Morphometric Analysis of Taqtaq Watershed / Koysinjaq District, Iraqi-Kurdistan Region

ID No. 152

(PP 206 - 220)

https://doi.org/10.21271/zjhs.26.2.14

Huner Abdullah Kak Ahmed Khayyat
Department of Geography, College of Arts, Salahaddin University-Erbil
hkhayyat@su.edu.krd

Shevan Jameel Jirjees
Department of Earth Sciences and Petroleum, College of Science, Salahaddin University-Erbil
shevan.jirjees@su.edu.krd

Received: 05/01/2021
Accepted: 20/02/2022
Published:28/03/2022

Abstract

The goal of this study was to investigate the morphometric analysis of the Taqtaq watershed in the Koysinjaq district, which is in the northeastern portion of Erbil, Kurdistan Region of Iraq (KRI). The watershed has an area of 881 km2. The Digital Elevation Model-Shuttle Radar Topography Mission SRTM-DEM data, as well as Geo-information methodologies, were utilized to determine and analyze morphometric parameters, like lineal, aerial, and relief characteristics in order to achieve the study's goals. To create and producing maps, as well as analyzing and evaluating specific criteria, a variety of functionalities in ArcGIS 10.8 software were utilized. By R2 values (R2 = 0.79 and 0.80 of the sub-basin), the major results revealed a difficult opposing connection between stream order, number, and length in the watershed of the study area. The watershed is elongated in form, with drainage patterns ranging from dendritic to sub-dendritic to parallel to sub-parallel. According to the study's findings, the drainage also has poor drainage, low permeability content, and a slight slope. The creation of landforms and watershed efficiency has been impacted by the research region's structural geology and climatic circumstances. The current study can be beneficial, and significant for watershed preservation and rainfall preparedness.

Keywords: Morphometric characteristics; R.S.; STRM DEM; GIS; Taq Taq Watershed.

1. Introduction

Watershed refers to the hydrological units that occur naturally, are defined by the natural occurrence of the boundary, and are distinguished by identical physical, environmental, and climatic situations. A Watershed is characterized as a land area contributing to runoff along a water path to a mutual point. It is thus considered an appropriate unit for the containment of flood risks and the conservation of water supplies. Watershed management needs to use a given watershed for the best development and minimal damage to natural resources for different aspects of ground cover, such as land, water, soil, and forest resources (Biswas et al., 1999, pp. 155 - 166). Morphometric investigation can be identified as a scientific analysis of the surface structure, form, and measurement of the landforms of the Earth. The Geographic Information Systems (GIS) reflects it to be an important tool (Aziz et al., 2018, pp. 36-49; Agbasi et al., 2019, pp. 1013-1017) for the study of water resources in the basins, delineation, morphometric analysis for the drainage basin (Al-Sudani, et al., 2018, pp. 165 - 168), and water management suitability analysis. The use of remote sensing (RS) and GIS for morphometric variable analysis considers that the classification of watersheds for soil, water protection, and management of natural resources is of major importance. One of the maximum active, time-saving, and reliable morphometric basin analysis techniques is remote sensing satellite data (Rai et al, 2017, p. 218).

Digital Elevation Model (DEM) is commonly used to reflect and analyze surface topography and topographical analyses and determine topographical characteristics that are one of the greatest significant exponents of the extraction of hydrological attributes. The appearance of dry valleys (watersheds and drainage systems) may be defined through DEM research. DEM is also used in hydrological research to delineate the drainage network, the catchment boundaries, and the hydrological descriptors in the calculation. The Shuttle Radar Topographic Mission (SRTM) offers a satellite DEM that is commonly used with acceptable precision for watershed delineation and hydrological studies due to its overall exposure to the Earth's surface (Bhang and Schwartz, 2008, pp. 497 - 501). Various studies have discussed the production algorithms for basin characteristics in recent decades. (R. Turcotte et al., 2001, p 225-227).

An incorporated RS and GIS technique was used in this analysis to delineate the watershed and to measure Taqtaq sub-basin morphometric parameters in the Koysinjaq Area. The morphometric research findings help predict floods, their magnitude, and intensity. In addition, it is also essential to define and manage the future groundwater zones and the protection of the watershed, including the entire range of natural resources related to the watershed. This analysis may benefit the municipal planners, and public policymakers for agricultural/water management approaches.

2. The Study Area

The Taqtaq sub basin (Fig. 1) is located in Koysinjaq district, Erbil Governorate, KRI. It is situated in a mountainous region east of the province of Erbil in northeastern Iraq. Astronomically, Taqtaq watershed is extended between latitudes (35°48’ N to 36°8’ N) and longitudes (44°16’ E to 44°44’ E). It occupies an area of approximately (881 Km2). Koisinjaq district consists of five sub-districts: Shorash, Ashti, Segrdkan, and Taqtaq. Geographically, the district has major positions connecting three Iraqi governorate centers: Erbil, Sulaimaniyah, and Kirkuk, to the north-east, is Haibat Sultan Mountain and to the west is Bawaji Mountain.

The primary source of surface water initiating as of the Lesser Zab River, and rapid growth and progress have been experienced in the past two decades. Also, the northern part is distinguished by numerous uphill (Babir and Ali, 2016, pp. 423-426). The position of the study area is between the foothill and high-folded area and the Chemchemal-Butma sub-zone zone in terms of tectonics (Jassim and Goff, 2006, pp. 71-73). PilaSpi, Fatha, Injana, Miqdadiya, Bai-Hassan, and Quaternary deposits are the geological formations in the study basin (Bellen et al., 1959, p. 214).

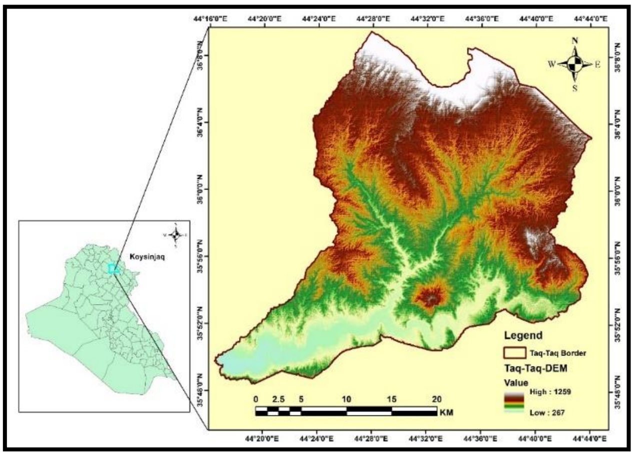

Fig. 1: DEM (SRTM) represents the location map of the Taqtaq watershed.

3. Materials and Methods

The morphometric computation was conducted using SRTM - DEM data with 30 m spatial resolution meters that have been downloaded from (Earth Explorer. USGS). SRTM data is a

Near-Global digital elevation model using Radar interferometry. A topographical map with a scale of 1:25,000 was used to delineate the watershed boundary. The hydrology tool of Arc GIS 10.8 (Spatial Analyst Tools) was used to delineate the sub-basin and to achieve morphometric analysis such as linear and aerial aspects. Furthermore, DEM was employed to extract hydrological information such as drainage networks and the boundary to delineate the watershed. The research methodology flowchart is illustrated in the diagram below (Fig. 2).

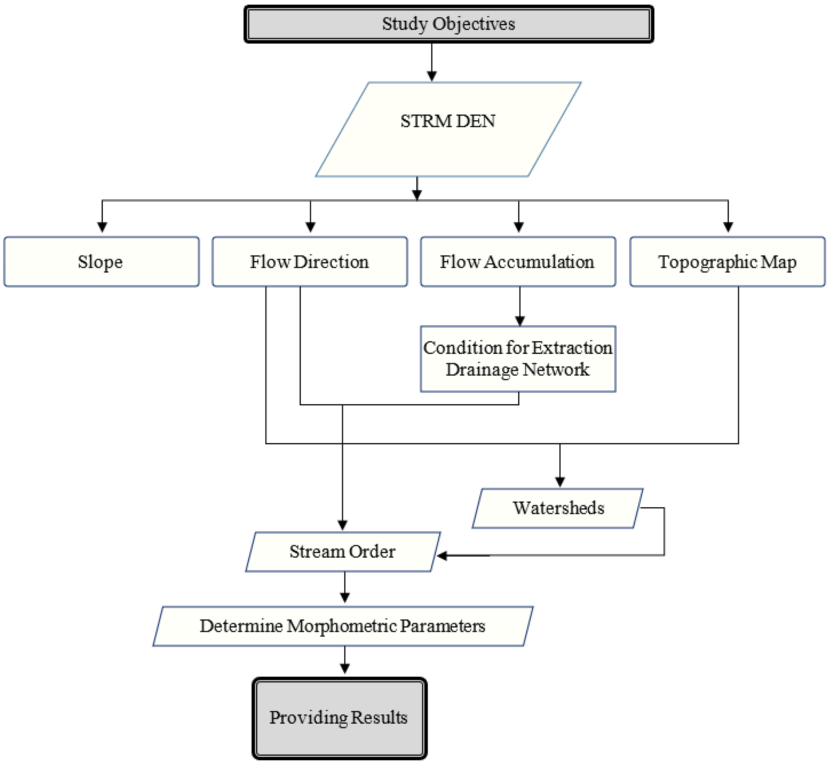

Fig 2: Research Methodologies Flowchart

3.1. Fill the Depressions

The cells with an elevation lower than the bordering cells usually correspond to the stressed cells in this process. In this case, when extracting a watershed parameter from DEM data caused by the current noise in sensors, DEM can create depressed cells (Lindsay, J.B., 2016, pp. 658-660). The sinks were eliminated with the fill alternative to reduce the drainage discontinuity. The depression filling system usages an 8-flow path matrix (D8) to prepare valid DEM information. The D8 solution is known to be one of the most efficient. Popular methods have been used from DEM data to delineate the basin networks (Fig. 3).

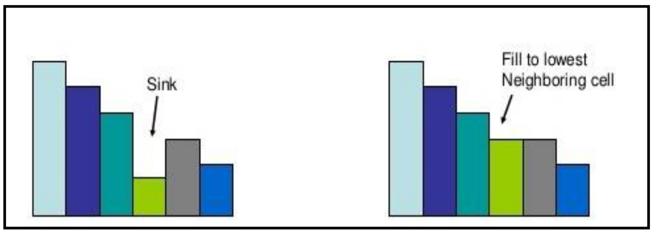

Fig. 3: The process of filling the sinks.

3.2. Flow Direction

In hydrological modeling, the flow direction is an important step that has been utilized to define the direction of flow for each cell (Fig. 4). Before defining the flow path, the filling phase must be completed. The D8 approach was used in this analysis to define the flow directions using the filled DEM. It is one of the easiest approaches to classify each cell's flow direction depending on its eight surrounding cells (Martz and Garbrecht, 1993, pp. 901-903). ArcGIS-hydrology tools allow water to flow in various directions from one cell to a single neighboring cell, along with the steepest descent path encoded (Maidment, 2002).

3.3. Flow Accumulation

In this step, each cell has a specified value equivalent to the integer number of cells that flow into it (O'Callaghan and Mark, 1984, pp. 324-326) (Fig. 4). Using the flow accumulation method, which depends on the direction of flow of any cell, the basin was created (Mark, 1983, pp. 359-360). It is necessary to delineate the watersheds by pouring points (the lowest point at the side of the basin) where the water runs out of the area.

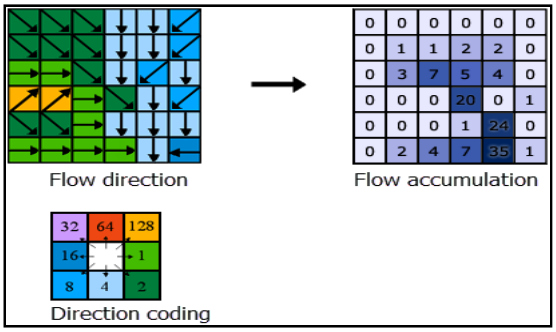

Fig. 4: Cell neighborhood indicating the course of flow and aggregation of flow.

3.4. Basin Delineation

The whole land and water area from which rainfall-runoff drains into any water body, such as a stream, river, lake, or ocean, is referred to as a watershed. It could be a level location or one with hills or mountains. Watershed is often used interchangeably with the term’s drainage basin and catchment area. The watershed boundaries are the limits that separate watersheds from one another. It classifies all sets of related cells belonging to a certain watershed (Figs. 5-6). The drainage basins are extracted by locating the pour points on the edges of the study window (where the water flows from the raster) and perhaps even the sinks and then defining the involvement region in front of each pour point. This applies to the drainage basin system (Maidment, 2002, p. 14).

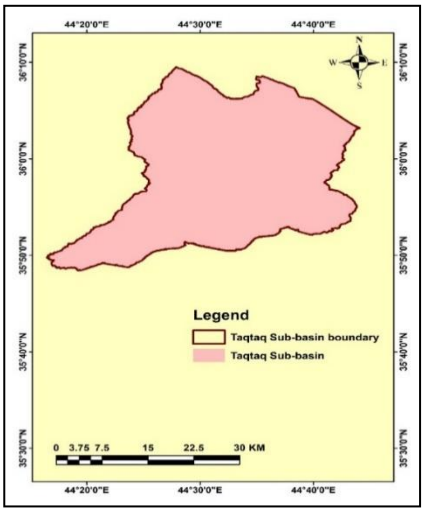

Fig. 5: Taqtaq Sub-Basin Boundary.

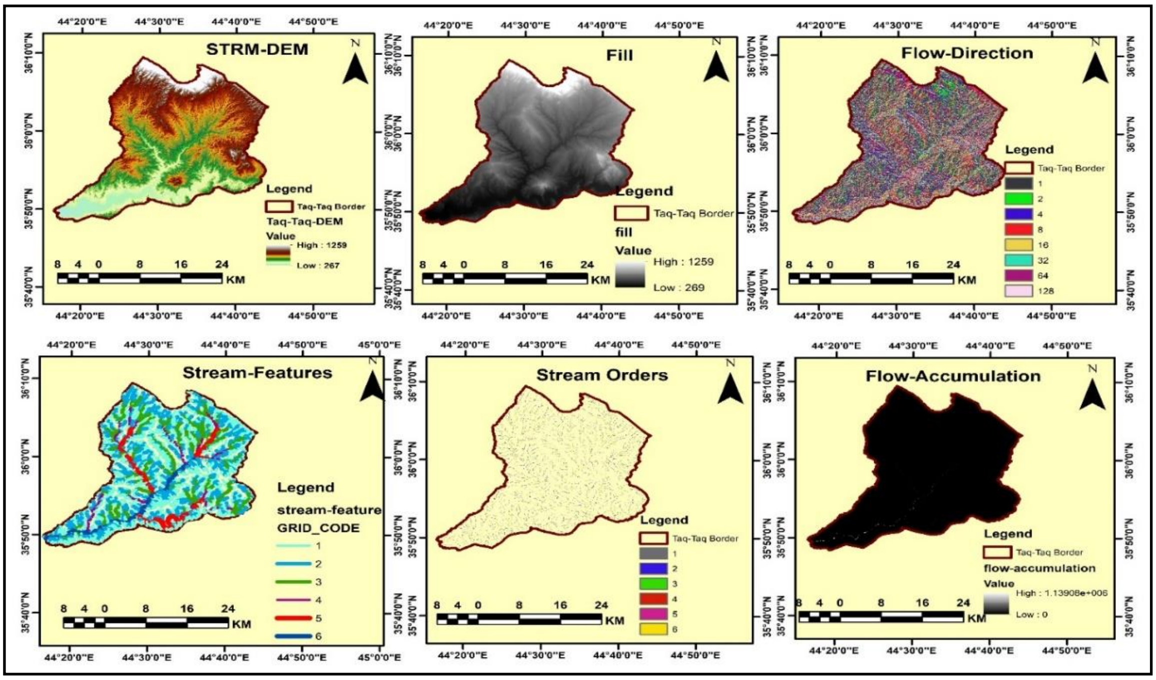

Fig. 6: Watershed outlining, stream order, and extraction of the basin borderline.

3.5. Morphometric Analysis and Parameters

The morphometric characteristics of a given basin deal with its quantitative morphological investigation, identifying the area's basin relationship, the measurements, and the quantitative study of the relief of the basin and its density texture (Abou-El-Enin, 1990). These studies are very relevant and must be recognized when developing programs and constructing irrigation systems to measure runoff in the intermittent and perennial basins. To delineate the basin and morphometric analysis of linear and aerial aspects, the Arc GIS 10.8 (Spatial Analyst) hydrology method was used. Moreover, DEM was used to extract hydrological data such as drainage networks and boundaries of watershed delineation. Three types of morphometric parameters are available, namely linear, areal, and relief aspects (Table 1 and Fig. 7).

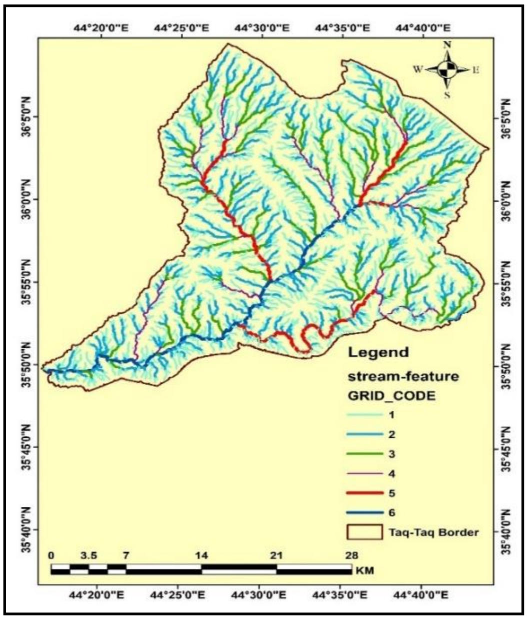

Figure 7: Drainage network and morphometric analysis of the watershed studied.

No.	Morphometric Parameters	Formula	Results	Reference
Linear Morphometry				
1	Stream Order N(u)	GIS	6th Order	Strahler (1964)
2	Stream Length (Lu)	Length of the basin	Total = 1775 km	Horton (1945)
3	Mean Stream Length (Lu-)	Lu = ∑Lu / ∑Nu - 1	Table 2	Strahler (1964)
4	Stream length ratio (RLu)	RLu = ∑Lu / ∑Lu – 1	Table 2	Horton (1945)
5	Bifurcation ratio (Rb)	Rb = ∑Nu / ∑Nu +1	Table 2	Schumm (1956)
6	Mean bifurcation rastio (Rb-)	Rb = ∑Rb / Toaql No. of orders Where, Rb = Average of bifurcation ratios of all orders	30.89	Strahler (1964)
7	Basin length (Lb)	$Lb = 1.312 * A^{0.565}$	61.8 km	Rawat et al.,2017
8	Basin Perimeter (LP)	Length of basin boundary	170 km	Rawat et al.,2017
Areal Morphometry				
1.	Drainage Area (A)	Area of a drainage basin	881 km^2	GIS
2.	Mean Basin Width (Wb)	Wb = A / Lb	14.27 km	Horton (1945)
3.	Drainage Density (Dd)	Dd = ∑Lu / A	2.01 km-1	Horton (1945)
4.	Stream Frequency (Fs)	Fs = ∑Nu / A	3.31 km^2	Horton (1945)
5.	Drainage texture (Td)	Dt = ∑Nu / Lp	17.17 km^2	Horton (1945)
6.	Circularity Ratio (Rc)	$Rc = 4 * Pi * A / Lp^2$	0.38	Bhawan (1998)
7.	Elongation Ratio (Re)	Re = 2 / (A/Pi) / Lb	0.71	Schumm (1956)
8.	Form Factor (Ff)	$Ff = A / Lb^2$	0.23	Horton (1945)
Relief Morphometry				
1.	Basin relief (Rb)	Rb = H (maxi) – H (mini) Where H = Elevation (m)	992m	Veeranna et, al (2017)
2.	Relief ratio (Rr)	Rr = R / Lb	0.06	Veeranna et, al (2017)
3.	Ruggedness number (Ra)	Ra=(H/1000) *Dd	2	Veeranna et, al (2017)

Table 1: Methods and results assumed for calculating Taqtaq watershed morphometric parameters.

3.6. Linear aspects

Linear aspects include several parameters, through which the characteristics of linear drainage can be measured. For instance, basin-length, stream-order, perimeter, stream-number, stream-length, mean stream-length, stream-length ratio, and bifurcation-ratio are mentioned below.

3.6.1. Basin-Length (Lb)

The length of the Basin is the distance between the catchment and the point of confluence (Gregory and Walling 1973, p. 321). This measurement is necessary to determine the shape and the relative relief of the watersheds.

The basin's length is the geometric measurement of the structure and length of the drainage watershed. It is the basin's maximum length inside a full circle along the basin's boundary, which runs in the same direction as the mainline (Rawat et al.2017, pp. 3-4).

3.6.2. Perimeter length (Lp)

Lp Perimeter length is the linear length of a drainage basin perimeter. It is the boundary of the stream's watershed (Rawat et al., 2017, pp. 3-4).

3.6.3. Stream order

The first phase in morphometric analysis of drainage basin analysis is stream ordering, which is a measure of a stream's position in the hierarchy of tributaries (Strahler 1964). When two channels with various orders join, according to Strahler's method, the higher order is then established (Strahler, 1952). In this research, Strahler's method, which is a marginally updated Horton system (Horton, 1945, pp. 285-293), was used.

3.6.4. Stream number (Nu)

A stream number is a collection of branches of distinct stream segments that attempt to approximate Horton's converse geometric ratio in an assumed drainage watershed (Horton, 1932, pp. 350-361 in Ali and Khan, 2013, p22). The relationship between stream order and stream number has been discovered to be inverse.

3.6.5. Stream length (Lu)

(Lu) The length of each stream order in a drainage basin is known as stream length that can be produced by using ArcGIS software on the base of the proposed stream length (Horton, 1945, p 291). The number of the extents of all streams in a certain order is the total length of each stream segment.

3.6.6. Mean stream length (Lu-)

By multiplying the overall length of the stream in a given order into the overall number of stream orders as in the basin, the average length of the stream can be determined. The mean stream length is said to have a direct relationship with the stream's order, with each increasing stream segment lengthening the total mean stream length. (Aravinda and Balakrishna, 2013, pp. 514-522).

3.6.7. Stream length ratio (RLu)

RLu is the ratio between the total length of the stream order (Lu) and the next lower order's entire stream lengths (Horton, 1932, pp. 350-361 in Ali and Khan, 2013, p22).

3.6.8. Bifurcation ratio (Rb)

Rb is the proportion of the number of stream lengths of the order to the number of constituents of another higher stream order. It was known as the Release and Separation Index (Schumn, 1956, pp. 603-608 in Ali and Khan, 2013, p24).

3.6.9. Areal Aspects

3.6.9.1. Area of the basin A

The watershed region is the area beyond the basin's boundaries.

3.6.9.2. Stream frequency (Fs)

The proportion of the total number of streams in a watershed divided by the watershed's area is the frequency of the stream, which was introduced by Horton (1945). Precipitation is the most essential factor in influencing this ratio. The greater the stream values, the better. High surface and subsurface rock resistance, low permeability lithology, increased relief, and scant vegetation cover are all frequency indicators. On the other hand, low stream frequency values are associated with low resistance, low surface and subsurface material lithology, and low relief (Kumar, 2013, p. 3).

3.6.10. Drainage Density (Dd)

Drainage density is the total length of streams of all orders (km) per drainage area (km2). It is a crucial numerical parameter for displaying watershed growth due to the influence of climate, geology, structure, area relief, and landscape shape governed by variables that indicate drainage density ratio. The drainage density is determined by dividing the complete stream tributary length of all orders into the total stream length of all orders in the area of the watershed (Horton 1932, pp. 350-361; Pareta and Pareta, 2011, pp. 249-253). The high drainage density number indicates permeable subsurface lithology, lower relief, and a denser vegetation cover region. On the other hand, the low value is due to less permeable or poor subsurface lithology, increased relief, and sparse vegetative cover (Rawat et al.,2017, pp.3-4).

3.6.11. Drainage Texture (D.t)

The drainage texture, which indicates the relative spacing of drainage lines and those used to evaluate permeable and impermeable materials, is one of the most important aspects in the morphometric examination. The drainage texture is calculated by multiplying the basin's circumference by the total number of streams in all orders. (Horton, 1932 in Ali and Khan, 2013, p. 24). The drainage texture is split into five types: extremely rough (less than 2), rough (2–4), moderate (4–6), fine (6–8), and very fine greater than 8. (Rawat et al., 2017, p. 3-4).

3.6.12. Elongation ratio (R.e)

The ratio of the circle's diameter to the watershed's extreme length is the same as the watershed's length (Schumm, 1956, pp. 597-646; Kumar, 2013, pp. 3-4). Over a broad variability of climatic and geologic forms, the ratio values typically range between 0.6 and 1.0. Circular (>0.9), oval (0.8-0.9), and somewhat elongated to elongated (0.7) values are further characterized.

3.6.13. Circularity ratio (Rc)

As the ratio of the watershed region to the amount that the circle has the same diameter as the basin (Ali and Khan, 2013, p. 24). As a quantitative technique, the circularity ratio is a dimensionless parameter used to compute and estimate the form of the watershed, and it goes from 0 to 1 for an elongated watershed to a circular basin (Veeranna et al., 2017, p. 1805).

3.6.14. Form factor (Ff)

The form factor is a ratio of watershed area to the square of the length of the watershed. It is the division of the watershed area by a square of the maximum watershed length (Aravinda and Balakrishna, 2013, pp. 514-522).

3.6.15. Relief Aspects

Relief aspects are represented by several critical parameters in the morphometric study. Variables such as basin relief, relief ratio, watershed slope, and roughness number may identify the pattern of water movement and are used to comprehend the development and denudation of the watershed.

3.6.15.1. Basin relief (Rb)

The difference between the maximum and minimum altitudes within a watershed is known as basin relief (Rawat et al., 2017, p. 5). A 30 m resolution DEM was used to get the elevation values of the field.

3.6.15.2. Relief Ratio (Rr)

The relief ratio was obtained by dividing the overall relief of the watershed by the extreme length of the basin estimated close to the stream's highest line. (Schumm, 1956, pp. 596-646; Pareta and Pareta, 2011, p. 256). The steep gradient and high relief basin result in a high relief rating, whereas the low value indicates hard rock and a smooth slope. (Veeranna et al., 2017, p. 1805).

3.6.15.3. Ruggedness Number (R.n)

The roughness number reflects the terrain's structural complexity in relation to relief and drainage density. It also suggests that the land is prone to soil erosion. (M Rashid et al 2011). It can be obtained as a result of drainage density multiplying to the watershed relief. This parameter is important to evaluate the watersheds impedance to soil erosion for high gradients and the drainage system slope (Aravinda and Balakrishna, 2013, pp. 516-520). The low ruggedness number indicates that the watershed is more susceptible to soil erosion and more influenced by structural geology. On the other hand, the high ruggedness score shows that the watershed is vulnerable to soil erosion as a result of the area's increased relief and drainage density (Rawat et al., 2017, p. 5).

3.7. Results and Discussion

The study results showed that the length of the Taqtaq sub-basin is 61.8 km, while its perimeter is (170 km, while the stream order of the watershed is the 6th order (Table 2 and Fig. 7). The total stream number of the Taqtaq watershed is 2919, wheras the total length of stream and stream orders have a generally inverse relationship. The overall stream length decreases as the stream order increases, and vice versa. The watershed's stream extent in the study area is illustrated in (Table 2). The ratio of the stream length of Taqtaq watershed is ranging from 0.5 for the 1st order and 0.8 for the 5th stream order. The lesser bifurcation ratio value shows that geological and structural disturbances have little or no impact on a region's drainage system. The watershed drainage segment controlled by the structural and geological influences, is demonstrated by the larger value of the bifurcation ratio. The bifurcation ratio of Taqtaq watershed ranges from 2.14 to 147. The average bifurcation-ratio is 30.89. The higher values of the bifurcation ratio are appearances of the watershed, which has a lower risk of flooding. The influence of local geological structure is principal. However, the shape of a basin also has a significant effect, and the bifurcation ratio inclines to be in height value when the shape is elongated (Verstappen, 1983, 149-150).

Stream Order (u)	Stream Numbers (Nu)	Stram Length (Lu) km	Mean Stream Length (Lu -) km	Stream Length Ration (RI)	Bifurcation Ration (Rb)	Mean Bifurcation Ration
1st	1530	916	0.60	0.50	2.14	30.89
2nd	714	459	0.64	0.46	1.97	
3rd	362	213	0.59	0.39	2.19	
4th	165	83	0.50	0.70	1.12	
5th	147	58	0.39	0.80	147.00	
6th	1	46	46.33			
Total	2919	1775				

Table 2: Parameters of the linear characteristics of the drainage basin in the study area.

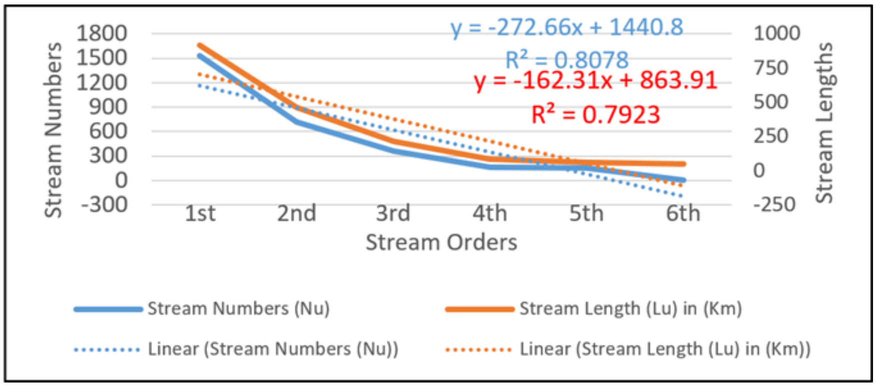

Figure 7: Relation of a stream number and stream length values of the Taqtaq sub-basin stream order values.

The area of the Taqtaq sub-basin is about (881 km2), while the stream frequency of the watershed is 3.31 no./km² which is moderate to high. In the watershed, this entails high relief and low permeable rocks. Non - permeable subsurface substance, shallow vegetation, more relief, high surface runoff, and less infiltration capability of the regions are commonly correlated with high basin frequency (Vincy et al. 2012, pp. 661-684). Furthermore, the area's drainage density value is 2.01, which indicates an intermediate drainage density. According to Reddy et al. (2004), the presence of impermeable surface material, sparse vegetation, high relief, and heavy rainfall (Seasonal and Annual) are largely responsible for the value of drainage density in the studied area, which indicates of more runoff, and subsequently a low infiltration rate. It demonstrates that stream frequency is proportional to density texture (Table 3). The drainage density of the analyzed basin was calculated and mapped using the spatial analyst tool in ArcGIS 10.8 software (Fig. 8).

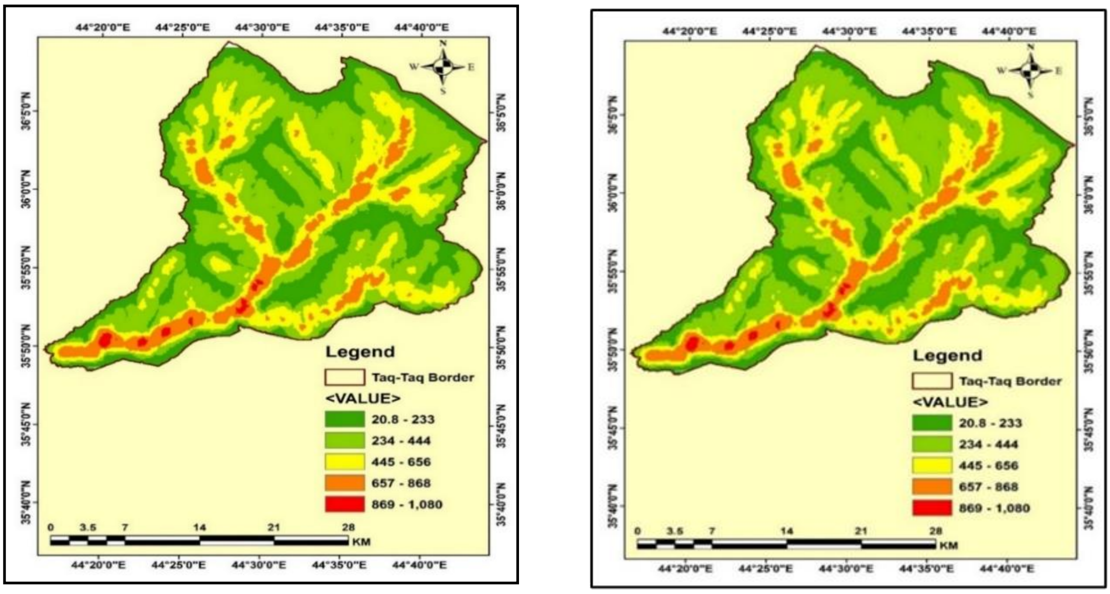

Fig. 8: Drainage density linearization map of the drainage basin in the study region.

According to Horton (1945), The value of 17.17 km3 of the Taqtaq sub-basin has demonstrated that the analyzed watershed belongs to very fine drainage textures. The result of the elongation ratio is 0.7.

The elongation ratio value less than 0.5 denotes a more extended watershed, elongated watershed (0.5 to 0.7), and the increased value of this ratio to 1 reflects the basin form, which becomes circular. (Schumm, 1956, pp. 597-646). The watershed's circularity ratio is 0.38, indicating an elongated shape in the study area, exposing the impermeable significant and intermediate slope angle in the chosen watershed.

The examined watershed's form factor value is low (0.23), indicating that the watershed has a lower peak flow with longer time and an elongated basin form (Table 4). The relief value ratio of Taqtaq watershed is 0.06. The low ratio value of the watershed is attributed to the study area's low permeability material. The watershed's relief is 992 meters. The roughness number for the Taqtaq watershed is 2.

According to Magesh, 2014, the value of ruggedness is high, and the basin is classified as an exciting morphological appearance. It contributes to complex geomorphic processes, long and steep slopes broken by sharp slope breaks, high susceptibility to soil erosion, and mass movement due to rejuvenation processes (Reddy et al., 2004, 1189-1202).

No.	Morphometric Parameters (Relief Aspect)	Result Values
1	Basin relief (Rb)	992 m
2	Relief ratio (Rr)	0.06
3	Ruggedness number (Rn)	2

Table 4: Drainage Basin Parameters of the Relief Elements in the Study Area

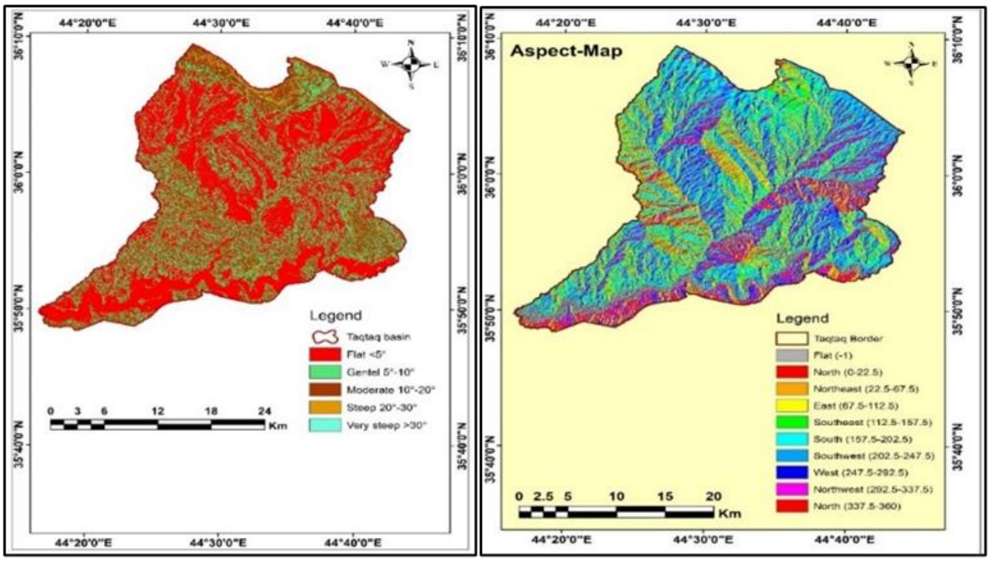

Fig. 9: Slope and Aspect maps of the study area

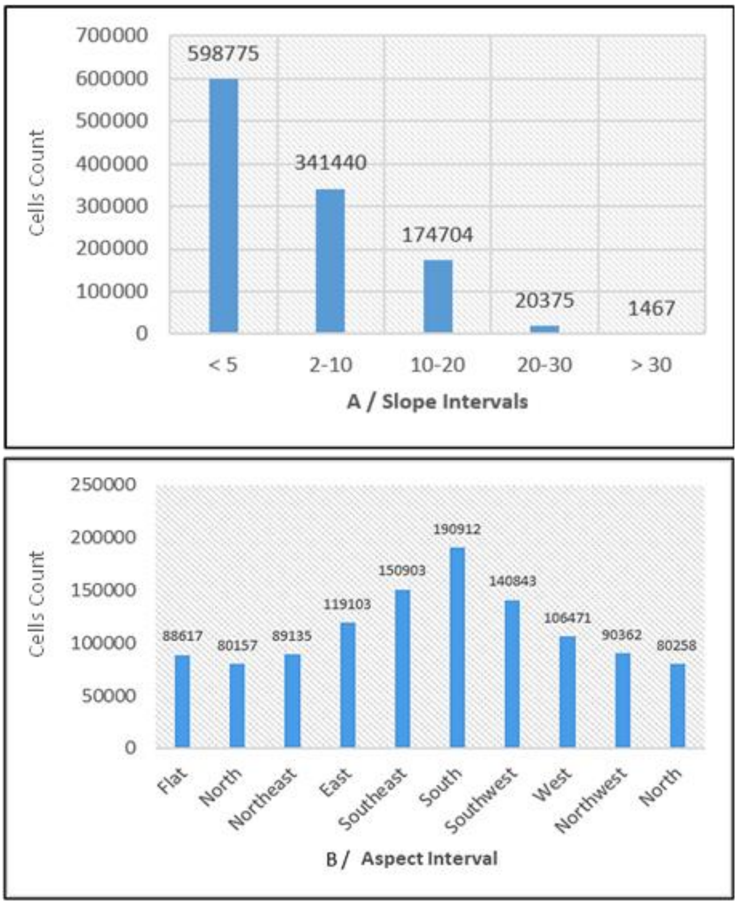

Fig. 10: The chart displays the distribution of (A / Slope and B / Aspect) values in the research field.

3.8. Conclusions

In this study, remote sensing combined with GIS techniques were used to examine the morphometry of the Taqtaq watershed in the Koysinjaq district. The stream orders in the studied area are the 6^{th} stream orders. For morphometric investigation, morphometric parameters in terms of linear, aerial, and relief aspects were used. The stream number and stream length values in the study area's watershed are inversely connected to stream order values.

The findings showed that the stream length ratio changes correspond to changes in the basin's slope and topography. The considered basin's mean bifurcation ratio is large, indicating a structural influence on the evolution of drainage networks in the watershed. Due to circularity and elongation ratios, the watershed in the study area has an elongated shape, which was investigated to establish the importance of watersheds for water management and rainfall harvesting in the area.

It was also discovered that the basin has low permeability material, a moderate slope, is structurally regulated, and has a large amount of surface runoff as evidenced by moderate to high stream frequency, a moderate drainage density value, and a very fine drainage texture.

The research discovered that the basin has a temperate slope for flow from the base to the watershed's entrance by examining relief characteristics. As a result, it can be stated that morphometric analysis can benefit greatly from the use of remote sensing data and GIS techniques. It could be used to understand watershed growth better, compare watershed, natural resource, and water management, and identify flood vulnerabilities.

4. References

- ABOU-EL-ENIN, (1990) Physical Geography of the Basin of Wadi Dibba I UAE and its effect on Agricultural Development. Kuwait Univ.
- Agbasi, Okechukwu & Aziz, Nadia & Abdulrazzaq, Zaidoon & Etuk, Sunday. (2019). Integrated Geophysical Data and GIS Technique to Forecast the Potential Groundwater Locations in Part of Southeastern Nigeria. Iraqi Journal of Science. 60. 1013-1022. 10.24996/ijs.2019.60.5.11.
- ALI, M., (2012) Identifying neotectonic features using lineament analysis of satellite images in a tectonically active Muzaffarabad area, Azad Jammu and Kashmir. MSc. Thesis. University of Peshawar, 101 P.
- Ali, R. T and Omar, A. A, (2014) extraction and Analysis of Tectonic Lineaments using Geoinformatics Techniques, in Tawke Oil Field, Duhok area, Iraqi Kurdistan Region.
- Ali, S. A., and Khan, N., 2013. Evaluation of morphometric parameters - a remote sensing and GIS-based approach.
- Al-Sudani, H.I.Z., 2018. Study of Morphometric Properties and Water Balance Using Thornthwaite Method in Khanaqin Basin, East of Iraq. Journal of University of Babylon for Engineering Sciences, 26(3), pp.165-175.
- Arabameri, A., Pradhan, B., Pourghasemi, H. R., and Rezaei, K. 2018. Identification of erosion-prone areas using different multi-criteria decision-making techniques and GIS. Geomatics, Natural Hazards, and Risk, 9(1), 1129-1155.
- Aravinda, P. T., and Balakrishna, HBB, s2013.Morphometric analysis of vrishabhavathi watershed using remote sensing and GIS. International Journal Resource, Eng.Tech, 2(8):514-522.
- Aziz, N. A., Abdulrazzaq, Z. T., and Mansur, M. N., 2020. Gis-based watershed morphometric analysis using dem data in Diyala river, Iraq. Iraqi geological journal, 53(C): 36-49.
- Babir, G.B. and Ali, S.M., 2016. Hydrogeologic and water balance of Koi Sanjaq basin, northern Iraq. Iraqi Journal of Science, 57(1B), pp.423-435.
- Bellen, R.C. van, H.V. Dunnington, R. Wetzel, and D.M. Morton, eds., 1959, Lexique stratigraphic international: Paris, v. III, Asie, Fascicule 10a Iraq, 333 p.
- Bierman, P.R., and Montgomery, D.R. 2013. Key Concepts in Geomorphology, Freeman. ISBN 978-1429238601.
- Biswas, S., Sudhakar, S.and Desai, V.R. 1999, Prioritistion of sub-watersheds based on morphometric analysis of drainage basin, district Midnapore, West Bengal. Journal of Indian Society of Remotesensing, Vol.27(3) pp 155-166.
- BLOOM, ALL, (2002) Geomorphology – A systematic analysis of Late Cenozoic landforms (3rd edition). Prentice-Hall of India Private Limited, New Delhi.
- El-Enin, H.A. 1990. The physical geography of the basin of Wadi Dibba in UAEAE and its effect on agricultural development. Department of Geography, Kuwait.
- Gregory KJ, Walling DE (1973) Drainage basin form and process—a geomorphological approach. Edward Arnold Pub. Ltd., London, p 321.
- Horton, R. E., 1932. Drainage-basin characteristics. Eos, Transactions Am. Geophysics Union, 13(1): 350-361.
- Horton, R. E., 1945. Erosional development of streams and their drainage basins; hydrophysical approach to quantitative morphology. Geological Society of America Bulletin, 56(3): 275-370.
- https://www.researchgate.net/publication/269793129_Evaluation_of_Morphometric_Parameters-A_Remote_Sensing_and_GIS_Based_Approach.
- Hussein I, Z, A,2018. Study of Morphometric Properties and Water Balance Using Thornthwaite Method in Khanaqin Basin, East of Iraq. Journal of University of Babylon, Engineering Sciences, Vol. (26), No. (3).
- Jassim, S.Z. and Goff, J.C. eds., 2006. Geology of Iraq. DOLIN, sro, distributed by Geological Society of London.
- K. J. Bhang and F. Schwartz, "Limitations in the Hydrologic Applications of C-Band SRTM DEMs in Low-Relief Settings," in IEEE Geoscience and Remote Sensing Letters, vol. 5, no. 3, pp. 497-501, July 2008, doi: 10.1109/LGRS.2008.920712.
- Kaiwan, F,Shwan, S and Shevan J,2020.Morphometric analysis using geo-information techniques for different watersheds in the northeastern part of Erbil city, Kurdistan region, north Iraq.
- Kumar, N., 2013. Morphometric analysis of river catchments using remote sensing and GIS (a case study of the Sukri River, Rajasthan). International Journal of Scientific and Research Publications, 3(6): 1-6.
- Lindsay, J.B., 2016. The practice of DEM stream burning revisited. Earth Surface Processes and Landforms, 41(5), pp.658-668.
- LINSLEY, R. K., KOHLER, M. A., and PAULHUS, J. L., (1975) Applied hydrology. McGraw-Hill, New York.
- LOGET, N., & VAN DER DREISSCHE, J., (2009) Wave train model for knick point propagation, Geomorphology, Vol. 106, No. 3-4, pp. 376-382.

- M. Rashid, M. A. Lone, and S. A. Romshoo, "Geospatial tools for assessing land degradation in Budgam district, Kashmir Himalaya, India," Journal of Earth System Science, vol. 120, no. 3, pp. 423–433, 2011.
- Maidment, D.R. and Morehouse, S., 2002. Arc Hydro: GIS for water resources. ESRI, Inc.
- Mark, D.M., 1983. Relations between field-surveyed channel networks and map-based geomorphometric measures, Inez, Kentucky. Annals of the Association of American Geographers, 73(3), pp.358-372.
- Martz, L.W. and Garbrecht, J., 1993. Automated extraction of drainage network and watershed data from digital elevation models 1. JAWRA Journal of the American Water Resources Association, 29(6), pp.901-908.
- Miller, V.C., 1953. A Quantitative Geomorphic Study Of Drainage Basin Characteristics In The Clinch Mountain Area Virginia And Tennessee. Columbia Univ New York.
- O'Callaghan, J.F. and Mark, D.M., 1984. The extraction of drainage networks from digital elevation data. Computer vision, graphics, and image processing, 28(3), pp.323-344.
- Pareta, K., and Pareta, U., 2011. Quantitative morphometric analysis of a watershed of Yamuna basin, India using ASTER (DEM) data and GIS. International Journal of Geomatics and Geosciences, 2(1): 248-269.
- R Turcotte, J.-P Fortin, A.N Rousseau, S Massicotte, J.-P Villeneuve, Determination of the drainage structure of a watershed using a digital elevation model and a digital river and lake network, Journal of Hydrology, Volume 240, Issues 3–4, 2001, Pages 225-242, ISSN0022-1694,https://doi.org/10.1016/S0022-1694(00)00342-5.
- Rai, P.K., Mohan, K., Mishra, S. et al. A GIS-based approach in drainage morphometric analysis of Kanhar River Basin, India. Appl Water Sci 7, 217–232 (2017). https://doi.org/10.1007/s13201-014-0238-y.
- Rawat, U., Awasthi, A., Gupta, D.S., Paul, R.S. and Tripathi, S., 2017. Morphometric analysis using remote sensing and GIS techniques in the Bagain River Basin, Bundelkhand Region, India. Indian Journal of Science and Technology, 10(10).
- Reddy, A.R., Chaitanya, K.V. and Vivekanandan, M., 2004. Drought-induced responses of photosynthesis and antioxidant metabolism in higher plants. Journal of plant physiology, 161(11), pp.1189-1202.
- S. A. Schumn, "Evolution of Drainage Systems and Slopes in Badlands at Perth Amboy, New Jersey," Bulletin of the Geological Society of America, Vol. 67, No. 5, 1956, pp. 597-646. (19) (PDF) Evaluation of Morphometric Parameters A Remote Sensing and GIS Based Approach. Available from:
- Schumm, S.A., 1956. Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey. Geological society of America bulletin, 67(5), pp.597-646.
- Strahler AN (1964) Quantitative geomorphology of drainage basins and channel networks. In: Handbook
- Veeranna, J., Gouthami, K., Yadav, P. B., and Mallikarjuna, V. R., 2017. Calculating linear and areal and relief aspect parameters using Geo-Spatial Techniques (ArcGIS 10.2 and SWAT model) for Akkeru River Basin Warangal. International Journal of Current Microbiology and Applied Sciences, 6(10):1803-1809.
- Verstappen, H.Th. 1983: Applied geomorphology: geomorphological surveys for environmental development. The Netherlands, Amsterdam: Elsevier.9(1):149-150. doi:10.1177/030913338500900125.
- Vincy, M.V., Rajan, B. and Pradeepkumar, A.P., 2012. Geographic information system–based morphometric characterization of sub-watersheds of Meenachil river basin, Kottayam district, Kerala, India. Geocarto International, 27(8), pp.661-684.

شیکردنەوەی تایبەتمەندییە مۆرفۆمەتریەکانی ئاوزێڵی تەق تەق – قەزای کۆیە – هەرێمی کوردستانی عێراق

هونەر عبدالله کاك أحمد الخیاط
بەشی جوگرافیا، کۆلێژی ئاداب، زانکۆی سەلاحەددین-هەولێر
huner.khayyat@su.edu.krd

شیڤان جمیل جرجیس
بەشی زانستەکانی زەوی و نەوت، کۆلێژی زانست، زانکۆی سەلاحەددین-هەولێر
Email:shevan.jirjees@su.edu.krd

پوختە

ئامانجی ئەم توێژینەوەیە بریتیە لە شیکردنەوەی تایبەتمەندێتییە مۆرفۆمەتریەکانی ئاوەزێڵی تەق تەق لەقەزای کۆیە، کە دەکەوێتە بەشی باکووری ڕۆژهەڵاتی پارێزگای هەولێر. ڕووبەری ناوچەی تویژینەوە بریتیە لە 881 کیلۆمەتری دووجا، وە لەم توێژینەوەیەدا STRM DEM بەکارهێنراوە لەگەڵ ئامرازەکانی سیستەمی زانیارییە جوگرافیەکان GIS هەستکردن لەدوورەوە RS بەمەبەستی دەستنیشانکردن و شیکردنەوەی تایبەتمەندی شێوەیی هێلی و تۆپۆگرافیی بەمەبەستی پێکانی ئەمانجەکانی توێژینەوەکە وە بۆ ئامادەکردنی نەخشەو ئەنجامدانی ئیکردنەوەکانی توێژینەوەکە پشت بەستراوە بە بەرنامەی ArcGIS 10.8.

بەپێی ئەنجامی R2 لە توێژینەوەکە، دەرەنجامەکان دەرخەری ئەوەن کە پەیوەندییەکی دژیەکی ئاڵۆز هەیە لەنێوان ڕیزەوە ئاویەکان، ژمارەیان، درێژیان لەناوچەی توێژینەوە. وە ئاوەزێڵەکە زیاتر مەیلی درێژکۆڵویی هەیی هەیە لەتایبەتمەندێتیەکانی شێوەیی، وە شێوازەکانی ئاڕێژی شێوە لقە داری و نیمچە لقە داری، وە شێوە هاوتەریب و نیمچە هاوتەریبن.

بەپێی دەرەنجامەکانی توێژینەوەکە، یەکێك لەتایبەتمەندێتیەکانی ئاوەزێڵەکە بریتیە لە کەمی لەبەر ڕۆیشتن و کەمی هەناسەداری و کەمی پلەی لێژاییەکەی. وە پرۆسەی دروستبوونی بەرزی و نزمیەکانی و توانستی ئاوەزێڵەکان کەوتوونەتە ژێر کاریگەری پێکهاتەی جیۆلۆجی و بارودۆخی کەش و هەوای ناوچەکە. ئەم توێژینەوەیە دەکرێت بەکاربهێنرێت بۆ پاراستنی ئاوەزێڵەکان و ئامادەکاری بۆ کاتی باران بارین.

ووشە کلیلەکان: تایبەتمەندییە مۆرفۆمەترییەکان، هەستکردن لەدوورەوە، STRM DEM، سیستەمەی زانیاریە جوگرافیەکان، ئاوەزێڵی تەق تەق.

تحليل الخصائص المورفومترية لحوض طق طق – قضاء كويسنجق – إقليم كوردستان العراق

هونەر عبدالله كاك أحمد الخياط
قسم الجغرافيا، كليه الآداب، جامعة صلاح الدين - أربيل
huner.khayyat@su.edu.krd

شيڤان جميل جرجيس
قسم علوم الارض والنفط، كليه العلوم، جامعة صلاح الدين - أربيل
shevan.jirjees@su.edu.krd

ملخص

هدفت هذه الدراسة الى اجراء تحليل للخصائص المورفومترية لحوض طق طق في قضاء كويسنجق، والتي تقع في الجزء الشمالي الشرقي من محافظة أربيل، أقليم كردستان العراق. تبلغ مساحة حوض طق طق 881 كم2، وقد تم استخدام نموذج الارتفاع الرقمي DEM بالإضافة الى منهجيات وأدوات نظم المعلومات الجغرافية GIS والتحسس النائي RS لغرض تحديد وتحليل الخصائص الشكلية لمنطقة الدراسة من حيث الخصائص الخطية والطوبوغرافية لغرض تحقيق اهداف الدراسة.، تم توظيف برنامج ArcGIS 10.8 لإعداد الخرائط الخاصة بالدراسة واجراء التحليلات وتقييم المعايير المختلفة.

ومن خلال قيم R2 المستحصلة في هذه الدراسة، فقد اشارت النتائج الرئيسية للدراسة الى وجود علاقة متعارضة صعبة بين ترتيب المجاري، اعدادها، واطوالها في منطقة الدراسة. وكذلك أظهرت ميل الحوض الى الاستطالة من حيث الشكل مع أنماط تصريف تتراوح بين الشجيري وشبه الشجيري، الى النمط المتوازي وشبه المتوازي.

ووفقا لنتائج الدراسة، يتميز الحوض بتصريفه المنخفض بالإضافة الى ضعف النفاذية في المحتوى، وقلة انحداره. وقد تأثرت عملية انشاء التضاريس وكفاءة الاحواض المائية بالتركيبة الجيولوجية والظروف المناخية لمنطقة الدراسة. هذه الدراسة بالإمكان ان تكون مفيدة وهامة للمحافظة على الاحواض المائية و الاستعداد لفترات سقوط الامطار.

الكلمات الدالة: الخصائص المورفومترية، التحسس النائي، نموذج الارتفاع الرقمي STRM DEM، تطبيقات الـ GIS، حوض طق طق.