Qurain AL-Thamad Valley Hydrological Aspects Extraction Using Remote Sensing and GIS Techniques

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Abstract

In the arid to semi-arid lands the extracted hydrological features are essential ones, since their effect on water projects managing, agricultural projects administrating, and animals grazing, so that this research is considered to be a vital research because the climate of Qurain AL-Thamad basin is arid climate and basin region inhabited by many tribes who work in agriculture and grazing fields. The illustration of hydrological features using morphometric analyses is optimized since the quantization issue of basin factors, in the past this would be difficult using classical procedures (i.e. using paper topographic maps and planimeter). Recently as in this work, modern procedures have been used (i.e. satellite imagery DEM as ancillary image and Arc GIS 10.5 as geo-measuring and spatio-analyzing program).

The pattern of Qurain AL-Thamad basin's drainage network shows a dendritic configuration in low orders streams and parallel configuration in the high order streams. The spatial analysis using GIS environment categorizes basin's shape parameters into three categories: firstly one is the linear parameters with streams divided into 1st order streams with (611.587 km) length, 2nd order streams with (384.015 km) length, 3rd order streams with (181.868 km) length, and 4th order streams with (103.674 km) length. Bifurcation ratios were calculated, R_{b1} is (2.046), R_{b2} is (1.869), and R_{b3} is (1.624), with (1.852) R_b mean value. Secondly categorize deals with a areal parameters; The longitudinal drainage density was (0.259 km^{-1}), the drainage frequency was (0.035 stream /km²), Drainage Texture value was (0.338 stream / km), the elongation ratio was (0.483), the circularity ratio value was (0.244), the form factor was (0.183) , and the relief ratio was (0.447). according to these quantitative results the flood hazard in the basin main stream is absent, basin soil is highly permeable and region rainfall rate is very low, there are significant differences in regional geological structures solidity, land steepness and relief ratio are low valued yielding a few water erosion power, sediment yield, and runoff flood peak in the basin water catchment area.

Keywords: Hydrological features, Quantitative parameters, Spatial analysis, and SRTM DEM.

إستنتاج الخصائص الهيدرولوجية لوادي قرين الثماد باستخدام تقنيات الإستشعارعن بعد ونظم المعلومات الجغرافية

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الخلاصة

يعتبراستخراج الخصائص الهيدرولوجية امراً جوهرياً في المناطق الجافة الى شبه الجافة، لما لها من تأثير على ادارة مشاريع المياه,التحكم بالمشاريع الزراعية, و عملية رعي الماشية. لذلك يعد هذا البحث حيوياً لكون

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مناخ حوض قرين الثماد جافاً مع استيطان الحوض من قبائل عديدة يعمل ابناؤها في مجالي الزراعة والرعي.

يعد تبيان الخصائص الهيدرولوجية باستخدام التحليل المورفومتري امراً مثالياً بسبب القدرة على تكميم قيم معاملات الحوض، في الماضي كان هذا صعب التحقيق باستخدام الوسائل التقليدية(أي استخدام الخرائط الطوبوغرافية الورقية ومقاييس الخرائط العامة). حديثاً كما في هذا البحث يتم استخدام الوسائل المتطورة (بمعنى انموذج الارتفاعات الرقمية المحتسب من الصور الفضائية كبيانات خام وبرنامج   "Arc GIS 10.5" كبرنامج للقياس جغرافي والتحليل المكاني).

الانموذج المستحصل لشبكة تصريف حوض قرين الثماد يظهر الشكل النجمي لجداول المراتب الدنيا والشكل المتوازي لجداول المراتب العليا. التحليل المكاني باستخدام بيئة ال "GIS" صنف معاملات الحوض الشكلية لثلاث انواع: اولها المعاملات الخطية وبجداول موزعة الى: جداول المرتبة الاولى بمجموع اطوال قدره 611.587 km, جداول المرتبة الثانية بمجموع اطوال قدره 384.015 km, جداول المرتبة الثالثة بمجموع اطوال قدره 181.868 km, جداول المرتبة الرابعة بمجموع اطوال قدره 103.674 km. نسب التفرع للحوض تم احتسابها وكانت على التوالي (1.624) ,(1.869), (2.046) اما معدل نسبة التفرع فهو1.852. ثانيها المعاملات المساحية, بلغت قيمة كثافة التصريف الطولية‎¯km 0.259 تكرار جداول التصريف كان 0.035 stream /km² قيمة نسيج التصريف كانت 0.338 stream / km نسبة الاستطالة بلغت 0.483 , نسبة الاستدارة كانت 0.244 . معامل الشكل بلغت قيمته0.183 والصنف الثالث فيه نسبة الوعورة 0.447 . وفقاً لهذه النتائج المكممة فان خطر الفيضان في مجرى الحوض الرئيسي غير محتمل, نفاذية تربة الحوض عالية ونسب تساقط الامطار منخفضة جداً, هنالك اختلاف واضح في صلابة التراكيب الجيولوجية المكونة للحوض, انحدار الارض ونسبة الوعورة منخفضة مما يؤدي الى انخفاض (قدرة التعرية المائية, كمية الرواسب, وقمة سيل دفق السيح السطحي) في منطقة الحصاد المائي للحوض.

Introduction

The explanation of region land topography by utilizing the means of area, shape, perimeter, and length is well-known as morphometry [1]. The morpho-parameters have a great influence on the drainage network streams flow because of their effect on the time of runoff water concentration [2]. The first to discover the importance of these parameters was A. N. Strahler [3], he pointed that basin geomorphological activates has the major control on basin streams flow pattern. The validity of this assertion continue as many researches [4], [5], and [6] referred to geomorphological aspects to be responsible of basin's hydrological features, according to this point of view the morphometric analysis is not only a procedure to understand basin hydrological aspects but also to find out basin forming processes that could be covered by spatio-temporal veiling.

In the past, there was only weak describe for water shade using Davisian method (i.e the water shade said to be poor or well drained and pass in young, mature, or oldness stage of forming process). James Hotton [7] open the door of " basin quantitative expression" era through his works which considered the actually basin's river channels forming mechanics [8]and [9]. Since then quantitative mathematical equations of land shape parameters were used to identify basin climate, geological, hydrological, and geomorphological aspects because of their accuracy and objectivity [10]. In this work the previous aspects of Qurain AL-Thamad basin were extracted by utilizing quantitative morphometric analyses factors.

The study area

Qurain AL-Thamad valley is an arid basin lays in AL-Najaf desert which is a normal extension of Iraq's western plateau. Its area mostly falls in AL-Najaf province, the residue falls in AL-Muthana and AL-Dewaniya provinces. Qurain AL-Thamad geographical borders extends between (43° 59' 57.427" to 44° 40' 25.688") east longitudes and (30° 13' 50.63" to 31° 23' 25.23") north latitudes. Geologically it composed of many petrosal formations with different resistance for erosion factors such as (AL-Zahra, AL-Furat, and AL-Damam) formations. According to AL-Najaf, AL-Muthana, and AL-Dewaniya metrological stations, the regional climate is typically "desert climate" with high (air temperatures, evapotranspiration) [11]rates and (few, rare) rainfall storms with rates less than (100 mm/year) that affect the shape and dense of the basin streams[12]. Figure-1 shows the position of Qurain AL-Thamad valley. The location of this valley is shown in Figure-1.
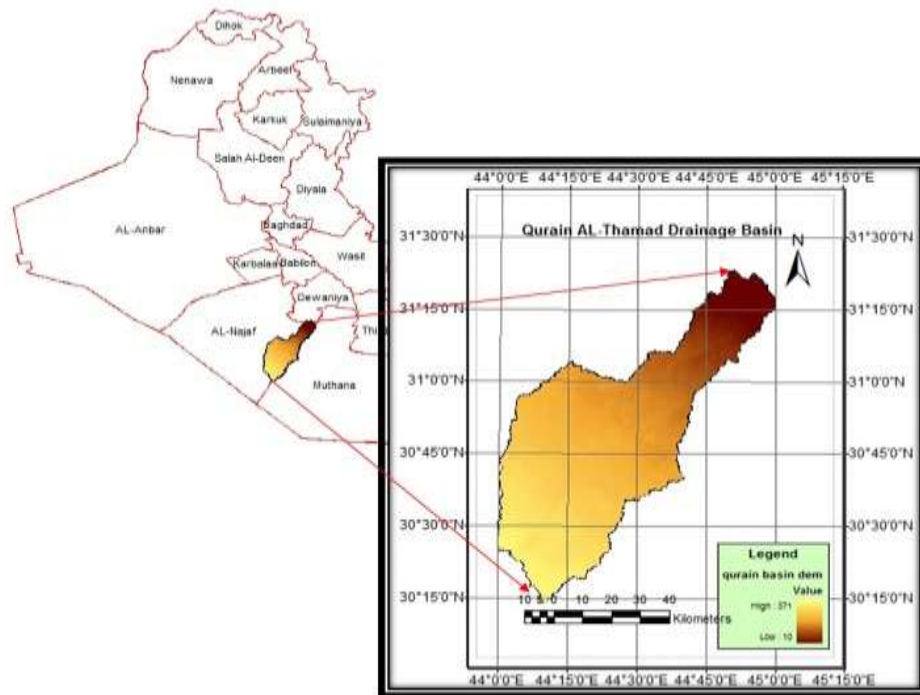
**Figure 1-** The study area location illustrative within Iraq administratives map.

Materials and Methods

The demanded layers for hydrological (Linear, Areal, and Relief) features extraction were illustrated in the next diagram (Figure-2):
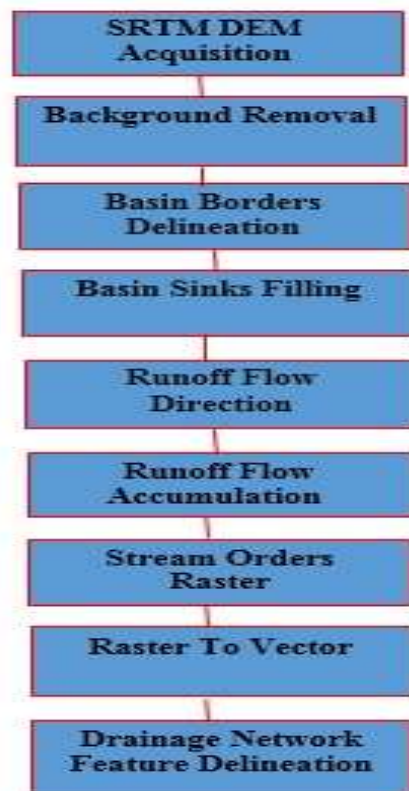

Figure2- The block diagram of traditional steps for configured basin's watershed and drainage network pattern illustration.

These layers could be seen in Figure-3, as follow:
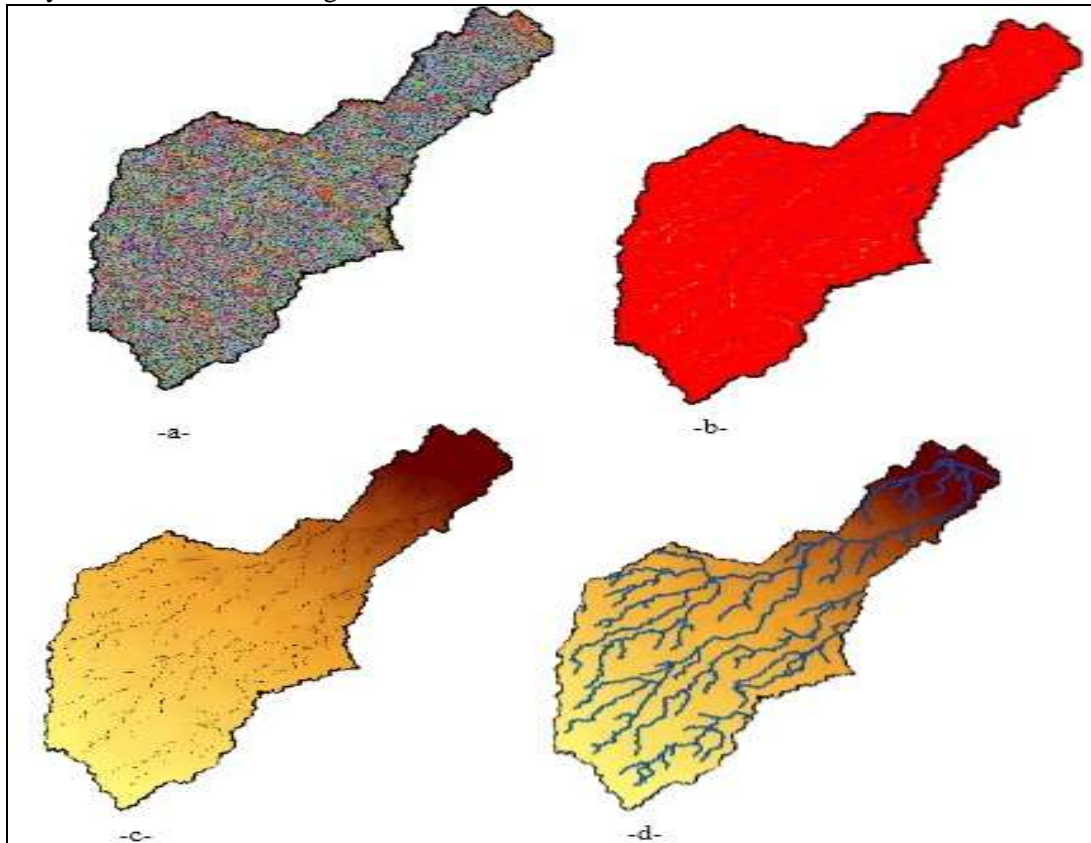
Figure 3- a) flow direction layer b) flow accumulation layer c) calibrated flow accumulation layer d) streams polylines feature layer The sub- basins in Qurain AL-Thamad drainage basin valley can be seen in Figure-4:
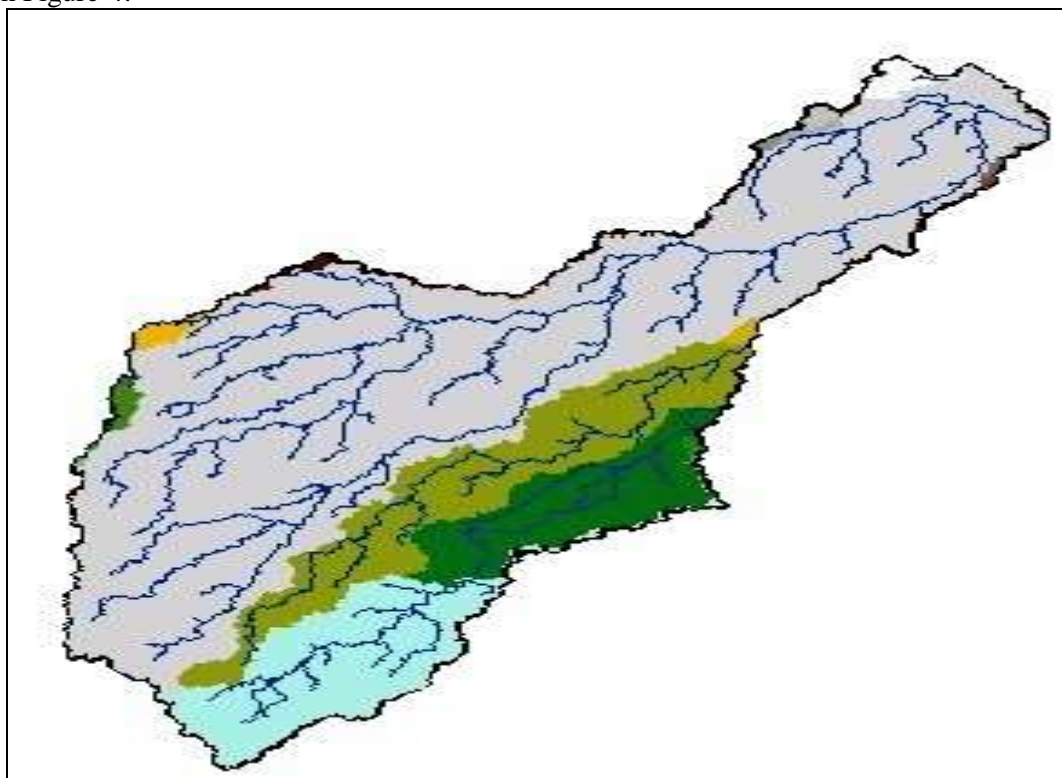
Figure 4-The sub-basins in studied region illustration.

While snapped pour points were utilized for watershed delineation. As can be showed in Figure-5
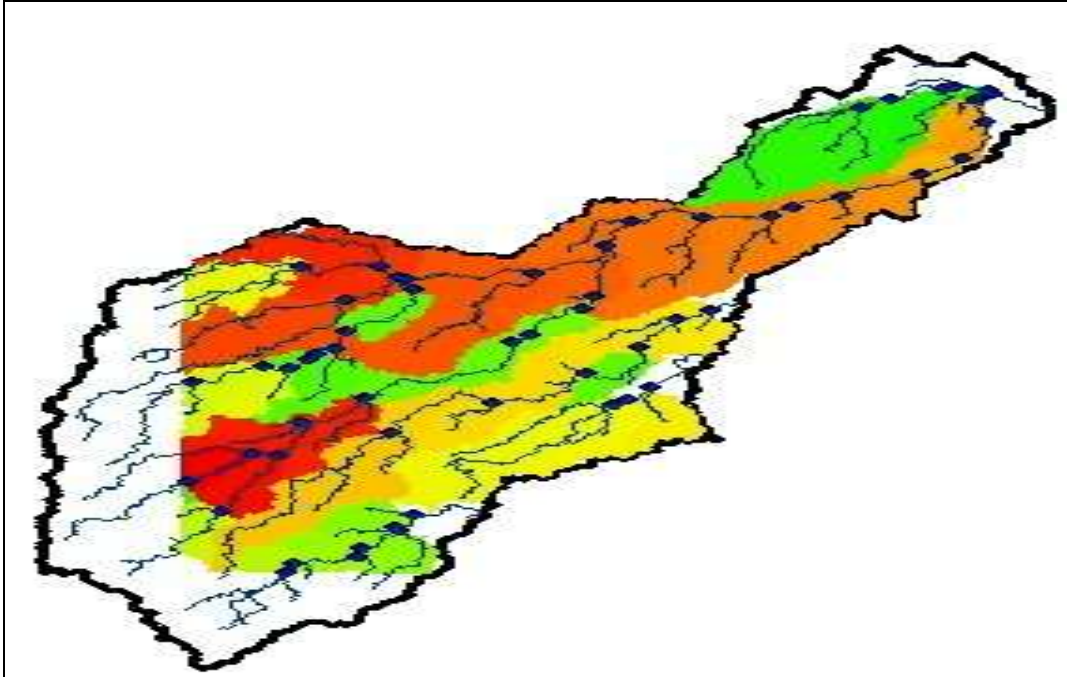
Figure 5- The studied region watershade illustration with their distinct pour points.

- **Linear aspects**

The sorting scheme of the basin's streams is considered the first stage in hydro-morphometry analyses because The water and its sediment travel through the drainage system to a single stream, this one is the basin distinct order (in other meaning the highest order stream of basin) [13]. By using Arc GIS environment measurements, studied area real length was 161.6275 km and its ideal length was 128.639 km. the basin width was 66.346 km, while the perimeter was496.4972 km.

Stream Order (U)

Five different schemes for sorting streams into orders, Graveliues, Horton, Strahleir , Shiver, and Schideggar. The modified Strahler scheme by Horton has been chosen because of its simplicity and clearness. Basin ninety meter SRTM imagery was adopted to delineate ordered drainage network using the hydrology ARC tool. Qurain AL-Thamad was founded as a four order drainage basin, as in Figure-6.
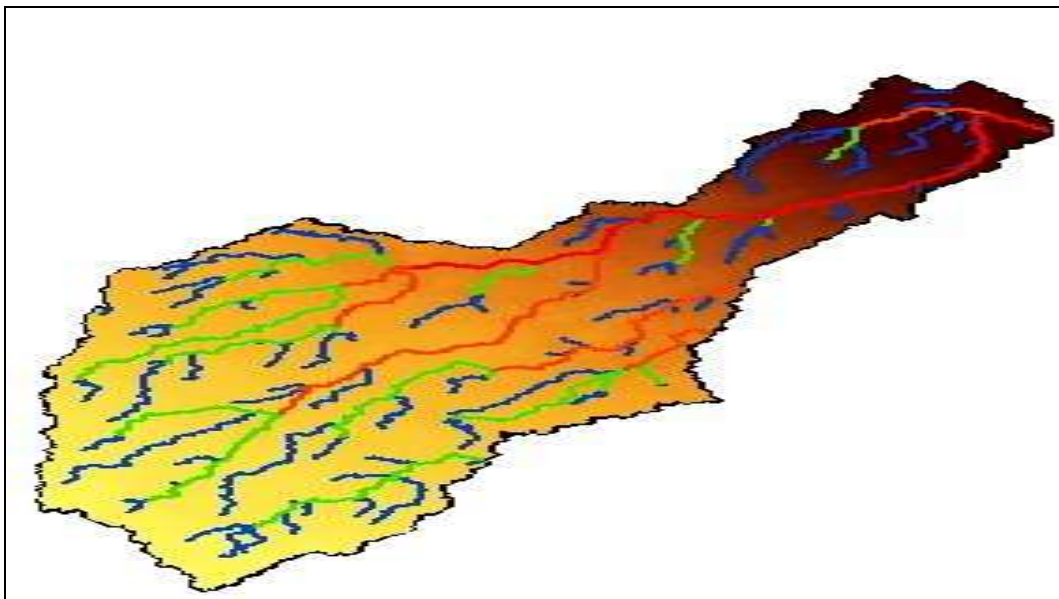
Figure 6- The studied region ordered streams.

Stream Number (Nu)

The stream number (Nu) presents the total number of stream pieces found in each order [13]. In the present basin, there were (88 1st order streams, 43 2nd order streams, 23 3rd order streams, and 14 4th order ones). Figure-7 illustrates the stream segments for each order of Qurain AL-Thamad basin.
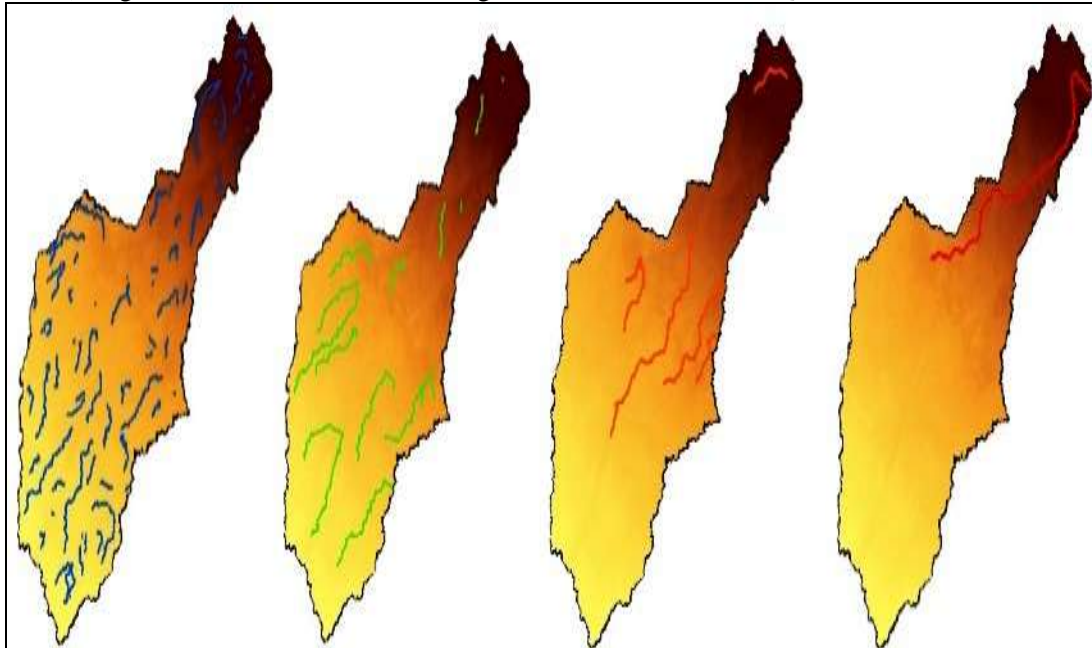
Figure 7- Qurain AL-Thamad basin each order streams A) 1st order streams, (B) 2nd order streams, (C) 3rd order streams, (D) and 4th order streams.

Stream Length (Lu)

In Qurain AL-Thamad the (1st order Lu was 611.587 km, 2nd order Lu was 348.015 km, 3rd order Lu was 181.868 km, 4th order Lu was 103.674 km).

The Bifurcation Rate (Rb)

This rate presents the ratio of the number of the river in an order to the others on the next one. For Qurain AL-Thamad basin the 1st order Rb was 2.046, 2nd order Rb was 1.869, 3rd order Rb was 1.624), the average Bifurcation Ratio was calculated to be 1.852.

- **Areal Aspect**

Drainage density (Dd)

drainage density is considered as a sensitive factor because it explains the link between the form attributes of the watershed and working processes that effecting on the river stream course[14]. Qurain AL-Thamad drainage basin Dd is very low (0.259 km^{-l}).

Drainage frequency (Fs)

Drainage frequency is majorly controlled by the lithological features of the region, structure hills usually are high valued drainage frequency, while the alluvial fans are low valued ones [15]. Qurain AL-Thamad drainage basin Fs is 0.035(stream / km) which considered as low valued frequency.

Drainage Texture (Rt):

Basin's Drainage Texture is the ratio of 1st order streams total number to the perimeter of the basin. It has vital importance because the capacity of infiltration and the lithology of underlying layers depend on Rt. Many factors affected Rt value such as the density of vegetated cover, the permeable quantity of soil, relief, and climate. there are five various basin drainage textures (very coarse <2, coarse 2-4, moderate 4-6, fine 6-8, and very fine >8). Qurain AL-Thamad basin Rt was 0.338 stream / km, indicating to very coarse texture and high permeability generally, since the variance in drainage texture values along the study region.

Elongation ratio Re

Re is the ratio of a circle diameter which had same area value like catchment area to the maximum length of the catchment region. The variance in elongation ratio is ranging from 0 (basin shape would be very elongated) to 1 (basin shape would be circular). Qurain AL-Thamad basin Re value is 0.483,

so that (the basin is median elongated shape and the geological structures solidity is equivalent all over the crust of it).

Circularity ratio Rc

Miller was submitted This ratio in 1953, it is the ratio of the catchment area of the basin to the area of a circle that had a similar circumference as a catchment's area perimeter. Rc value ranging from 0 (in line case) to 1 (in circle case), low Rc value sometimes indicates a structural control on the drainage pattern evolution. Qurain AL-Thamad basin Rc is 0.244 (i.e. it is far away from the circular shape and its drainage pattern is controlled by the lineaments and the fracture traces, in addition to that watersheds lines are irregular and the basin is generally in youth stage of geomorphic period).

Form factor Rf

It is a realistic index for catchment area presentation. Its rang extend between 0.1 to 0.8, so in the case of Rf converging from 0.8, the flow peak is high and the discharge duration is short and vice versa. Qurain AL-Thamad basin Rf is 0.183 indicating to an elongated shape, runoff with flow of a low peak and long duration to basin mouth yielding the absence of flood risk).

- **Relief Aspect**

Basin Relief (H):

The difference (measured in meters) between the lower edge and the highest one of the basin valley is known as Basin relief. Qurain AL-Thamad basin relief is(361m). in general it is a highly valued relief basin.

Relief ratio (Rh)

The ratio of the longest path parallel to the major drain river in the basin to its relief is known as a Relief ratio (Rh) or (Relative Relief). This parameter determines the potential energy convolution into a kinetic one for water drain along the basin valley (i.e. Rh controls erosion activity that work within the basin. Qurain AL-Thamad basin Rh is (0.447) Meaning basin's primary stage of maturing since low valued Rh means lower erosion power and sediment yield towards basin's mouth).

Conclusions

Qurain AL-Thamad basin was determined to be a four orders basin (88 1st order streams, 43 2nd order streams, 23 3rd order streams, and 14 4th order ones). The value of the average bifurcation ratio "Rb" was stated to be 1.852 indicating to the absence of the flood hazard in the basin main stream because the interest region soil is sandy (i.e. high permeability soil) yielding that the runoff water quantity is few. Longitudinal drainage density value calculated to be (0.259 km^{-1}) illustrating that not only soil is high permeable but also region rainfall rate is very low. Rt value was (0.338 stream / km) indicating to very coarse texture referring to a highly permeable basin" generally", since texture varies from zone to another in the basin (this is obvious from basin wideness variance along the region area and from the basin elongation ratio that indicates clearly too significant differences in regional geological structures solidity). Re also reflects a low peak flow and long duration time (flood hazard absence second proof). The land steepness and relief ratio are low valued so that few (erosion power, sediment yield, and flood peak) in the basin outlet area.

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