EJENS
European Journal of Engineering and Natural Sciences
e-ISSN : 2458-8156

Determination of Watershed Features Using Geographic Information System (GIS)

Erkan Karakoyun[1]*, Nihat Kaya[2]
[1]*Muş Alparslan University, Faculty of Engineering and Architecture, 49250, Muşl, Turkey.*
[2]*Fırat University, Department of Civil Engineering, 23119, Elazığ, Turkey.*
**Corresponding Author email: e.karakoyun@alparslan.edu.tr*

Abstract

A water basin covers the entire area giving water to the river between the source of the river and where it ends. In simple terms, it's the area that carries the water from higher altitude to lower altitude. Factors affecting the basin, such as topography, basin size, land use, and soil type affect the process of water from upstream to downstream. For this reason, it is important to know the properties of a basin for hydrological analysis. In this study, the boundaries of the Murat-1 watershed which is the sub-basin of the Euphrates-Tigris basin were determined using Geographic Information System (GIS) and some hydrological features of the basin (flow direction, accumulated flow network, drainage boundaries, slope map, aspect map) is aimed to determine. Firstly, in the study, a digital elevation map (DEM) was obtained from Shuttle Radar Topography Mission (SRTM) satellite offered by USGS. The data obtained from USGS were merged using the ArcGIS 10.7 program and then the physical properties of the watershed were determined. As a result, GIS software, which gives faster and less costly results compared to traditional methods, has been accepted as a very effective tool in determining basin characteristics and boundaries.

Key words

GIS, Watershed, DEM

1. INTRODUCTION

Water is the most important element for the continuation of life and the sustainability of the ecological balance. Nowadays, the increase in water pollution, decrease in the amount of usable water and natural disasters caused by water threaten the future of water. Because of this, water resources management is one of the problems that need to be solved. This has led to the conclusion that water should be used sparingly and that we should know the movements of water in nature [1]. For this reason, all necessary data collection, processing and analysis must be carried out reliably and quickly in order to protect water resources, which is one of the main objectives of integrated watershed management [2]. There are some basic components that become prominent for the basin characteristics. These are: basin area, slope, minimum, maximum and average elevation of basin, basin aspect etc. By revealing the characteristics of the basin, all definitions of the area can be made and these features can be used effectively in planning studies [3]. The process of

determining the boundaries of the basin and sub-basin with classical methods is done manually from printed or digital contour maps that express the surface shapes of the land. However, these classical approaches require a very long process and cost. Especially when the size of the working area is large, the operation process becomes even more difficult [4].

With the developments in Geographic Information Systems (GIS) in recent years, getting spatial data analysis become easier. In this context, digital elevation model (DEM) is created from various remote sensing data, and river drainage network and basin and sub-basin boundaries can be automatically extracted from DEM with various spatial analyzes in GIS environment, quickly, economically and with high accuracy [4,5].

In this study, the basin characteristics of the Murat-1 basin area, which was chosen as the study area, were determined with the help of GIS technologies and the effective role of this technology in hydrology studies was tried to be revealed.

2. MATERIAL AND METHOD

2.1. Study Area

Murat River, the most important branch of the Euphrates, rises from the foothills of Ağrı Mountain and joins with the Karasu River, which comes from the North, after flowing for about 500 km towards the southwest. In the region where the continental climate is effective, winters are wet and cold, summers are warm and dry. In the region where the most precipitation falls in the spring, the amount of precipitation falls below 20 mm between June and October. The Euphrates Tigris basin is the basin with the largest area in our country, Turkey. Thirty percent of the annual flow in our country flows from this basin. The important hydroelectric power plants of our country are located in this basin. The Murat-1 basin is located in the upper Euphrates basin and was selected for this study. The location of the Murat-1 basin was shown in the Fig.1.

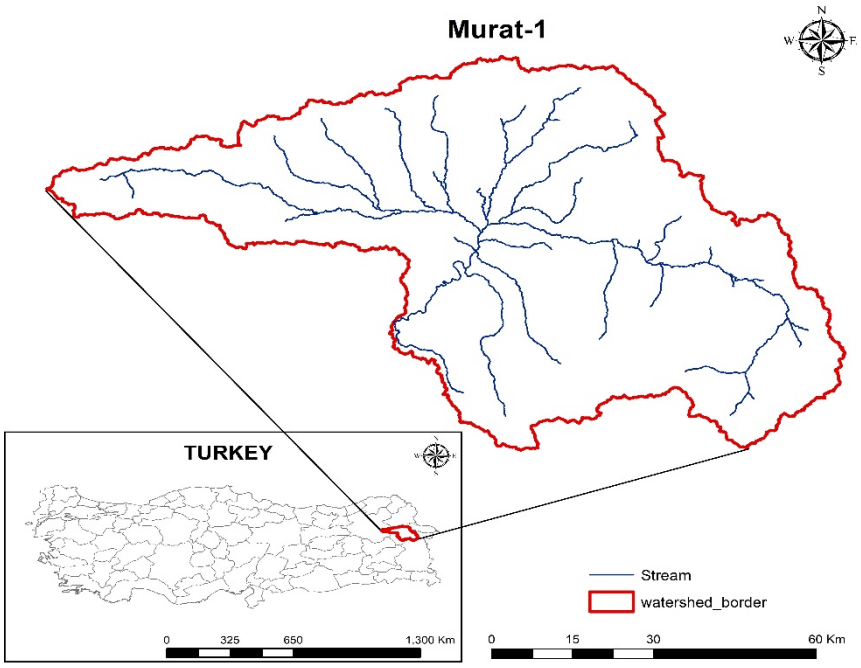

Fig.1. Study Area, Murat-1 watershed

2.2. Method

Within the scope of determining the basin characteristics and boundaries, first of all, it is necessary to obtain a digital elevation map of the study area. In this context, 30m x 30m resolution data obtained from the Shuttle Radar Topography Mission (SRTM) satellite, whose DEM data are provided by the USGS, has been downloaded. When the downloaded data has more than one layer, tessellation, which is the process of merging according to the common areas of the satellite images, should be done to create a continuous data. This process is done with the help of the ArcGIS program. After mosaic, the DEM data is corrected. The accuracy of the DEM data is very important, because this step

and the next steps are performed using DEM data. In Fig. 2, mosaicked DEM data and Murat 1 watershed boundaries are seen.

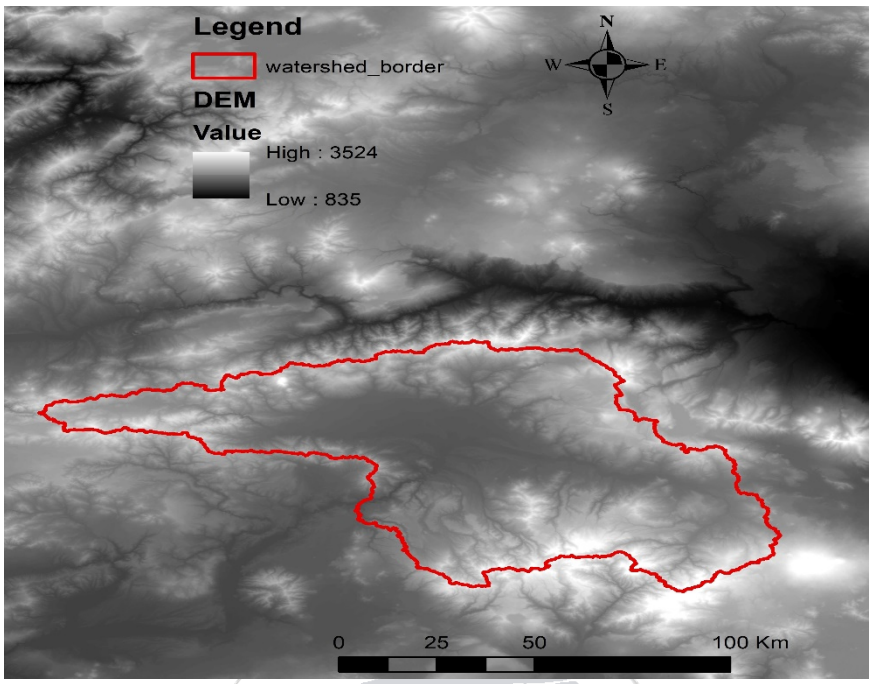

Fig.2. *Mosaicked DEM and watershed border of Murat-1 watershed*

After the DEM data is transferred to the ArcGIS program, the first thing to do is to remove the errors found in the DEM. When a cell is surrounded by cells with a higher elevation, the water will flow towards the area where is the lower elevation and therefore no surface flow will occur. To eliminate this error, the spaces will be filled and the height values will be rearranged by using the Fill command in the program (Fig. 3).

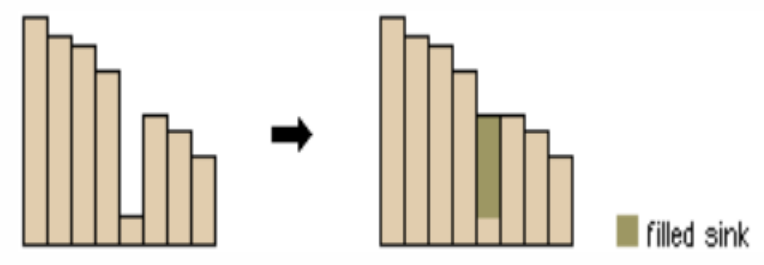

Fig.3. Correction of DEM error [6]

After the errors in the DEM are eliminated, the flow directions should be determined. Algorithms such as D8, Rho8, MFD are available for these operations. The D8 algorithm was used in the determination of the flow directions due to its ease of use and speed. D8 is a one-way algorithm that assumes that the flow in any cell is in the direction of its neighbor with the highest slope and low elevation [7]. Flow on a surface, always occurs from the highest to the lowest elevation. If the flow direction of each cell is known, the total number of cells flowing into any cell can be determined (Fig. 4). Flow direction is calculated for a given grid system with the Flow Direction command in the ArcGIS program.

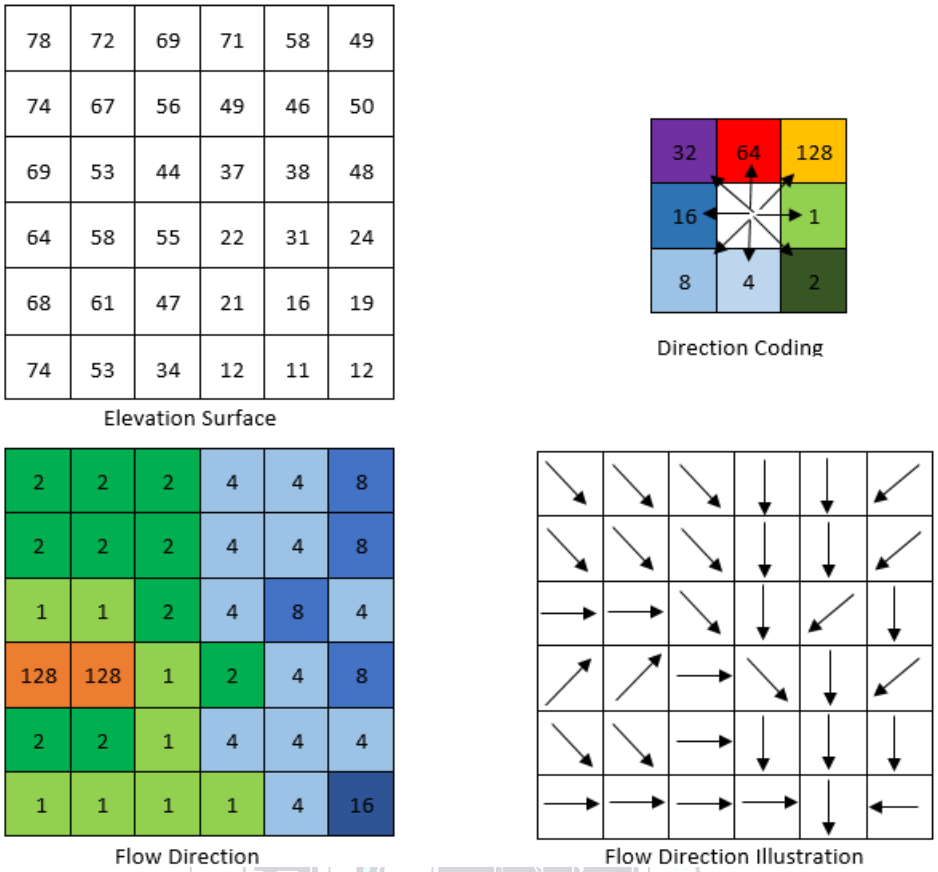

Fig.4. D8 Algorithtm [6]

After determining the flow directions, the Flow Accumulation command determines where the total flow in the cell comes from. After this process, the river branches begin to appear. The flow accumulation is illustrated in the Fig. 5 [6]. In Fig. 6, calculated flow accumulation for the Murat-1 watershed has shown.

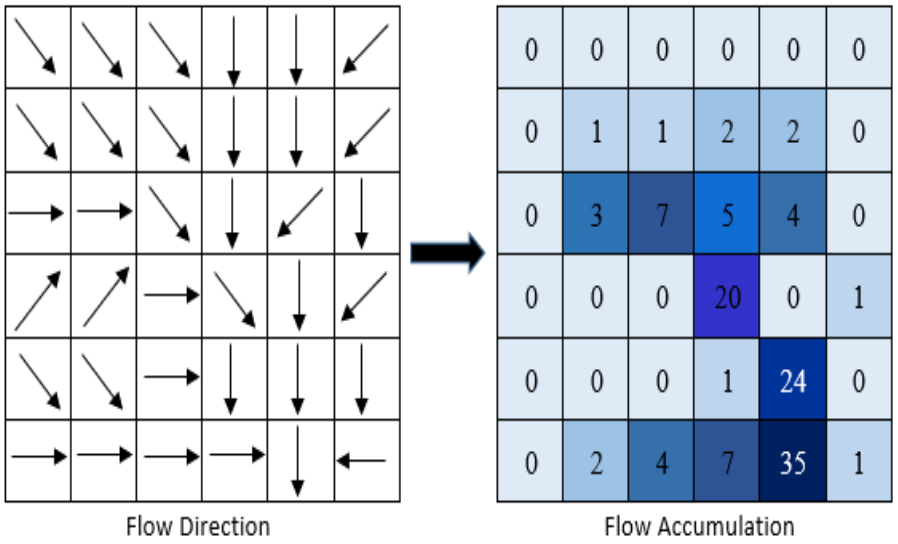

Fig.5. Flow Accumulation

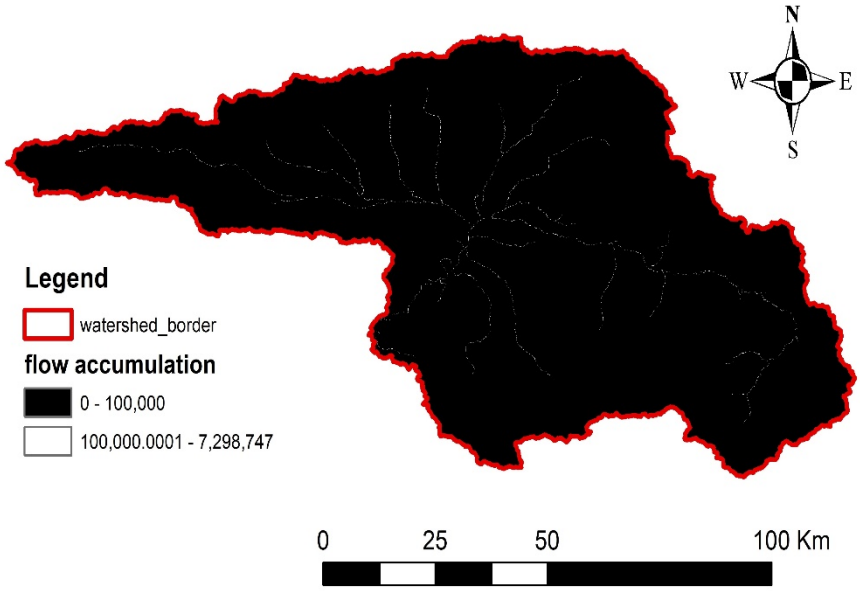

Fig.6. Murat-1 watershed flow accumulation

3. RESULT AND DISCUSSION

After the DEM data is transferred to the ArcGIS program, first of all, the gaps in the grid are filled with the Fill command and cut with the clip command and displayed in a way that represents only the work area. The screenshot obtained from the program is shown in Fig. 7.

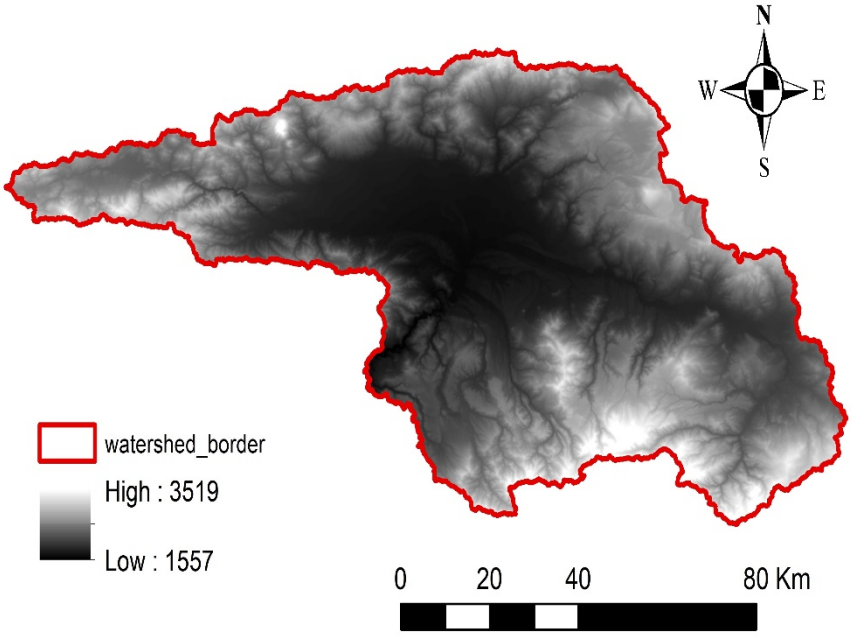

Fig.7. Correction of DEM of Murat-1 watershed

After filling the gaps in each grid, the flow direction is determined by the Flow Direction command. Flow directions map of Murat-1 basin obtained from the program and is given in Fig. 8.

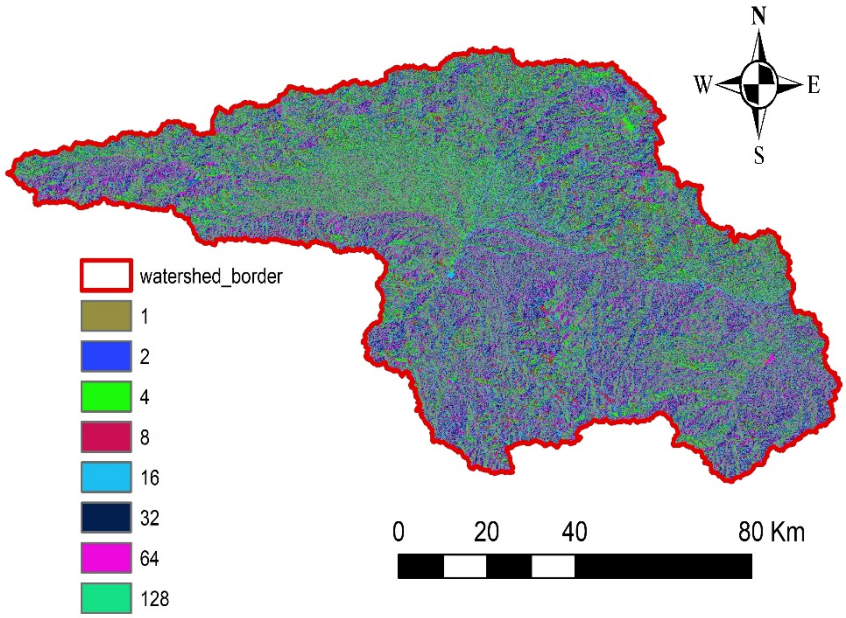

Fig.8. Flow direction of Murat-1 watershed

After the determination of the basin boundaries and the river network, the hillshade map of the region was also created and loaded on the DEM map as a basemap. The final map is shown in Fig. 9.

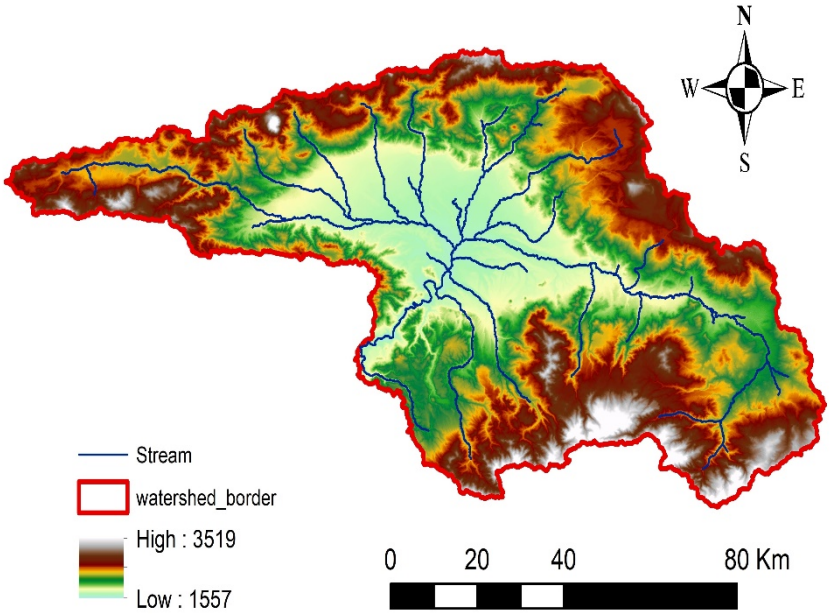

Fig. 9. Murat-1 watershed with defined DEM, watershed borders and river network

After all operations, it is aimed to create a slope and aspect map of the basin. The slope features of the basin are important in understanding the morphological features of the basin in the formation of floods and landslides. In addition, aspect can be explained as the direction in which the mountains in a region receive the Sun's rays or the part of their view towards the Sun. In Fig. 10 and Fig. 11, the slope and aspect distributions of the Murat-1 watershed are shown respectively. The average slope of the basin is found at 10.6 % and the maximum slope is 70.2 %.

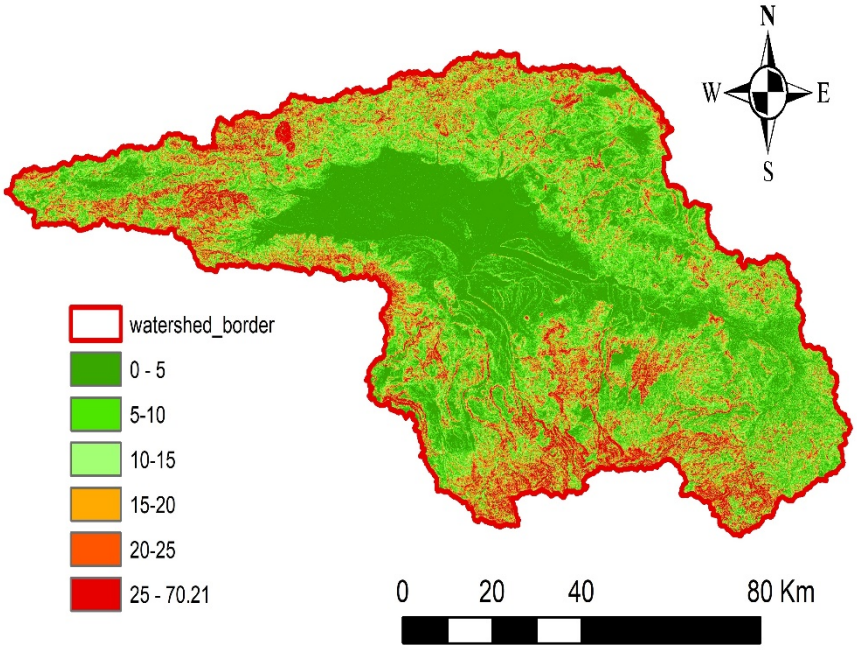

Fig. 10. Slope map of Murat-1 watershed

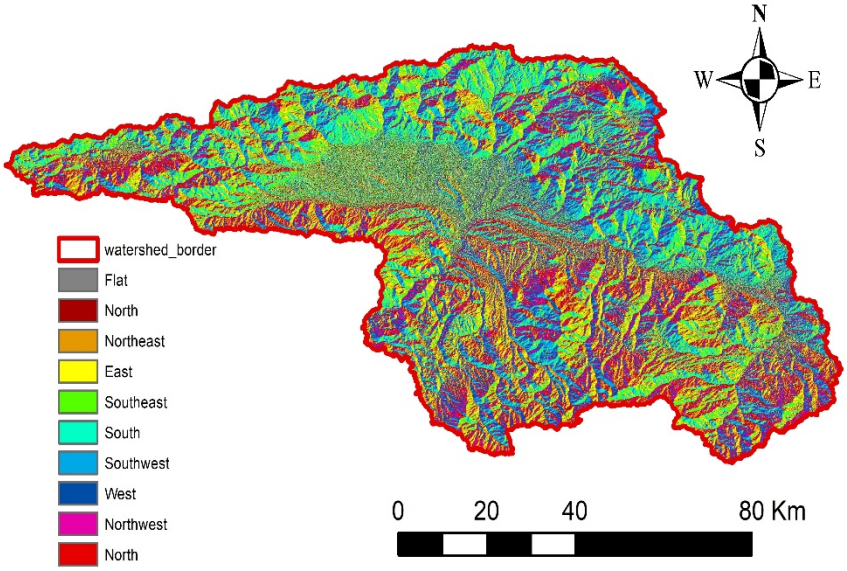

Fig. 11. Aspect map of Murat-1 watershed

4. CONCLUSION

Determination of basin boundaries, features and river drainage networks is a time-consuming and costly process with classical methods. These maps, which were obtained from topographic maps in the past, are obtained more quickly in the GIS environment with the rapid development of computer technology today. These analyzes, created by using the obtained DEM data, give fast and easily accessible results with the help of the programs used.

In this study, stream drainage networks of Murat-1 sub-watershed, which is a part of the Euphrates-Tigris basin, were created using DEM data, the boundaries of the basin were determined, and maps such as slope and aspect distributions of the basin were created. As a result of the study, it has been shown that GIS programs are an important

tool that can be used for data processing, determining watershed boundaries, creating drainage networks and visualizing the physical and morphological features of the watershed.

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.

REFERENCES

[1]. A.A.Karadag, "Kovada Gölü Alt Havza Sınırlarının Belirlenmesi", *Düzce Üniversitesi Ormancılık Dergisi*, 8(1), 58-76, 2012.
[2]. B.T.Meric, "Su Kaynakları Yönetimi ve Türkiye", *Jeoloji Mühendisliği Dergisi*, *28*(1), 27–38, 2004.
[3]. M.C.Bagdatli and B.Ozturk,"Havza morfolojik özelliklerinin belirlenmesinde coğrafi bilgi sistemlerinin (CBS) etkin rolü", *SAU Fen Bilimleri Enstituüsü Dergisi*, *18*(1), 11, 2014.
[4]. A.Uyar, D.Ozturk, " *Kızılırmak Havzası Drenaj Ağının ve Alt Havza Sınırlarının Uzaktan Algılama ve CBS İle Otomatik Çıkarımı", 3*, 362–365, 2018.
[5].T.Dindaroglu, M.Ozgul and M.Y.Canbolat, "Sayısal Yükseklik Modeli Kullanılarak Bazı Havza Karakteristiklerinin Saptanmasi ve Arazi Kullanımı", *KSU Journal of Engineering Science, Special Edition, 197-205*, 2012.
[6]. Esri website [Online]. Available:https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/an-overview-of-thehydrology-tools.htm.
[7]. J.F.O'Callaghan and D.M.Mark, "The extraction of ordered vector drainage networks from elevation data", *Computer Vision,Graphics and Image Processing*, *47*(1), 45–58, 1989.