DOI: 10.24996/ijs.2024.65.1.45

ISSN: 0067-2904

Horan Valley Basin Geomorphological Aspects Assessment by Integrating Hypsometric Analysis with Remotely Sensed Morphometric Characteristics

Laith A. Jawad*, Ahmed A. Zaeen, Tariq Z. Hamood
Remote Sensing Unit, College of Science, University of Baghdad

Received: 17/8/2022   Accepted: 16/2/2023   Published: 30/1/2024

Abstract

The extraction, study, and accurate interpretation of the morphology database of a basin are the basic blocks for building a valid geomorphological understanding of this basin. In this work, a new approach is presented which is to use three different GIS based methods to extract databases with specific geographical information and then use the concept of information intersection to make a realistic geomorphological perspective for the study area.

In the first method, data integration of remote sensing images from Google Map and SRTM DEM images were used to identify Horan basin borders.

In the second method, the principle of data integration was represented by extracting the quantitative values of the morphometric characteristics that were affected by the geomorphological condition of the studied basin, such as the shape factor, circulation factor, and relief ratio, then eliciting an optimal conception of the geomorphological condition of the basin from the meanings and connotations of these combined transactions.

The third method used the same principle by taking the optimal inferences from the integration of the interpretation of the values of the Hypsometry integration coefficients for each area in the basin separately with the integration value of the drawing curve for the relative heights of the basin areas with their relative areas. It was found, from the values of the coefficients, that the areas (A, B, C, D, and F) were still in the early stages of youth. Whereas the E region was in the maturity stage and the G region was in the monadnock stage of the geomorphological cycle. As for the integral value of the curve, it indicated 48. 559 % erosion from the surface of the basin only, and that its boundaries were subject to change and widening.

Keywords: Geomorphology, SRTM DEM, Hypsometric analysis, GIS, Remote sensing

تخمين السمات الجيومورفولوجية لحوض وادي حوران بمكاملة التحليل الهبسومتري مع الخصائص المورفومترية المستشعرة عن بعد

ليث عزيز جواد*، أحمد أسعد زعين، طارق زيد حمود
وحدة الأستشعار عن بعد، كلية العلوم، جامعة بغداد

*Email: laith1910saadi@gmail.com

الخلاصة

يعد استخراج قاعدة بيانات مورفولوجيا الحوض ودراستها وتفسيرها الدقيق لبنة البناء الأساسية لبناء فهم جيومورفولوجي صحيح حول هذا الحوض. في هذا العمل تم تقديم نهج جديد وهو استخدام ثلاث طرق مختلفة تعتمد على نظم المعلومات الجغرافية لاستخراج قواعد البيانات بمعلومات جغرافية محددة ثم استخدام مفهوم تقاطع المعلومات لعمل منظور جيومورفولوجي واقعي لمنطقة الدراسة.

في الطريقة الأولى ، تم استخدام تكامل بيانات صور الاستشعار عن بعد من Google Map ودقة مكانية جيدة وصور SRTM DEM لتحديد حدود حوض حوران.

في الطريقة الثانية ، يتم تمثيل مبدأ تكامل البيانات باستخراج القيم الكمية للخصائص المورفومترية التي تتأثر بالحالة الجيومورفولوجية للحوض المدروس ، مثل عامل الشكل ، وعامل الدوران ، ونسبة التضرس ، ثم استنباط التصور الأمثل للحالة الجيومورفولوجية للحوض من معاني ودلالات هذه المعاملات مجتمعة.

استخدمت الطريقة الثالثة نفس المبدأ من خلال أخذ الاستدلالات المثلى من تكامل تفسير قيم معاملات تكامل قياس الضغط لكل منطقة في الحوض بشكل منفصل مع قيمة تكامل منحنى الرسم للارتفاعات النسبية لمناطق الحوض مع مناطقهم النسبية. وتبين من قيم المعاملات أن المناطق (A, B, C, D, and F)لا تزال في المراحل الأولى من الشباب. أما بالنسبة للمنطقة E في مرحلة النضج والمنطقة G في مرحلة monadnock من الدورة الجيومورفولوجية. أما بالنسبة للقيمة التكاملية للمنحنى ، فقد أشارت إلى تآكل 48.559٪ من سطح الحوض فقط ، وأن حدوده قابلة للتغيير والتوسع.

Introduction

Geomorphology is the science that exploits the nature of the Earth's surface as well as the history of its evaluation, dealing with surface morphology resulting from weathering, depositing, transportation, rosining, and tectonic processes [1]. Hypsometric analysis is effective in comparing and approximating the geomorphological evolution of the terrain shape of the various types of areas of the Earth's surface [2]. Hypsometric analysis is used in various fields, including hydrogeological studies [3, 4], erosion studies [4, 5, 6], and soil sedimentation in drainage basins [7], as well as military studies.

The analysis includes two parts, the first of which is a curved drawing of the relative heights of the Earth’s surface for specific areas of the basin as a function of the relative areas of these areas [8, 9], and the second of which is the integration process to know and interpret the integration value of the hypsometric curve for the whole of the basin as well as for the specific areas of the basin [10, 11]. In the current research, a new approach is suggested by utilizing three different schemes to extract specified morphometric databases for each of them. In each method, the principle of data integration was used to increase the accuracy and reliability of the measured or computed topological characteristic before it was included in the database. Then after extraction, the principle of intersection of geographical information was applied to form a realistic geomorphological understanding of the study area.

Materials and Methods

The importance of this valley is presented by the fact that it is the largest in Iraq in terms of length, as it is located in the western plateau in general, and in Anbar Governorate in particular, and extends from the area near the Iraqi-Saudi border to the Euphrates River near the city of Haditha. The region's climate is characterized by being arid to semi-arid, with few rainstorms in the winter. The work can be divided into three stages, in each of which the data were integrated to obtain specific geographical information that was useful to form a geomorphological understanding of the study area, as shown in the diagram below:

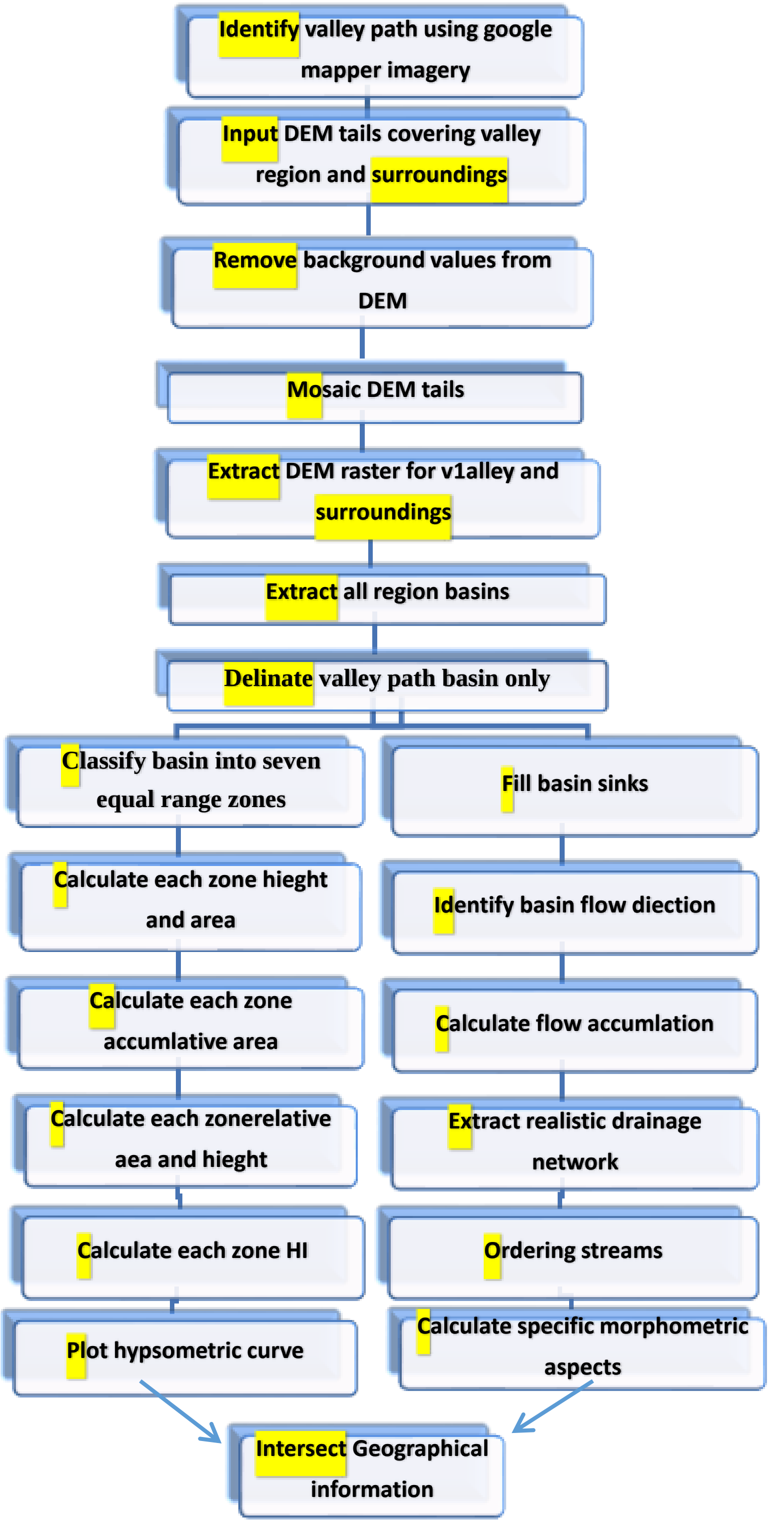

Figure 1: Illustrative block diagram for the utilized approach.

In the first stage, for any drainage basin, accurate delineation of the basin's boundaries is essential as it affects the accuracy of the geographical information deduced from it, such as hydrological, morphometric, and geomorphological features. With this article, a new approach is proposed to know the boundaries of the basin of Horan valley, represented by using good spatial resolution Google Map images of 15m per pixel to trace the path of the valley from its source to its estuary. Then, using the USGS Shuttle Radar Topography Mission digital elevation model images that were acquitted in 2002 with a resolution of 3 Arc- degrees (i.e., 90 meters per pixel) after removing the background, filling the gaps and making the mosaic for them within the Arc GIS 10.5 environment to extract all the basins within the valley and the surrounding areas, and then isolate the basin in which the valley passes only, as shown in Figure (2):

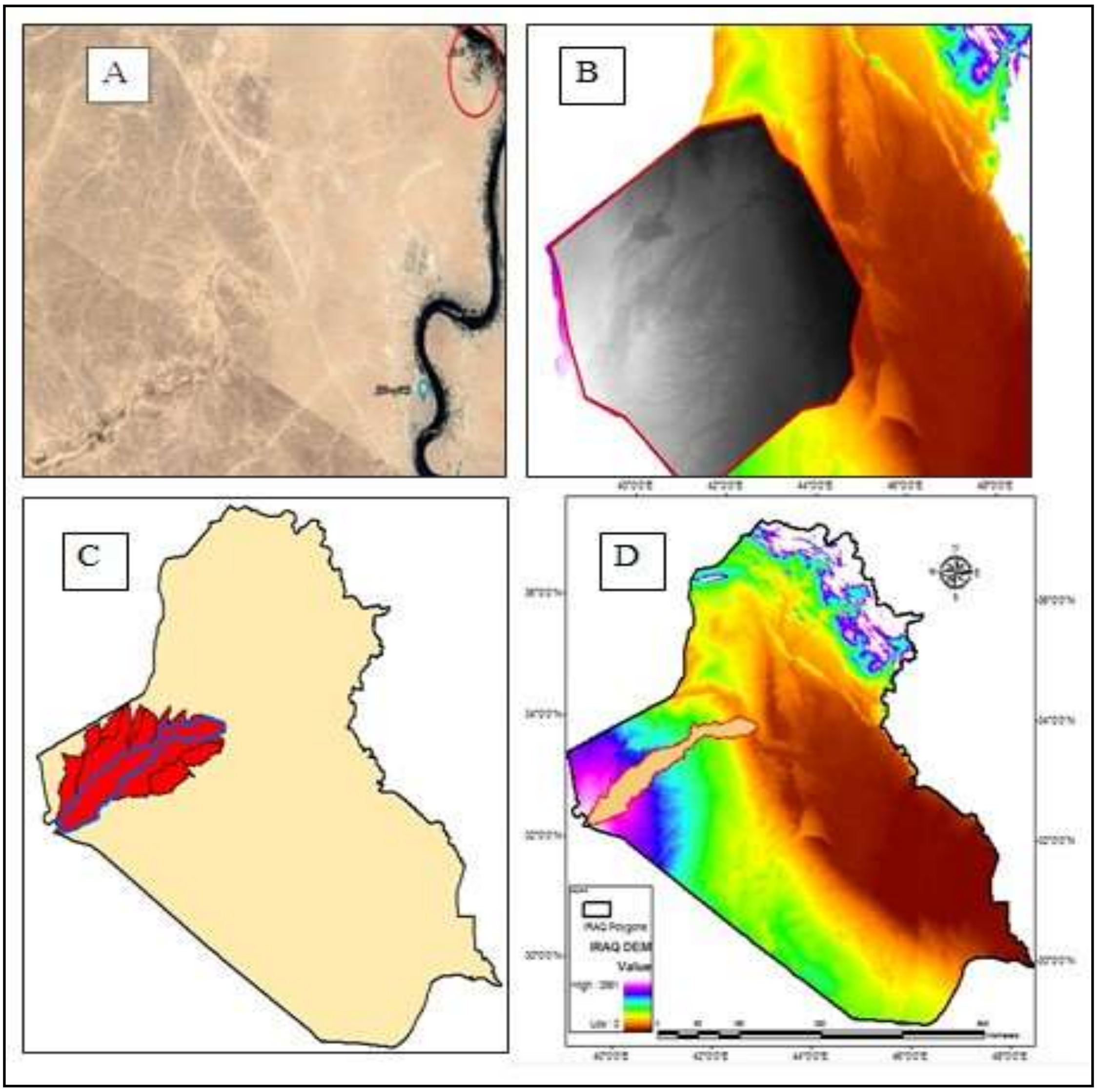

Figure 2: A. Google Mapper image of the region of interest, with the valley end indicated by a red circle, B. SRTM DEM image for the valley and its surroundings, C. Main basins of the area, D. The isolated Horan basin

The utilization of the “extent” option in the Arc tool of GIS 10.5 shows that the basin extends sandwiched from (39° 17´ 19.37´´E) to (42° 45´ 35.5´´E) and from (32° 15´ 2.66´´N) to (33° 59´ 57´´N) with 12947 km^2 area, as shown in Figure (3):

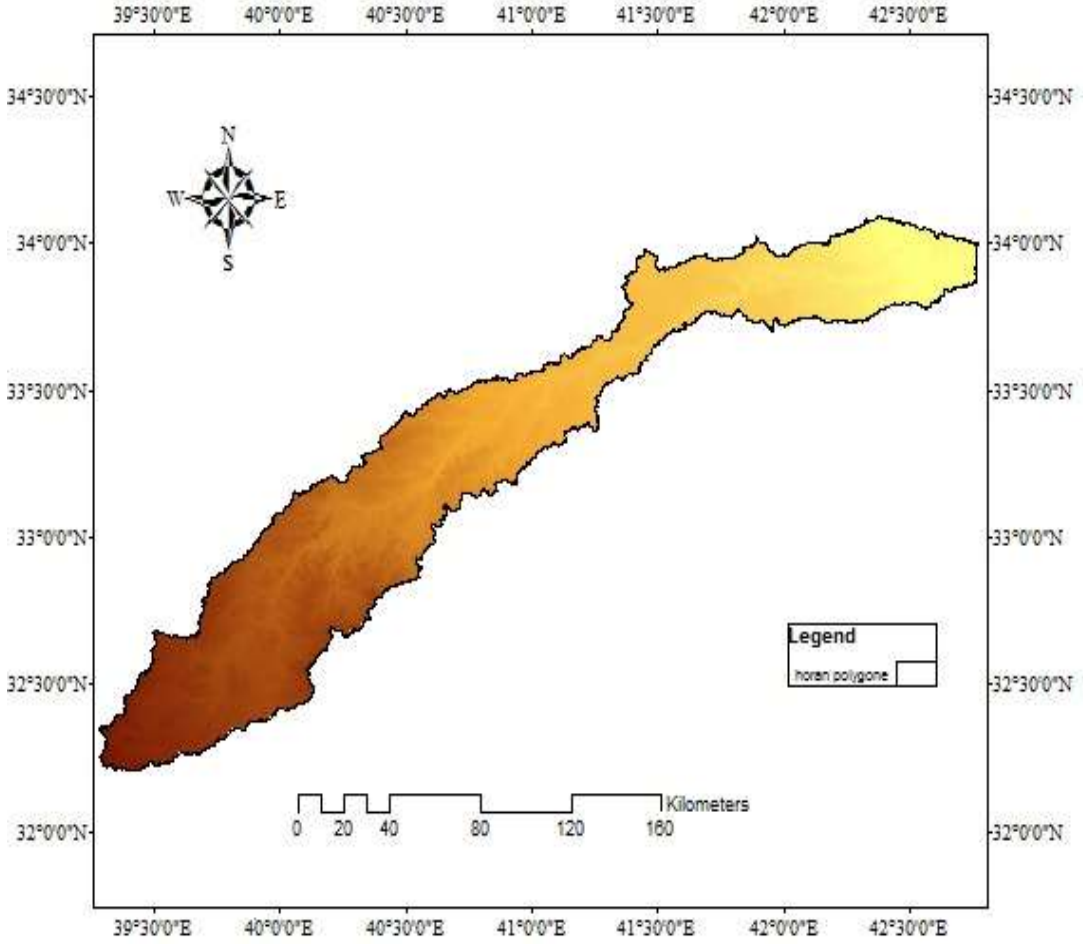

Figure 3: The map of Horan valley drainage basin

In the second stage, the obtaining of morphometric aspects demands accurate extraction of drainage system pattern. Accordingly, in this work, digital elevation model is used for drawing an automated pattern of the drainage network in the basin since it has more accuracy and reliability than the traditional methods, but there are several stages that must be implemented before obtaining the model. Those stages are: 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, which means the accumulation value of the flow in each cell of the image, then drawing a reliable automated model by removing the cells with low accumulation, for example less than 15000, and finally switching from the graphic system to a vector for ease of calculations on computer systems. This is illustrated in Figure (4) below:

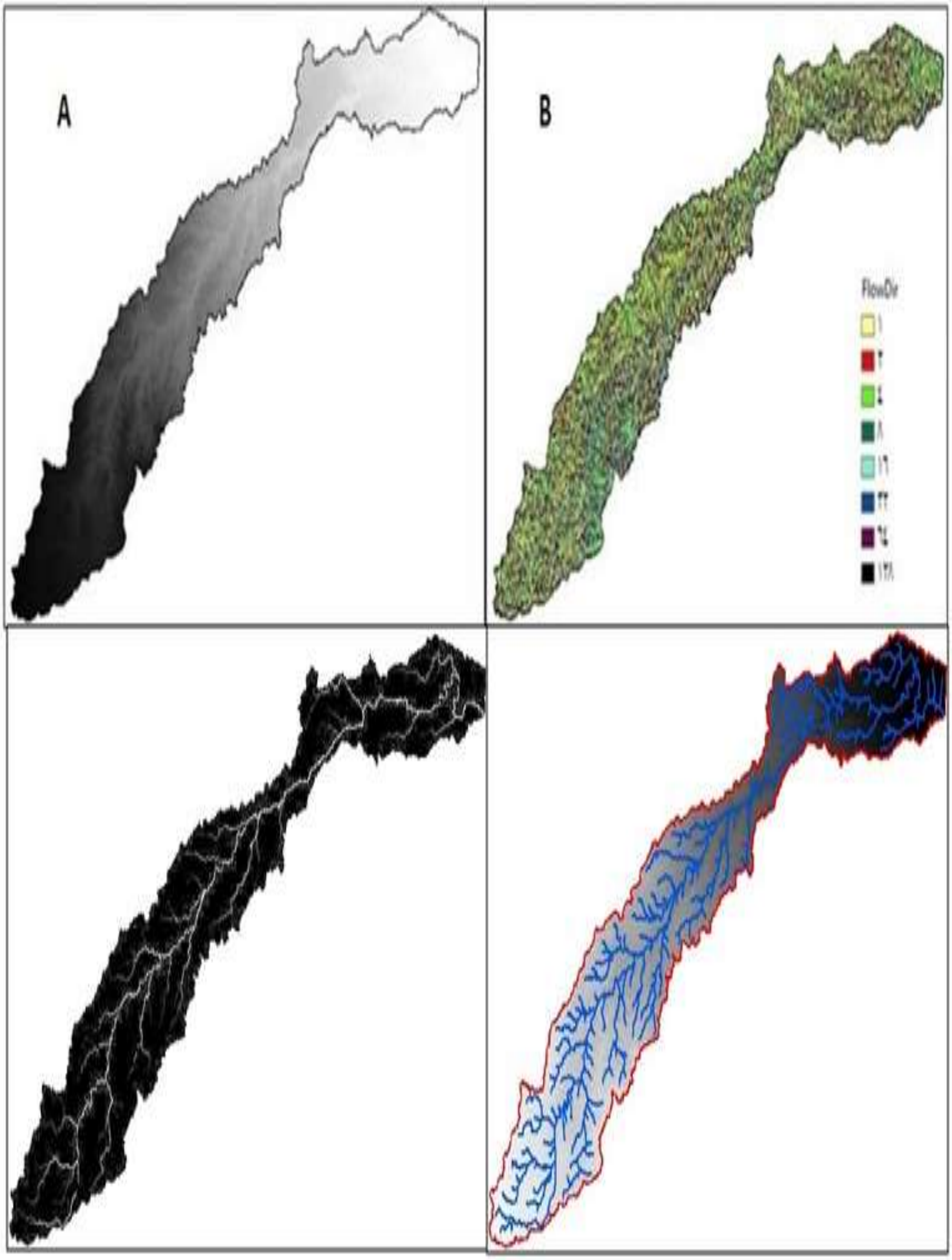

Figure 4: A. Horan basin DEM gaps filling, B. Flow direction for each basin cell, C. The flow accumulative value for each cell, D. Most reliable drainage network pattern.

The most accurate factor in describing the shape of the drainage basins is the form factor, and the experimental value measured for it ranges between (0.1-0.8), where the measured value converges from 0.8 to a high flow peak and a short discharge period and vice versa. The importance of this factor lies in several points, including the use of its value to know the average geomorphological age of the basin, as well as diagnosing the condition of the drainage network, whether it is led by linear structures in the basin or not. It is calculated by dividing the value of the area of the basin by the area of a circle having the same circumference as the circumference of the studied basin. The shape factor of the Horan Basin is 0.069.

The circulation factor indicates the convergence of the drainage basin’s shape or its distance from the circular shape. The convergence means a high probability of flooding for the river water during rain to reach the mouth of the basin quickly (monadnock phase). The value of the circulation coefficient of the Horan Basin is 0.086.

The relief of the basin has an important impact in determining the dominant factor of the even activity in the basin. The higher the relief, the higher the velocity of the surface runoff, and consequently the kinetic energy of the water wave increases during rain and the water erosion increases to be dominant in the developed activity of the basin, which leads to the very rugged basin being in the final stages of the geomorphological cycle. For the study area, the relief value is 918 meters, but it is low compared to the length of the basin of 436.02 km. Therefore, the relief ratio of the valley is 2.132 m / km,

In third stage, hypsometric analysis explains the ripples (highs and lows) spread in a specific area of the Earth's surface to know the evolutionary original reasons of this area and compare that evolution to nearby areas; it also shows the most powerful factor in the basin for the events of development, whether the factors of declining erosion or the tectonic movements that lifts up the surface of the Earth.

Results and Discussion

The value of the shape factor of the Horan Basin indicates several facts, namely the distance of the basin from the circular shape, and thus the absence of the risk of flooding in its main course when the rain storm formed. This low value also indicates that the entire basin is characterized by areas with a young geomorphological age on average, and that the basin rocks are similar in terms of composition and ruggedness.

The low value of the circulation factor for the Horan Basin indicates the beginning of the geomorphic cycle for most of its regions; its topographical characteristics have the greatest role in the process of geomorphological evolution through continuous water erosion processes, and that the basin’s linear structures, arising due to tectonic activity, which is not dominant in the process of its development, are controlling the shape of the water drainage network for streams.

The relief ratio of the valley is 2.132 m / km, which means a small number of sediments in the downstream area and primary stages in the geomorphological cycle for most sections of the Horan basin.

To achieve hypsometric analysis for the Horan basin, it was divided into individual geomorphic zones using isopleth contour lines. The required measurements and calculations for hypsometric integral factor obtaining of each zone are illustrated in table (1).

Table 1: The Hypsometric factor of Horan basin's zones

Zone	Area(km^2)	Min height (m)	Max height(m)	Accumulation area(km^2)	Relative area	Relative height	Hypsometric Integral
A	1132.131	58	183	12947.67	0.092111203	1	0.557088
B	1093.53	184	308	11815.53	0.372113041	0.856322	0.506362903
C	1648.576	309	433	10722	0.564835436	0.713793	0.573903226
D	1760.128	434	558	9073.428	0.700777167	0.571264	0.524927419
E	2495.305	559	683	7313.3	0.828103291	0.428736	0.464604839
F	3625.37	684	808	4817.995	0.912560991	0.286207	0.513758065
G	1192.625	809	934	1192.625	1	0.143678	0.25848

For the studied region, the sub-basins have been isolated, as illustrated in Figure (5) below:

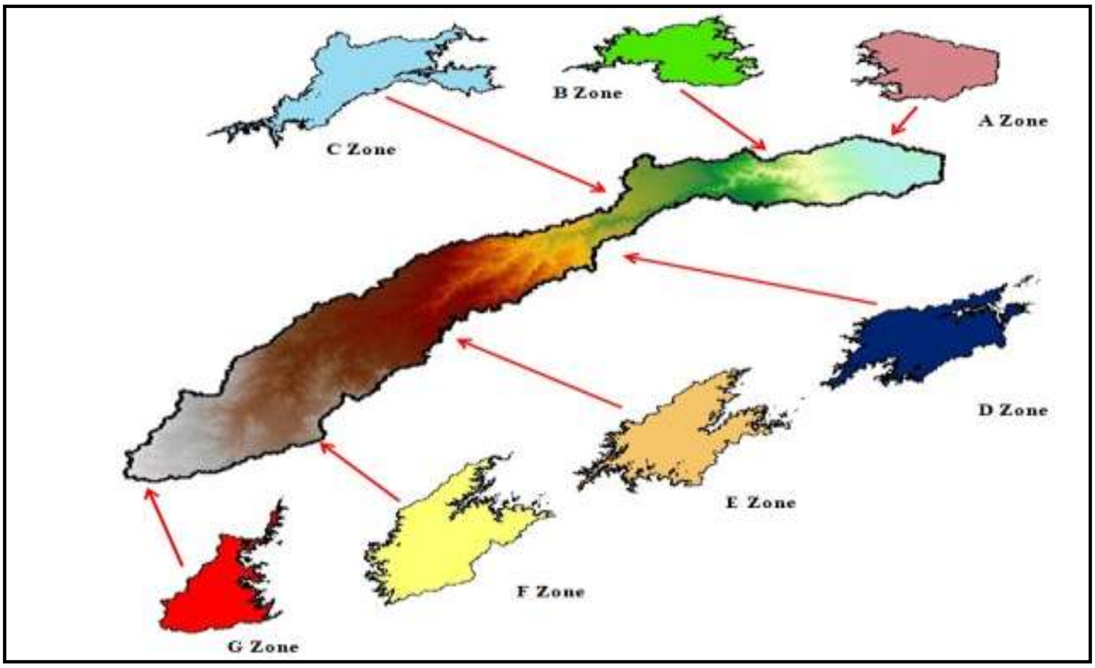

Figure 5: Horan basin DEM with its specified geomorphic zones

.
Eventually, the hypsometric curve was used to identify the erosional area of the interest region and to state predominate geomorphic process in the Horan area, as shown in Figure (6):

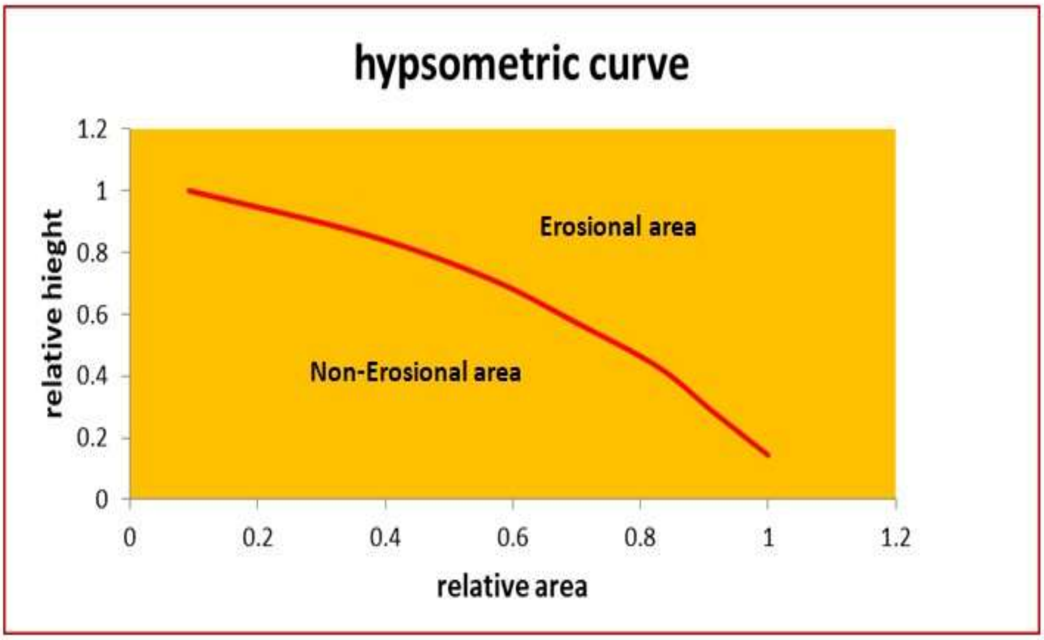

Figure 6: Hypsometric curve for the Horan valley basin.

The hypsometric analysis of the separated zones, the hypsometric factor values, and curve integral reveal that (A, B, C, D, and F) zones are still in the early stages of youth, and the E region is in the maturity stage and the G region is in the monadnock stage of the geomorphological cycle. As for the integral value of the curve, it shows that the erosion of 48.

559 % from the surface of the basin only, and that its boundaries are subject to change and widening.

Conclusions

Remote sensing images are one of the most important means of obtaining geographic information, and since they depend on electromagnetic radiation reflected or emitted from ground targets, and because there is a certain spatial resolution per pixel, the information is speculative and not very accurate, so the reliance on one remote sensing-based scheme to provide geographic information means weakness in spatial analysis and unreliability of the results. Therefore, in this work a new approach has been applied which is to adopt more than one reliable source to obtain the same geographic information, and, provided that the source is credible, is to use the principle of data integration from several ways to elicit the most accurate information for the relevant source by analyzing images of the Google Map and the SRTM DEM.

It has been found that the basin of the Horan valley is the largest valley in Iraq and flows into the Euphrates River near Haditha city. Through the quantitative analysis of the morphometric parameters, it has been found that most of the basin areas are in the youth stage and that water erosion is the prevalent geomorphic process in the region, but it is weak due to the low slope of the basin and the similarity of its topography in terms of hardness and geological structure. Furthermore, morphometric factor values indicate that the risk of flooding in the basin main drainage stream when the rain storm formed is absent. As for the Hypsometric integration coefficient, it shows the presence of some geomorphologically developed places in the basin (i.e., E and G zones), with others still in evolution progress (i.e., A, B, C, D, and F zones). While the hypsometric curve reveals the number of surface erosion patches and those in the process of erosion.

References

[1] R.A. Hajam, A. Hamid, S.U. Bhat, “Application of Morphometric Analysis for Geo-Hydrological Studies Using Geo-Spatial Technology,” *hydrology current Research*, vol. 4. no. 3, pp. 1-12, 2013

[2] R. Mudashiru, B.M. Olawuyi, A.I. Yusuf, M.A., Oyelakin, “Morphometric Analysis of Asa and Oyun River Basins, North Central Nigeria Using Geographical Information System,” *American Journal of Civil Engineering*, vol. 5, no. 6, pp. 379-393, 2017

[3] R.S. Pate, D. S. Gupta, S. Tiwari, S.B. Dwivedi, “Morphometric aspects of a small river system of Mirzapur District, Uttar Pradesh, India: A case study of Barhi river system,” *International Journal of Multidisciplinary Research and Development*, vol.3 no. 3, pp. 250-255, 2016

[4] V. Jain, R. Sinha, “Evaluation of Geomorphic Control on Flood Hazard through Geomorphic Instantaneous Unit Hydrograph,” *Research communication journal*, vol.85, no. 11, pp.26-32, 2006

[5] A. Mohamed, L. A. Jawad, F.H. Mahmood, "the use of ground penetrating radar to assess the concert," *Iraqi journal of science*, vol.60, no.9, pp. 2095-2101, 2019

[6] P.K. Sarma, K. Sarmah, P.K. Chetri, A. Sarka, “Geospatial study on morphometric characterization of Umtrew River basin of Meghalaya, India,” *International Journal of Water Resources and Environmental Engineering*, vol. 5, no.41, pp.489-498, 2013

[7] L.A. Jawad, W.A. Huda, “The Al-Abiadh Valley Drainage Basin Environmental Aspects Extraction Using Quantitatively Morphometric Analyses of Shuttle Radar Topographic Mission Data,”, *Baghdad Science Journal*, vol.16, no. 1, pp. 97-103, 2019

[8] Abdulla H.H., “Morphometric parameters study for the lower part of lesser zap using GIS technique”, *Diyala Journal of Pure Sciences*, vol.7, no. 2, pp. 127-155, 2011

[9] Y. Arhan, A. Anbar, O. Enaba, N. Al-Shaikh, “Quantitative Analysis of Geomorphometric Parameters of Wadi Kerak, Jordan Using Remote Sensing and GIS,” *Journal of Water Resources and Protection*, vol.7, no.13, pp. 456-475, 2015

[10] M. Bishop, J. Shroder, R. Bonk, J. Olsenholler,"Geomorphic Change in High Mountains: A Western Himalayan Perspective," *Journal of Global Planetary Change*, vol. 32, no. , pp. 311-329, 2002

[11] E.T. Abdel Ghani, M.K. Ibrahem, E.M. Abdel Hameed, "A morphometric analysis of Horan valley by using remote sensing and geographic information systems," *AL Anbar journal of Agricultural Sciences*, vol. 15, no. 1, pp. 37-54, 2017

[12] L.A. Jawad, "Demonstration of Net Solar Radiation Geographical Behavior Revers Correlation with Relative Humidity in Iraq," *Iraqi Journal of Science*, vol.63, no. 6, pp.2741-2754, 2022.