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Geomorphological Analysis Methodologies for Houran Valley Basin in Iraq

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Abstract

Extracting, studying and interpreting the morphological database of a basin is a basic building block for building a correct geomorphological understanding of this basin. In this work, Arc GIS 10.8 software and SRTM DEM satellite images were used. The principle of data integration was adopted by extracting the quantitative values of the morphometric characteristics that are affected by the geomorphological condition of the studied basin, then eliciting an optimal conception of the geomorphological condition of the basin from the meanings and connotations of these combined transactions. Hypsometric integration was extracted for each region in the basin separately with the value of integration of the plot curve for the relative heights of the basin regions with their respective regions.

Hypsometry coefficients reveal that regions (A, B, C, D, and F) are still in their formative years, while region E is in the maturity stage and region G is in the monadnock stage of the geomorphological cycle.

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Geomorphology, DEM, Hypsometric Analysis, GIS, Spatial Analysis.

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1. Introduction

The geomorphological evolution of the terrain shape in various areas of the earth's surface can be compared and approximated using hypsometric analyses [1, 2]. Several disciplines have used hypsometric analysis, including hydrogeological studies [3, 4], erosion studies [4-6], studies of soil sedimentation in drainage basins [7], and military studies.

The hypsometric analysis is divided into two sections: the first is a curved representation of the earth's surface's relative heights for various basin areas as a function of these areas' relative areas [8, 9]. The second is the integration procedure, which determines and interprets the integration value of the hypsometric curve for both the entire basin and individual basin areas [10, 11]. In the current study, a novel strategy is proposed using three separate extraction strategies to obtain particular morphometric databases for each. Before being entered into the database, the measured or computed topological characteristic in each technique was improved using the data concept integrative. The aim of the study is to incorporate remote sensing-based morphometric analysis with hypsometric analysis to evaluate the geomorphological characteristics and create a realistic geomorphological understanding of the studied area.

Abd Elghany et al. [12] studied the possibility of creating a spatial morphometric database for Wadi Hauran, the largest wadi in the Western Desert. They used the digital elevation model to measure the morphological characteristics, whether they were spatial, morphological, or hydrological. ArcGIS software was used because these characteristics are an important basis for developing future work plans for wet and dry valleys and river basins, which reduces costs, time, and effort to study areas.

Muhammad et al. [13] adopted different approaches to collecting information, including descriptive, quantitative, and quantitative analytical processes. In particular, in their research, they dealt with the geomorphological characteristics of the selected study area in Kirkuk Governorate. The characteristics of the water network in terms of the direction and pattern of the water basin were determined using a process based on the use of GIS applications. The study revealed that remote sensing is a useful method for monitoring geomorphological changes and phenomena and land surface shapes, as well as determining their dimensions and slopes through a set of analytical maps generatted by geographic information systems.

Ahmed et al. [14] used geographic techniques for site selection of water harvesting systems within the Hauran Basin. The Analytical Hierarchy Process (AHP) and pairwise comparison were used to determine the importance of selected water harvesting attributes (area of soil texture, surface runoff, and ground cover). A total of 96 water catchment sites were identified, of which 11 were found to be the most important. The problem statement was studying the hydrological changes and morphological characteristics affecting the study area and knowing the observed measurements by applying the equations of the morphometric analysis of the basin represented by the spatial and morphological characteristics.

2. Water Harvesting Area

The western plateau stretches into the deserts of Syria, Jordan, and Saudi Arabia and along the region west of the Euphrates River. It is mostly arid, home to Bedouins, and contains numerous valleys, some of which are 400 km long. It is located between the latitudes of 34°30'10.77° and 29°0'38°N and the longitudes of 38°45'31° and 48°17'12.58°E. The region is 220,948 square kilometers, making up around 55% of Iraq's landmass; its altitudes range from 100 to 1000 meters. Winter rain can occasionally cause floods that pose a hazard to the Bedouin population [15]. Fig. 1 shows a selection of water harvesting areas.

3. Geomorphic and Geological Setting

This work can be categorized into three stages, each involving the integration of data to produce specific geographic information crucial for developing a geomorphological understanding of the studied area. The working steps are shown in Fig. 2.

3.1. First Stage

The delineation of the drainage basin's boundaries is important because it impacts the accuracy of its inferred geographical information, such as hydrological, morphometric, and geomorphological aspects. By employing medium-resolution Google Mapper pictures to follow the valley's course from its source to its estuary, a novel method for determining the boundaries of the Houran Valley basin was offered in this article [16, 17]. After removing the background, filling in the gaps, and creating a mosaic for it, one can then use the SRTM digital elevation model images with a resolution of 30 meters per pixel inside the Arc GIS 10.8 environment to extract all the basins within the valley and the neighboring area, as shown in Fig. 3.

Using the "extent" option in the Arc tool of GIS 10.8 revealed that the basin spans an area of 13264.17 km^2 and is sandwiched between (39° 17' 19.37"E) and (42° 45' 35.5"E) and (32° 15' 50"N) and (34° 0' 6"N), according to Fig. 4.

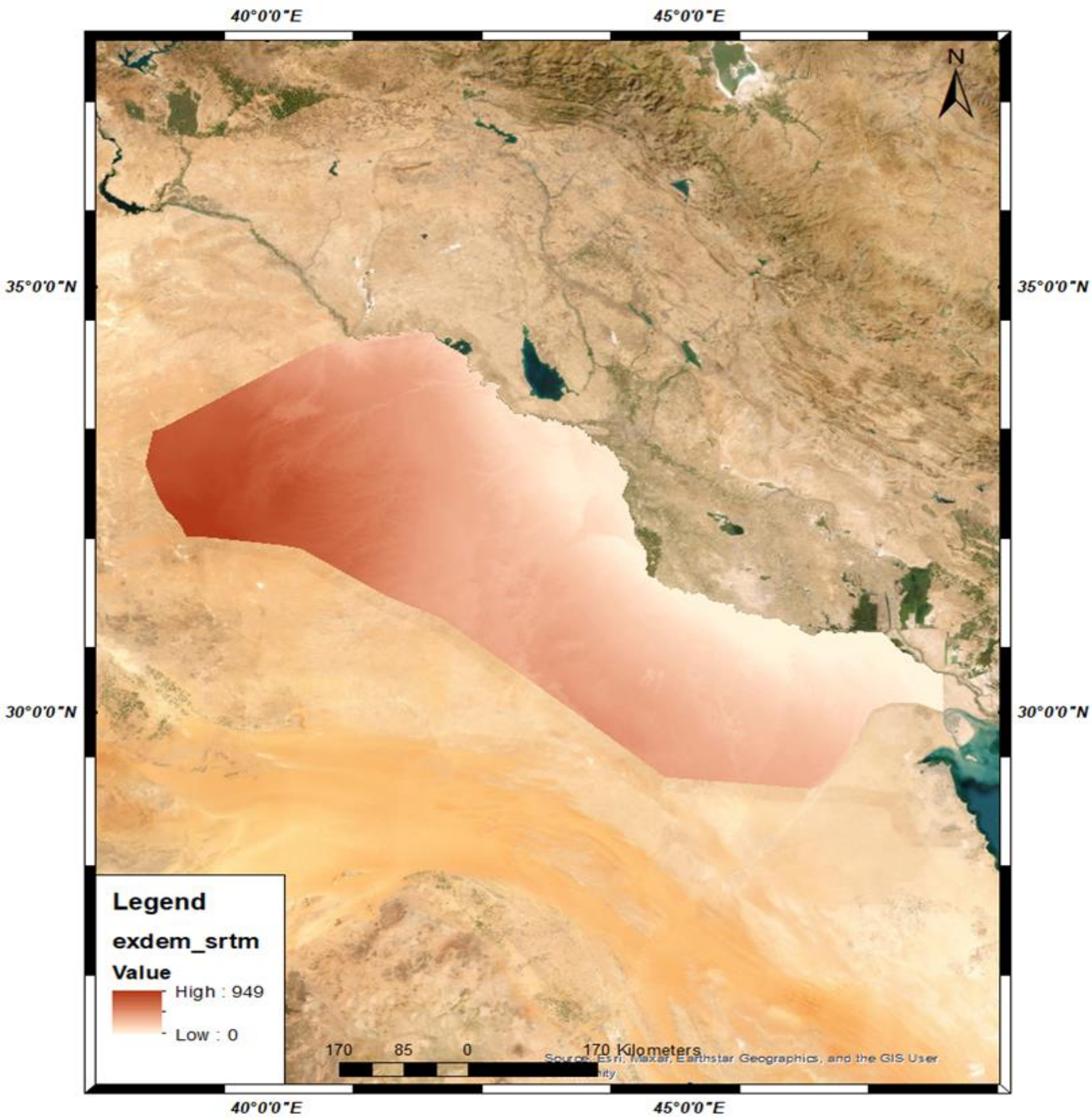

Figure 1: Selection of water harvesting sites in western plateau.

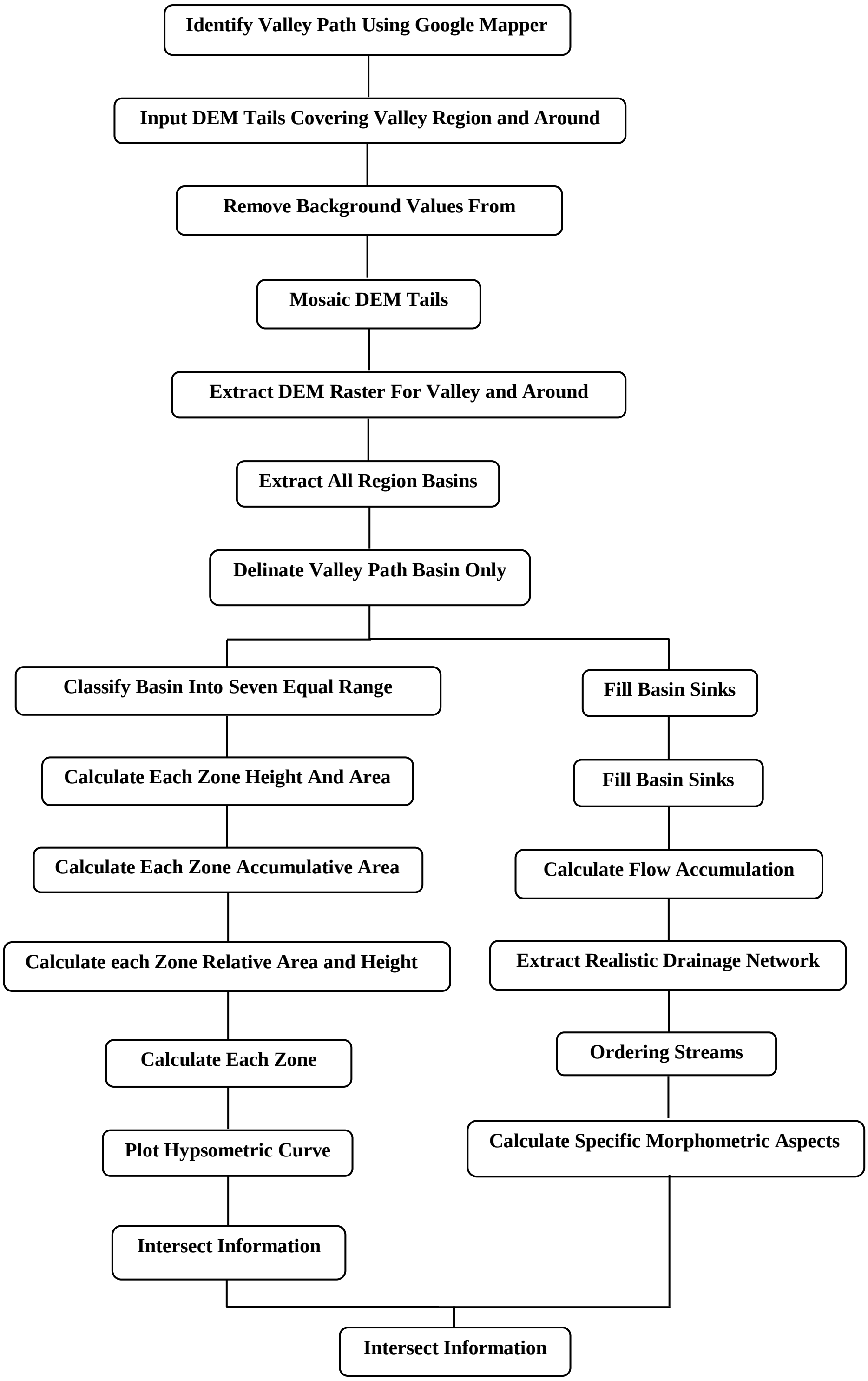

Figure 2: A block diagram for the utilized approach.

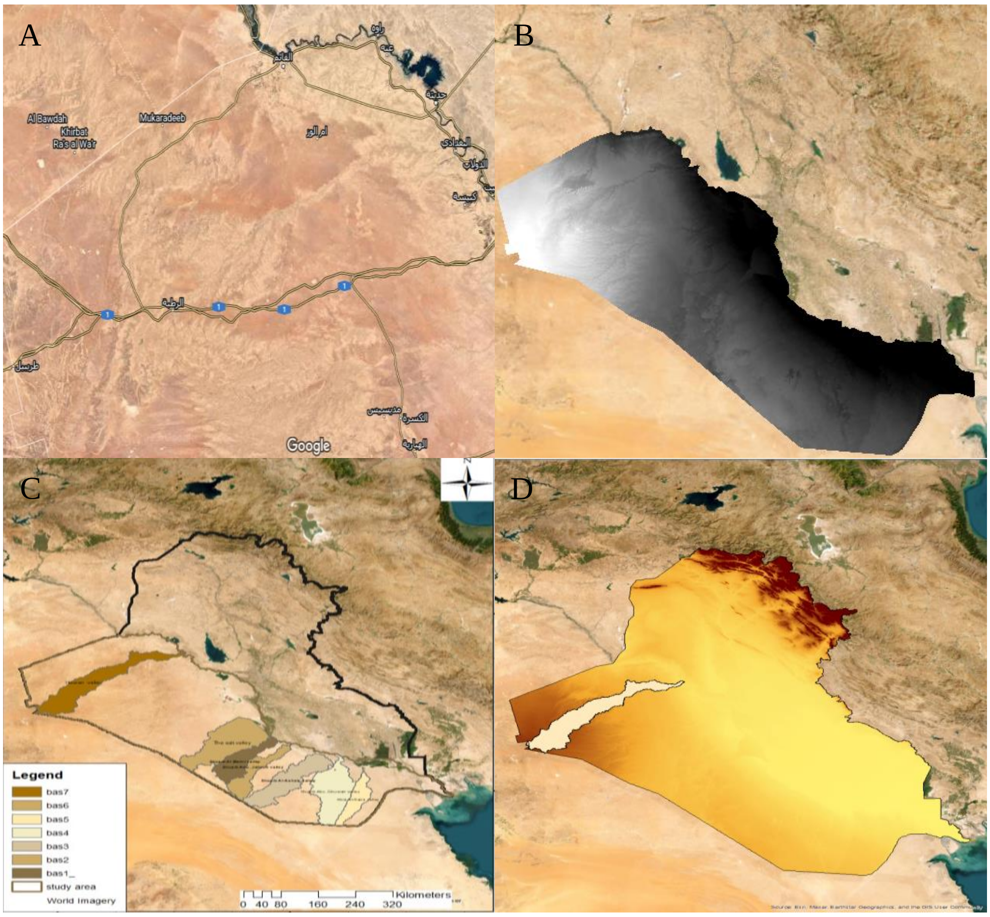

Figure 3: A. Google Maps showing an area of interest, indicating the valley end with a blue circle. B. SRTM DEM image of the studied area. C. main basins of the area. D. the isolated Horan basin.

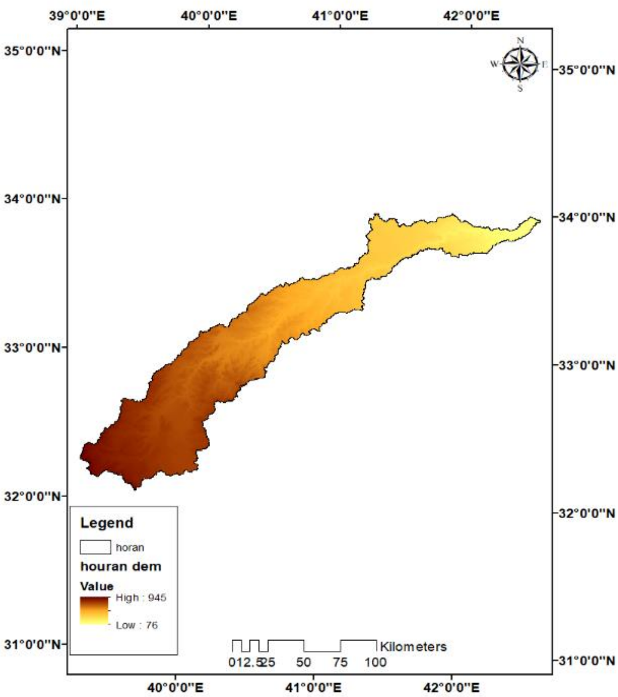

Figure 4: Location of studied area.

3.2. Second Stage

Accurate extraction of the drainage system pattern is necessary to obtain morphometric aspects; so, in this work, a digital elevation model, since it is more accurate and reliable than conventional methods, was used to automatically draw the drainage network in the basin. However, there are several steps that must be carried out before obtaining the model, including filling the image gaps with zero values and defining the flow direction for each pixel within the digital image, then determining the number of pixels that pour into each pixel meaning the accumulation value of the flow in each image cell, creating a trustworthy automated model by excluding cells with low accumulation, those of less than 15000, and ultimately transitioning from the graphic system to a vector for the convenience of computer computations [18, 19], as illustrated in Fig. 5.

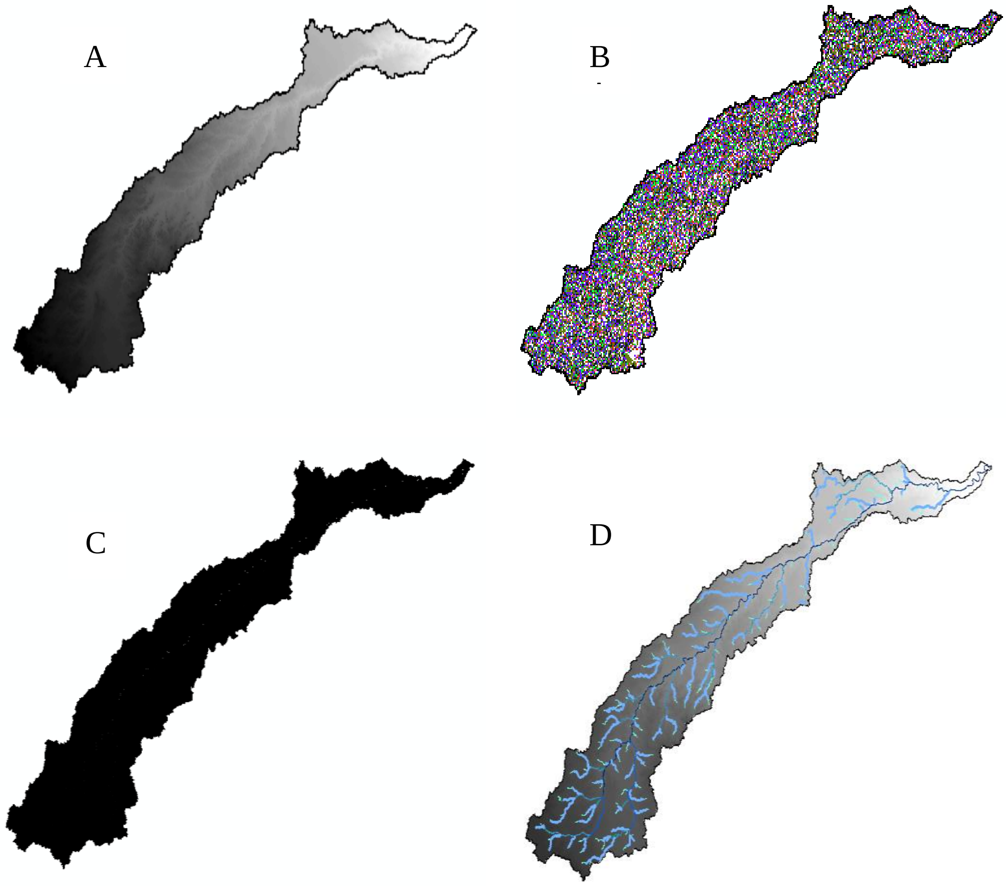

***Figure 5:** A. Filling up DEM gaps for the Horan basin. B. the direction of flow in each basin cell. C. the flow accumulative value in each cell. D. the most dependable drainage network pattern.*

The experimental value measured for the form factor, which most accurately describes the shape of drainage basins, was from 0.1 to 0.8 [20]. The measured value converged from 0.8 to a high flow peak and a short discharge period, and vice versa. The value of this component can be used to determine the average geomorphological age of the basin and to diagnose the state of the drainage network, including whether or not it is led by linear structures in the basin. It was computed by dividing the basin's area by the size of a circle whose radius is equal to that of the analyzed basin. The shape factor of the Houran Basin is 0.098.

The circulation factor indicates whether the drainage basin is converging toward or diverging from a circular form. Due to the convergence, the river water has a high likelihood of flooding when it reaches the basin's mouth after a downpour (monadnock phase). The Houran Basin has a circulation coefficient of 0.085 streams per km^2. The relief of the basin significantly influences the major element governing the activity in the basin. The kinetic energy of the water wave grows during rain and the water erosion increases, dominating the developed activity of the basin; the higher the relief, the higher the velocity of the surface runoff. It implies that the extremely difficult basin is nearing the end of its geomorphological cycle. The relief value for the studied region was 869 meters, which is modest given the basin's length of 366.61 km. As a result, the valley's relief ratio was 2.37036 meters per kilometer.

3.3. Third Stage

Hypsometric analysis explains the ripples (highs and lows) that spread across a particular region of the earth's surface to understand the area's evolutionary origins and compare those origins to those of nearby regions. It also identifies the basin's most potent driver of development events, whether it be factors that cause erosion to decline or tectonic movements that raise the earth's surface [20, 21]. The sub-basins for the studied region were identified using isopleth contour lines, as shown in Fig. 6.

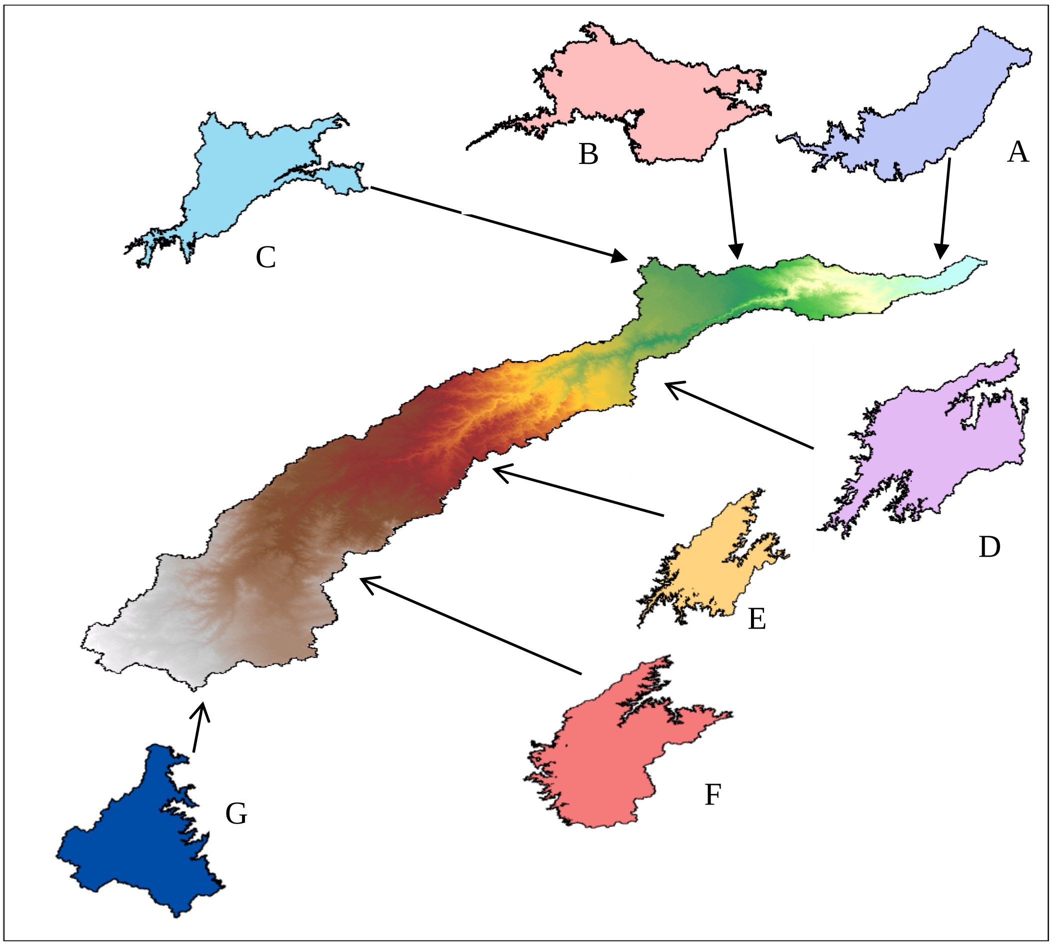

Figure 6: The geomorphic zones for the Houran basin DEM.

The calculations and measurements needed to determine the hypsometric integral factor for each zone are shown in Table 1.

Table 1: Houran zones basin hypsometric factor.

Zones	Area (km^2)	Min height (m)	Max height (m)	Accumulation area(km^2)	Relative area	Relative height	Hypsometric Integral (Men-min/max-min)
A	211.98	76	200	13264.15	1	0.14	0.64178366649
B	742.54	201	324	13052.16	0.98	0.29	0.60305384837
C	1983.72	325	448	12309.63	0.93	0.43	0.58306100476
D	1861.85	449	572	10325.91	0.78	0.57	0.50833760832
E	2433.30	573	696	8464.06	0.64	0.71	0.44070467177
F	4329.01	697	820	6030.75	0.45	0.86	0.54274403449
G	1701.74	821	945	1701.74	0.13	1	0.31120538519

Ultimately, a hypsometric curve, Fig. 7, was employed to pinpoint the interest region's erosional area and to identify the dominant geomorphic process in the Houran region.

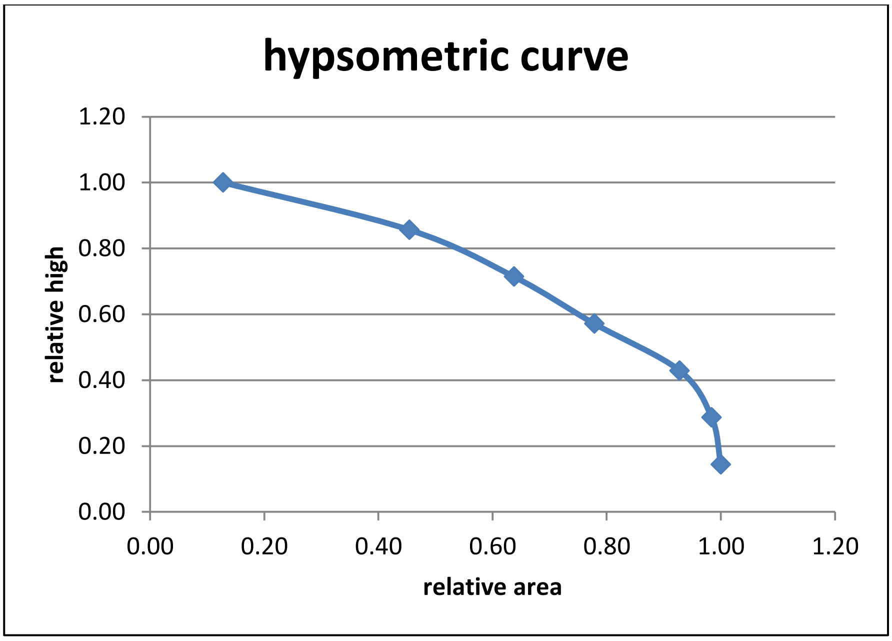

Figure 7: Houran valley basin hypsometric curve.

4. Results and Discussion

The Houran Basin's shape factor value of 0.098 reveals several facts, including its distance from a circular shape and the absence of any risk of flooding in its main stream during a rainstorm. This low number also suggests that the rocks within the basin are comparable in composition and roughness and that the basin as a whole is notable for its areas with a young geomorphological average age.

The Houran Basin's low circulation factor value denotes the beginning of the geomorphic cycle in most of its regions. The basin's topographical features also play a major role in the process of geomorphological evolution through continuous water erosion processes. Its linear structures were formed as a result of tectonic activity, which determines the structure of the water drainage network for streams but is not dominant in the process of its development.

The valley has a relief ratio of 2.37036 m/km, which indicates that the geomorphological cycle is in its early phases and that there aren't many sediments in the area downstream.

Analysis of the separated zones using hypsometry: A, B, C, D, and F zones are still in their formative years, while the E region is in the maturity stage and the G region is in the monadnock stage of the geomorphological cycle, according to hypsometric factor values and curve integrals.

5. Conclusions

Dependence on a single source for geographic data results in inadequate spatial analysis and unreliable findings. A new strategy was used in this work, to obtain the most correct information for the relevant source, which involved using multiple trustworthy sources, by scrutinizing the SRTM and Google Mapper images.

It turns out that the Hauran Valley basin, which drains into the Euphrates River close to Haditha, is the broadest valley in the western plateau region. Due to the low slope of the basin and the similarity of its topography in terms of hardness and geological composition, it was discovered through quantitative analysis of morphometric criteria that most of the basin areas are in the early stages. Water erosion is widespread but weak in these areas. The hypsometric curve depicts the number of surface erosion sites and those that are now undergoing erosion; while the hypsometric integration coefficient depicts the presence of specific geomorphologically formed locations in the basin and others that are still developing.

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Conflict of Interest

There is no conflict of interest in this research.

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منهجيات التحليل الجيومورفولوجي لحوض وادي حوران في العراق

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الخلاصة

يعد استخراج ودراسة وتفسير قاعدة البيانات المورفولوجية للحوض لبنة أساسية لبناء فهم جيومورفولوجي صحيح لهذا الحوض. في هذا العمل ، تم استخدام برنامج ARCGIS10.8 وصور القمر الصناعي SRTM DEM. استتند تكامل البيانات إلى مبدأ تكامل البيانات عن طريق استخراج القيم الكمية للخصائص المورفومترية التي تتأثر بالشرط. الجيومورفولوجيا للحوض المدروس (مثل معامل الشكل ، ومعامل الدوران ، ونسبة التضرس) ومن ثم اشتقاق التصور الأمثل للحالة الجيومورفولوجية للحوض من معاني ودلالات هذه المعاملات مجتمعة. تم استخدام الاستدلالات المثلى من تكامل تفسير قيم معاملات التكامل لكل منطقة في الحوض بشكل منفصل مع قيمة تكامل منحنى الارتفاعات المناطق النسبية للحوض مع مناطقها النسبية. وقد أظهرت المعاملات أن المناطق (A,B,C,D,F) لا تزال في سنواتها التكوينية ، في حين أن E في مرحلة النضج و G في مرحلة الشيخوخة من الدورة الجيومورفولوجية.

الكلمات المفتاحية: الجيومورفولوجيا، DEM، تحليل هبسومتري، نظم المعلومات الجغرافية، التحليل المكاني