Determination of the River Basin Boundaries with the Help of GIS in Turkey

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Abstract

The aim of the study is to establish an approach that the basin boundaries can be provided faster than classical methods. Today, the digital elevation model (DEM) can be formed by different methods. One of these methods is the creation of the digital elevation model by remote sensing method. Remote sensing model was used in this study. It is time consuming and challenging to create a digital elevation model using classical methods. Moreover, Turkey to create up to cover a large area digital elevation model, due to the size of the area can cause a lot of mistakes. The created model may not represent the surface correctly. Digital elevation models obtained by remote sensing method have higher accuracy and give more accurate results in analysis. Digital elevation model obtained by remote sensing. In this study, watershed boundaries in Turkey have been identified using the geographic information system. It has been shown that it is much easier and quicker to identify the basin boundaries with this method.

Keywords: *Basin Boundaries, Digital Elevation Model, Turkey, GIS*

1 Introduction

The aim of the study is to establish an approach that the basin boundaries can be provided faster than classical methods. Today, the digital elevation model can be formed by different methods. One of these methods is the creation of the digital elevation model by remote sensing method. Remote sensing model was used in this study. Operation is shorter than the conventional method and has high accuracy rates.

DEM is a model with raster data feature that represents the topographic surface in three dimensions (Yomralıoğlu, 2011). Satellite images, photographs and laser data are used to create DEM by photometric methods. In the classical method, the elevation curves are digitized by the operator and a digital elevation model is obtained from stereo images (Yomralıoğlu, 2011).

Today, the digital elevation model is also obtained through satellites. Many different information about the land can be obtained from the images taken through satellites and this data can be obtained very quickly. This study is used the digital elevation model created by Terra satellite in 2011 (Ok and Türker, 2005).

2 Material

Turkey was chosen as the study area for to show that the basin boundaries can be obtained more quickly and easily. The digital elevation model and computer software used to determine the basin boundaries are mentioned in this section.

2.1 Digital Elevation Model

The digital elevation model (DEM) is a raster data model that represents the topographic terrain surface in three dimensions (Figure 1). DEM can be created by many different methods such as photogrammetry, terrestrial methods and satellite images.

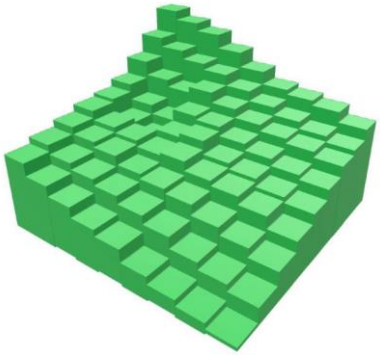


Figure 1. Digital elevation model

The hachures in the topographic maps are digitized by the operator to obtain SYM from stereo images in the classical method (Yomralıoğlu 2000). 1 / 25.000, 1 / 50.000 and 1 / 100.000 scale topographic maps produced by General Directorate of Mapping can be used for this purpose.

DEM is produced using theodolite and levelling instrument in another classical method. Horizontal and vertical positions of many points are determined depending on the polygons whose horizontal and vertical positions are predetermined. DEM is created from these points where the coordinates are known by means of GIS based software. With this method it is possible to produce very detailed DEM (Öztürk, 2016). But in a great area such as Turkey would be challenging and time-consuming to work with this method.

Today, digital elevation model is obtained through satellites. It is possible to have very different information about the land from the images taken via satellite and it is possible to obtain these data very quickly. In this study, the DEM that the Terra Satellite created is used.

2.2 ASTER GDEM Data and ArcGIS Software

Photographs from different angles of a zone are taken with high-resolution infrared cameras in the satellite and DEM is produced with these images. DEM was produced by different satellites for all the terrestrial regions of the World. These DEM's have different resolutions and are created at different times. The ASTER GDEM data generated by the Terra satellite was used in this study. This data was published in 2011 on the website of the United States Geological Survey (USGS) Institute. Researchers can download DEM at a resolution of 30 meters free of charge on this site (Ok and Türker 2005).

There are different software based on GIS that provides analysis on DEM. GeoMedia, NetCAD, ArcGIS, AutoCAD MAP can be given to GIS-based software. ArcGIS 10.5 software was used in this study.

3 Methodology

In the first step of this study, a registration is made in order to download data from the website "www.earthexplorer.usgs.gov" of the United States Geological Survey Institute (USGS). DEM data covering the whole of Turkey is downloaded from this site. Each cell in this DEM data represents the elevation of 30 square meters of land. After obtaining the DEM, basin boundaries were obtain by applying the main process steps of the study shown in Figure 2.

Figure 2. Main Steps of Study

3.1 Improvement of DEM

Small amounts of pits or crests in the DEM can cause errors in analysis. Before any surface information is obtained, the top and bottom errors must be corrected in the DEM. Otherwise, incorrect results are obtained when calculating the flow direction of the water (Öztürk, 2009). İt is shown that a peak pixel value is truncated according to neighboring pixels and that the pit pixel is filled to improve SYM in Figure 3. SYM is a data source used in many analyzes. A more accurate realization of the analyzes is related to the correctness and quality of the SYM. For this reason, the improvement of the SYM by making necessary preliminary actions will increase the accuracy of the analysis results.

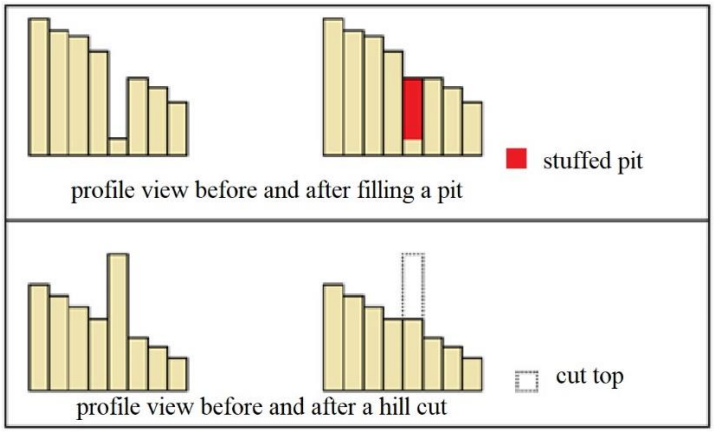


Figure 3. Removal of pit and hill defects (Erdede, 2016).

This work was done using ArcGIS which is a software based on geographical information system. Improvement of DEM by applying the following command in ArcGIS software;

ArcToolbox / Spatial Analyst Tools / Hydrology / Fill,

3.2 Find Flow Direction

The flow direction on a surface is from highest to lowest. The hills on the water flow takes place from the hill to the low places (Öztürk 2009). Flowing water first reaches larger waters and then pours into the sea. By determining the flow direction and flow sum according to these rules, can be obtained stream drainage network and basin boundaries.

The method that ArcGIS software uses to detect water flow aspects was examined and the following results were obtained.

The land is represented by cells of equal size and grid structure in the digital elevation model. The flow can be toward only one of the neighboring cells whose height value is itself low in cells. There are 8 possible directions for flow from each cell to neighboring cells and these directions are indicated as down, up, right, left, up right, down right, up left, and down left. Figure 4. shows possible flow directions from cell x and values representing flow direction in ArcGIS software according to these flow directions.

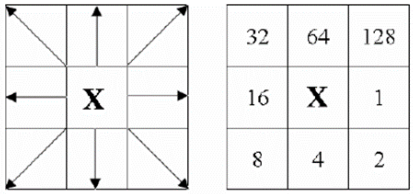


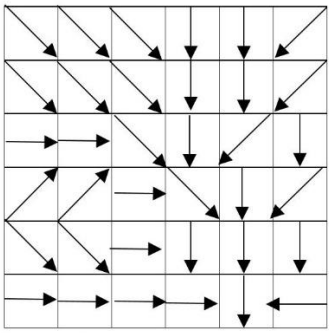
Figure 4. Flow Direction and Representation in ArcGIS Software (Aslan Akkaya, 2004).

The cell with the lowest height around each cell is selected to determine the flow direction and mark this cell in the direction of the selected cell. How many different cells have water flow to any cell is calculated from the flow direction table. Figure 5. shows the calculation of flow directions in ArcGIS software. Flow direction is find by applying the following command in ArcGIS software;

ArcToolbox > Spatial Analyst Tools > Hydrology > Flow Direction

68	62	59	61	48	39
64	57	46	39	36	40
59	43	34	27	26	38
54	48	45	12	21	14
58	51	37	11	16	9
64	43	24	8	6	7

A - **DEM**



B – **Water Flow Directions**

2	2	2	4	4	8
2	2	2	4	4	8
1	1	2	4	8	4
128	128	1	2	4	8
2	2	1	4	4	4
1	1	1	1	4	16

C – **Representation of directions in ArcGIS Software**

Figure 5. Shows the Calculation of Flow Directions

3.3 Determination of the River Basin Boundaries

The command to apply in ArcGIS software to determine river basin boundaries after healing DEM and finding the flow direction;

ArcToolbox > Spatial Analyst Tools > Hydrology > Basin.

The basin boundaries are reached when the process steps mentioned are applied on the DEM. All operations applied to find the basin boundaries from the digital elevation model are as follows (Aslan Akkaya, 2004).

- Improvement of DEM
- Find Flow Direction
- Determination of the River Basin Boundaries

4 Discussion

Process steps outlined in the methods section to find the watershed boundaries were applied in Turkey. But the used ArcGIS software gave an error in the "Basin" command. Due to the analysis carried out in a large area covering Turkey, it is understood that the computer's processing power (CPU) is insufficient in the "Basin" command. The number of cells to be processed by the computer has been reduced in order to eliminate this error caused by insufficient power of the computer.

One side of the cells in the existing digital elevation model is 30 meters long. In other words, 30 meters * 30 meters = 900 m^2 area on the ground represents a cell in software. First, cells with a side length of 60 meters were created to reduce the number of cells present. For this, a cell with one side of 30 meters was taken with the average of the surrounding cells. As a result, the size of the cells forming the DEM is increased to 2 times and the number of cells is reduced. The process steps summarized in the methods for finding basin boundaries were reapplied on the reconstructed digital elevation model. But again a “Basin” error was encountered.

It is decided to enlarge the cells 3 times upon this error. The size of the cells is increased to 3 times and cells of size 90 m * 90 m are formed (Figure 6.). When the process steps summarized in the methods section are repeated on the last organized DEM, the boundaries of the basin are determined this time. As a result, the map of the basin boundary in figure 7. was obtained.

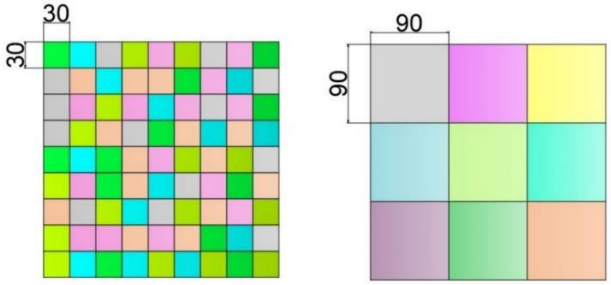


Figure 6. Decreasing the number of cells in ArcGIS software

Figure 7. Obtained basin boundaries

This map was compared with the basin boundary maps of state water works. This comparison is shown in figure 8. As a result of the comparison, it is seen that the boundaries of the basin do not completely coincide with each other.

It is seen that comparing the borders of DSİ with the limits determined by software are different around Antalya, Burdur, Isparta and Van Lake. Additionally, it is observed that the boundaries between Konya and Kızılırmak Basin and between Seyhan and Ceyhan Basin cannot be determined.

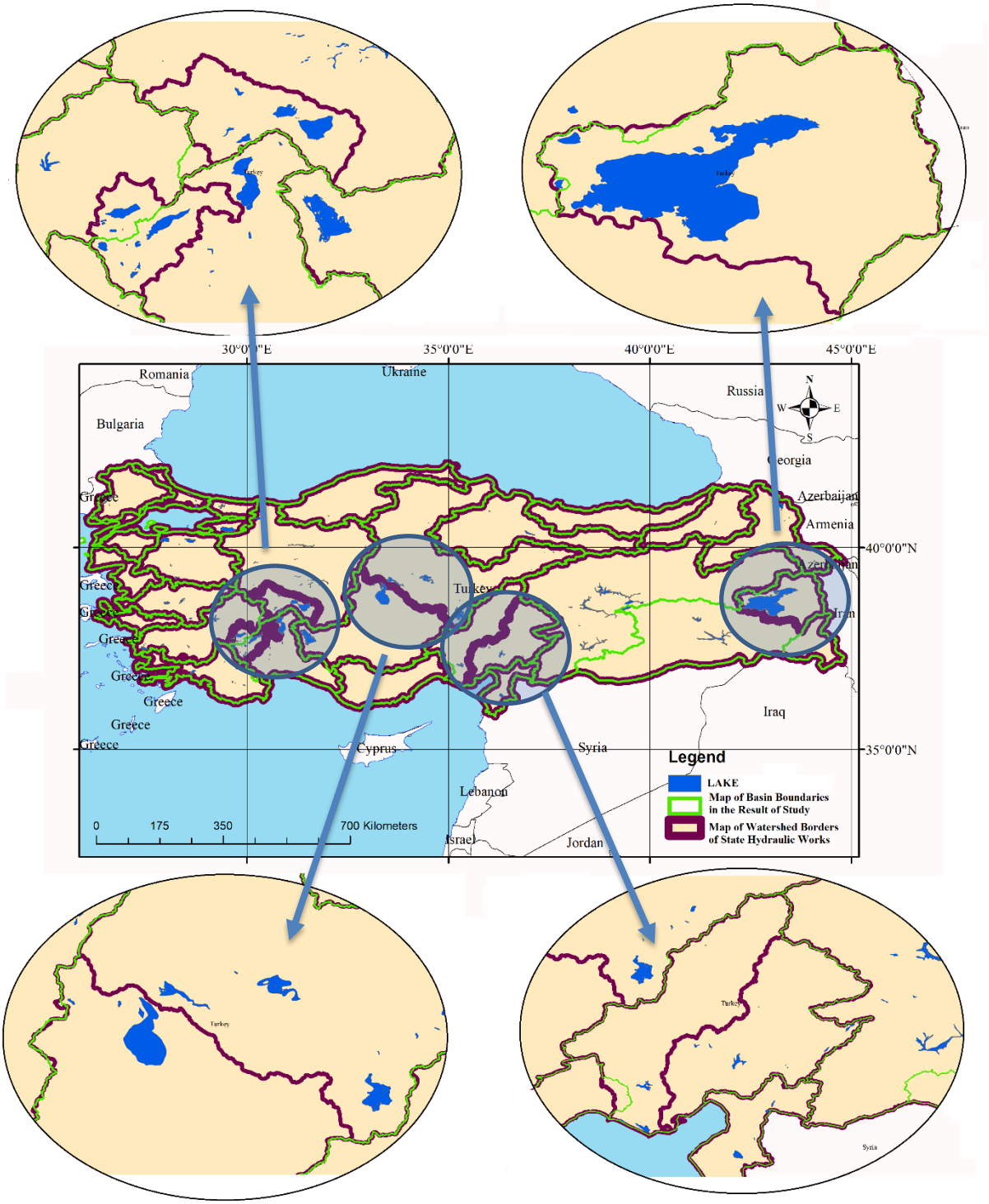


Figure 8. Comparison of Watershed Boundaries Map-I

The basin boundaries around the lakes are examined in detail because the errors that occur are generally around lakes. Streamlines detected in ArcGIS software are endings in lakes or seas. But lakes are not defined in software. Places where the lakes are located appear as flat land in software. The Streamlines on the lakes end, but since the lakes are considered as flat terrain, the streamlines do not end. It is observed that the streamlines that does not end in the lakes is mixed with the neighboring river basins. Because of this, it is understood that some basin boundaries around the lakes cannot be detected.

All lakes in Turkey were removed from the digital elevation model for the correct detection of basin boundaries. When the process steps summarized in the methods section are repeated on the last organized DEM, the boundaries of the basin are correctly determined this time.

Map of Watershed Borders of State Hydraulic Works and map of watershed boundaries obtained in this study are compared in figure 9. It is observed that this comparison is accurate over 90% of the basin boundary map obtained.

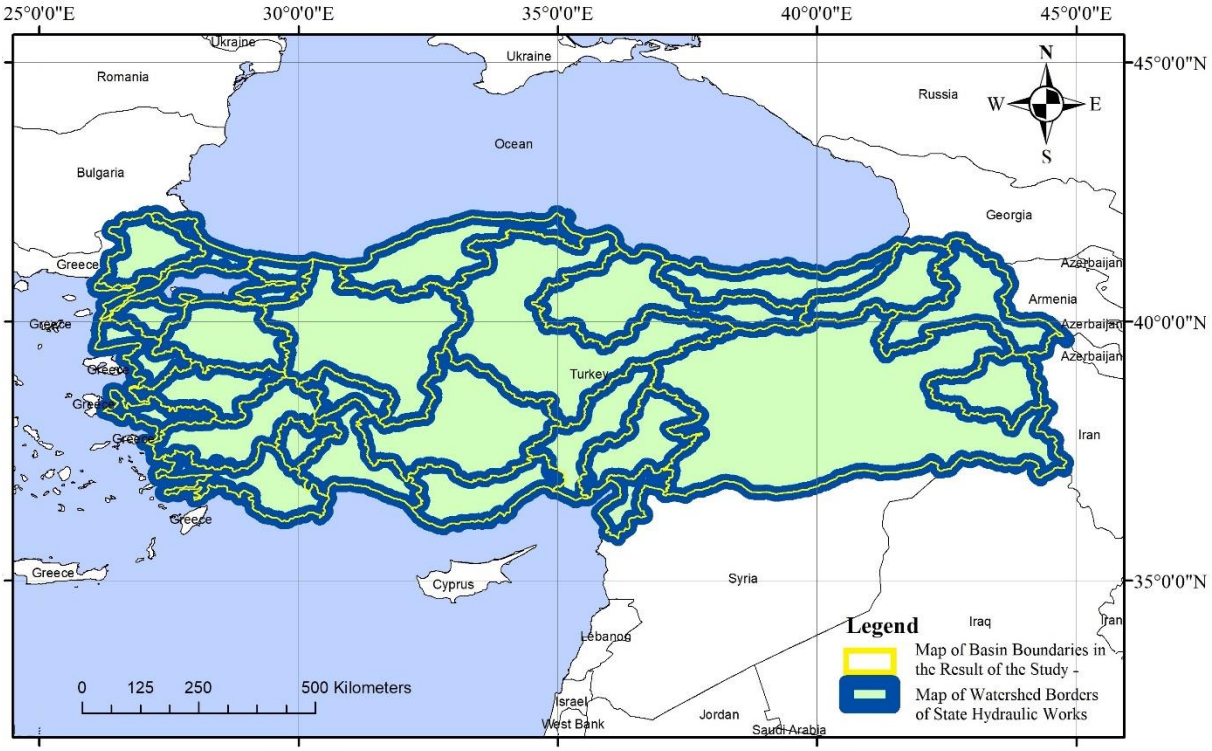


Figure 9. Comparison of Watershed Boundaries Map

5 Conclusions

It is time consuming and challenging to create a digital elevation model using classical methods. Moreover, Turkey to create up to cover a large area digital elevation model, due to the size of the area can cause a lot of mistakes. The created model may not represent the surface correctly.

Digital elevation models obtained by remote sensing method have higher accuracy and give more accurate results in analysis. Digital elevation model obtained by remote sensing In this study, watershed boundaries in Turkey have been identified using the geographic information system. It has been shown that it is much easier and quicker to identify the basin boundaries with this method.

The method used to determine basin boundaries is a known method. However, there is no existing work on the problems encountered when using this method. In this study, information about errors caused by digital height data and ArcGIS software was given.

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