed covers an area of (30211.8) km², indicating it is a substantial watershed capable of collecting and channeling significant volumes of water. The total perimeter of the watershed measures (1356.4) km, providing insight into the boundary length and its potential influence on shape and drainage features. The watershed's length dimension, recorded at (374) km in Table (10), is used in various shape indices to evaluate its morphology and hydrological characteristics. The elongation ratio, defined as the ratio of the diameter of a circle with the same area as the basin to the maximum basin length, reveals that an elongation ratio of (0.5) indicates a stretched-out basin. Ratios approaching (1) suggest a rounder form, while significantly lower ratios point to elongation. The circularity ratio compares the basin area to that of a circle with the same perimeter. A circularity ratio of (0.2) signifies that the basin is not circular, suggesting an elongated or irregular shape (see Table 10). This ratio assesses how closely the watershed resembles a circle; values nearing (1) indicate a more circular shape.

The form factor, calculated as the watershed area divided by the square of its length, reflects the similarity of the watershed shape to a rectangle. Values near (1) suggest a more rectangular shape, while a form factor of (0.2) indicates a more elongated shape. This low value suggests that the watershed may be either rectangular or linear, which could lead to rapid water movement along its central axis, potentially increasing flow velocity and triggering flash floods.

Table (10) Morphological Characteristics of Abo Habil

Abo Habil Basin	Basin Area km^2/	Basin Perimeter /km	Basin width/km	Basin length/km	Elongation Ratio	Circularity Ratio	Form Factor
	30211.8	1356.4	233	374	0.5	0.2	0.2

Relief Basin Characteristics:-

Total Basin Relief :

Table (11) displays the total relief of the watershed, which has a value of (1082)/m. This indicates a significant elevation difference within the basin, suggesting that the terrain is steep and rugged. Basins with high relief typically discharge water quickly, potentially leading to increased surface runoff speed and a higher likelihood of flooding.

Relief ratio:

The relief ratio is a metric utilized in the fields of geomorphology and hydrology to assess the level of topographical diversity in a designated region, such as a watershed. Dividing the main horizontal distance of the basin by the difference between the highest and lowest points gives this ratio. (Schumm 1956)If the relief ratio is (2.9)/m/km in the watershed, it indicates that the elevation rises by an average of (2.9) meters for every horizontal kilometer Table (11).This ratio gives a sense of the slope of the land in the basin, where a higher ratio means a steeper terrain and a lower ratio means a flatter terrain. This proportion plays a significant part in determining the velocity of water movement and drainage in the basin, influencing the creation of land shapes and the transfer of sediments and other substances.

The relief was calculated using the formula: $Bh=H\text{-}h$

Where "H" is the maximum elevation, "h" is the minimum elevation

Relative relief:

Relative relief refers to the ratio of elevation differences within a certain area compared to the total elevation range of that area, (Schumm 1987) It is expressed as a ratio or percentage. The relative relief of a watershed was (0.797). Table(11). This indicates a considerable difference in elevations within the watershed and watershed is not flat but rugged, with many hills or mountains and valleys.the relief ratio was calculated using the formula: $Rh=Bh/Lb$

Ruggedness number:

The ruggedness number is a metric utilized in the fields of geomorphology and hydrology to assess the roughness and intricacy of the terrain in a specific watershed. The calculation considers the watershed's area, length, and the watercourses' lengths. A watershed with a high ruggedness number of (0.22) indicates numerous watercourses and a rough, complex terrain Table (11). This has the potential to impact the flow of water, resulting in quick runoff and higher chances of erosion and sediment transportation.

Elevation in the Abo-Habil watershed gradually increases from north to south , lower elevation areas (dark green and light green) are found in the north and northeast, while higher elevation areas (orange and red) are in the south and southeast. The overall slope of the basin is (2.8) degree, represent light slope which indicate that the valley flow in the area geologically weak structure, Table (11).

Table (11) Topographical Characteristics of Abo Habil

Abo Habil Basin	Total Basin Relief/ M	Relief Ratio m/km	Relative Relief m/km	Ruggedness number	Basin Slope	Hypsometric integral
	1082	2.9	0.797	0.22	2.8	19.6%

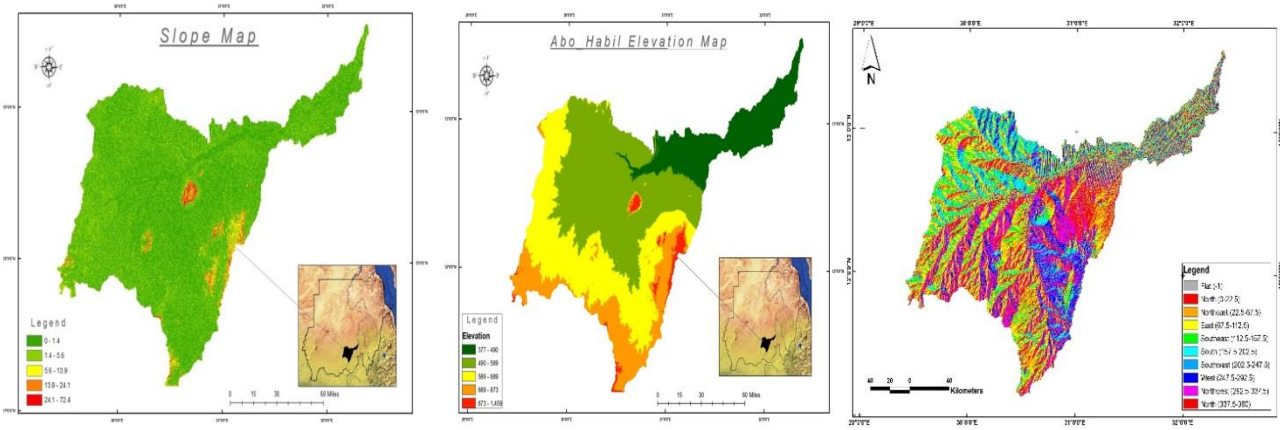


Fig (13) Stream slope & Elevation & Aspect of Abo Habil watershed.Source:The Researcher depend on (RSTM)

Hypsometric analysis:

The hypsometric integral is calculated by comparing the area under the hypsometric curve to the total area of the watershed ,which involves analyzing the correlation between elevation and area. (Strahler 1952) A hypsometric integral of (19.6%) was documented, indicating the level of development and erosion in the watershed Table (11). This value suggests that the landscape tend to slope towards lower elevations, with the most of the watershed area situated at elevations below the highest point. Generally, watersheds with a low hypsometric integral (less than 40%) are more level and eroded, while those with a high hypsometric integral display more varied terrain, indicative of younger landscapes.Thus a value of (19.6%) is considered low, indicating that this watershed features relatively flat terrain with minimal elevation variation. Moreover, this suggests that the watershed may be be relatively old and generally more worn down.

Drainage network characteristics analysis:

The drainage network is the a result of the interaction between the type of rock, its system, and the prevailing climatic conditions (Abu Radi, 2011), and it also reflects the relationship between geological factors, both lithological and structural and the processes of erosion and stages of geomorphology.The linear aspects of the morphometric analysis of s basin include stream order, stream length, mean stream length, stream length ratio and bifurcation ratio. Using these parameters, we can analyze and define the characteristics of the drainage networks in the Abo Habil watershed as presented in Table (12)**.**

Table (12) Characteristics of the Drainage Networks of Abo Habil watershed

Abo Habil Watershed	Number of Streams	Streams Length/ km	bifurcation Ratio	Drainage Density/km/ km^2	Stream Maintenance / km^2
	832	7271	5.13	0.24	0.29

Table (12) indicated the characteristics Abu Habil watershed.The number of Streams is (832)

highlighting the complexity and extent of the drainage network. In term of stream length, which is the one of the most significant hydrological features as it reflects surface runoff characteristics, the total is (7271) km. This length provides insight into the scale of the drainage network and its capacity to transport water. Additionally, the bifurcation ratio is (5.13), representing the ratio of the number of streams of one order to the number of streams of the next higher order. A bifurcation ratio of (5.13) indicated that, on average, there are (5.13) times as many streams of a lower order as there are of the next higher order.This relatively low ratio suggests that the watershed has fewer, more elongated tributaries, indicating a less branched drainage network and relatively homogeneous geologic conditions.Drainage density, indicating the relation between the length of streams and their areas, divided by the total area of the basin(Al Dughairi, Shargawy(2018), is measured at (0.24)/km/km^2. This suggests that there are 0.24 kilometers of streams for every square kilometer of land. Table (12). This value implies a moderate level of drainage density, indicating a balanced terrain where the landscape has neither an excess nor a deficiency of channels relative to its area. The density of the stream network can provide insights into soil permeability and the amount of precipitation the region receives. In areas with a high density of streams, the soil may be less permeable, or the region may experience high precipitation.Stream maintenance,an indicator of the amount of drainage area required to sustain one unit length of stream, has a value of 0.29/km. This suggests that for every kilometer of stream, there is 0.29 square kilometers of drainage area. Table (12). This relatively low value indicates a well-developed drainage network where less drainage area is necessary.

Streams orders. & Counts lengths:

A system introduced by Horton (1932) and later modified by Strahler (1964) and Schumm (1956) has been adopted for analyzing drainage networks. By examining, evaluating, and quantifying stream lengths, we can gain a comprehensive understanding of the drainage network's infrastructure. The size of these networks is closely related to the arrangement of stream lengths, and the number of stream orders is directly correlated with flow volume, (Gregory & Walling, 1973). The map categorizes streams into five orders, from 1st order for the smallest tributaries to 5th order for the largest streams table (13). Figure (14) illustrates the stream hierarchy of Abu Habil watershed. Upper streams (3rd, 4th, and 5th) are less in number and are primarily located in the lower central and eastern areas of the watershed. In contrast, 1st and 2nd order streams are widely distributed throughout the entire watershed, indicating a high level of complexity in the drainage system. Figure (14) also reveals a concentrated network of primary and secondary streams, particularly in the northern and central regions of the watershed. This concentration suggests significant runoff and potentially low soil permeability in these areas. The streams appear to converge toward a central location or the pour point of the watershed, which may be a major river or drainage basin. In the eastern section of the watershed, streams tend to be longer and more abundant, possibly indicating a gentler incline or a consistent water supply.

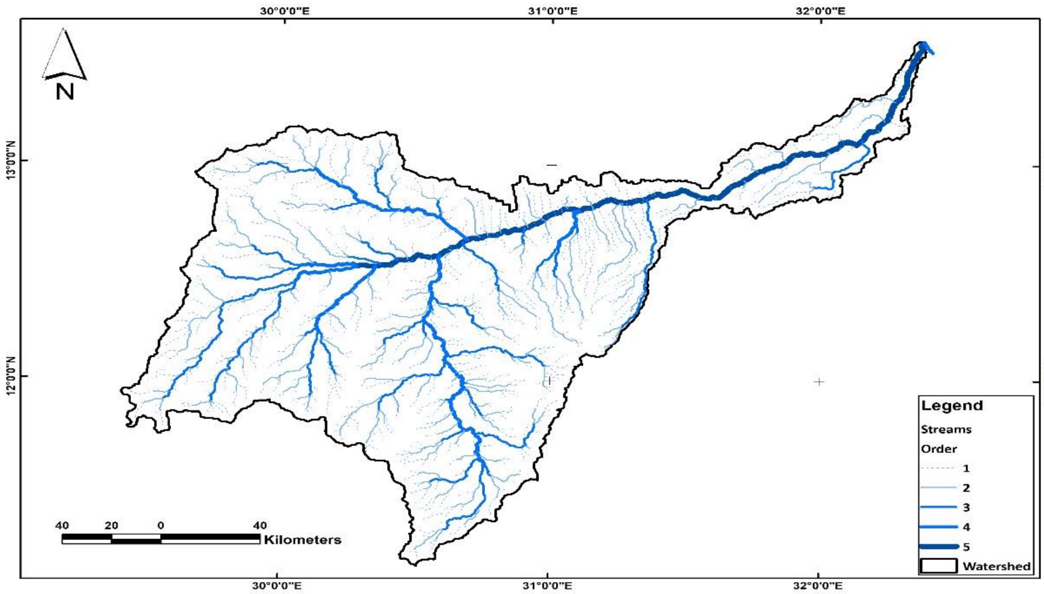


Fig (14) Stream Order of Abo Habil watershed :source researcher depend on (DEM).

Hydrological Implications:

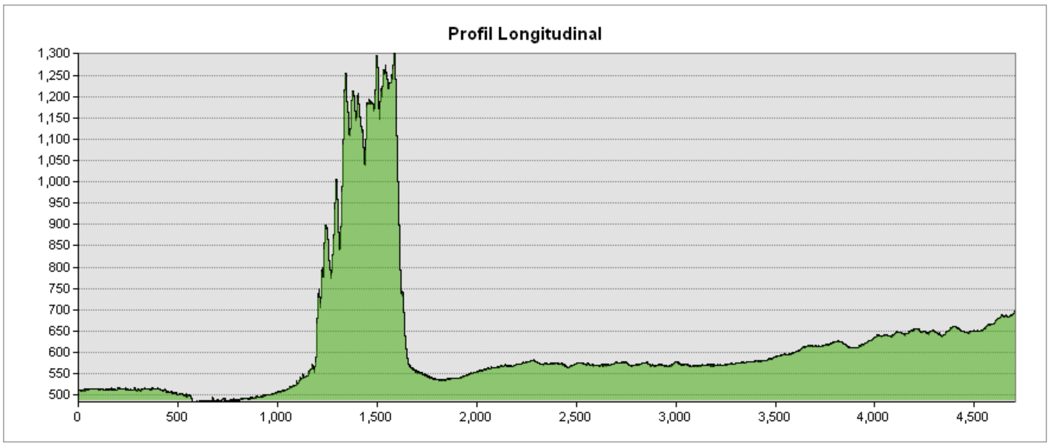
Regions with higher stream orders are more prone to flooding due to their increased capacity to retain water. Conversely, lower-order streams with high density indicate potential sites for soil erosion, especially in steep terrain.

Table (13) Stream Order and Stream Lengths in Abo Habil Watershed

Stream order	Stram count	Stream length/km
1	640	3800
2	150	1820
3	34	970
4	7	367

Stream order	Stram count	Stream length/km
5	1	314
Total	832	7271

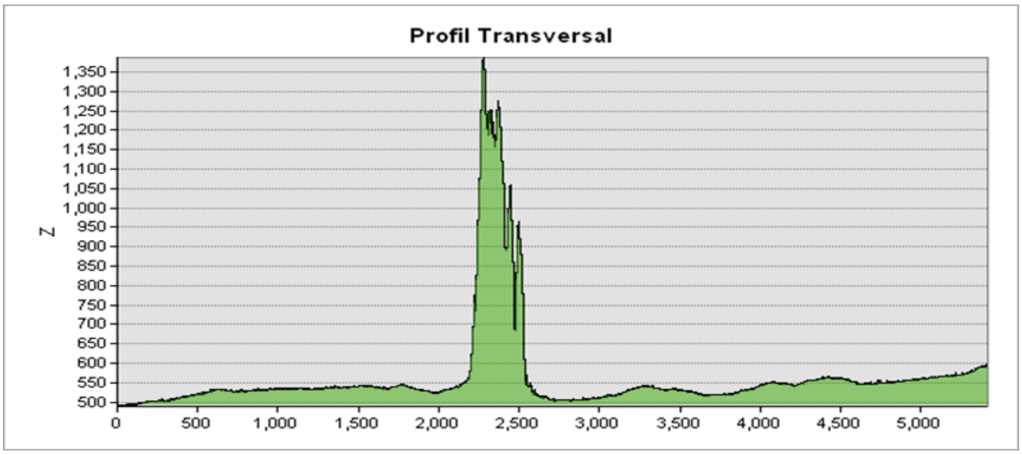
Longitudational Profile:



Longitudational Profile of the Abo Habil watershed: Source:the Researcher depend on (RSTM)

The longitudinal profile illustrated here shows the changes in elevation along a specific path on the Earth's surface. This type of chart is valuable for understanding the terrain and elevation variations along a defined line. Interpretation of the Data in the Chart: This axis represents the distance along the path as depicted in the Digital Elevation Model, ranging from 0 meters to approximately 4500 meters. Vertical Axis (Elevation in meters):This axis indicates the elevation above sea level, ranging from approximately 500 meters to 1300 meters. Analysis of the Longitudinal Profile:Beginning (0 - 1000 meters):At the beginning of the path, the elevation ranges between (500) and (600) meters, indicating relatively low terrain.At the start of the path, the elevation varies between 500 and 600 meters, indicating relatively low terrain. Middle Section (1000 - 1500 meters):There is a steep and rapid increase in elevation reaching over (1200) meters, suggesting the presence of a high mountain or hill.Following the peak, there is a sharp decrease in elevation, indicating a steep slope. Section After the Peak (1500 - 4500 meters):After the sharp decline, the elevation stabilizes around 500 to 600 meters for a period, indicating a relatively flat plain or area. Subsequently, the elevation gradually rises again after 2500 meters, reaching about 750 meters by the end, suggesting rolling hills or gradual terrain.

Transversal Profile:



Transversal Profile of the Abo Habil watershed: Source:the Researcher depend on (RSTM)

The transversal profile: The depicted transversal profile illustrates the elevation changes across a specific cross-section of the terrain. This type of chart effectively conveys the terrain and elevation variations perpendicular to a defined line, making it useful for analyzing cross-sectional terrain features.

Interpretation of the Data in the Chart:

Horizontal Axis (Distance in meters**):** This axis represents the distance across the cross-sectional path on the Digital Elevation Model, ranging from 0 meters to approximately 5000 meters. Vertical Axis (Elevation in meters): This axis indicates the elevation above sea level, ranging from approximately 500 meters to 1350 meters.

Analysis of the Transversal Profile:

Beginning (0 - 2000 meters): The elevation begins at around 500 meters, featuring minor undulations, which suggests relatively flat terrain or low hills. Middle Section (2000 - 3000 meters): A significant and steep increase in elevation occurs, peaking at about 1300 meters around the 2500-meter mark. This indicates the presence of a prominent mountain or steep hill in the middle of the cross-section. Following the peak, there is a sharp decline in elevation, dropping back down to approximately 550 meters, suggesting a steep slope or cliff. Section After the Peak (3000 - 5000 meters): After the sharp decline, the elevation stabilizes around 500 to 600 meters for a stretch, indicating a flat or gently undulating plain. Toward the end, the elevation rises slightly again, reaching about 700 meters, which suggests the presence of small hills or a gradual incline.

Conclusions:

The morphometric features and hydrological patterns of the Wadi Abo-Habil Basin were analyzed using GIS technology,along with morphometric and quantitative analysis for water management purposes. The basin covers an area of (30211.8) km² has a perimeter of (1356.4)/ km and extends of (374) km in length.The drainage network length (6490.3) km with a bifurcation ratio of (1.8), indicating moderate streams branching. The basin total relief of (1082) m and a slope of (2.8) degree, suggesting potential flood risks. Key factors influencing the hydrology of the Abo Habil watershed include topography, stream order and density, soil types and permeability, as well as climate impact. Precipitation patterns, temperature variability, and geographical distribution all contribute to the hydrological behavior of the watershed. The southern region receives more precipitation compared to the northwest and northeast, leading to uneven water distribution and potential flooding in saturated areas. Soil types, such as Lithosols and Chromic Luvisols, impact infiltration rates, erosion susceptibility, and water retention capacity, which in turn influence groundwater recharge, surface runoff, and overall hydrological balance within the watershed. Management strategies should prioritize soil conservation and flood risk management to mitigate potential hazards and ensure sustainable water management in the area.

References:

- Abu Elaineen.H.A. (1995). Origins of geomorphology, Study of the landforms of the Earth's surface. (11 ed), Egypt Skendarya, University Culture Foundation.
- Abu Radi, F.A. (2011). General principles in climate geography, University Knowledge House, Alexandria.
- Alburki.A.A., Alburki.E.A.Almabruk,A.F.,Ramadan.M.M.(2018). Morphometric Basin Analysis around Safaga Eastern Desert of Egypt, Zaytona Journal university , 208-238
- Al Dughairi. A.A, El Sharqawy. M.A. (2018). Characteristic of Wadi Al Risha Basin Hydrological Network. .ournal of Arab and Human Sciences,volume, pp 1563-1608
- Altaf,F.Merja, G.Romshoo, S. A. (2013): Morphometric analysis to infer hydrological behavior of Lidder watershed, Western Himalaya, India. Geography Journal, pp. 1-15.
- Alvaro, Juan Pablo, Luisa Martínez, Guillermo J. John Freddyand Lambraño.(2022).Assessment of Morphometric Parameters as the Basis for Hydrological Inferences in Water Resource Management: A Case Study from the Sinú River Basin in Colombia. International Journal of geo information. MDPI.
- Ashish, Mani, Maya, Komari, and Rushi, Badila. (2022), Morphometric Analysis of Suswa River Basin Using Geospatial Techniques, India.
- Eltom. M.A., A.B. 2007. Geography of Sudan Physical & Human, book. Sudan Open University.

- GRAS, & International, Robertson Research. (1995). Accompanying geological notes to the 1:1000, 000 scale geological atlas the Republic of the Sudan. Sudan: Ministry of Energy and Mining.
- Gregory, k. J. and Walling, K.E.(1973) Drainage basin form processes: a Geomorphological approach. Arnold, London.
- Horton, 1932 R.E. Horton Drainage Basin Characteristics. Trans. Am. Geophys. Union., 13 (1932), pp. 350-361.
- Horton, 1945 R.E. Horton. Erosional development of streams and their drainage basins; hydro physical approach to quantitative morphology.Bull. Geol.Soc. Am.,56 (275–370)
- Jawdeha Hassnain Jawdeha, 2003, Geomorphology. University Knowledge House, Alexandria.
- Leopold, L. B., Wolman, M. G. and Miller, J. P. 1964.Fluvial Process in Geomorphology. Freeman and Co., London.
- Majda Abdullah Al-Daidi. 2021.Digital analysis of morphometric and topographical characteristics and their geomorphological implications, in the Rahjan Valley Basin in the city of Makkah.Arab Journal for Geographic Studies, v.o. 4
- Melton, M.A. (1957)An analysis of the relations among elements of climate, surface properties and geomorphology. Dept. Geol., Columbia University, Technical Report, 11, Proj.NR389-042.off. of Nav. Res., New York.
- Mustafa, Ahmed Suleiman, Ahmed, Ummhani Idris, et al. (2016). Drainage Basin Morphometric Analysis of Galagu Valley. Journal of Applied and Industrial Sciences, 4(1), 6-12.
- Mustafa. El Shareef , , M. A. A.H. (2012).The Economic, Social and Environmental Impact of Abu Habl Agricultural Project in North Kordufan western Sudan. Phd. dissertation, Um Dorman University.
- Schumm, S.A. (1956) Evolution of drainage systems and slopes in Badlands at Perth Amboy, New Jersey. Bull. Geol. Soc. Amer., v.67, pp.597-646.
- Soni, S. (2017). Assessment of morphometric characteristics of Chakrar watershed in Madhya Pradesh India using geospatial technique. Applied Water Science, 7, 2089–2102.
- Strahler, A.N. (1952). Hypsometric analysis of erosional topography. Bulletin of the Geological Society of America. 63: 1117-42.
- Strahler. A.N. (1958): Dimensional analysis applied to fluvially eroded landform rams, Geol, soc Amar, Bull, vol 69.
- Strahler, A.N. (1964). Quantive geomorphology of drainage basins and channel networks. In:Ven Te Chow (ed.) Hand book of Applied Hydrology. McGraw Hill Book Company, New York.
- https://www.altaghyeer.info