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Haditha region hydrological aspects extraction using remote sensing and GIS techniques

Anas Abdulrazzaq Mohammed [1*] and Amen Abdulrazzaq Mohammed [2]

[1] *Directorate of Space and Communications, Ministry of Science and Technology, Baghdad, Iraq*
[2] *Directorate of Environment and Water, Ministry of Science and Technology, Baghdad, Iraq*

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Abstract

In this study, advanced means in remote sensing techniques and Digital Elevation Models (DEMs) computed from modern satellite images of the studied area were used as raw data by a program for measuring spatial and geographical analysis.

Results of morphometric analyses are based on field data analysis and manually drawn watershed boundaries. Results from GIS depend on how accurate the DEM data utilized it after eliminating all no-data voids and filling in sink holes in the raw DEM data for the study area. It was discovered that SRTM-DEM with a reasonable resolution of 30 meters per grid cell provided accurate delineation for the surrounding topographic area of Hadetha Dam Lake in morphometric analysis.

The hydrogeological study indicated that there are five underground basins: the modern sedimentation basin, the Injana basin, the Fattah basin, the Euphrates basin and the Umm Al-Raduma basin. There are also basins within the water formation in Injana and the Euphrates. The basin area and circumference were measured using the GIS Arc View geographic information system. The area and the circumference of the basin were 166 Km^2 and 244 Km, respectively. The soil permeability ratio of the main basin is high and rainfall is low. Therefore, the area is characterized by the presence of large and karst caves and cracks spread, thus creating a good area for the process of filtering rainwater into the ground to feed the layers that have the ability to collect water, and forming layers that contain groundwater.

Keywords: Hydrology, Umm Al-Raduma, water, remote sensing

*Corresponding author anasrazzak@yahoo.com

1 Introduction

The digital elevation model (DEM) is an important technological tool for interpreting surface phenomena particularly land formations on which this study is based. Because of its direct and indirect effects on all other earth shapes, as well as its impact on land usage, the water network is one of the most essential ground forms investigated in terms of drainage and valley slopes as well as valley estuaries (Alhamamy, 2006).

One of the most basic attempts in morphometric research is the investigation of surface water drainage networks, which is critical in many hydrographic applications (Ifabiyi, 2004).

One of the most important uses of earth surface analysis is the analysis of the hydrographic properties of the earth surface which is required by experts in a variety of sectors including agriculture, the environment, natural disasters, and urban development. The geological properties of the earth determine the characteristics of the earth surface. The study of data collection was based on several approaches such as descriptive and quantitative approach, and quantitative analysis methodology which analyzes and paints the information of satellite images and digital elevations (DEM) in graphic form.

Due to their impact on the time of runoff water concentration, morpho-parameters have a significant impact on the drainage network and streams flow (Al-Kafaji and AL-taee, 2015).

Strahler (1957) was the first to recognize the significance of these variables. The mentioned study pointed out that basin geomorphological activities have a significant influence on basin streams flow pattern. Today, this claim is still true because numerous studies (Jain and Sinha, 2003; Easterbrook, 2013) have suggested that geomorphological factors are to blame for the hydrological characteristics of basins. From this perspective, morphometric analysis is a method not only for comprehending basin hydrological factors but also for identifying basin-forming processes that might be obscured by spatio-temporal veiling.

Through his contributions, Horton (1932) helped to usher in the "basin quantitative expression" period.

2 Materials and methods

2-1 Obtain digital elevation data

This study consists of a variety of data collection approaches, including a descriptive and quantitative approach, as well as a quantitative analytical strategy which contains an examination of the Landsat 7 ETM+ return data and the SRTM digital elevation models (DEMs) using the ArcGIS 14.1 program. These statistics are useful for regional research, thus at the province level in Iraq. The National Aeronautics and Space Administration (NASA) of the United States provides this statistics for free. The data utilized in this study was digital elevation with a resolution of 30 m, yield of the SRTM satellite for the study area (Figure 1) (Chaplot et al., 2006).

2-2 Problem of the study

Because discharge ponds are the most important geomorphological phenomenon in arid places, drainage basins are one of the most important geomorphological investigations. In studies of drainage basins and hydrological factors, there is still a dearth of information. As a result, there is a pressing need to create a massive database of water basins using geographic information systems.

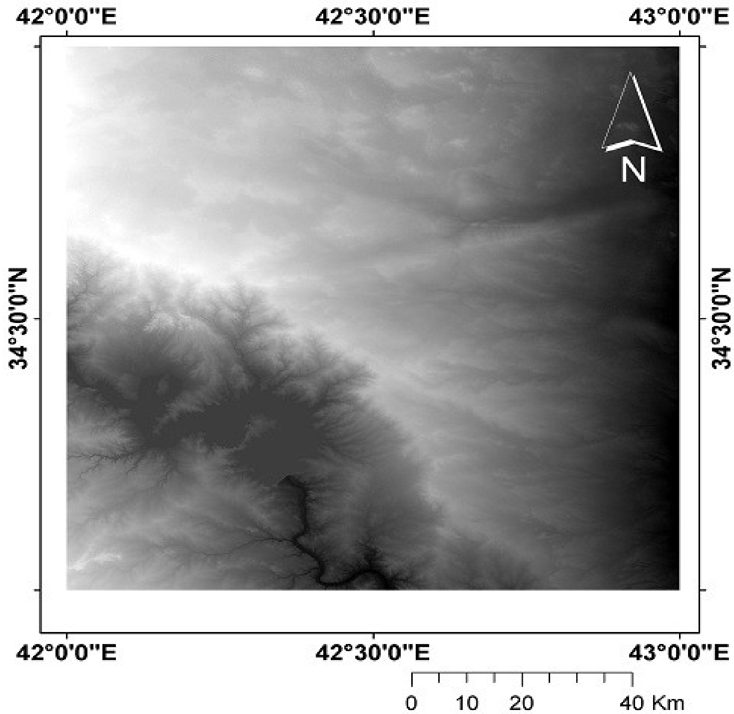

Figure 1. Digital height image (DEM), yield of the SRTM satellite for the study area.

2-3 The location of the study region

The research region was in the Al-Anbar Governorate in Iraq's western desert which includes Haditha city and the surrounding area located at an altitude of 107 m, and Haditha dam that stretches 35 km northwest of the Haditha city. The study area is located between latitudes 33°59'55"N and 34°37'22"N and longitudes 41°59'55"E and 42°35'48"E (Figure 2).

Figure 2. The image of the study area.

2-4 The climate of the region

The current climate of the region is semi-desert, with monsoon rains, high temperatures in the summer and mild temperatures in the winter, low humidity and moderate winds (Figure 3). The focus of this study is on the use of the global rainfall system. This system is used in many regions of the world, especially those where sufficient climatic data is not available, as well as for large areas of land cover (Safi El-Din, 2005).

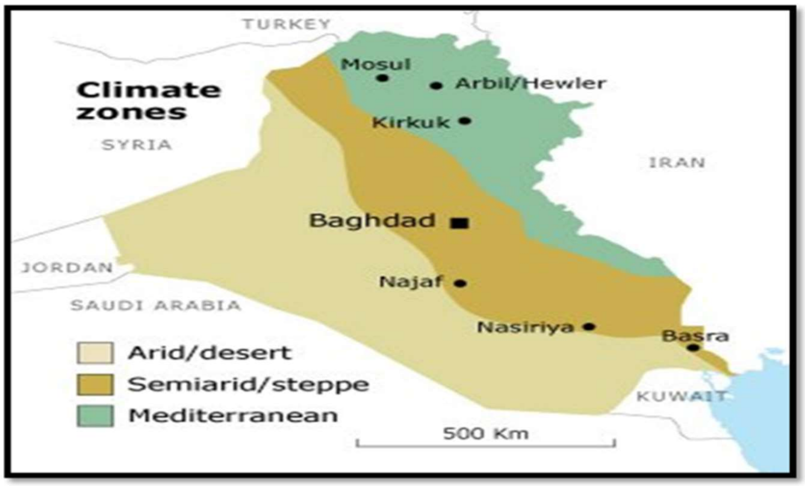

Figure 3. The climate of Iraq (Hussain et al., 2018).

Many researchers have used this approach to find rain showers that produce rain. The information is available from this system either through functional contour maps and graphs, or tables displaying precipitation rate obtained at daily intervals. The data provided by these techniques may be reliable as the comparison between them and the data from ground monitoring stations has shown a correlation between the two sources. The annual rainfall rate in the region is 100-125 mm (Figure 4). The annual average temperature for the region ranges between 20 and 22 C. The average temperature is 9.6°C in the winter and 32.9°C in the summer. The average annual rate of relative humidity is 35-40%. The annual rate of evaporation is 3000 mm (USAID, 2017).

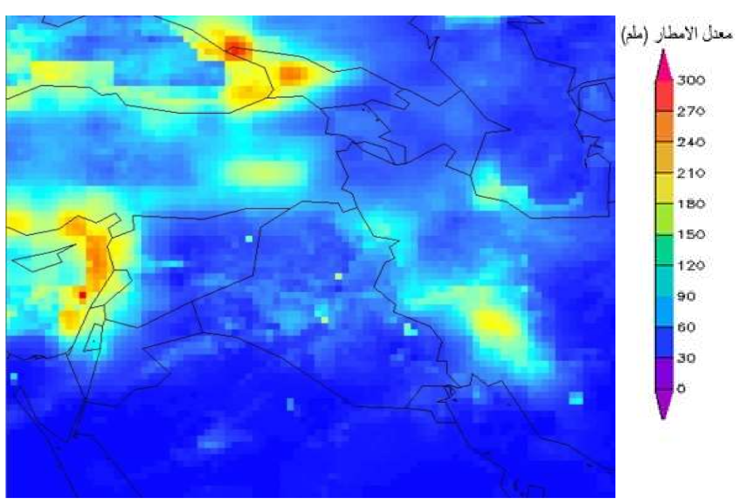

Figure 4. The average cumulative annual precipitation during 2000-2018.

2-5 The topography of the area

This area consists of a plateau surface that is an extension of the height of the plateau of the Western Desert. The maximum height of the study area is 247 m in the western center at the highest peaks of the southern valley of Haklan and the minimum height is 60 m around Lake Tharthar.

The surface of the area descends from the west and southwest to the east and north-east at no more than half a degree on the surface of the plains of the corrugated plateau. This slope continues on the surface of these plains until it oversees the Euphrates River. The edges of the plains overlooking the Euphrates River cut short and deep valleys Wadi Tharthar, which extends from the north of the map to its outlet in Lake Tharthar (Figure 5).

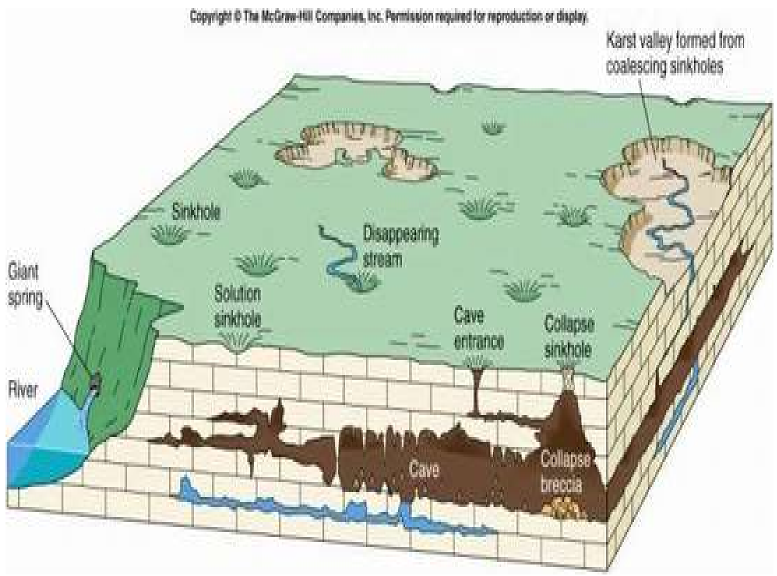

Figure 5. Topography of the area (Hussain et al., 2018).

3 EXPERIMENTAL PART

3-1 Digital Elevation Model

A Digital Elevation Model (DEM) is a digital file consisting of terrain elevation. It is a raster (grid) representation of a continuous surface where each cell value in the raster represents elevation (Figure 6). To get an accurate result from surface analysis, you must make sure that the data has been projected. If the data has a geographic coordinate system but no projected coordinate system, use the project raster tool to project the data to an appropriate projected coordinate system. The main analysis of this study is carried out using ArcGIS 10.4 software.

3-2 DEM processed by "Fill" tool

To fill sinks in the DEM, the tool "Fill" was employed.

3-3 Hydrology analysis

The hydrology tools are used to model the flow of water across a surface. During modeling the flow of water, you may want to know where the water comes from and where it is going. The following topics explain how to use the hydrologic analysis functions to help model the movement of water across a surface, the concepts and key terms regarding drainage systems and surface processes. Moreover, they explain how the tools can be used to extract hydrologic information from a DEM, and sample hydrologic analysis applications (Figures. 7 and 8) from each cell to its steepest down slope neighbor.

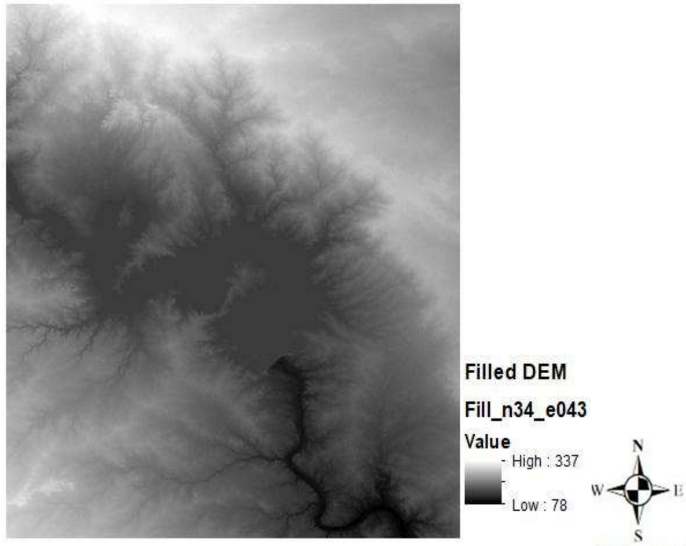

Figure 6. DEM of the study area processed by “Fill” tool.

In Figure. 9, the tool “Raster calculator” has been applied by more than 20000 values to show the main streams in the study area. In the map legend, “1” means stream cells and “0” means empty cells.

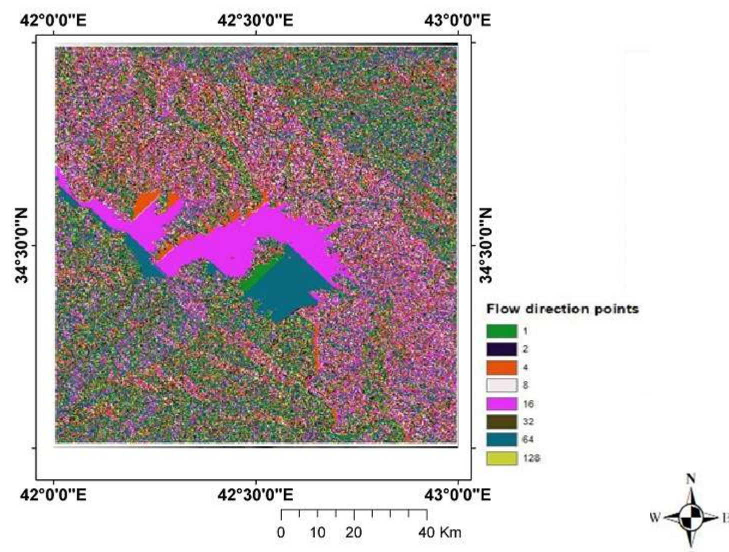

Figure 7. The raster of flow direction from each cell to its steepest down slope neighbor.

To show secondary drains, “Con” tool was applied by 1000 values (Figure 10). Watershed, also known as basin or catchments, is physically delineated by the area upstream from a specified outlet point.

To apply “Stream Link” tool in the input columns, the layer from (Con) tool and the layer from “Flow Direction” tool were applied. For the study area the highest value of stream link is 2523, while the lowest is 1 (Figure 12).

For applying “Stream Order” tool, the “Stream Link” and below “Flow Direction” layers must be put in the input columns (Figure 13).

The “Stream to Feature” tool was applied by using “Stream Order” and “Flow Direction” layers in the input columns (Figure 14).

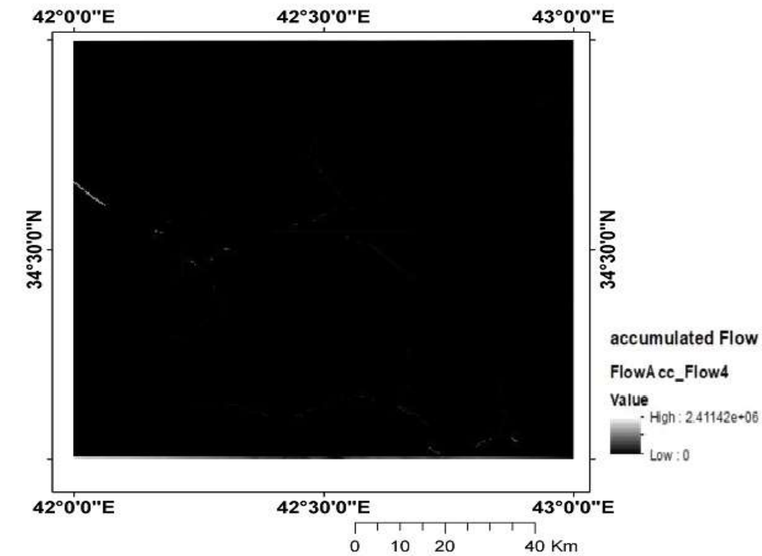

Figure 8. The flow accumulation which is a raster of the accumulated flow to each cell.

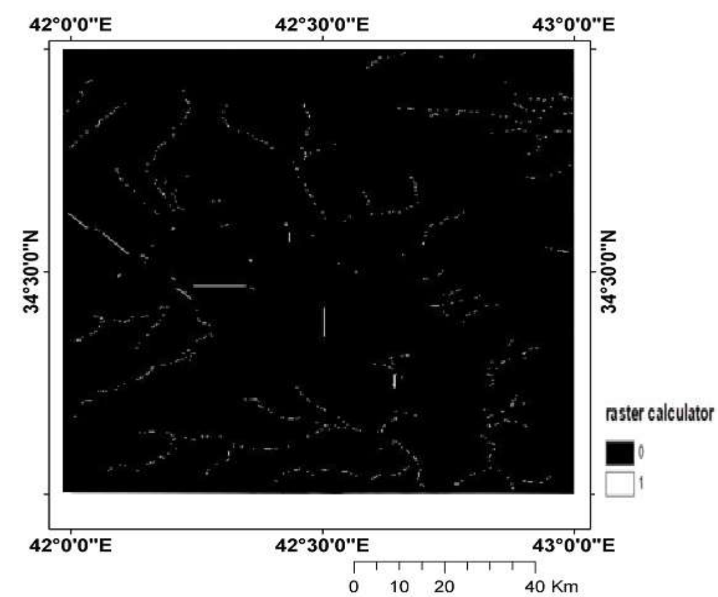

Figure 9. The result from the "Raster Calculator" tool by value > 20000 for the study area.

The result will be shown in 6 degree orders. For determining the main and the secondary streams, there is a need to simplify the formation for streams; therefore, in the "properties of the layer" icon follow: "Categories" > "Symbology" > "Value Field" > "Grid Code ". Then, press on "Add all Values". Next, apply "Group" for the first with the second values and the third with the fourth values and the fifth with the sixth values to produce the final formation.

These drainage patterns depend on the topography and geology of the land. It is clear from the Figure 14, there are many contributing streams (analogous to the twigs of a tree), which are joined together into the tributaries of the main river (the

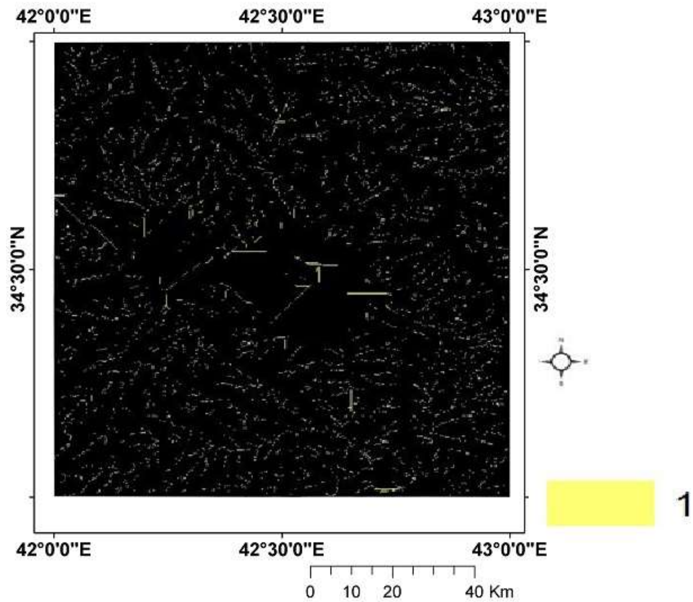

Figure 10. Primary and secondary drain shown by "Con" tool.

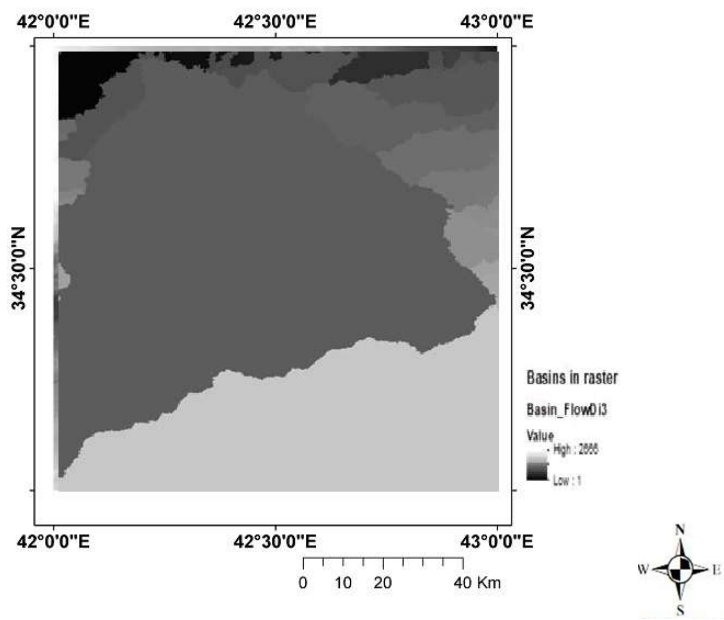

Figure 11. Raster basins of the study area.

branches and the trunk of the tree, respectively). They develop where the river channel follows the slope of the terrain.

4 Conclusions

The following points can be concluded from this study:

1) The study was based on morphometric analysis. The water network and its type (Dendritic Network) was identified and the direction of water flow was determined from the higher elevation areas right up the lower elevation areas which indicates the homogeneity in texture.

2) The maturity to ancient stage of river

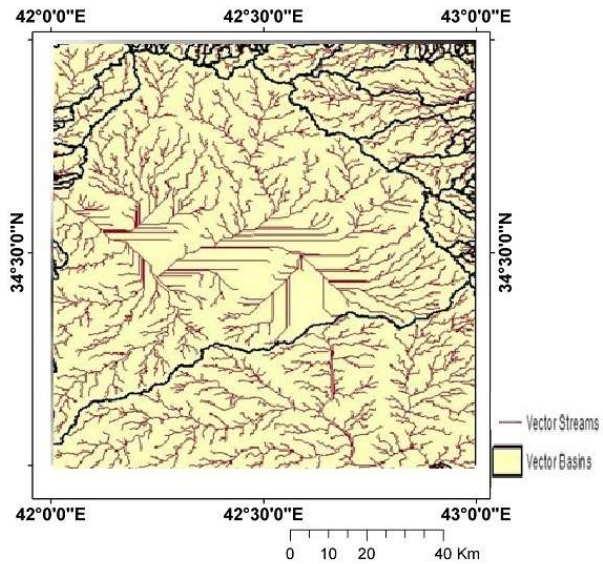

Figure 12. Vector streams and basins.

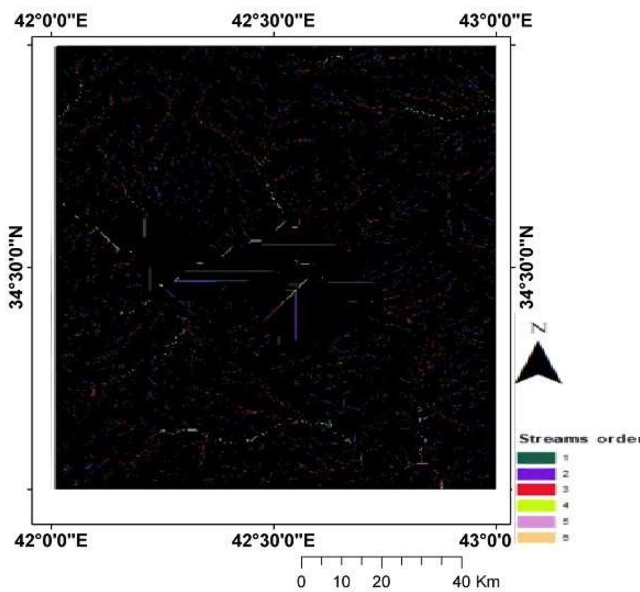

Figure 13. Stream ordering.

geomorphologic evolution is reflected by hypsometric analysis for drainages delineation. DEM with resolution 30×30 m is used since it provides more features and is more in line with the surface than 90×90 m depending on the map of the subdivision.

3) Although the rainfall rate of the region is quite low, the earth is highly porous which refers to a highly permeable basin "usually" while implying a very coarse texture because the texture varies from zone to zone in the basin (this is seen from the variation in basin width along the region).

4) Various hydrogeological investigations in the area indicate that there are five underground reservoirs, the modern sedimentation reservoir, the Injana reservoir, the Fatha reservoir, the Euphrates reservoir and the Umm Al-Radhuma reservoir.

5) There are basins within the Injana and Euphrates water formation. The basin area and circumference were measured

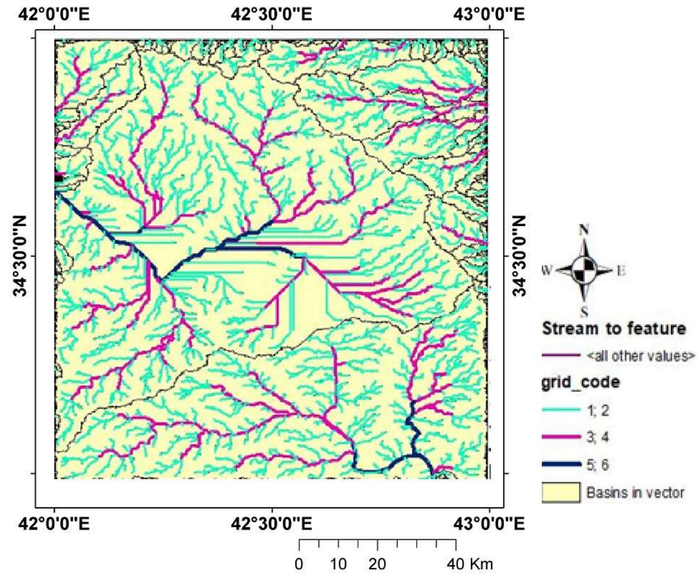

Figure 14. "Stream to Feature" tool.

using the GIS Arc View geographic information system. The basin area was 166 km^2, and the basin circumference was 244 km.

6) The area is characterized by the presence of large caves, karsts, and cracks spread in the area, which are not far from the Euphrates Valley. Thus, a good area was formed for the process of filtering rainwater into the ground to feed the layers that have the ability to collect water, forming layers that contain groundwater.

7) The underground water movement is characterized in a modern painting as being multi-directional, as it can be seen from the hydrogeological map. The direction of movement is towards the east and north-east because of the water divider. For the southwestern part of the plate, the direction of movement is towards the south and southwest, i.e., towards Haditha Lake and the Euphrates River. For the south of Haditha Lake, it is towards the northeast, i.e., towards the Euphrates River and for the middle of the plate in general, the movement of groundwater is towards the east, i.e., towards the Tharthar depression. In the central southern part, the movement is towards the southwest, i.e., towards the Euphrates River because of the water divider.

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