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The Al-Abiadh Valley Drainage Basin Environmental Aspects Extraction Using Quantitatively Morphometric Analyses of Shuttle Radar Topographic Mission Data

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Abstract:

The accurate extracting, studying, and analyzing of drainage basin morphometric aspects is important for the accurate determination of environmental factors that formed them, such as climate, tectonic activity, region lithology, and land covering vegetation.

This work was divided into three stages; the 1st stage was delineation of the Al-Abiadh basin borders using a new approach that depends on three-dimensional modeling of the studied region and a drainage network pattern extraction using (Shuttle Radar Topographic Mission) data, the 2nd was the classification of the Al-Abiadh basin streams according to their shape and widenings, and the 3rd was extracting then taking up the quantitative analysis technique to estimate the basin morphometric aspects and the basin's environmental parameters that created them.

The Al-Abiadh valley basin is a six-order one with a dendritic, parallel, and deranged drainage network. The flood hazard is absent at the basin mouth because the valley runoff takes a long time to reach the sink (Al-Razaza Lake), located in the middle part of Iraq, with a low flow peak due to the high permeability soil, the arid to semi-arid climate, and the low annual precipitation rate.

The region studied is an alluvial basin with similar geological structural solidity in most places. The drainage network was found to be controlled by lineaments and fracture traces; the basin has passed its youth geomorphic phase.

Key words: Digital elevation model, Environment factors, Morphometric analyses, Three-dimensional modeling.

Introduction:

The existence of water resources is the principal underpinning that civilized society builds on. Every ancient civilization, Sumerian, Egyptian, and Indus arose from great river basins (1). From this perspective, the extraction of a basin's hydrological aspects (in terms of geometrical morphometric parameter delineation) is essential for good planning and control of irrigation projects especially in arid or arid-threatened regions. Recently Iraq has suffered from increment evapotranspiration rates due to rising average temperatures (2, 3).

The key factor for this rise is the effect of global warming. In Iraq, the ratio of arid land area was 88% of its total area in the first decade of this millennium compared to 72% in the seventies. (4)

The application of the quantitative morphometric approach that was submitted by Horton and improved by many scientists, notably Strahler, is proven to accurately delineate not only the basin hydrological aspects, but also the lithological, geomorphological, and climatic aspects (5). The utilization of GIS techniques to implement quantitative analyses on remotely sensed data rather than classical techniques that depend on a topographical map is important to certify measurement accuracy (6).

The Study Area:

The Al-Abiadh valley drainage basin is one of Iraq's western plateau endorheic basins that drains into the Al-Razaza sink. The extent of the basin spans from 40º 32' 42". 304 to 43º 46' 15". 134 east longitude and from 31º 27' 29".222 to 32º 39' 15".134 north latitude which covers 18608.924 square kilometers. 90.72% of the basin area falls in the Al-Anbar province, 4.76% in Karbala province,

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0.85% in Al-Najaf, and 3.6% of the basin area is located in Saudi Arabia (a cross borderline basin).

The region's climate is arid to semi-arid with rare seasonal rainfall that does not exceed (120 mm); the annual mean of the minimum/maximum temperatures are (24Cº) and (36Cº) respectively. The basin's inhabitants are the wandering nomads that travel along the Al-Abiadh valley rivulets to graze their livestock on desert plants such as wormwood (7). Figure (1) illustrates this region.

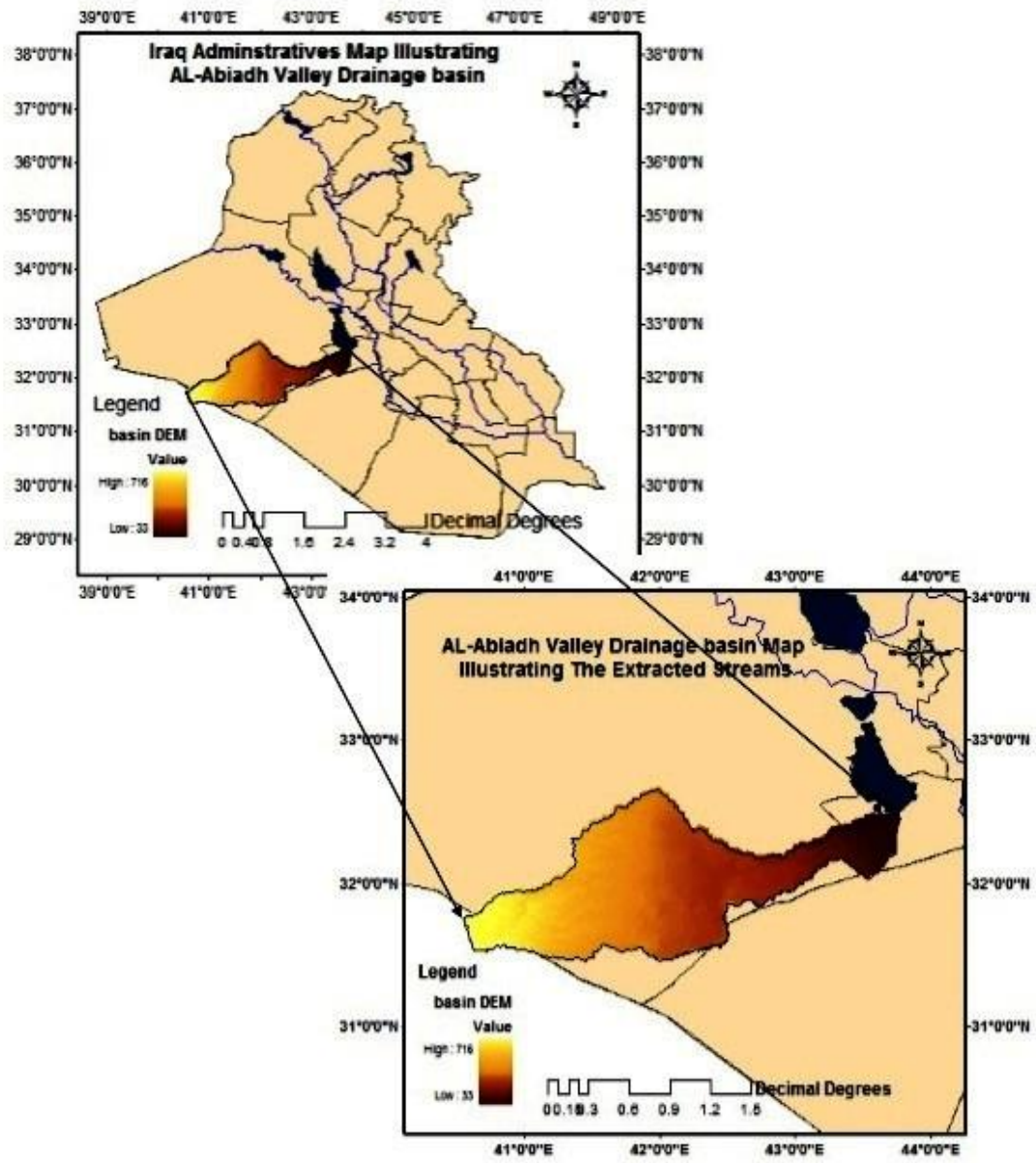

Figure 1. Iraqi administrative map illustrating the Al-Abiadh valley basin's drainage network.

Materials and Methods:

For this article the work was divided into three stages:

A. The basin's watershed delineation and drainage pattern extraction from 90m using Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM).

B. The classification of basin streams according to their pattern shape and according to their channels' width and gradient.

C. The determination of basin morphometric aspects using empirical mathematical equations and/or Arc GIS facilities, then taking a quantitative analysis approach to estimate the basin's geological, lithological, geomorphological, and climate characteristics using morphometric parameter values.

The first stage was achieved by following the classical steps illustrated in fig. (2) below:

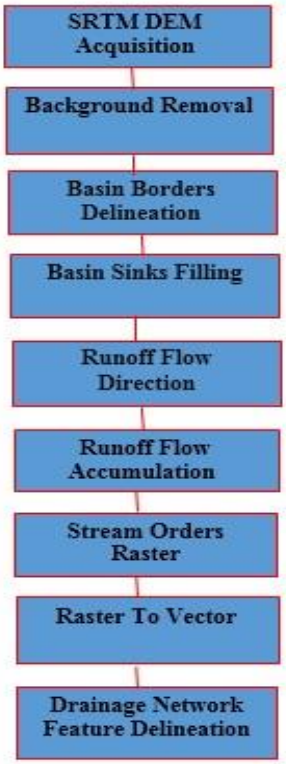

Figure 2. The block diagram that demanded traditional steps to define a basin's watershed and drainage network.

The semi-flat terrain of the basin and its surroundings make the watershed determination difficult, so in this work a new approach was submitted, which is the use of three-dimensional modelling of the region with a double increment in the terrain's height than its real one. Using this technique was sufficient to isolate the basin's border (watershed) from its neighborhoods as in fig. (3)

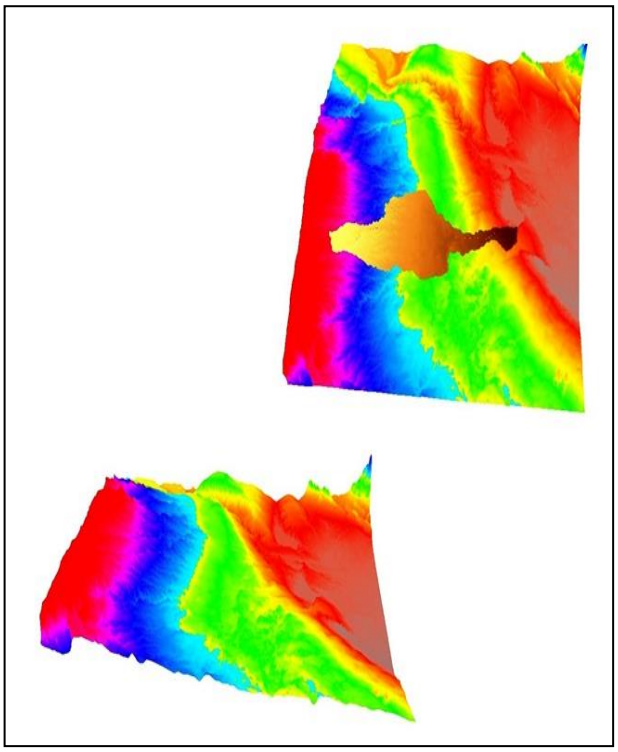

Figure 3. The three-dimensional modelling of the region with an illustration of the extracted basin area.

The second stage involves two approaches as follows:

Visual classification of the streams according to their pattern shape. This is a subjective process that requires an expert interpretation, as the Al-Abiadh valley drainage basin's network pattern system can be distributed among three classes as shown in fig.(4).

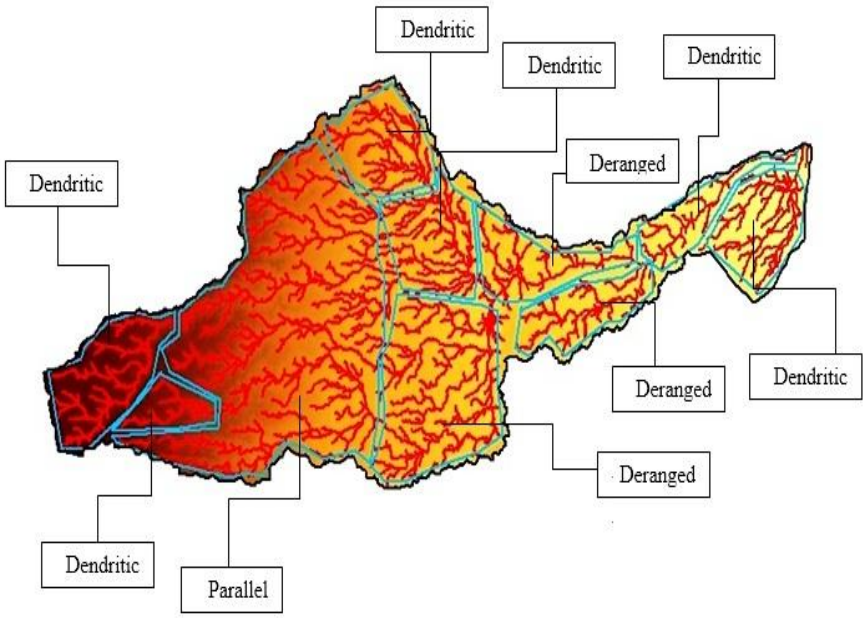

Figure 4. The Al-Abiadh valley's drainage basin network pattern system classes.

Visual classification of the streams according to their channels' width and gradient. To achieve this (the interpolate line tool and the create profile graph tool), which are 3D analyst tools of Arc GIS, were utilized. For the Al-Abiadh valley drainage basin the stream's width increases as the order increases, while the stream channel gradient decreases with the increment of the stream order, with one exception, the 6th order stream which represents the basin valley stream, and the gradient of this valley is very high referring to primary geomorphic stage of this valley. These situations are shown in fig. (5)

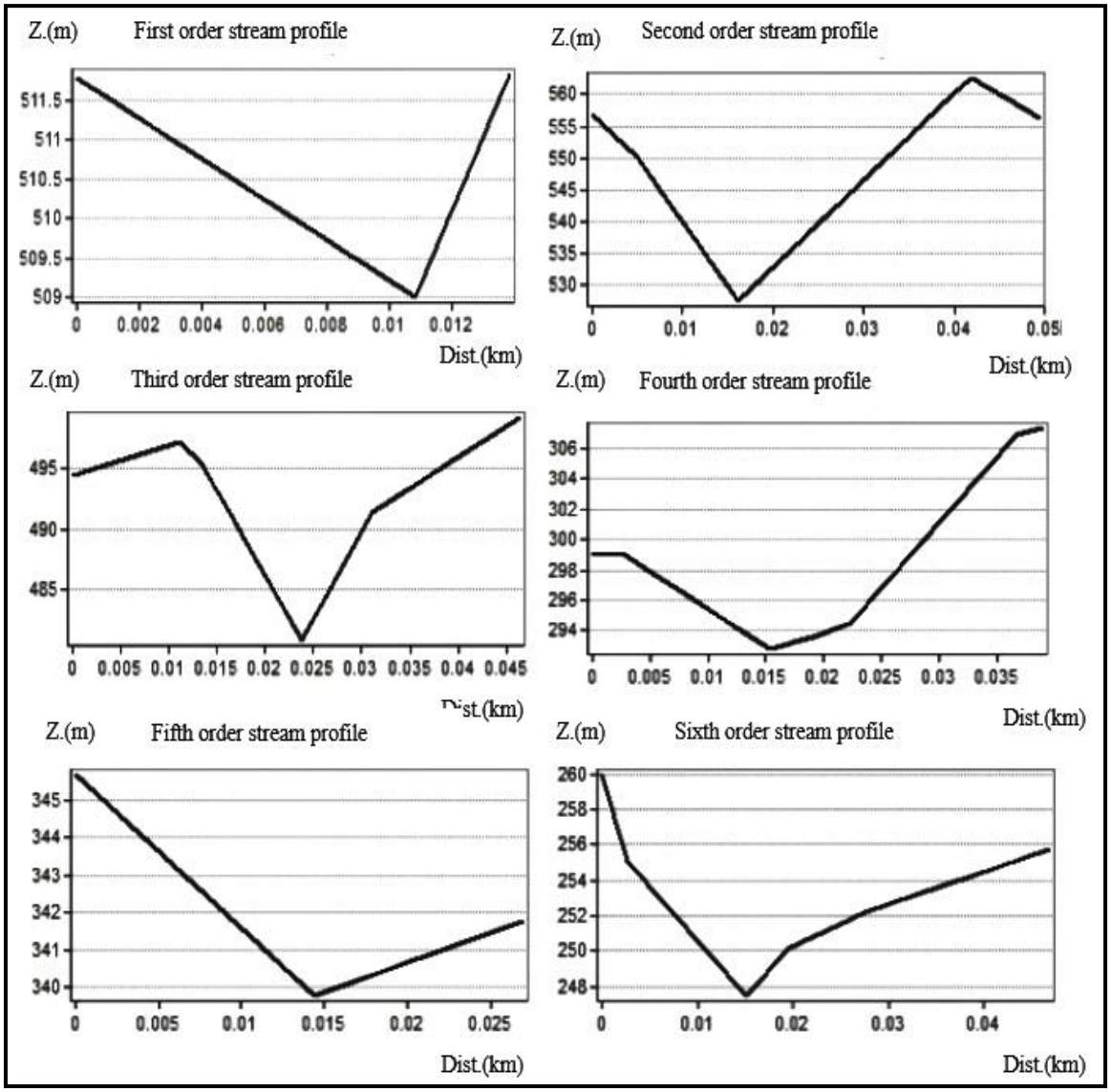

Figure 5. The Al-Abiadh valley drainage basin streams' order profile graph; a) 1st stream's order profile b) 2nd stream's order profile c)3rd stream's order profile d) 4th stream's order profile e) 5th stream's order profile f) 6th stream's order profile

The third stage consists of determining and analyzing the following aspects:

Linear aspects:

The ordering process of the basin's streams is the first step of hydro-morphometric analysis because the water and sediments of the cachement area are moving through the drainage system to a single stream, which is considered the basin order (i.e. the highest order stream in the basin) (8). By using Arc GIS measurements, the basin's real length was 310.2km and the ideal length was 380.475km. The basin's width was 55.941km, while the perimeter was 950.816km.

1.Stream Order (U):

Five distinct schemes of stream ordering was submitted; the 1st scheme was introduced by Gravelius, the 2nd was Horton's scheme, the 3rd was Strahler's, the 4th was Shreve's, and the 5th scheme was Schideggar (9). The method utilized in this

paper was Strahler's, which is considered a slight modification of Horton's ordering process.

The Al-Abiadh basin drainage pattern was automatically modelled by utilizing ArcGIS 9.3 hydrology Arc tools for modelling software and 90m SRTM as ancillary data. The Al-Abiadh valley basin was found to be a six-order basin.

2.Stream Number (Nu):

The Al-Abiadh basin has (672 1st order streams, 321 2nd order streams, 213 3rd order streams, 59 4th order streams, 28 5th order streams, and 44 6th order streams). The streams of each order can be seen in fig.(6)

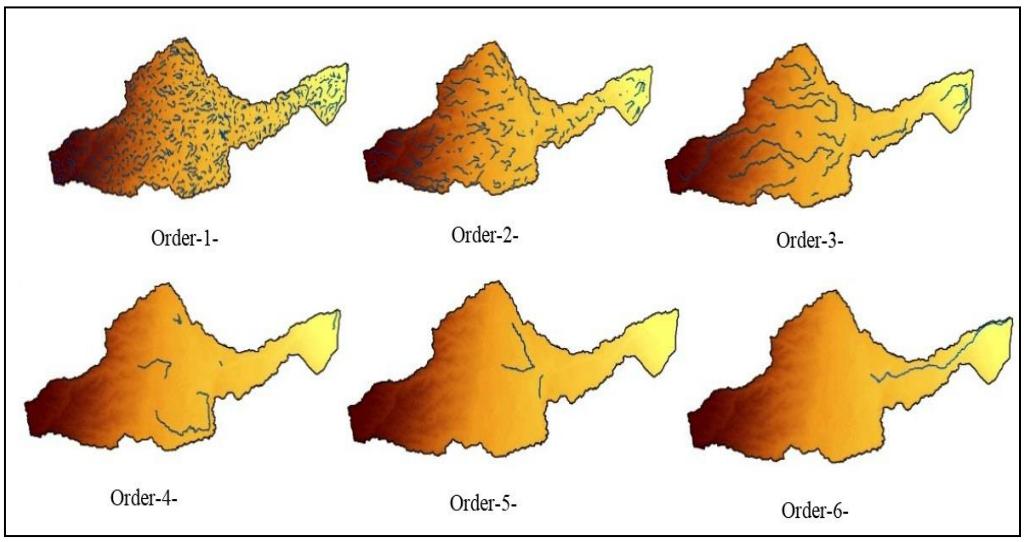

Figure 6. The Al-Abiadh valley drainage basin streams for each of its orders.

3. Stream Length (Lu):

In the Al-Abiadh basin the (L1 is 2861.897m, L2 is 1635.961m, L3 is 1041.228m, L4 is 227.637m, L5 is 108.117m, and L6 is 174.435m).

4. Bifurcation Ratio (Rb):

The mean value of all Rbs of the basin is a considerable measurement because of its impact on the discharge rate (i.e. a higher Rb value means lower flood hazard in the discharge area and vice versa) (9). The average was 1.9906, which means that a flood hazard is absent – this is because the soil of the study area is sandy (high permeability), resulting in a low runoff yield. The 5th Bifurcation Ratio refers to a high discharge rate in the valley (the 6th order streams).

Areal Aspect:

1. Drainage density (Dd):

Drainage density is a topographic aspect with principal importance, since it is a parameter with high sensitivity that links the basin's attribute configuration and the processes working on the stream channel shape. It is a reflection of the landuse which influences the infiltration and response time between rainfall and discharge (10). Dd value can be classified into three categories as follow in table 1.

Table 1. The drainage density categories according to the Strahler classification.

Dd (km/km²)	Description
3-4	Low
4-12	Medium
>12	High

The Al-Abiadh valley basin's Dd is low (0.325km/km²), which in general refers to highly permeable soil and an arid to semi-arid climate with a low precipitation value.

2. Stream (Drainage) frequency (Fs):

Fs is directly related to the lithological properties of the region, structure hills often have high Fs values, while alluvial fan basins usually have lower Fs (11). For every basin there is a direct correlation between Dd and Fs values (12). The Al-Abiadh valley basin's Fs is 0.071 stream/km² highlighting that the region is an alluvial basin.

3. Drainage Texture (Rt):

Rt has an essential importance because the capacity of infiltration and lithology of underlying layers has a major dependence on it. Rt is influenced by vegetated cover density, the permeable quantity of soil, relief, and climate (5). There are five various textures (very coarse <2, coarse 2-4, moderate 4-6, fine 6-8, and very fine >8) (10). The Al-Abiadh valley basin's Rt was 0.706 stream/km, indicating that the drain texture was very coarse and basin permeability was very high,

due to variants of the drainage texture along the study area.

4. Elongation ratio (Re):

The Al-Abiadh valley basin's Re is 0.496 (i.e. the basin shape is median elongated and the geological structures' solidity is the same throughout the basin).

5. Circularity ratio (Rc):

The Al-Abiadh valley's basin Rc is 0.258 (i.e. it is far from a circular shape and its drainage pattern is controlled by the lineaments and fracture traces. In addition, the watershed's lines are irregular and the basin is generally in the youth phase of the geomorphic cycle).

6. Form factor (Rf):

The Al-Abiadh valley's basin Rf is 0.193 (i.e. it has an elongated shape with a low peak flow, long duration, and absent of a flood risk).

Relief Aspect:

1. Basin Relief (H):

The Al-Abiadh valley's basin relief is (677m). It is generally a highly valued relief valley.

2. Relief ratio (Rh):

The Al-Abiadh valley's Rh is 0.458 (i.e. the basin is in the primary stage of maturing, since a low value Rh means lower erosion power and sediment yield towards the basin's mouth).

3. The Constant of Channel Maintenance (C):

C of the study area is 3.076km (i.e. The Al-Abiadh basin is an alluvial basin with strong lithology control).

Conclusions:

The use of the quantitative morphometric analysis is essential not only to determine the environmental factors that created any basin, but to also find the best ways to invest in it. The Al-Abiadh valley drainage basin was found to be a six-order basin. The mean value of the Bifurcation Ratio was (1.9906), reflecting the absence of a flood hazard at the basin mouth, and the high permeability soil in it.

The value of the drainage density was 0.325 km/km², indicative of an arid and/or semi-arid climate with a low annual precipitation rate. The stream frequency value is 0.071 stream/km² indicating that the study region is an alluvial fan basin. The basin's geological structure solidity was found to be the same all over the basin since elongation ratio value was 0.496. The basin's drainage network is controlled by the lineaments and fracture traces as circularity ratio is 0.258.

The valley runoff water takes a long time to reach the sink (Al-Razaza Lake) with a low flow peak because form factor value is 0.193. Relief ratio was 0.458 indicating that erosion power is low and the sediment yield quantity towards the basin's outlet is low. This low R_f value and the steepness of the sixth order stream (basin stream) indicates the primary stage of the geomorphic cycle for the Al-Abiadh valley.

Conflicts of Interest: None.

References:

1. Crawford H E. Sumer and the Sumerians. 2nd Edition, Cambridge University Press, 2004, ISBN: 0-521-38850-3, The Edinburgh Building, cb2 2ru, UK, 20-22
2. Jawad L A. The Use of Geographic Information System Facilities to Estimate the Evapotranspiration in Iraq According to Thornthwaite Adjusted Formula,.*IJS*, 2016, 57 (4A): 2566-2574
3. Atiaa A M, Abdul-Qadir A M. Using fuzzy logic for estimating monthly pan evaporation from meteorological data in Emara/ South of Iraq. *BSJ*. 2012, 9 (1): 133-140
4. Jawad L A. The Climatic Quality Index Determination for Iraq Using Meteorological Stations Data. *IJS*.2016; 57 (4C): 3005-3016
5. Pate R S, Gupta D, Sen Tiwari S, Dwivedi S B. Morphometric aspects of a small river system of Mirzapur District, Uttar Pradesh, India: A case study of Barhi river system. *IJMRD*. 2016; 3(3): 250-255
6. Abdulla H H. Morphometric parameters study for the lower part of lesser zap using GIS technique. *DJPS*,.2011, 7 (2): 127-155
7. Hajam R A, Hamid A, Bhat S U. Application of Morphometric Analysis for Geo-Hydrological Studies Using Geo-Spatial Technology. *HCRJ*. 2013; 4 (3): 1-12
8. Ifabiyi P A. Reduced Rank Model of Drainage Basin Response to Runoff in Upper Kaduna Catchment of Northern Nigeria. Geo-studies Forum.2004, 2 (1): 109-117
9. Hanan A, Hasan B. The role of geographic information system in laban valley basin morphometric characteristics study, MSc thesis, King Saud University, 2008.
10. Mudashiru R, Olawuyi B M, Yusuf A I, Oyelakin M A. Morphometric Analysis of Asa and Oyun River Basins, North Central Nigeria Using Geographical Information System. *AJCE*,.2017; 5 (6): 379-393
11. Jain V, Sinha R. Evaluation of Geomorphic Control on Flood Hazard through Geomorphic Instantaneous Unit Hydrograph. *CSJ*. 2003; 85 (11): 26-32
12. Okoko E E, Olujinimi J A B.The Role of Geomorphic Features in Urban Flooding: The Case of Ala River in Akure, Nigeria. *IJEI*. 2013; 1(1): 192-201

استخلاص الخصائص البيئية لحوض تصريف وادي الابيض باستخدام التحليلات المورفومترية المكممة لبيانات المكوك الراداري للمهمة الطوبغرافية

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الخلاصة:

ان الدقة في الاستخلاص والدراسة والتحليل للخصائص الشكلية لحوض التصريف يعد شانا هاما للتحديد الدقيق للعوامل البيئية التي اسهمت في تكوينها مثل (المناخ، النشاط الحركي للقشرة الارضية، التركيب الصخاري للمنطقة، و الغطاء الخضري لسطح الارض).

هذا العمل تم تقسيمه على عدة مراحل: المرحلة الاولى تمثلت بتحديد حدود الحوض باستخدام مقاربة جديدة تعتمد نمذجة ثلاثية الابعاد لمنطقة الدراسة ثم استخلاص الانموذج الالي لشبكة التصريف، الثانية يتم فيها تصنيف جداول الحوض حسب الشكل والاتساع، اما الثالثة فكانت استخلاص الخصائص الشكلية للحوض وتنفيذ تقنية التحليل الكمي عليها من اجل تحديد عوامل الحوض البيئية التي كونتها.

حوض وادي الابيض سداسي المراتب ذو شبكة تصريف بانماط نجمية ومتوازية ومشوشة. ان خطر الفيضان منعدم عند مصب الحوض بسبب الفترة الطويلة التي يستغرقها السيح السطحي وصولا لقعر الوادي (بحيرة الرزازة) والتي تقع في وسط العراق مع قمة واطئة للدفق المائي للسيح والناتجة عن النفاذية العالية للتربة كذلك المناخ الجاف الى شبه الجاف ومعدل التساقط المطري السنوي المنخفض للمنطقة. منطقة البحث عبارة عن حوض طميي ذو صلادة متقاربة لتراكيبها الجيولوجية. تم اثبات ان شبكة التصريف متاثرة بالتراكيب الخطية واثار التصدع وان حوض وادي البيض يمر بمرحلة الشباب التحاتية.

الكلمات المفتاحية: إنموذج الارتفاعات الرقمية، المعاملات البيئية، التحليلات المورفومترية، النمذجة ثلاثية الابعاد.