Watershed basins delineation using GIS and Digital Elevation Model (DEM) to the region NI-38-14 Karbala-Al-Najaf Plateau, Iraq

Hayder H Kareem¹*, Aseel A Alkatib², and Waseem H. Mahdi³

¹,² Structures and Water Resources Engineering Department, Faculty of Engineering, University of Kufa, Al-Najaf, Iraq
³ Civil Engineering Department, Faculty of Engineering, University of Kufa, Al-Najaf, Iraq

E-mail: hayderh.alshaibani@uokufa.edu.iq

Abstract. The available watersheds in the vast lands need extraction and determination in order to benefit from them and estimate the quantities of water supplied by these watersheds. The satellite image is uploaded to the NI-38-14 Karbala-Al-Najaf plateau from the USGU website in the form of a Digital Elevation Model (DEM). GIS technology is used to calculate the morphometric properties and output them in the form of tables and cartographic models. The water networks of the geographical plateau NI-38-14 located between the administrative borders of the provinces of Al-Najaf and Karbala in Iraq are devised by extracting a topographic map of the area and calculating the areas of the watersheds and their perimeters. The topographic map showed great variations in the level of the earth's surface, as the heights of the area ranged between 20m and 120m. The number of watersheds extracted in the Karbala-Al-Najaf plateau is 150 watersheds with different areas, the large area is about 4882 km², while the small area is about 1 km², and between those areas there are various areas. The largest recorded watershed circumference reached 580km in area (4882 km²), while the lowest recorded perimeter is 8km for the area (1 km²).

1. Introduction
In light of the dams that Turkey built at the beginning of the twenty-first century (GAP-Project, 22 dams) at the headwaters of the Euphrates and Tigris Rivers, and with climate changes and their increasing impacts on the environment and climate of Iraq, all this casts a frightening shadow on the future of water resources. The policies of neglect and waste, and poor planning for future projects in the water sector, which were adopted by the institutions and departments of the Iraqi state during the past periods, led to the waste of fresh water to the Arabian Gulf. Where the report of the Iraqi Ministry of Water Resources showed, 90% of the surface water flowing in the Euphrates River will be depleted, which will cause desertification and pollution problems. The agricultural sector in Iraq consumes 65% of the water of the Tigris and Euphrates Rivers, in addition to 80% of domestic use, depending on the water of these rivers. In the last two years, Iraq lost 20% of its arable lands as a result of desertification, which resulted in the loss of 70% of the agricultural crops. As two reports prepared by specialized international organizations revealed that Iraq will lose all the flowing water of the Euphrates and Tigris Rivers by 2040 [1]. Therefore, it requires searching for different water sources and determining their quantities and quality in order to exploit them for different purposes. A water
drainage basin, watershed, or waterfall basin is the location or area of land in which the surface water resulting from rain or melting snow collects at one point of low elevation, where it is usually at the outlet of the drainage basin. The accumulated water merges with other bodies of water, such as a river, lake, reservoir, creek, lagoon (wetland), sea or ocean. The watershed can be divided into drainage basins based on gathering points within the catchment higher in the direction of the higher stages of the drainage network. For example, a tributary of a river (or a stream) that joins a small river - which also constitutes a tributary of a larger river - is essentially part of a series of successive drainage flats with smaller areas representing drainage basins (or waterfalls) have a higher elevation. Likewise, both Tigris and Euphrates Rivers are part of their drainage basins (watersheds) as well as those of the Shatt al-Arab River. It can be concluded from the foregoing that drainage basins drain into other drainage basins in a hierarchical or graded pattern, so that the smaller sub-basins meet to form larger basins. Where in trapped drainage basins, water converges and collects at one point inside the basin, known as subsidence, which may form a permanent lake, or a dry lake, or a point at which surface water is lost in the ground [2, 3]. The drainage basin includes all streams and rivers that carry water through it, as well as the terrain (or surfaces) from which water flows to be discharged into those water channels, as its borders with other neighbouring basins are distinguished by the drainage boundary [4].

The drainage basin acts like a funnel that collects all the water within the area it covers and directs it to a single drainage point. Each drainage basin is surrounded by a topographical ring that isolates it from the neighbouring basins, called the drainage boundary or waterfall point, and it consists of a series of high geographical features (or peaks) (such as ridges, or hilltops and mountains) that constitute a geographical barrier [5]. Drainage basins are similar to hydrological units but not identical to them. Hydrological units are drainage areas whose boundaries have been demarcated to overlap and bifurcate into a multi-level hierarchical drainage system (or network of drains). Hydrological units are designed to allow multiple inlets and outlets for water or depressions. It can be said accurately and conclusively that all drainage basins are hydrological units, but not all hydrological units are essentially sewage basins [6].

Effective planning and efficient management of watersheds is an urgent necessity through which it is possible to assess surface runoff and sedimentation at the entrances and exits of watersheds, providing insight into the geological, hydrological and climatic characteristics that affect these watersheds in order to strengthen their management and control the activities to which the watersheds are encountered. One of the most famous and largest sites that provide Digital Elevation Models (DEM) is the USGS Earth Explorer (earthexplorer.usgs.org), as it provides DEMs in the Shuttle Radar Topography Mission-SRTM format with a resolution of (10m, 30m, and 90m) through which it is possible to extract the raw data stored for the area to be studied [7].

Due to the importance of the watersheds, many researchers have used various programs such as the Geographical Information System GIS, QGIS, GLOBAL MAPPER, and Digital image processing to extract the topographic characteristics and drainage networks, as well as to determine the flowing valleys and the ramifications in which the water flows to form the watersheds by relying on the raw data carried by the DEMs [8]. In the United States of America through relying on DEM provided by satellite images with a resolution of 10m, Jensen and Domingue (1988) derived a statistical relationship linking the characteristics of the DEM with the characteristics that the watershed possesses such as depth, width and cross-sectional area of the channels paths through which water flows towards the collection point of the water catchment [9]. Padilla et. al. (2015) used the 30m DEM to derive the characteristics of watersheds such as determining the locations of drainage points and catchment areas, watershed boundaries, slope of pathways in which the water flows, and the absorptive capacity of the pathways to carry water. The analysis process showed high accuracy of the results, which provides the possibility of adopting the study by decision-makers [10]. Gopinath et. al. (2014) used the DEM to determine the locations of the watersheds and the characteristics that possess through the use of the GIS program, where the topographic and topological drainage network of the target area was deduced for a study [11]. Pandey et. al. (2007) have depended on GIS and Remote Sensing RS techniques to study the watersheds of Hazaribagh which is located in India. The DEM of
the area was analyzed and the topographical characteristics of the watershed were determined, such as the area of the basin, the ramifications and flows carried by the waterways, the density of the branches and branches of the waterways, the flow quantities and the percentages of variation, in addition to determining the hardness number. In the end, the study led to the extraction of fixed parameters for the study area that could be adopted in watershed management [12]. Through applying the GIS, Fu-quan et. al. (2010) extracted the hydrological characteristics of the watersheds of Ya'an City in China such as cumulative flow quantities, flow directions, path lengths the flow takes, flow starting points and final gathering places, and sub-networks in which the flow takes place. It was found through the study a great similarity between the analytical results obtained from the study and those that the actual river system has in the reality [13]. Aziz et. al. (2020) has extracted the morphological characteristics such as the flow value and density of Diyala River, Iraq, by analyzing aerial images using GIS software [14]. Shamkhi et. al. (2019) has explored the topography of the basin of AL-Adhaim, Iraq and extracted the morphometric properties of the basin with the help of the tools provided by the GIS program [15]. Using the ARC HYDRO tool included in the GIS program, Ayad and Moutaz (2015) have analyzed the DEM of the Lesser Zab River Basin, Iraq to extract the main and secondary networks (watersheds) and the hydrological factors of the watersheds [16]. Al-Saady et. al. (2016) has studied the Lesser Zab River Basin located in northern of Iraq through the extraction of subsidiary water basins and the characteristics that characterize these basins such as size, height, amounts of flow carried by the branches of water and other morphometric properties [17].

The topographic maps provided by digital elevation images, in addition to the information contained in these images, are among the main sources that through their analysis can be extracted the watersheds and the various characteristics that these watersheds contain. Whereas, the availability of DEMs and the development of GIS have facilitated the process of extracting and identifying large and small watersheds and all their branches. The use of GIS began to increase in recent years, despite its complexities, but on the other hand, it is distinguished by the accuracy and efficiency of its results, as it requires high experience by users in the process of spatial, geographical and topological analyses in order for the outputs to be reliable and approved by researchers and decision-makers [18, 19].

In the present study, the watersheds, their areas, and their perimeter lengths will be extrapolated to the NI-38-14 geographic plateau located between longitudes (450 00', 430 30') East and latitudes (330 00', 320 00') North. The plateau represents part of the unstable shelf of the sedimentary plain and the Salman area of the stable berth, which is located between the provinces of Karbala and Al-Najaf Governorates in Iraq. The extraction of watersheds and their characteristics in the study area is the first of its kind as most of the previous studies were looking for the availability of groundwater and the geological and hydrological characteristics of aquifers. Therefore, this study will provide valuable information to researchers about watersheds in the area under study, with the aim of stimulating them to delve deeper into the chemical, physical, geological and hydrological properties of these watersheds, which will give a research vision for decision makers and stakeholders that will enable them investing the study area.

2. NI-38-14 Karbala-Al-Najaf Plateau Description

The current study area represented by the Karbala-Al-Najaf quarter-million plateau is located between longitudes (450 00', 430 30') East (96.5 km) and latitudes (330 00', 320 00') North (141 km) as shown in Figure 1. Its total area is (13606 km²) and it represents part of the unstable pavement of the sedimentary plain and the Salman range of the stable pavement. Geologically, the surface of the sedimentary plain gradually rises from south to north in relation to the unstable platform. As for the stable region (Al-Rutba-Al-Jazirah range), based on the physiographic divisions of Iraq, the region is characterized by its simplicity and devoid of folds and faults, with the exception of the Euphrates fault, whose effect is evident as the natural limit for the end of geological formations towards the east. The area is also characterized by the lack of surface and subsurface structures in it, with the extension of the Quaternary deposits and the detection of formations belonging to the Triple Age [20, 21, and 22].
The area along the land route between the cities of Karbala and Al-Najaf invested decades ago due to its hydrogeological importance. As the region is characterized by the presence of water reservoirs with distinct hydraulic specifications, and many water wells have been dug in it with the aim of exploiting the water of these reservoirs in many aspects, foremost of which is their exploitation for agricultural purposes [20]. In general, it is possible to divide the Karbala-Al-Najaf plateau into two different topographic regions: the alluvial plain and the desert flat area [21].

The alluvial plain constitutes about 50% of the Karbala-Al-Najaf plate area. The area is covered with sediments of river or wind origin and adjacent to the desert surface to the west. The topographic units in the region are of river origin linked to river activity, as well as shallow depressions and swamps. The process of erosion and sedimentation leads to the formation of different geomorphological forms, and human activity and the presence of irrigation channels have a clear effect on flat areas [21].

The desert flat area constitutes about 30% of the plate area and extends between Al-Najaf and Karbala and extends far northward. The region is bounded on the east by the alluvial plain, and on the south by Tar Al-Najaf, which reaches a height of about 50m, and from the west, there is Tar Al-Sayyed with a height reaches 20m. Both Tars have steep rims. The flat area is desert, with little corrugation and interrupted by shallow and intermittent valleys, whose waters collect in the southwestern parts and drain towards the northeast. The southwestern part of the area plateau reaches a height of 120m and slopes towards the northeast, reaching a height of about 30m, while the northern area of the plateau reaches a height of 75m. It descends towards the southeast to reach the limits of 30m as all the above information are illustrated in Figure 2. The desert flat area is covered with sandstones dating back to the Pliocene era of the Dibdibba Formation, which in turn is covered with a coherent sand gypsum crust of fibrous and prismatic shape [23].
3. Watershed Basins Extraction from DEM using GIS (Morphometric Analysis)

The GIS software has become a crucial and useful tool in the fields of geology, hydrology and statistics that help in particular water scientists in the scientific study and management of water resources. Climate change and the increasing demand for water resources require disposing of more knowledge in those most vital water resources. Because water differs in its spatial and temporal state during its hydrological cycle, therefore its study using geographic information systems is a practical and special method. Previously, GIS was generally static in its representation of geospatial hydrological features; but today, GIS platforms have become attractive in carrying out research which has narrowed the gap between historical information/data and the current reality of hydrological facts. The primary water cycle has an input equal to the output plus or minus the storage change. Hydrologists also make use of the hydrological budget when studying watersheds. A watershed is a spatial area, and the proportions of water presence throughout its domain vary with time. Therefore, the hydrological budget is the input which includes precipitation, surface flows, groundwater flows and outputs that includes evaporation, runoff, and surface/groundwater flows. All these quantities, including storage, can be measured or estimated, and their characteristics can be displayed graphically through GIS studies [24, 25].

To extract the watershed basins for the NI-38-14 Karbala-Al-Najaf plateau, it requires providing the Digital Elevation Model (DEM) from the Shuttle Radar Topography Mission (SRTM). SRTM is a global research shuttle owned by the United States Geological Survey that provides a geological, topographic and meteorological database for the Earth in a high-resolution digital format represented by digital elevation models (DEM). The digital elevation models are arranged in the form of tiles distributed from 56 degrees towards the south to 60 degrees towards the north, as each tile covers one degree of longitude and latitude and is represented by geographical coordinates (minute, degree and second). The accuracy of the DEMs provided by USGS ranges from (1-90) m, and may sometimes reach even less than 1m, depending on the type of study and the data that need to be provided. The current research has downloaded the DEM for the study area (NI-38-14 Plateau) in Raster format with a resolution of 90m from the website (https://earthexplorer.usgs.gov) as shown in Figure 3. The downloaded DEM needs to be projected to convert its coordinates from the geological coordinates to Universal Transverse Mercator (UTM) coordinates under the classification of the World Geodetic System (WGS) of the year 1984. To process the downloaded DEM, the Geological Information System program (GIS) will be implemented to the current study to delineate the watershed. Figure 4 shows the projected DEM.
The DEM is in the form of Raster contains cells' network. Each cell has a value, which is the height above sea level, and the cell with the highest height is poured into the cell of lower height in a continuum. This sequence continues from a greater height to a smaller one to a smaller one, and so on, so if an anomaly occurs in this sequence like if a cell with a height meets large blocks or a large drop such as a hole, then for the GIS it means the end of the valley and then begins to calculate a new valley. However, in reality the valley still the same valley one, but a pit or a hill interrupted its route, so from the beginning it must remove this abnormal height or this hole by giving them an average value of the adjacent cells by the process called Fill Sinks as illustrates in Figure 5.

After filling depressions, it will determine the direction of flow to the cells on the basis of height, and it should be noticed in this step that the work is at the level of the cell and not at the level of the tributary. This means that each cell leads to a cell next to it that is lower than it and the file resulting from this process is in the form of grid cells (Raster), where, each has a number of eight numbers (1, 2, 4, 8, 16, 32, 64, 128) as each number has a meaning of direction, East, Southeast, South, Southwest, West, Northwest, North, and Northeast respectively. The implementation of flow direction on DEM is illustrated in Figure 6.

After determining the directions of flow in the study area, at this stage it will calculate the pools of flow, as the result is a Raster file. Each cell in the Raster contains a value, as this value is the number of cells that are higher than this cell and pour into it, meaning that the fallen water collects in it. This process will lead to identify the watershed areas, as shown in Figure 7. To complete the process, it will transfer water catchment areas from Raster to Polygons so that the GIS program can calculate the areas of watersheds and the perimeter of each watershed as shown in Figure 8.

The areas where water collects are depressions and water accumulates in them as a result of the presence of streams of water runoff, which requires sensing/extracting those water channels. Figure 9a or Figure 9b shows the streams and their branches within the watersheds of the area under study.

Figure 3. Downloaded DEM. Figure 4. Projected DEM. Figure 5. Fill Sinks.
4. Results and Discussions

Morphometric analysis is used as a quantitative method in geomorphometric studies, and it refers to the process of digital analysis of the phenomena that occur on the Earth's surface based on data obtained from topographic maps, aerial photos, satellite images and field studies, which requires the importance of studying the morphometric analysis of drainage basins, which are the backbone of Geomorphological studies. The similarity of the basins in their dimensions and morphometric characteristics indicates the similarity in their geological and climatic characteristics, their origins, their formation and development factors, which sheds light on the geomorphology of the region's basins. The morphometric analysis of watershed network basins is performed by relying on satellite image analysis (DEM) through drawing watershed networks with the analysis of its topography and hydrology using GIS software.

The watershed surface waters flow from all the surrounding high directions towards the main course, which does not require its development into a permanent river, but may remain in the form of a temporary or seasonal watercourse according to the hydrological conditions prevailing in the drainage basin. The study of the area and dimensions of watershed basins includes the study of the total area of watershed basins and their dimensions, which are the length, width and circumference, which indicates the volumetric characteristics of these basins and the calculation of many morphometric characteristics related to the formal characteristics of drainage basins and their networks in the area basins. The
current research deals with studying some of the morphological characteristics of the NI-38-14 plateau located between Karbala and Al-Najaf governorates. The study of the area of drainage basins is useful in its close relationship with the network system, as in the case of the similarity of all the morphological factors, the volume of the flow and its height are mainly due to the area of the watershed basin. The total area of ponds in the NI-38-14 plateau is 13606 km². As it is found that there is a variation in the area of watershed basins in the region, the highest area is 4881.5 km², while the lowest area was 1 km². The variation in the area of watershed basins is primarily due to the influence of the lines of the geological structure and the natural characteristics of the rocks in addition to the time period that the watershed basins have cut from their geomorphological cycle as shown in Table 1. In addition, the number of watersheds located in the NI-38-14 plateau is significantly high reaching to 150 basins which reflect the availability of water in these region either in the form of surface or underground water, as this situation needs for an attention from the local governments of Karbala and Al-Najaf to invest that water for the various daily uses in these regions.

The perimeter of drainage basins is the length of the water division line between watershed basins. It is used in the computation of many morphometric variables related to the physical and terrain characteristics of watershed basins. It is clear from Table 1 that the perimeter of watershed basins varies from one basin to another, where the circumference of the largest basin reaches about 580 km, while the perimeter of the smallest basin reaches about 8.25 km despite the small size of the basin as illustrated in Table 1. This difference clearly reflects the severity of the meandering of the water dividing line of the basins and the asymmetry in the shape of the watershed basins.

| Watershed ID | Area (Km²) | Perimeter (Km) | Watershed ID | Area (Km²) | Perimeter (Km) |
|--------------|------------|----------------|--------------|------------|----------------|
| 1            | 4881.42    | 579.16         | 36           | 14.31      | 20.8           |
| 2            | 1878.51    | 328.09         | 37           | 13.78      | 21.21          |
| 3            | 1846.03    | 363.86         | 38           | 12.52      | 19.82          |
| 4            | 986.72     | 220.57         | 39           | 11.75      | 19.76          |
| 5            | 831.54     | 192.41         | 40           | 11.33      | 23.53          |
| 6            | 398.53     | 156.04         | 41           | 11.00      | 18.82          |
| 7            | 285.86     | 95.09          | 42           | 10.23      | 18.01          |
| 8            | 277.38     | 103.07         | 43           | 9.85       | 17.37          |
| 9            | 261.88     | 98.64          | 44           | 9.38       | 18.16          |
| 10           | 206.69     | 88.91          | 45           | 8.89       | 13.87          |
| 11           | 134.40     | 82.02          | 46           | 8.58       | 18.89          |
| 12           | 116.14     | 148.48         | 47           | 7.98       | 15.93          |
| 13           | 99.61      | 64.79          | 48           | 7.87       | 15.95          |
| 14           | 93.92      | 59.31          | 49           | 7.53       | 13.28          |
| 15           | 79.54      | 58.7           | 50           | 7.30       | 16.78          |
| 16           | 74.54      | 51.74          | 51           | 7.02       | 14.94          |
| 17           | 62.54      | 45.02          | 52           | 6.96       | 16.12          |
| 18           | 58.01      | 49.76          | 53           | 6.77       | 15.66          |
| 19           | 52.20      | 41.44          | 54           | 6.65       | 14.53          |
| 20           | 49.97      | 55.69          | 55           | 6.42       | 15.16          |
| 21           | 48.28      | 49.91          | 56           | 6.14       | 12.08          |
| 22           | 47.49      | 40.04          | 57           | 5.94       | 16.38          |
| 23           | 37.17      | 40.17          | 58           | 5.81       | 14.12          |
| 24           | 37.14      | 35.8           | 59           | 5.71       | 18.34          |
Table 1. Continued

| Watershed ID | Area (Km²) | Perimeter (Km) | Watershed ID | Area (Km²) | Perimeter (Km) |
|--------------|------------|----------------|--------------|------------|----------------|
| 71           | 4.05       | 11.06          | 111          | 1.71       | 7.85           |
| 72           | 3.97       | 10.71          | 112          | 1.70       | 6.11           |
| 73           | 3.80       | 10.27          | 113          | 1.69       | 16.00          |
| 74           | 3.76       | 13.1           | 114          | 1.65       | 7.08           |
| 75           | 3.60       | 10.58          | 115          | 1.65       | 6.67           |
| 76           | 3.53       | 18.68          | 116          | 1.62       | 6.89           |
| 77           | 3.46       | 10.55          | 117          | 1.60       | 6.47           |
| 78           | 3.16       | 11.6           | 118          | 1.56       | 6.64           |
| 79           | 3.09       | 9.38           | 119          | 1.55       | 6.13           |
| 80           | 3.03       | 17.94          | 120          | 1.54       | 6.77           |
| 81           | 2.92       | 8.67           | 121          | 1.51       | 7.45           |
| 82           | 2.91       | 9.19           | 122          | 1.49       | 8.75           |
| 83           | 2.89       | 9.01           | 123          | 1.46       | 6.37           |
| 84           | 2.78       | 8.13           | 124          | 1.42       | 6.95           |
| 85           | 2.74       | 8.43           | 125          | 1.38       | 8.8            |
| 86           | 2.69       | 8.52           | 126          | 1.36       | 5.99           |
| 87           | 2.64       | 10.57          | 127          | 1.36       | 8.95           |
| 88           | 2.59       | 7.80           | 128          | 1.33       | 6.54           |
| 89           | 2.56       | 7.33           | 129          | 1.32       | 6.51           |
| 90           | 2.47       | 8.34           | 130          | 1.28       | 5.72           |
| 91           | 2.45       | 8.48           | 131          | 1.22       | 7.29           |
| 92           | 2.36       | 6.97           | 132          | 1.21       | 5.02           |
| 93           | 2.26       | 7.63           | 133          | 1.21       | 6.62           |
| 94           | 2.23       | 8.51           | 134          | 1.20       | 5.10           |
| 95           | 2.17       | 7.29           | 135          | 1.20       | 5.59           |
| 96           | 2.15       | 7.65           | 136          | 1.16       | 6.54           |
| 97           | 2.11       | 8.05           | 137          | 1.15       | 6.42           |
| 98           | 1.99       | 7.30           | 138          | 1.12       | 5.54           |
| 99           | 1.96       | 8.39           | 139          | 1.11       | 5.10           |
| 100          | 1.95       | 8.19           | 140          | 1.11       | 6.23           |
5. Conclusion
Using the Hydrology Tool provided by Spatial Analyst Tools in the GIS program, a DEM image with a resolution of 90m is analyzed for the study area. Before the hydrological analysis is carried out, the image is projected as a preliminary stage with the aim of converting its coordinates from geographical (GRS) to metric (UTM). The accumulated flow and the directions of flow that the water travels to form the watersheds have been extracted and their locations, areas and perimeter are defined in order for the water accumulated in them (surface or groundwater) to be invested for future events. It is expected that there will be a scarcity of water, especially as Iraq suffers from scarcity in rainfall and high temperature rates which exacerbated the problem of water scarcity through increased evaporation rates. The extracted topographical map of the study area shows that the outer surface is graded in height from 20m in the northeast direction to 120m in the southwest direction, with the presence of a part of the Tar Al-Sayyed at the southwestern edge of the study area. The number of water catchments in the study area is 150 with different areas ranging from 1 km² to 4882 km², which indicates the existence of large watersheds whose waters can be used for various purposes, noting that the area is abundant with underground reservoirs close to the surface of the earth (such as Dibibba reservoir) and the other far from the surface of the earth (Such as Dammam and Umm Radhuma reservoirs). These underground reservoirs are considered one of the largest reservoirs and the largest capacity and the ability to supply the area with water in addition to the availability of those watersheds that are extracted in the current study. The perimeter is also extracted for each watershed and its boundaries are defined in order to be identifiable and in order for the watersheds to be distinguished between each other with the possibility of accurate and easy reference to them to be studied separately in the future. The current research provides a future study of the watershed areas in the panel NI-38-14 with the definition of the perimeter for each Watershed. In addition, the study can be used by researchers in detailed studies for each watershed separately by extracting the topographical, geological and hydrological characteristics that each watershed owns to provide studies for the benefit of decision-makers and investors in both Karbala and Al-Najaf Governorates as this will encourage the other researchers to study other geological panels from the Iraqi geological map.

6. References
[1] MOWR 2010 Water crisis reasons Ministry of Water Resource Al-Rafidain Magazine (Unpublished).
[2] Xu H. 2015 Information extraction of mountain river network in western Sichuan based on DEM Journal of Geospatial Information 13(4) 65-80.
[3] Song X., Zhang J. and Zhan C. 2013 Research progress of digital watershed feature extraction based on DEM, Journal of Progress in Geography 32(1) 31-40.
[4] Zhu H., Yang X. and Zhang X. 2013 Feature extraction and analysis of upstream watershed of Miyun reservoir based on DEM, Journal of China Soil and Water Conservation Science 11(3) 66-72.
[5] Rai P. K., Mohan K., Mishra S., Ahmad A. and Mishra N. 2014 A GIS-based approach in drainage morphometric analysis of Kanhar river basin, India, Applied Water Science 7 217-232.

[6] Zhang H., Huang G. H. and Wang D. 2013 Establishment of channel networks in a digital elevation model of the prairie region through hydrological correction and geomorphological assessment, Canadian Water Resources Journal 38 12–23.

[7] Arbind K. V. and Madan K. J. 2017 Extraction of watershed characteristics using GIS and Digital Elevation Model, International Journal of Engineering Science Invention 6(7) 1-6.

[8] Tarboto D. G., Bras R. L. and Rodriguez-Iturbe I. 1991 On the extraction of channel networks from Digital Elevation Data, Hydrologic Processes 5(1) 81-100.

[9] Jensen S. K. and Domingue J. O. 1988 Extracting topographic structure from digital elevation data for geographic information system analysis, Photogrammetric Engineering and Remote Sensing 54(11) 1593-1600.

[10] Padilla R. F. Q., Crisologo E. S., Romarate I. I., Rodolfo A. and Vedra S. A. 2015 Analysis of vegetation degradation using GIS and remote sensing at lake Mainit watershed, Mindanao, Philippines, Advances in Environmental Sciences 7(3).

[11] Gopinath G., Swetha T. V. and Ashitha M. K. 2014 Automated extraction of watershed boundary and drainage network from SRTM and comparison with Survey of India top sheet, Arabian Journal of Geosciences 7(7) 2625-2632.

[12] Pandey V. K., Pandey A. and Panda S. N. 2007 Application of remote sensing and GIS for watershed characterization: a case study of Banikdih watershed (Eastern India), Asian Journal of Geoinformatics 7(1) 3-15.

[13] Fu-quan N., Yao-sheng T., Li-ping X. and Cheng-wei F. 2010 DEM and ArcGIS-based extraction of eco-hydrological characteristics in Ya'an, China, 2nd International Workshop on Intelligent Systems and Applications (ISA) 22-23 May 1–5.

[14] 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(1C) 36–49.

[15] Shamkhi M. S., Abdullah T. J. and Mohson A. J. 2019 Determination of watershed characteristics using GIS technique (AL-Adhaim Watershed in Iraq), Proceedings of AICCE’19, Lecture Notes in Civil Engineering 53.

[16] Ayad A. A. and Moutaz A. A. 2015 Extraction drainage network for Lesser Zab river basin from DEM using Model Builder in GIS, Iraqi Journal of science 56(4A) 1895-1920.

[17] Al-Saady Y. I., Al-Suhail Q. A., Al-Tawash, B. S. and Arsalan A. O. 2016 Drainage network extraction and morphometric analysis using remote sensing and GIS mapping techniques (Lesser Zab River Basin, Iraq and Iran), Environ Earth Sci 75 1243-1251.

[18] Lin W. T., Chou W. C., Lin C. Y., Huang P. H. and Tsai J. S. 2008 Win basin: using improved algorithms and the GIS technique for automated watershed modelling analysis from digital elevation models, International Journal of Geographical Information Science 22 47-69.

[19] Lindsay J. B. 2016 Efficient hybrid breach-filling sink removal methods for flow path enforcement in digital elevation models, Hydrological Processes 30 846-857.

[20] Batoul M. A. A. 2012 Hydrogeological study of the area bounded by Al-Najaf-Karbala road, Iraqi Journal of Science 53(2) 353-361.

[21] Barwary A. M. and Nasira A. S. 1996 Geological map of Al-Najaf quadrangle sheet NH-38-2 of scale 1:250 000, 1st. ed. Iraq: General Commission for Geological Survey and Mining.

[22] Kareem H. 2018 Study of water resources by using 3d groundwater modelling in Al-Najaf Region, Iraq, PhD Thesis University of Cardiff UK.

[23] Barwary A. M. and Slew N. A. 1995 Report on the regional geological mapping of Karbala quadrangle - sheet NI-38-14, Iraq: General Commission for Geological Survey and Mining.

[24] Tracy J. Baker and Scott N. Miller 2013 Using the Soil and Water Assessment Tool (SWAT) to assess land use impact on water resources in an East African watershed, Journal of Hydrology 486 100-111.
[25] Azhar H. R. 2016 Modeling maps of water networks for the basins (The Oil and Harran) in Diyala Governorate, using Geographical Information Systems (GIS), Tikrit University Journal for Humanities sciences 23(2) 198-230.