HASAN KALYONCU UNIVERSITY
GRADUATE SCHOOL OF
NATURAL & APPLIED SCIENCES

HYDROLOGICAL MODELING OF GÖKSU (NURHAK-KAHRAMANMARAŞ) RIVER BASIN BY GIS IN ORDER TO SUPPLY WATER TO GAZİANTEP PROVINCE

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IN
CIVIL ENGINEERING

BY
HÜSEYİN ÇAĞAN KILINÇ
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Hydrological modeling of Göksu (Nurhak-Kahramanmaraş) river basin by GIS in order to supply water to Gaziantep province

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Supervisor
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KILINÇ HÜSEYİN ÇAĞAN

ABSTRACT

HYDROLOGICAL MODELING OF GÖKSU (NURHAK-KAHRAMANMARAŞ) RIVER BASIN BY GIS IN ORDER TO SUPPLY WATER TO GAZİANTEP PROVINCE

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Population projections are significant for managing and planning the research area. This study aims to examine the water need and water consumption of Gaziantep province. In order to determine the future population of Gaziantep city; arithmetic method, geometric method, İlbank method and regression analysis were utilized in the calculations. The optimum trend (increase) line and minimum error (R^2) was seen in exponential regression analysis. Düzbağ Dam which is considered to supply drinking water to Gaziantep is not sufficient after then 2044 and in order to supply water to the city it is estimated that there will be need for new water resources. Therefore, In Gaziantep province, The State Hydraulic Works (DSİ), Gaziantep Water and Sewerage Administration (GASKİ) and other state coorporation should take required precautions. Also the rainfall map was generated by ArcGIS program for whole meteorological stations located in Turkey. Comparing the IDW and Kriging methods the results showed that the best model to generate rain properties map was Ordinary Kriging with spherical and models. In this study GIS-linked interface was created. With this new model users can be delineated the watershed with one step. This model can be used in Python scripting and other models. When on-site measurements are considered, it will be easier to delineate the basin in areas by ArcGIS, where the topographic conditions are difficult.

Keywords: Inverse distance weighted, Ordinary kriging, ArcGIS model, GIS, Watershed.

ÖZET

GAZİANTEP İLİ SU İHTİYACININ KARŞILANMASI AMACIYLA GÖKSU (NURHAK-KAHRAMANMARAŞ) HAVZASININ CBS İLE HİDROLOJİK MODELLENMESİ

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Nüfus projeksiyonları, araştırma alanını yönetmek ve planlamak için önemlidir. Bu çalışma, Gaziantep ilinin su ihtiyacını ve su tüketimini incelemeyi amaçlamaktadır. Gaziantep'in gelecekteki nüfusunu belirlemek için; hesaplamalarda aritmetik yöntem, geometrik yöntem, İlbank yöntemi ve regresyon analizi kullanıldı. Üssel regresyon analizinde optimum eğilim (artış) çizgisi ve minimum hata (R^2) görüldü. Gaziantep iline içme suyu sağlayacak olan Düzbağ Barajı, 2044 yılından sonra yeterli değildir ve şehre su sağlamak için yeni su kaynaklarına ihtiyaç duyulacağı tahmin edilmektedir. Bu nedenle Gaziantep ilinde, Devlet Su İşleri (DSİ), Gaziantep Su ve Kanalizasyon İdaresi (GASKİ) ve diğer kamu kuruluşları gerekli önlemleri almalıdır. Ayrıca yağış haritaları, Türkiye'de bulunan tüm meteoroloji istasyonları için ArcGIS programı ile oluşturulmuştur. IDW ve Kriging yöntemlerini karşılaştıran sonuçlar, yağmurluk özellik haritası oluşturmak için en iyi modelin küresel ve modellerle Olağan Krig olduğunu göstermiştir. Bu çalışmada coğrafi bilgi sistemleri bağlantılı arayüz oluşturuldu. Bu yeni model ile kullanıcılar tek bir adım ile havza tanımlayabilir. Bu model Python komut dosyası ve diğer modellerde kullanılabilir. Yerinde ölçümler düşünüldüğünde, topografik koşulların zor olduğu alanlarda ArcGIS ile havzayı tanımlamak daha kolay olacaktır.

Anahtar Kelimeler: Coğrafi bilgi sistemleri, Havza, Modelleme, Ters mesafe ağırlık yöntemi, Kriging yöntemi.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS/ABBREVIATIONS

A	Catchment area (m^2)
D8	Eight direction flow model
DEM	Digital elevation model
C	Runoff coefficient
FMS	Flow measurement stations
GIS	Geographic information system
i	Rainfall depth – Average areal rainffal (mm)
Ø	one for cardinal neighbors cell, $\sqrt{2}$ for diagonal neighbors
cell k	Runoff coefficient at gauged site
mm	mean annual precipitation at gauged site (mm)
Q	discharge (m^3/s)

CHAPTER 1

INTRODUCTION

1.1. General Overview

Water, the common symbol for humanity, valued and respected in all religions and cultures, 9 billion by 2050. Consequently, as increasing in world population, also demands for water (fresh water) have also increased rapidly (UNESCO, 2000). It is a vital source for the continuation of the nations. The persistence of social and economic activities mostly depends on having clean and adequate water supply. Fresh water is emerging as the most critical resource issue facing humanity (Abramovitz, 1996). The amount of available fresh water is less than 1% of the total volume of water on the earth and it is unevenly distributed in time and space. While 70 percent of the earth's surface is water, only three percent of it is fresh water—and almost all of that three percent is inaccessible for human use (Hinrichsen, 1998; Lefort, 1996). About three-quarters of all fresh water on earth are locked away in the form of ice caps and glaciers located in polar areas far from most human habitation. In all, only about 0.01 percent of the world's total water supply is considered available for human use on a regular basis. In Turkey, southeastern region of Anatolia will be one of the regions that will need water in the future, if not now. This is because the water resources are polluted by increasing industrialization and urbanization shows that the region will have a water crisis in the future. Considering this, the city of Gaziantep in southeastern region of Anatolia that grows rapidly in terms of industrialization and urbanization is one of the places that will feel the danger of water shortage in the future (Istanbulluoglu et al., 2007). In Gaziantep, need for drinking and household water increases day by day in parallel with the increasing population, civic improvement and development in the area of industry. In addition to the available household and drinking water resources, more water reserves are needed. Local water usage is a multiplex element of social and physical characteristics, urban planning strategies, ground works and public water policies (Panagopoulos et al., 2012). Drinking and household water is a growing problem especially in Gaziantep. The lack of water management plans in Gaziantep may lead to increased problems of drinking water drought. Many cities of the southeast of the Turkey are already facing serious issues concerning water efficiency and cover of their drinking demands with water transportation from other areas (Metz et al., 2007). Estimation and management of water resources are really important because of the limited amount of fresh water in the world. The water management is necessary when predicting the present and future local water demands. Furthermore, urban water demands and the construction of the water supply and distribution system are necessary in development planning of city (Cihakova, 2006). Poorly managed water resources can cause water scarcity and water crisis which may lead to regional social and economic crisis. Water resources management can be also define as closely relationship between river basin management and water resources planning. The key to effective management of water resources is an understanding of the inextricable link between the hydrological cycle and the way land resources are managed (Bach et al., 2011). For the river management vital priority can be define as watershed management. An essential requisite for water management is factual assessment of land soil and ecological regimen of the area (Murthy, 2000). The watershed based management should include planning and conserving the available resources. Watershed is a naturally delineated unit of land that drains water, sediment, dissolved materials, heat, and biota to a common outlet along a stream channel.

It can also be explained as a delineated area from which the runoff drains through a common point in the drainage system (Murthy, 2000). Importance of water is increasing due to the high population growth and global warming in the World as well in Turkey. Therefore, basin and river management systems including hydrological modeling has become a very important issue in Turkey (Günal, 2015). Mathematical models are widely used in the engineering problems to reflect what is in reality and give solutions by using advanced computer technology. Because of this, modeling is the most powerful tool while solving engineering problems. Hydrological models give more realistic solutions due to the latest development in technology. They are very beneficial, however in reality most of them have many parameters and those parameters must be adjusted for good simulation (Günal, 2015). With gradual availability of any data and increased computer (software) power, most of the recent hydrological analyses make use of GIS (Geographic Information System) as the main methodological approach to analysis for developing accurate solutions (Kaptan, 2008). Also there is a strong emphasis on using GIS in basin, catchment analysis.

This is done to reduce cost, time and errors and GIS is effective in producing hydrological response zone (Watson et al., 1999).

The environmental systems research institute (ESRI) has created an opportunity to re-think the way that water resources data was represented in GIS. A GIS is a computer-based system that provides the data capture and preparation, data management including storage and maintenance, data manipulating and analysis, data presentation (Huisman and De by, 2009). The result is Arc Hydro, an ArcGIS data model for water resources. ArcGIS (formerly known as ArcView), which allows one to view spatial data, create layered maps, and perform basic spatial analysis; Arc Hydro is an ArcGIS-based system geared to support water resources applications. ESRI explained that Arc Hydro is a set of data models and tools that operates within ArcGIS to support geospatial and temporal data analyses. Arc Hydro has terrain preprocessing, terrain morphology, watershed processing, attribute tools, and network tools for both vector and raster processing (Strager et al., 2010). Arc Hydro, an extension for the ArcGIS Desktop developed by the University of Texas (Maidment, 2002) based on the maximum gradient method, D8 algorithm, proposed by O´Callaghan and Mark (1984) CUENCAS which extracts the drainage structure from a DEM using algorithms which is centered on a D8 algorithm (Ariza-Villaverde et al., 2013).

Geographical Information Systems have been traditionally used to accomplish the management functionalities in hydrologic applications (Brasington and Richards, 2007; Guertin et al., 2000). GIS techniques have proven to be powerful tools for watershed prioritization, sustainable development and management of land resources. Geographic Information Systems has made it possible to determine the boundaries easily and practically with the help of the processing power of computers and Digital Elevation Models (DEM). Drawing the basin boundaries quickly and automatically with the GIS applications is more advantageous than manual. In addition, placing a variety of data distribution on the drawing and repeating the basin drawing is much easier. Both times earnings, while the risk of error is reduced (Tribe, 1992). The benefits associated with the use of GIS in the watershed and hydrologic analysis include the improved accuracy, less duplication, easier map storage, more flexibility, ease in data sharing, timeliness, greater efficiency and higher product complexity (Downer and Ogden, 2004).Watershed analysis refers to the process of using Digital Elevation Models (DEM) and raster operations to delineate drainage area and to derive topographic features such as stream networks (Kang, 2008).

Digital Elevation Model is a continuous surface of the elevation from which terrain attributes (slope, aspect, curvature, topographic index, drainage area and network) are extracted (Mukherjee et al., 2013). Raster digital elevation models that represent continuous terrain elevations above a common base level are widely used in automated hydro logical analyses as well as in the extraction of watershed characteristics such as channel networks, hill slope flow length, sub catchments, soil erosion, and flood simulation (Zhang et al., 2013; Gomes et al., 2015). The accurate and efficient extraction of flow direction for flats in DEMs remains challenging despite the significant advances that have been reported in flow-routing algorithms (Costa-Cabral and Burges, 1994). Compared to traditional terrestrial analysis methods, the digital elevation models generated from high resolution satellite imagery offer the essential information in a rapid, accurate and reliable mode. A digital elevation model is convenient for representing the continuously varying topographic surface of the Earth, and it is a common data source for terrain analysis and other spatial applications. The utility of the DEM is evidenced by the widespread availability of digital topographic data and by the ever-increasing list of uses for and products from DEM. Common terrain attributes that are readily computed from a DEM include slope gradient, slope aspect, slope curvature, upslope length, specific catchment area upslope contributing area divided by the grid cell size, and the compound topographic, index, CTI (a hydrological based index that is related to zones of surface saturation) (Moore et al., 1993).

1.2. Aim of the Study

In this study Göksu river basin hydrological analysis was examined. The main objective of this study is to determine the hydrologic characteristics of Göksu river basin and estimate the reservoir capacity of the Düzbağ dam, considered to supply water to Gaziantep province, located in Göksu river basin. On the other hand, new hydrological interface was generated. In this study a new mathematical model was developed by using ArcGIS code system for calculation any reservoir capacity. ArcGIS V.10.4 and ArcHydro 10.4 were developed and sold by Environmental Systems Research Institute, Inc. (ESRI) were used in this study for finding the hydrologic parameters of the Göksu basin. Data layers for all of the Göksu River Basin were acquired. These layers include basin boundaries, the length of the main river, digital elevation models (DEMs), digital raster graphic maps, basin slope map, stream network, flow measurements stations, meteorological stations and Thiessen polygon area map around the basin. The main characteristics of the basin, like the area, shape, elevation, slope, orientation, soil type, channel networks, water reservoir capacity and land cover of the region was derived by using ArcGIS software. For determining the parameters, it is necessary to utilize DEM data in calculations for the corresponding basin. In Turkey, suitability of the data to determine the hydrologic characteristic of a basin and other necessary steps is not easy to find, therefore DEMs are taken from USGS (United States Geological Survey). DEMs are taken in format of ASTER and STRM of 30m x 30m resolutions.

1.3. Structure of the Thesis

Chapter 1-Introduction: Chapter 1 is a brief introduction to the research subject and the identification of the general scope and specific objectives are given in this chapter. General overview, aim, and structure of the thesis were introduced.

Chapter 2-Literature review: This chapter is a literature survey which is related on previous studies on GIS and other Hydrologic modeling according to examine basin characteristic and estimation of reservoir capacity in River Basin, watershed delineation and previous studies on Digital elevation model (DEM), Hydrologic conditioning digital elevation model.

Chapter 3-Study area: Chapter 3, general the background of the study area about the Geography, climate, meteorology, water quality, geology characteristics and water resource management of the Göksu river basin

Chapter 4-Methodology: Chapter 4 illustrates the broad scope of the necessary process and analyses that can be accomplished with ArcGIS tools

Chapter 5-Results and discussion: This chapter discusses the results obtained from processing and hydrological analysis of the study area.

Chapter 6-Conclusions: General conclusions are explained regarding the overall results

CHAPTER 2

LITERATURE REVIEW

2.1. Hydrology

Before modeling it is vitally important understanding hydrology. Hydrology is multi-disciplinary research field that arises to investigate and manage water in different forms at different positions near or on the land surface. This definition is widely held by Miller (1977), Viessman et al. (1989), Salih and Hamid (2017) and Maidment (1993). The term hydrology can be treated as an important subject for the people and their environment. It treats water of the earth, their occurrence, circulation and distribution, their chemical and physical properties and their reaction with the environment including their relation to living things (Ray 1975). It also deals with the relationship of water with the environment within each phase of hydrologic cycle (Devi et al., 2015). The hydrologic cycle is the continuous movement of water throughout the various components of the Earth’s climate system. Water is stored in the oceans, in the atmosphere, as well as on and under the land surface. The transport of water between these reservoirs in various phases plays a key role in the Earth’s climate. Water evaporates from the oceans and the land surface into the atmosphere, where it is advocated across the face of the Earth in the form of water vapor. Eventually, this water vapor condenses within clouds and precipitates in the forms of rain, snow, sleet, or hail back to the Earth’s surface. This precipitation can fall on open bodies of water, be intercepted and transpired by vegetation, and become surface runoff and/or recharge groundwater.

Water that infiltrates into the ground surface can percolate into deeper zones to become a part of groundwater storage to eventually reappear as stream- flow or become mixed with saline groundwater in coastal zones. In this final step, water re-enters the ocean from which it will eventually evaporate again, completing the hydrologic cycle (Pagano, 2002). Many hydrologists investigated hydrologic cycle by a number of studies. A summary of the cycle is given by Chow et al. (1988) or detail description of some processes can be found in the book of Kirby (1978).

2.2 Hydrological Models

Hydrological models are simplified, conceptual, mathematical representatives of hydrologic processes to simulate water balance and cycle (Moradkhani and Sorooshian, 2009; Wu and Chen, 2015). The hydrological modeling is quite important to forecast the water events in the future. Hydrological modeling and water resources management are related to each other. Generally speaking, hydrological research and modeling are interrelated. Most hydrological research concentrates on a modeling approach. The reasons are for a simplified, representative and logical presentation of a hydrological system. As well, most hydrological modeling endeavor depends mainly on the knowledge drawn from available measurements and experimental results. Hydrological models are often referred to as ‘‘hydrological system” (Raudkivi, 1979). Models of hydrological systems may be designed to explain and represent the behavior and relationships between the input and output of the system (Osman, 1996). In the past, a number of lumped hydrological models have been developed (Crawford and Lindsey, 1963; Sittner et al., 1969). Parameters of such models do not have a direct physical meaning and cannot be derived with ease from the measured properties of the watershed.

Now days, various hydrological models have been developed across the world to examine the river management and water resources. Each model has got its own unique characteristics. The inputs used by different models are rainfall, air temperature, soil characteristics, topography, vegetation, hydrogeology and other physical parameters. All these models can be applied in very complex and large basins (Devi et al., 2015; Neitsch et al., 2005).

According to Sorooshian et al. (2008), a model is a simplified representation of real world system. The best model is the one which give results close to reality with the use of least parameters and model complexity. Models are mainly used for predicting system behavior and understanding various hydrological processes. A model consists of various parameters that define the characteristics of the model. Sorooshian and Gupta, (1995) defined hydrological models as by state or prognostic variables which define the dynamics of a system, and also parameters as quantities characterizing the system. Hydrological models can be parametric (e.g., statistical regression techniques), analytical (systems analysis) or mathematical (physical analysis). Further, these models can be either stochastic conceptual, stochastic empirical, deterministic conceptual or deterministic empirical. The models can be systematically stored as linear or non-linear models, or spatially classified as lumped models or distributed (probability or physical) models (Harvey, 1969, Raudkivi, 1979 and Osman 1996, Li et al., 2017).

Systematic models are mostly data-driven black-box models that rely heavily on observation results at a specific site (Shang and Mao, 2014). Conceptual models are generally based on the theory of water balance and are commonly used in lumped hydrological models (Xu and Singh, 1998), (Figure 2.1).

Process-based mechanism models are based on more detailed description of the hydrodynamic processes that require solving non-linear partial differential equations numerically, and are commonly used for distributed hydrological models.

Lumped hydrological models take the advantage that regarding the research area as one unit and using the typical parameters to present the whole region, without considering the spatial variation of the parameters (Lu et al., 2008).

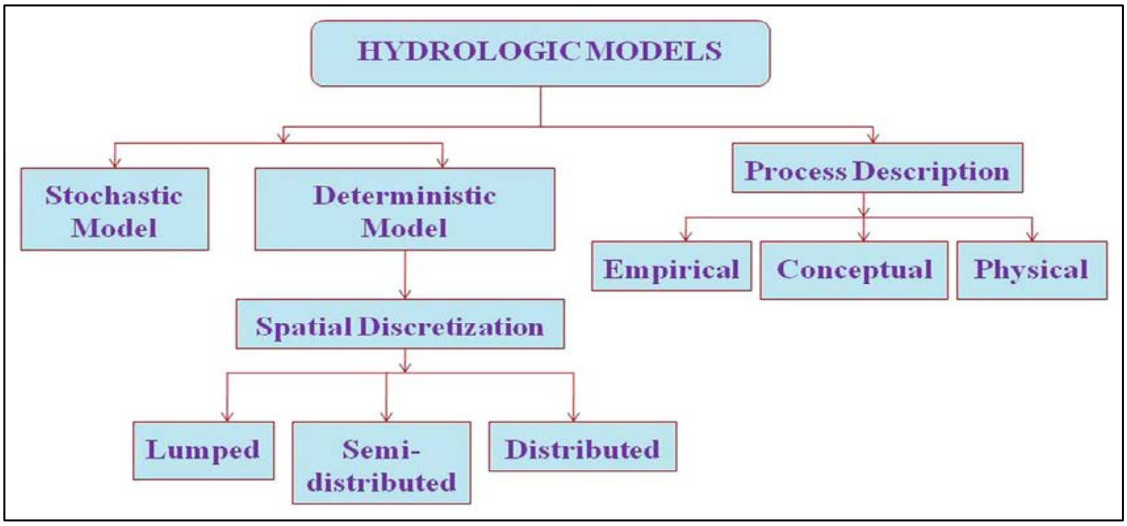


Figure 2.1 Hydrological models types

2.3. Overview of Geographic Information System

Stevovic and Nestorovic (2016) defined GIS as development of different technologies for mass geographical data collection (aerial photogrammetry, LiDAR and satellite techniques) as well as development of information and communication technologies, which allows efficient access and management of that information, introduced the term “GIS” in science and practice. GIS is a computer based information system used to digitally represent and analyses the geographic features present on the surface of the Earth and the non-spatial attributes linked to the geography under investigation.

Sánchez-Lozano and Bernal-Cones (2017) noted great advantages of GIS. According to them GIS make the task of locating and selecting the priority areas considerably easier. In order to relate methods see Fotheringham and Rogerson, (1994), Stillwell and Clarke, (2004), Kemp, (2008). Also Jeorinet et al., (2001), Chang et al., (2008), Sadeghi-Niaraki et al., (2011), Coutinho-Rodriguez et al., (2011) and Chow and Sadler, (2010) mentioned that GIS is a computer system used for analysis, consulting, developing, manipulating, storing, or in short, for handling geographic information. The reason of using GIS technology in hydrological models is because it allows the spatial information to be displaced in integrative ways that are readily comprehensible and visual. Nowadays the applicability of GIS can be found in many fields of study mainly the town planners, engineers, architects and scientists use GIS for measuring, mapping, monitoring and modeling environmental features and process such as studies on environmental impact or protection, emergency management, transportation planning, physical planning, land use planning or zoning, non-point source pollutants, monitoring hazardous waste sites etc. Thus, GIS is continuous process of data acquisition, pre-processing, data management, manipulation and analysis and product generation (Star and Estes, 1990; Congalton and Green 1995; Sivertun 1993). On the other hand GIS has some disadvantages when applied to necessary area. GIS is a very expensive, by the way geographic information system requires enormous amount of date makes it prone for error. Geographical error increases by using larger scale area and relative loss of resolution (Coyle, 2011).

Computer-based GIS have been used since at least the late 1960s. Their manual predecessors were in use about 100 years earlier. Tomlinson (1988) was involved in creating possibly the first true GIS and certainly the first to be so entitled. Tomlinson can be thought of as the father of GIS through his role in persuading Canadian government that the creation of the Canada Geographic Information System (or CGIS, as it became known) in 1966 was a worthwhile investment (Coppock and Rhind, 2003). The main aim of CGIS was to analyze Canadian land inventory data and to find marginal lands. Therefore, the first GIS application was developed to deal with environmental problems. Apart from this several institutes were interested in Geographic Information System for modeling. Environmental System Research Institute is one of the institute using GIS. ArcGIS, Arc Map, IDRISI are some of the software that using and developing from ESRI.

2.4. Applications of GIS in Water Resources Management

The recent explosion of computer technology has not only made it possible, but also easier to develop computer applications to address the problem of storing, manipulating and analyzing large volumes of spatial data related to water resources problems (Tsihrintzis et al., 1996). Prior to performing actual simulation, water resources modeling requires a number of time consuming steps, including collection, compilation, storage, retrieval and manipulation of spatial data. The spatial nature of data associated with water resources is the single most significant factor contributing to the complexity of data management. With their ability to combine a variety of data into an easily understood format, GIS software can drastically change the way engineers handle water resources modeling (Denning, 1993; Jeton and Smith, 1993; Tsihrintzis et al. 1996). GIS emerged as a considerable support tool for hydrologic modeling, during the 1990s. Hydrological models are important aid for water resources analysis, and hence its integration with GIS is extremely valued (Kherde and Sawant, 2013). River basin studies may cover a portion of a country or it may include several countries or jurisdictions. Modeling at the scale of an entire river basin requires large input databases. Therefore, a Geographical Information System is a very useful environment to model because of its advantages of data storage, display and maintenance. Thus, linking or integrating models with a GIS provides an ideal environment for modeling processes in a landscape (De Roo et al., 1989; Burrough and McDonnell, 1998; De Roo, 1998). Estimation of volume and water surface area of reservoir in GIS is essential to know the amount of potentially available water, storage location and storage capacity in region. By applying GIS approach, a large area can be precisely surveyed within a short period of time (İrvem and Taşkın, 2014). GIS applications are presented including surface hydrologic and groundwater modeling, water supply and sewer system modeling, stormwater and nonpoint source pollution modeling for urban and agricultural areas, and other related applications (Tsihrintzis et al. 1996). Other important parameter for access of the clear water is, getting water at the right palace under the conditions of economics, sufficient water capacity etc. ‘Reservoir location and capacity analysis using GIS’ by İrvem and Taşkın (2014) is examplary on GIS method that explained to identify hydrological characteristics of watersheds such as stream network. (Sattari et al., 2008) used GIS to determine reservoir capacity. (Moore et al., 1991) reported that widespread use of digital elevation map depending on developments in GIS technology accelerated hydrological and environmental research studies. The storage capacity was established for one or more different dam height and can be calculated by using the spatial information analysis on GIS. In particular, GIS offered a reliable method for delineation of watershed and stream network. There are numerous applications of GIS in a river basin surveys and water resources management. Singh et al. (2014) studied Hydrological inferences from watershed analysis for water resource management using remote sensing and GIS techniques. Hydrological module of ArcGIS software was utilized in their studies for calculation and delineation of the watershed and morphometric analysis of the watershed using SRTM DEM. The stream order of watershed ranges from first to sixth. It is a sign of the homogeneity in texture and lack of structural control of the watershed. The basin found elongated shaped. Also study reveals that SRTM DEM based hydrological evaluation at watershed scale is more applied and precise compared to other available techniques.

Ghoraba (2015) studied the hydrology of Simly Dam watershed located in Saon River basin at the north-east of Islamabad. Study was aimed to simulate the stream flow, establish the water balance and estimate the monthly volume inflow to Simly Dam in order to help the managers to plan and handle this important reservoir. The Arc SWAT interface implemented in the ArcGIS software was used to delineate the study area and its sub-components, combine the data layers and edit the model database. The model was calibrated from 1990 to 2001 and evaluated from 2002 to 2011. Based on four recommended statistical coefficients, the evaluation indicates a good performance for both calibration and validation periods and acceptable agreement between measured and simulated values of both annual and monthly scale discharge. These results revealed that if properly calibrated, SWAT model and ArcGIS can be used efficiently in semi-arid regions to support water management policies.

Pachri et al. (2013) studied water management of the Chirchik river basin and overview of hydrological model using Geomorphology Based Hydrological Model (GBHM). Various spatial data such as land-use layers and hydrological layers were developed in their study by conducting latest GIS technology. By extracting ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) Digital Elevation Model (DEM) and ALOS (Advanced Land Observing Satellite) data on autumn and spring, a series of land-use classification was created using the supervised classification method. They found in their studies that for regional-scale hydrological modeling, GBHM as a powerful tool was used to analyze the river basin by utilizing the geomorphological properties data for each catchment and hill slope hydrological processes. The result shows that, development of spatial modeling was obtained and GIS-based analysis is an effective method to study water management in Chirchik river basin in Uzbekistan.

Seaedrashed and Guven (2013) studied estimation of geomorphological parameters of Lower Zab River-Basin by Using GIS-Based Remotely Sensed Image. This paper tried to enhance water-based information in the region under study using the technique of GIS-based remotely sensed image that gives us more accurate results and less time consuming to process data comparing with the GIS-based Topographic Maps (GTMs). This modern technique provided powerful and cost-effective tools for managing and processing data and creating maps for water resources. This enables hydrologists and researchers to get better access to high quality hydrologic data. Thus, accurate geomorphological parameters for watersheds and catchments can be calculated. Günal and Güven (2015) studied geomorphological parameters of Damlıca basin using GIS. The digital elevation model (DEM) of the basin is downloaded from Aster-GDEM web page and this digital map is used in the GIS computer program to obtain the geomorphologic parameters of the Damlıca basin. The extracted parameters were compared with the parameters obtained by conventional methods. The study indicated that the geomorphologic parameters of the Damlıca basin obtained using GIS are much more precise than those produced by conventional methods. Sawunyama et al. (2006) studied to estimate small reservoir storage capacities using remotely sensed surface areas. A field study on 12 small reservoirs was carried out in Mzingwane catchment in Limpopo River Basin; Zimbabwe. The depths of water accompanied with their coordinates were measured; from which area and capacity were calculated for each reservoir using geographical information system based on data acquired from the field and that from satellite images. The output data was compared and a linear regression analysis was carried out to establish a power relationship between surface area and storage capacity of small reservoirs. The results from linear regression show that the relationship can be used as a tool in decision-making processes in integrated water resources planning and management in the river basin.

Kim et al. (2015) described the construct of a river data model linked to a relational database that can be populated with both measured and simulated river data to facilitate descriptions of river features and processes using hydraulic/hydrologic terminology.

Oikonomidis et al. (2015) assessed the groundwater potentiality of Tirnavos basin that is located in Thessaly (in Greece), combining Geographic Information System and Remote Sensing with data obtained from the field, as an additional tool to the hydrogeological research. GIS and Remote Sensing (RS) were used in order to create a map that depicts the likelihood of existence of groundwater, consisting of five classes, showing the groundwater potentiality and ranging from very high to very low. The results provide significant information and the maps could be used from local authorities for groundwater exploitation and management.

Satti and Jacobs (2004) developed a GIS based model to analyse agricultural water demand in Florida and demonstrate its ability to capture the heterogeneous nature of soil and climatic factors.

Graymore et al. (2009) have applied the GIS based decision support tool as a means for enhancing the regional sustainability of the Glenelg Hopkins Catchment region in Victoria, Australia. The objective of this study was to integrate a multiple criteria analysis of locally selected sustainability indicators into the GIS to produce a spatial decision support system for sustainability assessment. The robustness and sensitivity of the developed tool was tested by applying it to the sub-catchments of south west Victoria and in this way its usefulness for regional sustainability monitoring and evaluation. In their study, the multiple criteria analysis based on socio-economic and environmental indicators have been used as the basis to build a model in ArcGIS. This GIS-based multiple criteria analysis produced maps showing subcatchment sustainability, as well as environmental and socio-economic conditions. The evaluation of the tool proved that it was a robust and sensitive method of sustainability assessment.

Chen (2011) analyzed uncertainty sources in MCA (Multi-criteria analysis). Building on this review, an uncertainty analysis module developed for use within a GIS-based MCA tool for catchment management is presented. In this module, the influence of uncertainties on decision-making can be visually explored using an indicator based method. The indicator-based method provides a pragmatic approach to communicating areas of uncertainty to decision-makers without assuming any prior knowledge of uncertainty analysis techniques. This enables uncertainty analysis to be more effectively operationalized within the decision making process.

Çobanoğlu et al. (2006) studied to introduce of urban information system including results of hydrogeological information and evaluations for Adana, fourth big city of Turkey. The datas, obtained from this study, are located on topographical maps prepared with real coordinate system and a data base includes geotechnical information for all points are made. For this aim, ArcView 3.3 program is used. Numerical datas are evaluated with linear interpolation by utilizing Spatial Analyst 2.0 a computer program. Using all data, equal ground water level, equal pH, equal EC, equal water hardness and equal sulphate maps are made for investigation area.

Daene et al. (2001) have pointed out a method for the operation of water resources through geographic information systems in their articles. It is emphasized that there must be digital bases in order to put forward this objective connection path. At the same time, it was emphasized that regular field observations and hydrographic measurements must be made. This method is based on the assessment of the environmental aspects of the results of associating and analyzing spatial and temporal data. In this method, it is aimed to reveal information about the water resources of the field which are studied with numerical base maps and hydrographic models. In this way, it is seen as an important achievement that the method is compatible with the subject of this thesis and it is guiding.

Al-Abed et al. (2004), ‘’GIS- Hydrological Models for Managing Water Resources in the Zarqa River Basin, in Middle East Geography’’ is a model study of the use of water resources in Jordan. In this way, the planning and modeling of water resources in the basin is a useful for the regulation and the management. The emphasis was on the importance of Jordan's arid and semi-arid climate regions and the importance of water resources for the country, emphasizing that planning and management of water resources should be implemented in absolute terms. The main model in the study is based on geographic information systems.

Aslan et al. (2004), ‘’Determination of Some Basin Characteristics by using the Digital Elevation Model: The Basin Example of Bursa Karacabey İnkaya Lake’’ examined the basin characteristics by geographical information systems in their studies. It is an important advantage that the digital elevation models can scanning basin in three dimensions. In this study, the characteristics of the basin such as watershed area, sub-watershed areas, water flow directions, drainage networks are easily obtained from DEM (Digital Elevation Model). Digital elevation models (DEM) have great advantages in studies on water resources. By GIS it is easy to get slope maps, drainage network, basin length and slope of the features of the basin and sub-basin features. This study is the case in The Bursa Karacabey İnkaya lake is a case study for application GIS on water resources.

Dobtowolska (2004), indicated that modeling and water resources management in Poland by Geographic Information System is extremely necessary to obtain actual hydrographic data. In his study, it was figure out that the necessity of creating hydrographic models on the basin of environmental and watershed by renewing and developing these studies with Geographical information systems. The methodology of the study was applied by different researchers to their own countries.

Portoghese and Vurro (2005) studied Hydrogeological water balance on a regional scale in semi-arid environments. They were used Arc Hydro tool of GIS for evaluate the groundwater potential and its relationship with surface water and climate change. They were also underlined water and environment relationship in their studies in order to developing European-Union water-environment instructions.

Nişancı (2007) GIS Database Modeling Intended for River Basins the case of Trabzon Galyan Valley’’ In this study, designation of a system aiming to provide a spatial database for different professions about the Galyan Valley was realized. Atasu Dam that will provide drinking water to Trabzon in the future is located in this walley. Spatial analyses devoted to this river basin that will support different professional disciplines were conducted in CBS environment. The decision parameters such as areas sensitive to the landslides, slope groups, risk regions that could be exposed to environmental pollutions needed for planning are determined in the scope of this study.

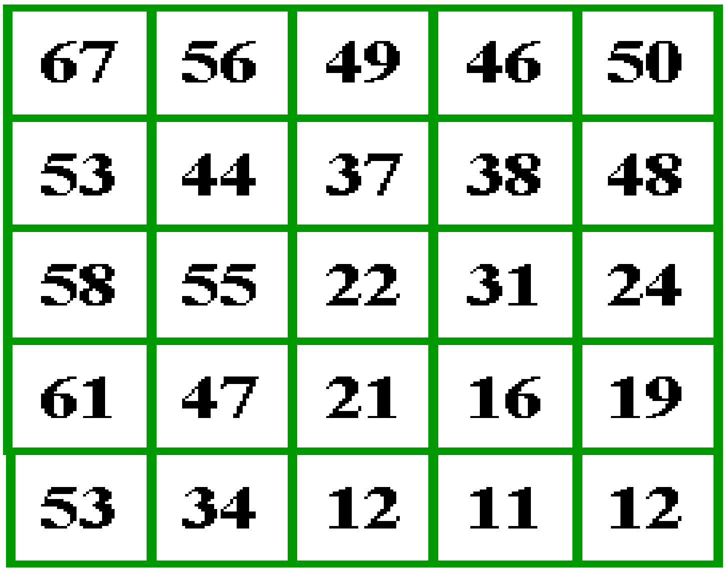
2.5. Digital Elevation Model

GIS depend on computer programs and are used for saving, restoring, controlling, and showing locative information (Sabins, 2000) about the sciences of geology, geography, the environment. Digital elevation model (DEM) method depending on SRTM and ASTER data through ESRI products ArcView, ArcGIS, and Arc Info for the establishment of morphometric parameters in Arc Hydro were used as described by Maidment (2002), Abboud and Nofal (2017). When the data considered are distributed over the Earth surface, the relief of the area involved can have a critical weight, and the choice of a suitable elevation dataset, typically a digital elevation model (DEM) becomes important (e.g. Wise, 2007). Digital elevation model (DEM) data have been widely applied in scientific fields such as ecology (Kellndorfer et al., 2004; Næsset et al., 2016), agriculture (Fu and Rich, 2002), and hydrological modeling (Wechsler, 2007; Zheng et al., 2015) (Marker and Guran, 2009). Previous studies related to DEM have underlined advantages of using Digital Elevation Models (Shaikh et al., 1989; Anbarasu, 1994; Lillysand and Kiefer, 2000; Wright et al., 2006; Waldhoff et al., 2008; Smith and Pain, 2009; Blanchard et al., 2010; Kaliraj et al. 2017). Most of the available algorithms (Tribe, 1992) automatically extract the drainage information, such as flow directions from cell to cell, river network segments and associated sub watersheds, from a digital elevation model (Turcotte, 2001).

Digital elevation model (DEM) data consist of a sampled array of regularly spaced elevation values referenced horizontally either to a Universal Transverse Mercator (UTM) projection or to a geographic coordinate system. The grid cells are spaced at regular intervals along south to north profiles that are ordered from west to east (Sassa et al. 2014).
A DEM consists of a sampled array of elevations for ground positions that are normally at regularly spaced intervals as shown in (Figure 2.2). They are generated in a variety of ways for a different map resolutions or scales. Different studies highlighted the influence of the DEM grid cell size on the accuracy of the extracted network (Zhang and Montgomery, 1994; Quinn et al., 1995; Wang and Yin, 1998).

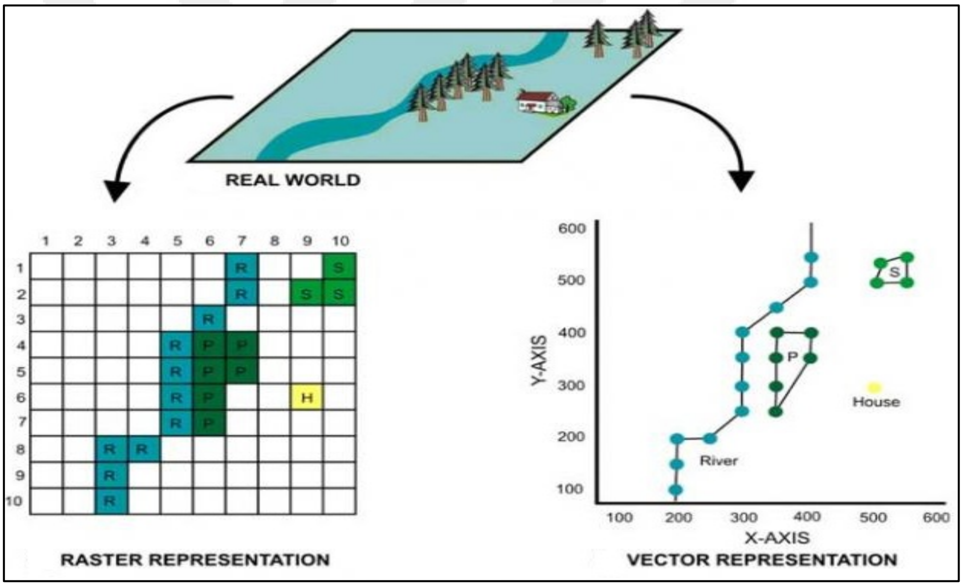
Coarse and medium resolution DEMs, for example, do not allow the resolution of topographic features such as hollows, low-order channels and hill slope characteristics. Wolock and Price (1994) concluded, however, that medium-resolution DEMs (f250-m grid) may be appropriate for topographically driven hydrological models, and Walker and Wilgoose (1999) showed that the most prominent features of the slope –area relationship, such as the inflection point that marks the start of the fluvial scaling line, can be determined with high confidence from such DEM. DEMs are point elevation data stored in computer files. These data consists of x, y grid locations and point elevation or z variables. DEM data provide a high-quality and high-resolution elevation data (Jarvis et al., 2004). Digital Elevation Models (DEM) is a commonly used digital elevation source and an important part of using for watershed, basin or catchments characterization. DEMs are used as a controlling variable for the spatialisation of other hydrological important variables such as temperature, rainfall, soil properties including soil depth, and vegetation characteristics. Moreover, DEMs are the information source for computing surface flow networks and their topology. Such flow networks are critical for modeling runoff accumulation, stream flow, and flood response, and are derived using a neighborhood operator over a DEM represented as raster grids, or from a triangular irregular network (TIN) (O'Callaghan and Mark, 1984; Tarboton, 1997; Jarvis et al. 2004). There are many resources available on the internet for finding elevation datasets to use. The best known source of free and low-cost DEMs is the USGS (United States Geological Survey). The widely publicized Endeavour mission this past year was most well-known for its SRTM mission that sought to gather topographical data for over 70% of the Earth's surface. Most common DEM datas are 90m, 30m, 10m and even 1m resolutions.

This data is used to yield important derivative products such as slope, aspect, flow accumulation, flow direction and curvature in process of watershed delineation.



67	56	49	46	50
53	44	37	38	48
58	55	22	31	24
61	47	21	16	19
53	34	12	11	12

Figure 2.2 Example of a DEM (Maidment, 2002)



	1	2	3	4	5	6	7	8	9	10
1							R			S
2							R		S	S
3						R				
4					R	P	P			
5					R	P	P			
6					R	P			H	
7					R	P				
8			R	R						
9			R							
10			R							

Figure 2.3 Representation of raster-vector data model

Typical DEM data structures can be categorized into DEM grid, TIN, Contours by Moore et al.1991). Recently, a new classification was proposed by Hengl and Evans (2009). They divide DEM in two big groups: vector-based and raster-based. TIN-DEMs and Contour-DEMs are part of the vector-based group; Grid-DEMs are raster-based group. Grid-Dem was the most widely used data structure in the past due to its simplicity, but it has the vital disadvantages. It is not able to represent abrupt changes in elevation easily; it can be missed important details of the land surface in flat areas. The most common example is the land surface terrain characterized by DEMs digital elevation models, represented as elevation grids in the field model. DEMs as grid structures comprise a square grid with the elevation of each grid square (Figure 2.3).

Alias et al. (1994); John et al. (2000); Li Z. et al. (2005) explained that The digital elevation model (DEM) is widely used in remote sensing, (GIS), virtual reality (VR) and so on. So far, Triangulated Irregular Network (TIN based DEM) and digital contours (Contour-based DEM), the grid-based DEM has been developed for the terrain representation, of these data structures, grid-based DEM has been the most commonly used data source for its own advantages, such as the implicit definition of point topology and the relatively compact storage, etc. On the other hand, the disadvantages of grid-based DEM are also obvious that it cannot handle abrupt changes in elevation and the size of grid mesh affects the obtained results and the computational efficiency (Carter 1988; Collins et al. 1981; Moore I. D. et al., 1991; Zevenbergen L. W. et al., 1987; Xuejun et al. 2008).

Artefact and actual depressions must be distinguished in DEMs before using these datas for hydrological applications. Topographic depressions, also called pits or sinks, are commonly removed from DEMs prior to use in many hydro geomorphic applications (Burrough and McDonnell, 1998; Wilson and Gallant, 2000). This practice reflects the fact that digital depressions are often artefacts that have the undesirable effect of altering and truncating simulated overland flow networks (Tarboton et al., 1991; Tribe, 1992; McCormack et al., 1993). Artefact depressions occur because of data errors, interpolation, and the limited horizontal and vertical resolution of DEMs (Qian et al., 1990; Tribe, 1992; Martz and Garbrecht, 1998, 1999; Rieger, 1998; Florinsky, 2002). Grid-based DEMs (i.e., elevation matrices), the most common terrain model format (Wise, 2000) frequently contain artefact depressions because of their inability to explicitly represent ridges and streamlines (Mark, 1988; Lindsay and Creed, 2006). Lindsay and Creed (2006) found five approaches to digital depression validation were proposed in their studies: ground inspection, examination of the source data, classification approaches, knowledge-based approaches, and a Monte-Carlobased modeling approach. Results have been showed that none of these approaches to depression validation are perfect; each has various advantages and disadvantages.

2.6. SRTM, ASTER, Digital Elevation Data

There are a number of DEM products available for global Earth observation and analysis. The Advanced Space borne Thermal Emission and Reflectance Radiometer Global Digital Elevation Model (ASTER GDEM) is a product generated from optical data collected by the ASTER instrument onboard NASA's Terra satellite (Hengl and Reuter, 2011). This dataset is the only DEM that covers 99% of the entire land surface at a high resolution, but the accuracy of the ASTER GDEM has attracted controversy due to the anomalies and noises caused by the limitations of the optical imaging (Tachikawa et al., 2011a,b; Mukherjee et al., 2013; Yue et al., 2017). Comparatively, the Shuttle Radar Topography Mission (SRTM) DEM is the most commonly used data source due to its relatively stable accuracy (Yang et al., 2011), (Figure 2.4). This near-global dataset was generated based on space borne radar measurements collected in 2000 (Jarvis et al., 2008).

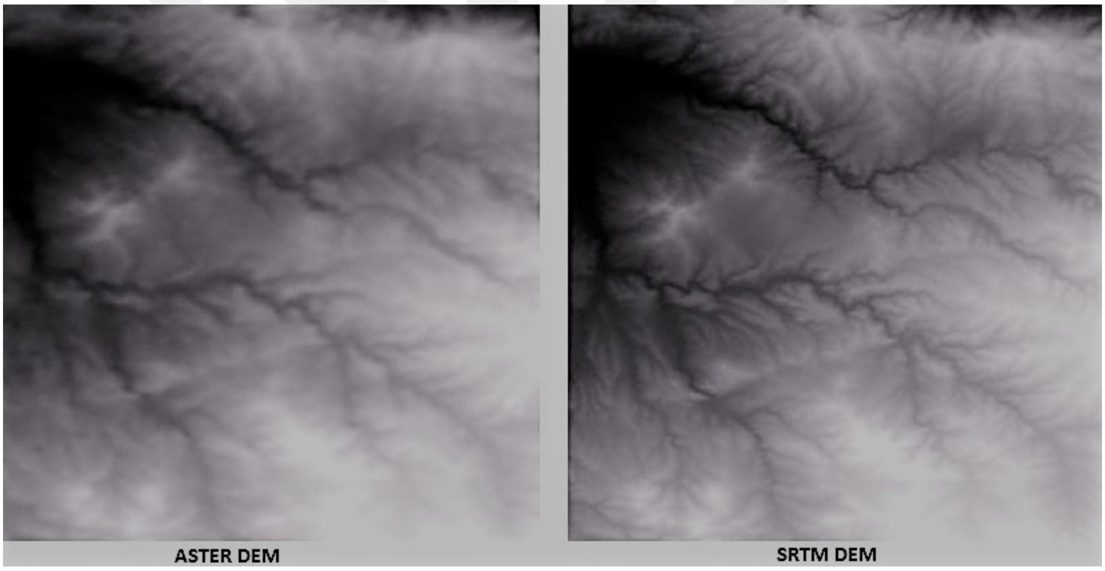


Figure 2.4 SRTM and ASTER DEM visualization

2.7. Watershed Delineation and Extraction

Terrain surfaces are generally represented by Digital Elevation Models (DEM) with relevant and useful applications in many areas of natural sciences. More specifically, hydrology applications commonly use terrain models to automate the generation of flow directions, drainage networks and watersheds that are essential elements in the understanding of hydrological processes (Freitas et al., 2016). In essence, drainage networks represent the main courses of water on a terrain surface, and can be used for the delineation of watersheds that play an important role in hydrological studies with a wide variety of applications (Zhang et al., 1990).

Watershed is a natural hydrological entity from which surface runoff flows to a defined drain, channel, stream or river at a particular point (Vittala et al. 2004). A watershed normally described as the total area of water flowing to the given outlet point or more often known as pour point (Figure 2.5). The boundary between two adjacent watersheds is the drainage line. Pour point is the point at which the water flows out of the area. This is the lowest point in elevation along the boundary or drainage lines. Delineation of watersheds depends on the catchment drainage pattern of the watershed (Venkatachalam et al., 2001).

With the development of computer and information technology, distributed hydrologic models become research focus, in which watershed delineation based on DEM (Digital Elevation Model) is the key step and priority (Luo et al., 2011). A watershed also called a drainage basin or catchment is defined as the area that on the basis of topography subscribes whole water to a particular stream area.

For a long time several studies focused on mapping of drainage networks and their watersheds for hydrological studies.

Tracing techniques were used in these studies to extract drainage network and delineate boundaries of basins for studying the characteristics of basins and their relationship to the geometries of those basins. Using classical approaches for delineation the drainage network, these studies need to measure linear features directly in the field or retrieve from secondary sources, (e.g., digitized from topographic maps, aerial photographs and stereo images). In many areas of the world, topographic maps are still the basic traditional reference for drainage network analysis because of their availability, simplicity and affordability. However, the extraction of information, such as delineation of drainage and watershed from topographic maps, requires much time and expertize in cartography, resulting in subjective decisions. Moreover, the results of manual procedures such as tracing methods still have to be transferred to digital data for further processing. Limitations and subjectivity of manual procedures in defining stream networks highlight the need for a more precise and efficient approach in depicting landscape dissection. The widespread availability of digital data including DEMs, radar images, stereo photogrammetry, and Light Detection and Ranging point clouds has opened new gates for more objective approaches to the delineation of channel networks (Sekulin et al., 1992; Bertolo, 2000; Lin et al., 2005; Afana, 2011; Omran et al., 2016).

Nowadays, many GIS like ESRI's ArcGIS, QGIS or Saga include in their toolboxes standard tools to extract the stream segments and basin watersheds from DEMs (Omran et al., 2016).

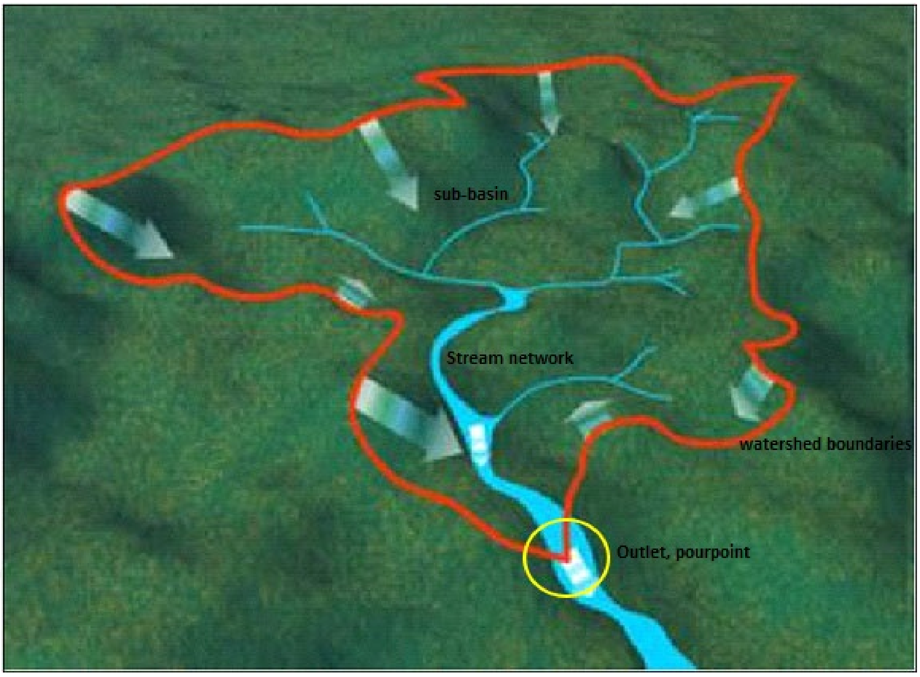


Figure 2.5 Example of watershed (ArcGIS V.10.4)

Generally, watersheds were delineated by using paper topographic maps or stereoscopically viewed air photographs. There are two basic ways for delineation for watershed; Automatic watershed delineation and Manual watershed delineation.

The traditional manual catchment delineation method for large scale watersheds where more than hundreds catchments are delineated in a watershed is time consuming and very tedious. Currently the traditional manual catchment delineation methods are quickly replaced by automated approaches, for the introduction of software algorithms that can do quick and efficient processing. Advantages of automatic catchment delineation methods include process reliability and reproducibility, savings of time and labor, and results within a digital domain, can be linked to other data sets easily (Akram et al., 2012).

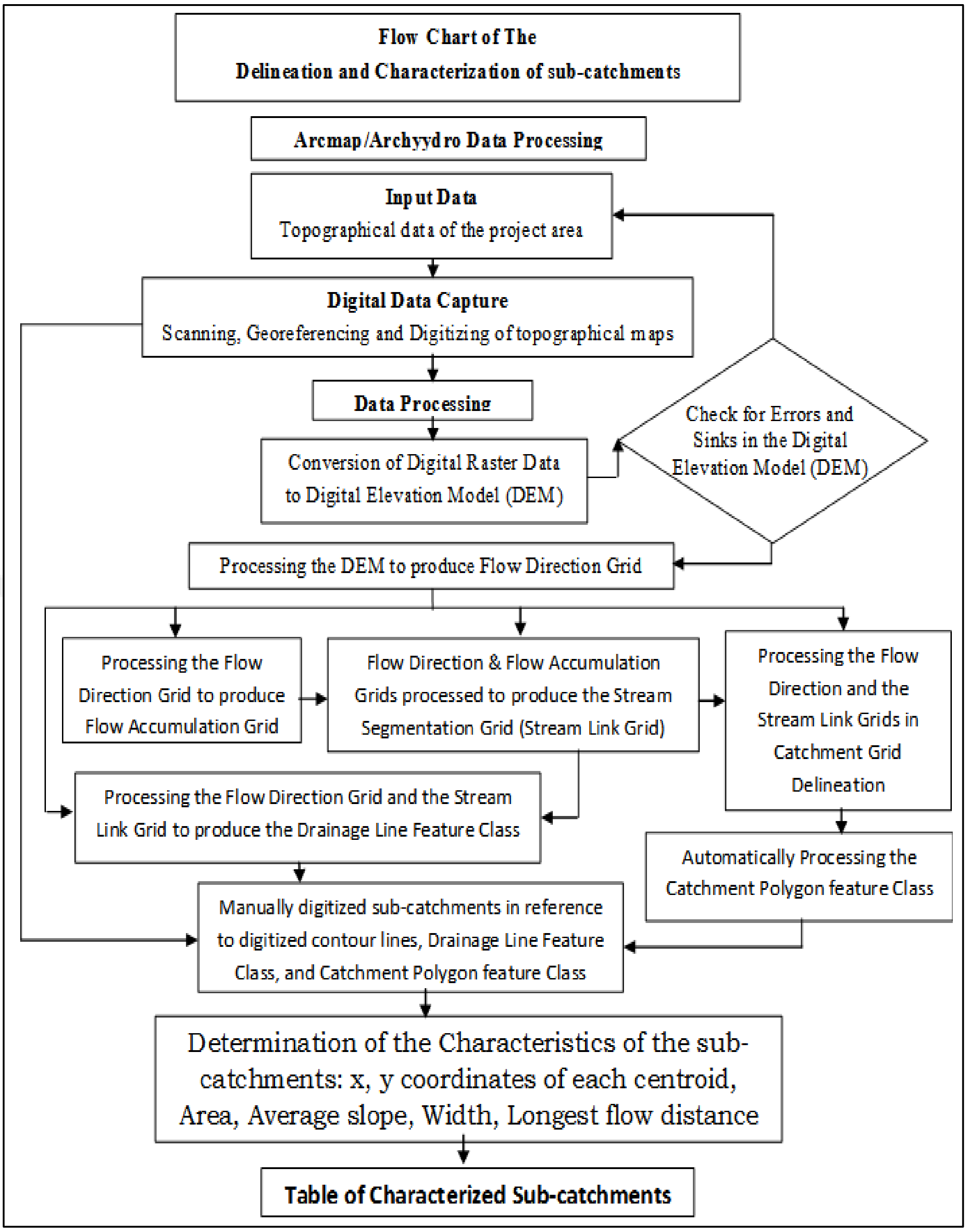


Figure 2.6 Flowchart process of the watershed delineation

Figure 2.6 is a very comprehensive flow chart to show the entire process involved in the Watershed Delineation using Arc Hydro extension toolbar in ArcGIS 10.4. The user would not be worried to remember the sequential steps to follow to complete the watershed delineation process by this flowchart.

This thesis study examines sustainable watershed management and its use, which has been felt in the last few decades. The proper use of water resources and the development and implementation of hydrological models for the management of water resources are becoming increasingly important worldwide. For this reason, this study focuses on hydrological modeling and the development of a new GIS based model. GIS and hydrological modeling, program analysis, situational and future situation assessment are considered important parts of this work. With the developing technology in recent years, the studies carried out in this subject have been increased in our country, and the watershed management, the morphological features of the basins, the water collection areas, the geographical information systems in the existing water situation determination and other models are utilized. Avoiding classical methods in the world literature, giving emphasis to simulation and program analysis shed light on this thesis. Moreover, in this thesis, a case study is presented with the analysis of the current situation of Gaziantep province and the management of watershed management and water resources for future water needs.

CHAPTER 3

STUDY AREA

3.1. General

The city of Gaziantep is located between 36^{o} 28’ and 38^{o} 01’ eastern longitudes and 36^{o} 38’and 37^{o} 32’ northern latitudes. The city has a total area of 6222km^{2}, corresponding to 1% of Turkey. The city is dominated by rolling and rugged land. Nur Mountains, which forms the borders of Hatay and Osmaniye, are located on the South. The other mountainous area of the city parallel to Nur Mountains is between Islahiye and Kilis starting from Syria in the South extending to the border of Kahramanmaraş and Adıyaman in the North and Fırat River in the east. Sof Mountain, which is in the east of Islahiye with a height of 1496 metres, is the peak of the city. The most important plains, which constitue ¼ of the city terrain, are Islahiye, Barak, Oguzeli, Araban and Yavuzeli. The most important river near the city center is Euphrates River. The stream that joins Euphrates River before it goes out of the city and the country is Nizip stream (TUIK, 2013).

The Euphrates is the longest river (2800) km of Western Asia and originating from the Eastern Turkey. It flows through Syria and Iraq to join the Tigris in the Shatt-Al Arab, which empties into the Persian Gulf. The Euphrates River has 10 main streams in Adıyaman Region and these are the streams of Kahta, Eğri, Çakal, Göksu, Bulam, Sofraz, Aksu, Ziyaret, Kömür, and Kalburcu connecting to Atatürk reservoir (Kara and Alp, 2016). In addition to the streams, 4 natural lakes present in Adıyaman region. These are Gölbaşı (2.19 km^{2}), İnekli lake (1.09 km^{2}), Azaplı lake (2.72 km^{2}) and Abdulharap lake (5 km^{2}) (Figure 3.2).

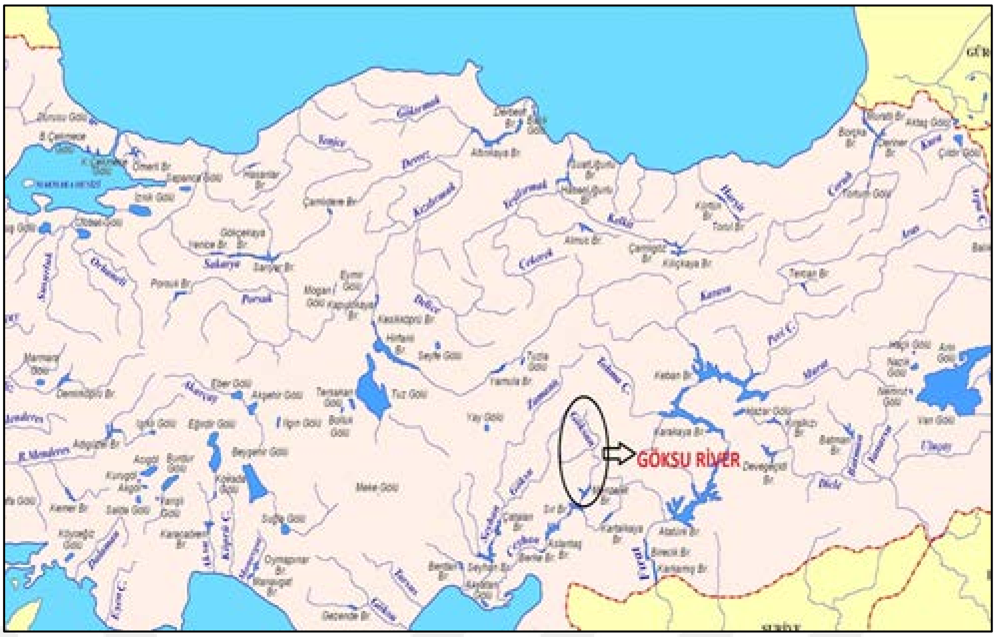


Figure 3.1 General location of Göksu River

Göksu stream (Nurhak-Kahramanmaraş) which is a tributary of Euphrates River, projected to supply water to Gaziantep province, located at Kahramanmaraş province (Figure 3.1). Göksu River; By drawing up the boundaries Besni groundbreaking, Nurhak of Mount (3081 m) in the southern foothills Koçdağ (2562 m) and extends to the eastern outskirts. Gölbasi depression in the northeast of the Goksu River Brook then mixed slider. The total length of 118 km. Adıyaman limits the length of 90 km, the flow of 63.42 m^3 / sec. Göksu River is a tributary of the Euphrates, near Nurhak district of Kahramanmaras province passes are then mixed into the Euphrates near Gölbasi Adiyaman (Demirci, 2007).

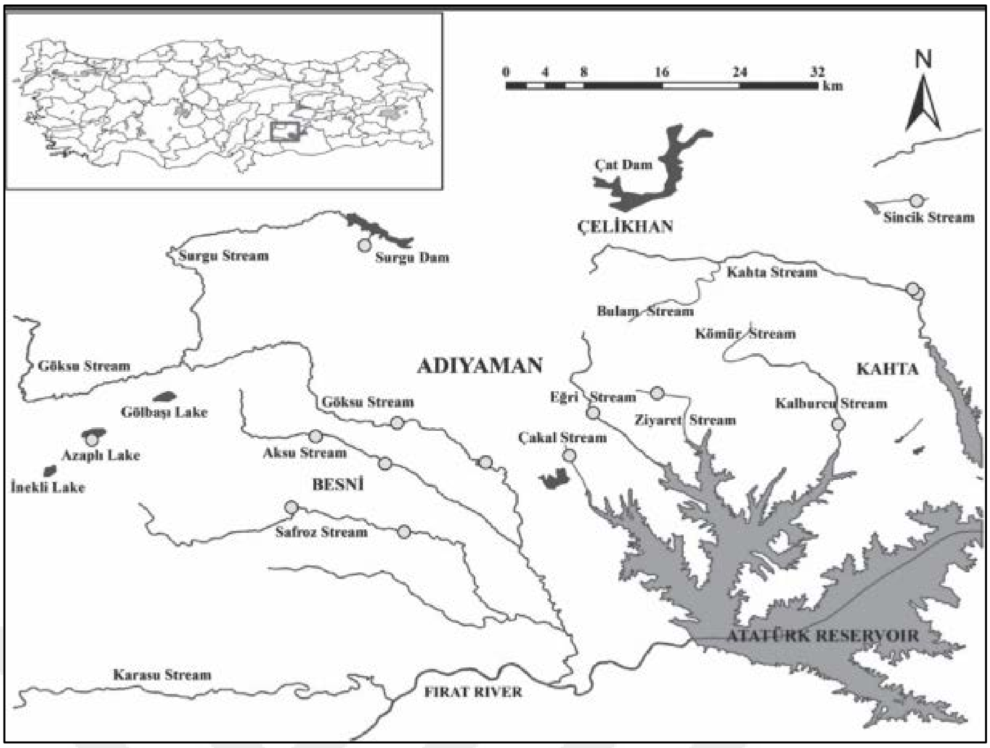


Figure 3.2 Euphrates River tributaries (Kara and Alp, 2016)

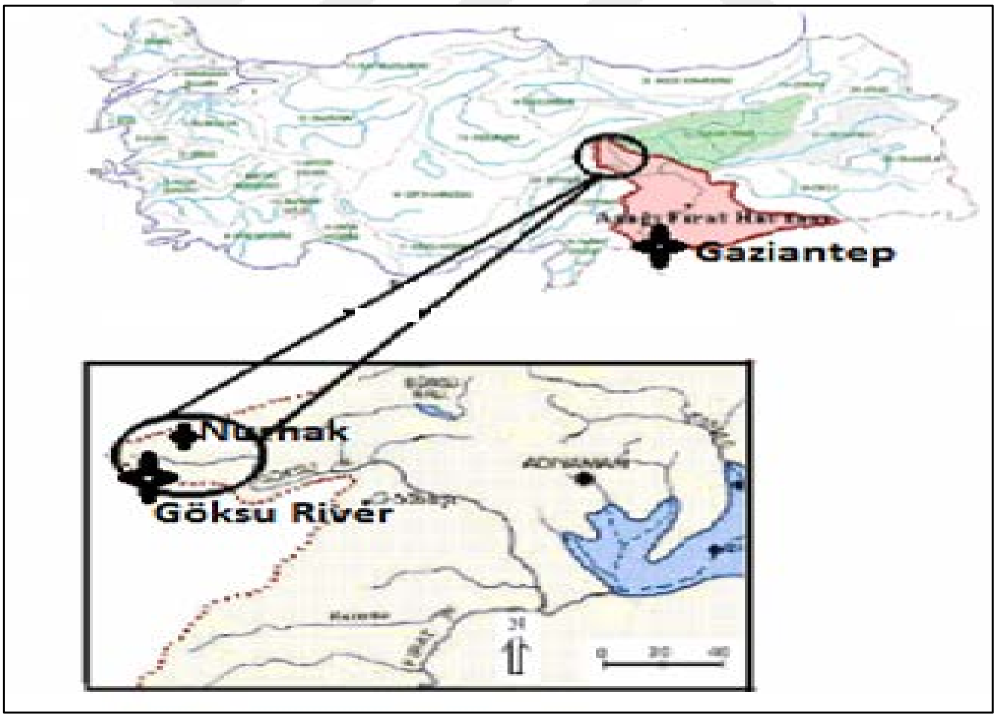


Figure 3.3 General location for study area

Figure 3.3 illustrates Gaziantep city which is located at South-East of Turkey. Şahinbey and Şehitkâmil are the city center districts and the Nizip, Karkamış, Yavuzeli, Oğuzeli are the rural districts of the city.

3.2. Geography and Geology

The latitudes and the longitudes of the Göksu River Basin are 37°54 N and 37° 59 E respectively. The area drained by the Göksu River is to the west of the Euphrates River. Göksu River basin is located in the northwest of the Southeastern Anatolia Region, which is one of the backward regions in Turkey. It has a drainage area about 648 km^2.

In the study area, compressional tectonics, which started from the Paleozoic era and has been widespread from time to time, has been effective from the Lower Campania. Until Cretaceous Early Tertiary times, the tectonic activity that constituted the rifting site in the restricted tensional areas of this compression regime formed Transform Faults and Graben Systems after the collisions of Anatolia and Arabian Cretaceous during the Miocene Pliocene. As a result, it can be said that this present taconite in the region resulted from the back-thrust in the red sea, the collision-compression along the orogeny zone in Southeast Anatolia and the re-activation of many transverse plate runs in the Arabian Plate.

3.3. Meteorology

The climate of the study area is characterized as arid Mediterranean. Annual mean temperature is about 15.2 ºC. According to the data of 36 years the maximum mean temperature is measured to be about 27.9 ºC, which is recorded in July 2000 and the minimum mean temperature is noted to be 3.3 ºC recorded in January 1965. The average annual rainfall is about 551.6 mm (TUIK, 2013) and the seasonal precipitation regime is winter, spring, autumn and summer (Bulletin, 2010).

Table 3.1 Weather condition of Gaziantep

Ave. temperature	+14.5°C
Maximum temperature	44.0°C
Minumum temperature	-17.5°C
Sunny Days	8.1 hour
Ave. of Humidity	50%
Ave. of Rainy Days	84.5 days
Ave. Rain	556.2 mm
Ave. Snowy Days	13 days
Ave. Nipping Days	56.5 days
Maximum Snow Elevation	100cm
Wind Direction	Northwest Wind
Ave. Max. Temperature(JULY)	35.6°C
Ave. Min. Temperature(JANUARY)	-0.3°C

Table 3.1 is about weather Condition of Gaziantep city with average values. Average maximum temperature is 35.6°C in July and average minimum temperature is -0.3°C in January.

Table 3.2 Annually average temperatures of Gaziantep city in between 1960 and 2012

Ave. Temp. (°C)	3	4.2	8.2	13.2	18.6	24.1	27.8	27.4	22.8	16.2	9.4	4.9
Ave. Max. Temp. (°C)	7.7	9.3	14.1	19.6	25.5	31.3	35.3	35.3	31.2	24.3	16.2	9.9
Ave. Min. Temp. (°C)	0.8	0	3.1	7.4	11.9	17	21	20.9	16.2	10.2	4.5	1.1
Ave. Sunny Days (hour)	3.4	4.3	5.4	7.1	9	11.6	11.2	10.3	9.1	7.2	5.3	3.4
Ave. Rainy Days	13	12.5	12.2	10.6	7	2.1	0.6	0.5	1.5	6.5	8.7	12.2
Montly Total Rain Amount	100	84.1	74	54	31.5	6.3	2.6	2.1	5.6	38.4	67.7	98.8

Table 3.2 is about annually average values between 1960 and 2012 for 12 months period. Average temperatures, average maximum temperatures, average minimum temperatures, average sunny days, average rainy days, maximum temperatures, minimum temperatures indicated with (°C). Monthly total rain amount indicated with (kg/m^2).

3.4. Population

In order to the estimation of the forecasting population of Gaziantep City; Population in the past years are indicated at (Table 3.3). Populations are calculated between 1965 and 2015. The total population of Gaziantep city (city center and rural) in 2015 is approximately 1,842,368.

Table 3.3 Population of Gaziantep city

Year	Population
1965	187756
1970	253981
1975	327104
1980	402743
1985	509047
1990	636842
2000	893617
2007	1175042
2008	1235815
2009	1278676
2010	1324520
2011	1386052
2012	1522359
2013	1607885
2014	1702912
2015	1842368

3.5. History

Gaziantep was formerly called Ayintab or Aintab in Ottoman Turkish and later it was called as Antep (Sarafian, 1957). In the first half of the 7thCentury, Arab armies of the Muslim Caliphate captured this region. In December 1921, City was independence and name was officially adopted in 1928 as Gaziantep (The Missionary Herald, 1990).

3.6. Current Water Supply System

The domestic water of the city of Gaziantep is supplied from three sources, namely, Kartalkaya dam, Mizmilli deep wells and a number of deep wells located within the city (Figure 3.4).

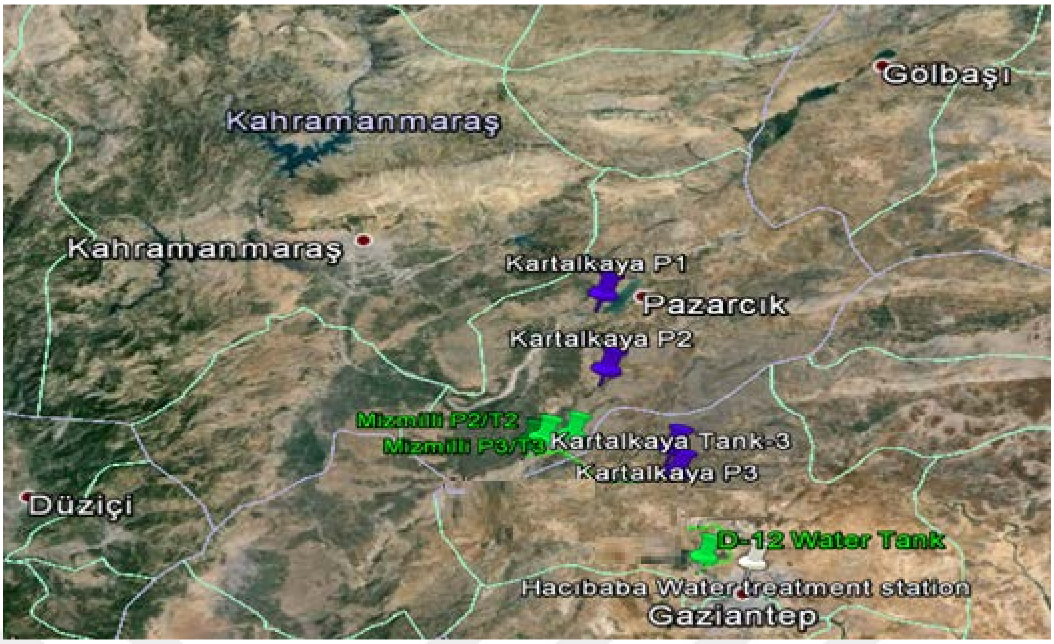


Figure 3.4 Water sources of Gaziantep city

3.6.1. Kartalkaya Dam

Kartalkaya Dam, from where Gaziantep takes its drinking water as 1/5 capacity, is one of the most important resources. The water, which is taken from the Kartalkaya via 3 pump with a 296-metres lifting and is carried to Hacıbaba water treatment station with 53.7 km water suppline. The project flow rate of this station is 4 m^3/sec. The whole service area is still in progress and keeps providing drinking water services to the city center.

3.6.2. Mizmilli Wells

The water, whose flow rate is 1.5 m^3/sec is taken from the plants of Mizmilli via 3 pump stations with a 602-metres lifting and is carried to DY12 water tank.Water supply line is about 43 km to Hacıbaba water treatment station.

3.6.3. Wells in the City

Approximately 0.5 m^3/sec water is carried from the wells in the city with lifting 21 wells existing in the city. TOKİ, TAŞLICA, BURÇ are some of the wells in Gaziantep city.

Table 3.4 Gaziantep water tanks and volume capacity

Water Tank	GC(m)	CC(m)	GBC(m)	V(m^3)
DY1	902	901	905	30
DMI	902	901	905	30
DY5	905	936	942	500
DM3	897	895	899	10
DY9	930	965	971	500
DM6	937	935	941	15
DY7	938	935	941	30
DYO	881	880	883	500
DY11	931	930	936	15
DY12	975	975	981	15
DM4	897	896	899	12
DM5	897	896	900	15
DY2	897	896	899	10
DY3	894	893	897	15
DY10	881	880	883	500
TAŞLICA	876	874	878	1000
DY17	961	960	965	10
DY18	1004	1003	1009	15
DY19	1031	1034	1037	1500
DT1	848	847	851	100
TOKİ	997	1031	1037	1000

Table 3.4 where water tanks are explained with their codes and special numbers. Volume capacities are indicated with metercube (m^3), ground levels, crests codes and graben codes are indicated in meter (m). In the event that, the current water supply is not enough, there are extra feeding points at Mizmilli wells those can be used in emergency cases.

3.7. Potential Water Resources

The domestic water of the city of Gaziantep is supplied from Kartalkaya dam, Mizmilli deep wells and a number of deep wells located within the city. These water resources are under stress in order to provide the drinking water demand of the city. In order to meet the water demand of the city, the authorities have to frequently feed Kartalkaya dam from Göksu River, a nearby basin. In addition to the existing drinking water sources, there is a need for new water resources. Çetintepe, Düzbağ and Birecik dams are the potential sources which need to be considered.

3.7.1. Çetintepe Dam

Çetintepe dam is being constructed on the main arm of the Göksu and fount of Kapıdere River, which is a tributary of Euphrates River, near Gölbaşı with a talweg code of 890m.

3.7.2. Düzbağ Dam

Düzbağ Dam, which is projected to supply drinking water to Gaziantep, is located on the Göksu River, 4 km in the north of Düzbağ village, Kahramanmaraş with a talweg elevation of 960m. According to official information, the population of the town is 6093 at 2008 (Anonymous, 2013). Düzbağ dam is planned to be constructed on between the Haramlı ridge and Göksu River.

3.7.3. Birecik Dam

The Birecik Dam, which is one of the 21 dams of the well-known Southeastern Anatolia Project (GAP) of Turkey, is located on the Euphrates River about 60 km downstream of Atatürk Dam and 8 km upstream of Birecik town. The height of dam is approximately 63 meter with a talweg code of 380m. The dam is in operation and designed for irrigation and energy production. There is a run-of-the-river hydroelectric power plant, with a power output of 672 MW, generating an average of 2 billion kWh per year (DSİ, 2011).

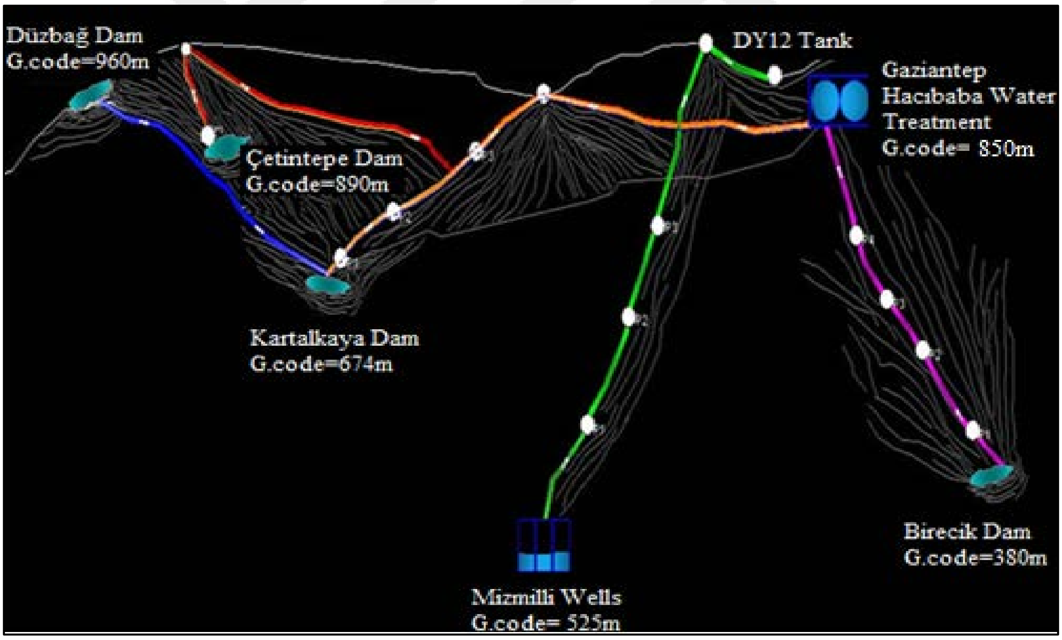


Figure 3.5 Features of Çetintepe, Birecik and Düzbağ dams

Figure 3.5 is about features of Çetintepe and Düzbağ Dams, where maximum and minimum water levels, elevations of dams, active volume capacity are showned.

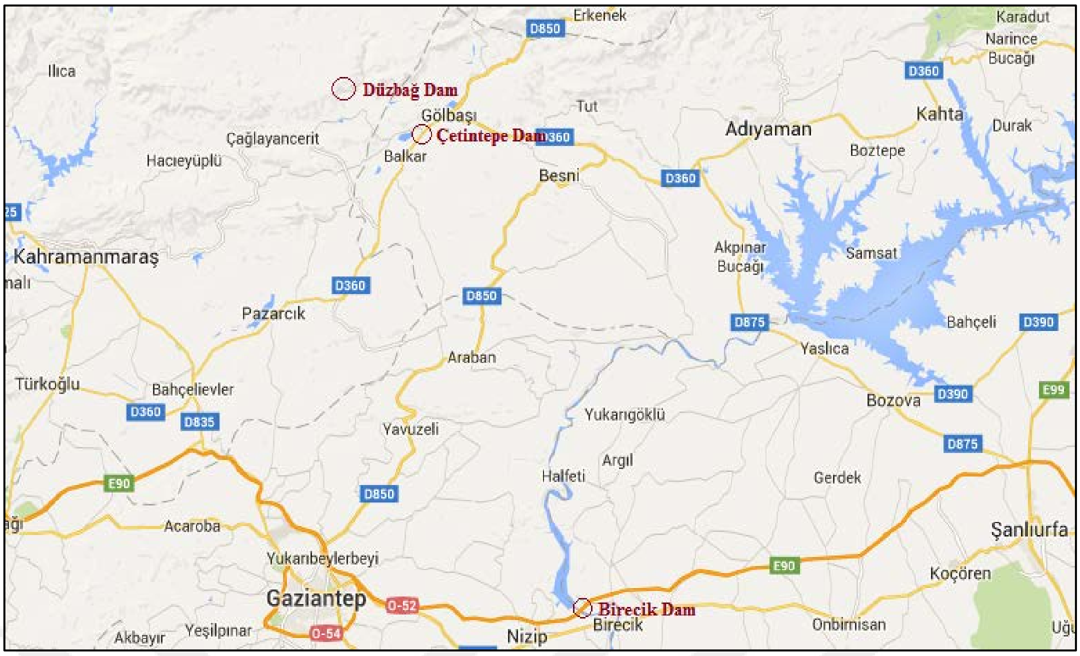


Figure 3.6 Location of Çetintepe, Birecik and Düzbağ dam

Figure 3.6 is about potential water sources of Gaziantep city. Birecik dam is located at Şanlıurfa city, Düzbağ dam which is considered to build at Kahramanmaraş city and Çetintepe dam which is considered to build at Adıyaman.

3.8. Comparing Water Sources

Supplying drinking water from Çetintepe or Birecik Dam to Gaziantep will need pumping, thus cost of energy since the elevation of the water treatment in the city is around 850m. However, if the domestic water is provided from Düzbağ Dam there will be no or very limited energy cost, which makes Düzbağ dam as the most appropriate project. Furthermore, there will be no expropriation cost when Düzbağ Dam is built, since it is in a mountainous district and there are no privately owned lands in the reservoir area. The water in the Düzbağ basin is not polluted and the treatment cost is expected to be limited, because there are no zones of occupation in the basin.

3.9. The Flow Measurement and Meteorological Stations at Düzbağ Region

Düzbağ Dam, which is projected to supply drinking water to Gaziantep, is located on the Göksu River, 4 km in the north of Düzbağ village, Kahramanmaraş with a talweg elevation of 960m. According to the flow discharge measurements obtained from the flow measurement Station (FMS) numbered D21A262, the river is able to provide an average annual water amount of around 403 million m^3 with an average discharge of 12.87 m^3/sec. FMS is located at 37°47'45’’N 37°28'17’’E with a drainage area of about 648 km^2. FMS actively involved in running from the year of the 1992 and located on M 38 numbered map and from this day-measured on a threaded instant maximum flow rate 130 m^3/sec measured at (07.03.1996). Since many years the flow of observation station, monthly average flow rate measurements are shown in the (Table 3.5). For many years, monthly average values taken into consideration annual average flow rate 12.87 m^3/s is understood. 12.87 m^3/s flow means about 403 million m^3 water passes pear year.

Table 3.5 Water resources projects on the Göksu River

Country	**Name**	**River**	**Completion Year**	**Target**
Turkey	Düzbağ Dam	Göksu	Under construction	Drinking and Household
Turkey	Çetintepe Dam	Göksu and Kapıdere	Under construction	Irrigation

3.10. Data

The data used in this study was 30-m spatial resolution digital elevation model (DEM) generated from SRTM- 30m high resolution which is most accurate data in the world and it is easy to delineate watershed because of its high resolution. The monthly average discharge data taken into account for this study covered the period of 1984-2014 (Table 3.5). Four rainfall measurement stations are located in Kahramanmaraş province. Long term measurements were taken in consider in order to estimate the rainfall in study area region. Also there is a rainfall measurement station in Düzbağ but because of the lack of long-term measurement data, Afşin, Elbistan, Göksun and Kahramanmaraş rainfall stations were utilized in estimations (Figure 3.7).

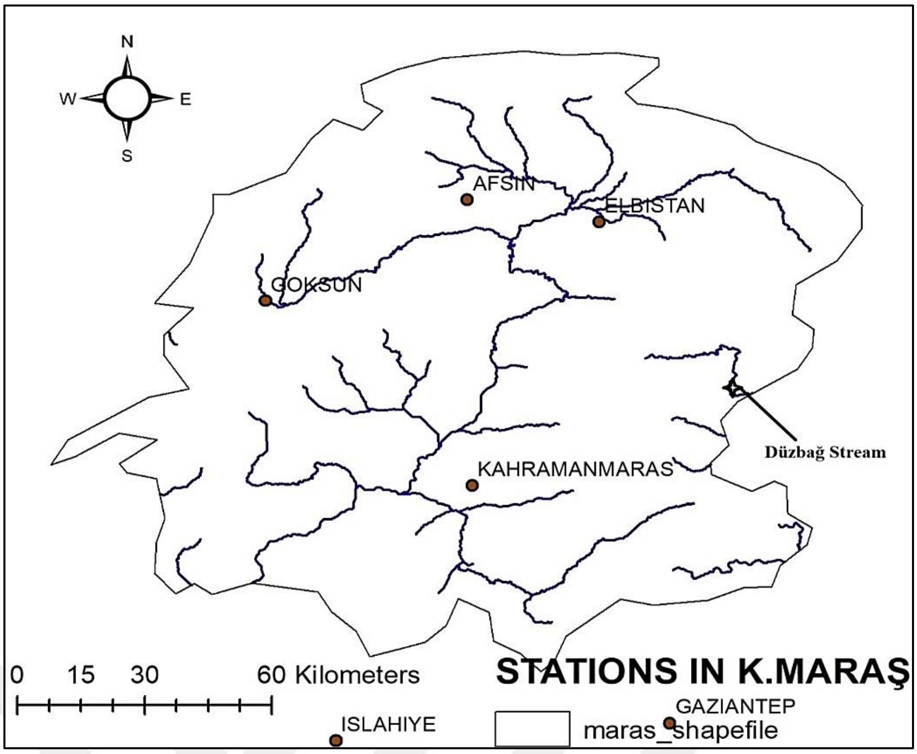


Figure 3.7 Location of rainfall measurement station

Rainfall stations are given with latitudes and longitudes. Table 3.6 explained that Kahramanmaraş rainfall measurement station has highest rainfall with 716mm.

Table 3.6 Meteorological stations around the study area

Station Latitude	Longitude	Annual (mm)	Data Used Rainfall	# of year	Data used
Afşin	36.91	38.24	432.20	2010 - 2015	5
Elbistan	37.19	38.19	399.70	2010- 2015	5
Göksun	36.48	38.01	611.60	2010 - 2015	5
K.maraş	36.92	37.59	716.00	2010 - 2015	5

CHAPTER 4

METHODOLOGY

4.1. Population Forecasting

The future population of the city was estimated by using five different methods. They are arithmetic method, exponential regression method, geometric (logarithmic) method, compound interest method, and Ilbank method.

4.1.1. İlbank Method

$$\text{Ç} = \left(\sqrt[a]{\frac{N_y}{N_e}} - 1 \right) 100 \tag{4.1}$$

Where Ny is the present population of the study area, Ne is the future Population of the study area, Ç, is the reproduction coefficient. ‘’a’’ is the time interval between Population of the based and future year.

$$N_g = N_y \left(1 + \frac{\text{Ç}}{100} \right) \tag{4.2}$$

Where Ng is the future population of the study area, Ny is the Population of the study area, Ç, is the reproduction coefficient. ‘’n’’ is the time interval between last population to future population.

Table 4.1 Population of Gaziantep city center between 1960 and 2014

Year	Population
1960	124097
1965	160012
1970	227652
1975	300882
1980	374290
1985	473635
1990	689848
1995	832703
2000	949559
2005	1155498
2007	1190963
2008	1256384
2009	1299143
2010	1370598
2011	1397313
2012	1442059
2013	1501556
2014	1556381

Table 4.1 indicates the city center population of Gaziantep between 1960 and 2014. City center increases about 1 432 284 between these time intervals.

4.1.2. Compound Interest Method

$$N_y = N_0(1+r)^t \tag{4.3}$$

Equation is about population calculation according to Compound Interest Method. Where No is the base population year of the study area, N_y is the present Population of the study area, r, is the reproduction coefficient, t is the time interval.

4.1.3. Geometric Method

$$N_1 = e^{lnN_y} \tag{4.4}$$

$$lnN_y = lnN_1 + K_y(t_y - t_1) \tag{4.5}$$

$$K_y = \frac{lnN_1 - lnN_0}{t_1 - t_0} \tag{4.6}$$

Equation is about population calculation according to Geometric method. Where N_1 is the base population year of the study area, N_y is the Population of 'y' year. 't_y' is the projection year, based year to increasing population, t_o, is the year 1945. K_y is the average population increase. N_o is the Population of 1945.

4.1.4. Exponential Regression Analysis

Regression analysis is designed for situations where a variable is associated with one or more measurements made on the same object. Purpose of analysis is using the observed values of the variables, the shape of the sought relationship, to estimate.

When two measurements are made on the same unit, they may be required to be examined together. The researcher, who shows these measurements as a scatter diagram, often asks the point on the diagram to line up in the best way. The evaluation of the methods is based on the determination coefficient (R^2) and the square root mean squared error (RMSE) given in equation (4.7) and (4.8).

$$R^2 = \frac{\sum_{t=1}^{N}[Nreal-Navr.]^2}{\sum_{t=1}^{N}[[Nreal-Nmet.]^2} \tag{4.7}$$

$$RMSE = \sqrt{(1/n)\sum_{t=1}^{N}[Nreal - Nmet.]^2} \tag{4.8}$$

4.1.5. Arithmetic Method

$$N_f = N_s + K_a(t_s - t_i) \tag{4.9}$$

$$K_a = \frac{(N_s - N_i)}{(t_s - t_i)} \tag{4.10}$$

Equation is about population calculation according to the Arithmetic method. Where Ni is the initial population year of the study area, Ns is the present Population of the study area, Ka, is arithmetic increase coefficient, Ts is the present year. Ti is the initial year. N_f is the future population of the study area.

4.1.6. Water Requirement

The domestic water demand is generally calculated by multiplying the requirement per capita with the population of a city and adding the amount needed by the industry, animals and fire requirements. The codes regarding the drinking and household water, in Turkey, are accomplished by Ilbank regulations. These regulations mandate that in cities with a population more than 500 000 the water demands per capita should be taken as 225lt/day. However, the city's unpredictable Syrian immigration, the rapidly developing industry, makes it more appropriate to prefer a safer value for water consumption values. According to this situation besides Ilbank regulation other population forecasting methods were utilized in calculations.

4.2. General Analysis

Performing hydrologic modeling involves delineating river basin boundary and getting some basic watershed properties. This includes the area of watershed, slope, flow length, and stream network density (Venkatesh, M., 2009). ArcGIS software it is main software to perform this study, with the availability of digital elevation models (DEM) and Arc Hydro extension tools in ArcGIS, watershed properties can be extracted by automatic procedures.

Methodology in this study it have three main processes. The first process in determining basin characteristics is executing terrain pre-processing models, namely, fills-sinks, flow direction, flow accumulation, stream networks and watershed boundary definition which are attained from digital elevation model (DEM) by ArcGIS hydrology tools. The process step is hydrological processing such as, map of sub-catchment, characteristics of sub-catchment, river network map and river network characteristics that have been delineated by employing Arc Hydro extension tools. The third step is accomplishing hydrological analysis; slope map (Figure 4.1).

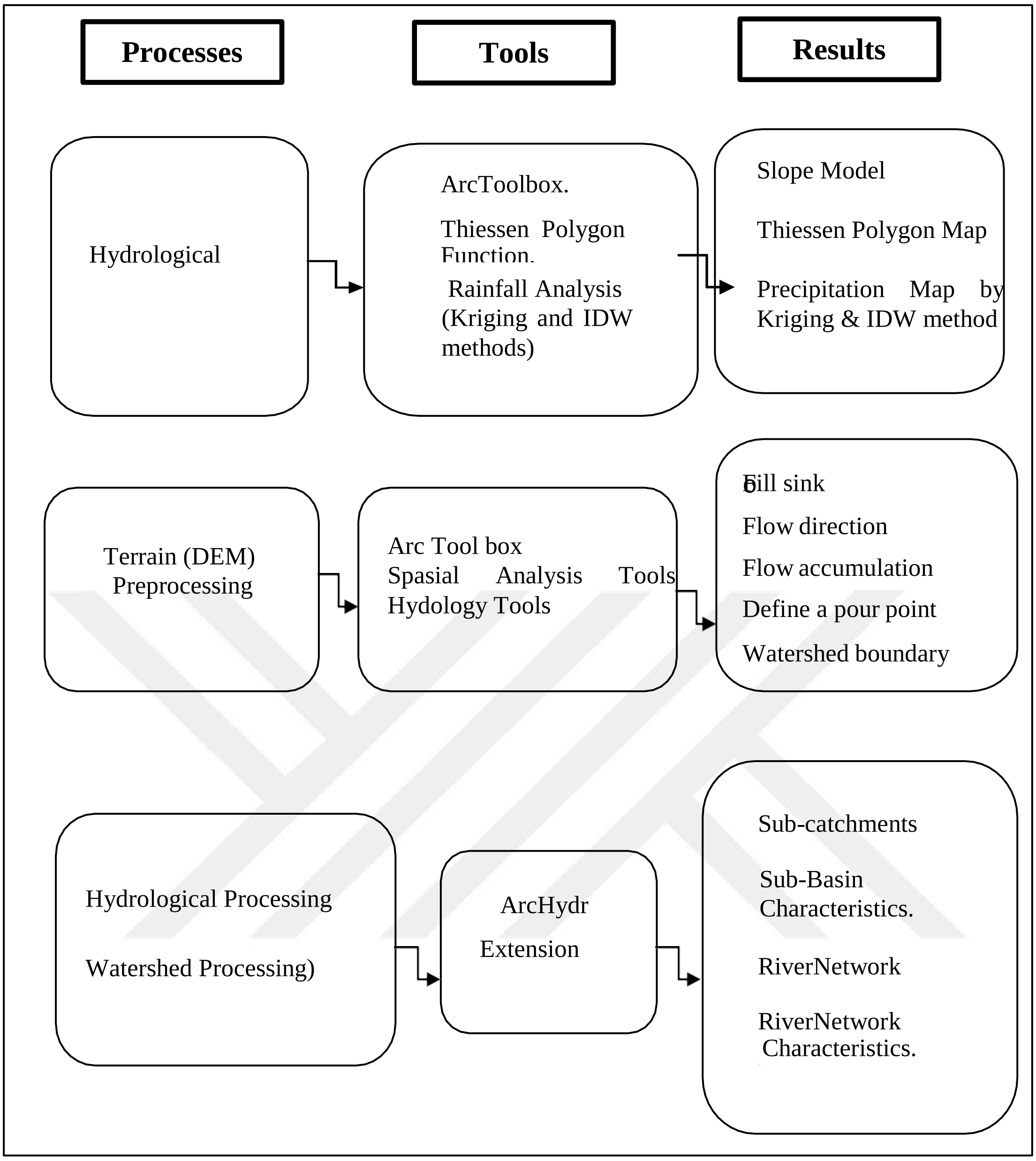


Figure 4.1 Methodology for the GIS processes

4.2.1. Software

ArcGIS software components which were used in this study to generate sets of digital maps for selected study area, the Göksu River Basin, were spatial analysis–Hydrology tools Arc-Map, Arc-Catalog, and Arc Hydro extension tools. The maps generated from SRTM 30m-DEM include drainage lines, river basin boundary, sub- catchments, and digital slope map. Explanation of each GIS function fragments are given below.

Arc-Hydro is a set of data models and tools that operates within ArcGIS to support geospatial and temporal data analyses. Use Arc Hydro to delineate and characterize watersheds in raster and vector formats, define and analyze hydro geometric networks, manage time series data, and configure and export data to numerical models (ESRI, 2009).

Arc-Map is the central application in ArcGIS Desktop. It is the GIS application used for all map-based tasks, including cartography, map analysis, and editing. In this application, you work with maps. Maps have a page layout containing a geographic window, or a data frame, with a series of layers, legends, scale bars, North arrows, and other elements. Arc Map offers different ways to view a map's geographic data and layout views in which you can perform a broad range of advanced GIS tasks (ESRI, 2009).

Arc-Catalog application helps you organize and manage all of your GIS information (maps, globes, datasets, models, metadata, services, and so on). It includes tools to: Browse and find geographic information. Record, view, and manage metadata. Define geo data base schemas and designs. Administer an ArcGIS Server. Search for and discover GIS data on local networks and the Web. GIS users apply Arc Catalog to organize, find, and use GIS data as well as to document their data holdings using standards-based metadata. A GIS database administrator uses Arc Catalog to define and build geo data bases. A GIS server administrator uses Arc Catalog to administer the GIS server framework (ESRI, 2009).

Arc-toolbox is an integrated application developed by Environmental Systems Research Institute (ESRI, 2009). It provides a reference to the toolboxes to facilitate user interface in ArcGIS for accessing and organizing a collection of geo processing tools, models and scripts. A tool box is a container which contains all the tools required to perform any advanced task in a particular domain. Similarly, Arc Toolbox is a container in which all the tools required to facilitate advanced Geoprocessing tasks are organized in a logical way. Arc-toolbox was utilized in this study in order to delineate the river basin of the Göksu Basin.

Creating GIS-linked Interface

Lots of software systems offer GIS decision-making capabilities. The important point to remember is that there are as many different types of GIS software systems as there are decision-making processes. The Intergraph Corporation's MGE/MGA system or ArcGIS (produced by the Environmental Systems Research Institute) have become well-known because they can be used in a wide number of applications. These general purpose systems also offer features that can be customized to meet various individual needs. SQL, C#, VBA, VB6, VB.NET, VC++ are some of the languages utilized in GIS. In this study it was considered to use these computer languages' in order to create GIS-linked interface. This process is considered to utilize in Hydrological applications in order to providing advice on domestic and international activities related to water programs that advance research, education, or training in water resources sciences or the application of water resources sciences to specific problems.

4.2.2. SRTM-DEM (Shuttle Radar Topography Mission)

Several radar satellite based DEMs like Shuttle Radar Topography Mission (SRTM- 30 m) is available for the public. The availability of shuttle radar based new topographic datasets has opened new venues for hydrologic and geomorphologic studies including analysis of surface morphology. The important application that has been widely used in surface hydrology modeling is the automatic extraction of the channel drainage network. Due to the increasing availability of grid DEMs, numerous research studies have been carried out to automate the extraction of drainage networks. In this study SRTM-DEM has been applied for all calculations.

4.2.3. Terrain Pre-processing

Terrain processing uses DEM to satisfy the surface drainage pattern. Once preprocessed, the DEM and its derivatives can be used for efficient watershed delineation and stream network generation. All the steps in the Terrain Preprocessing menu should be performed in sequential order, from top to bottom. All of the preprocessing must be completed before watershed processing function can be used. DEM reconditioning and filling sinks might not be required depending on the quality of the initial DEM. DEM reconditioning involves modifying the elevation data to be more consistent with the input vector stream. By doing the DEM reconditioning we can increase the degree of agreement between stream networks delineated from the DEM and the input vector stream (Abdullah, 2011) (Figure 4.2).

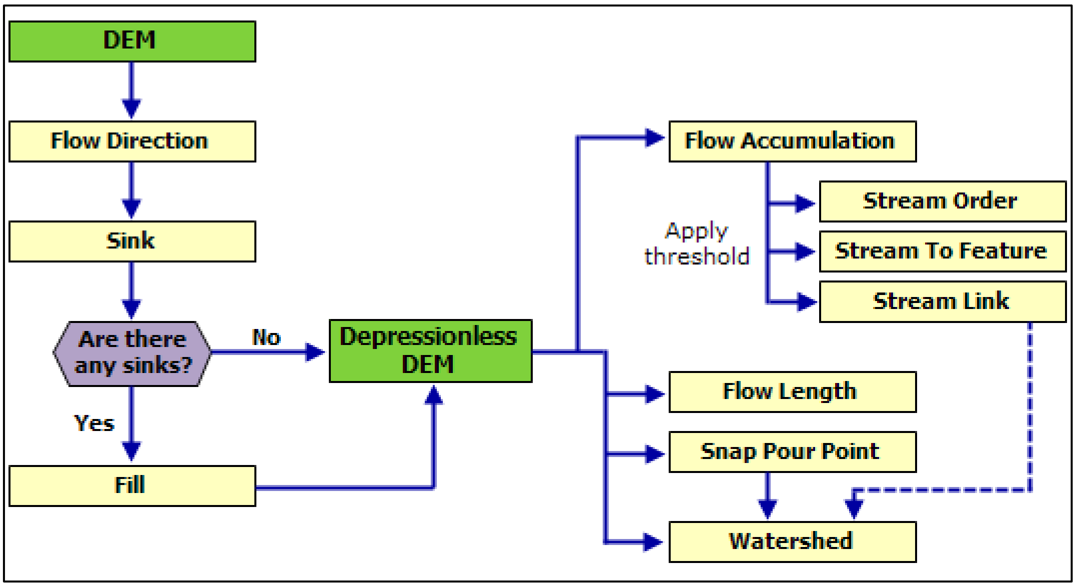


Figure 4.2 Flow chart of river basin boundary from DEM by ArcGIS

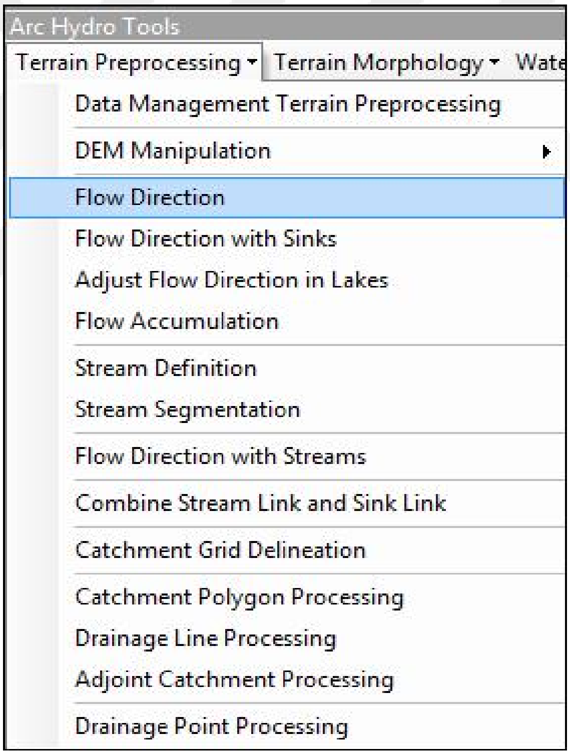


Figure 4.3 Steps of functions in hydrology tools

Flow direction, flow accumulation, stream definition are some of the process necessary for definition of river boundary (Figure 4.3).

4.2.4. Hydrological Processing

The hydrologic modeling tools in the ArcGIS Spatial Analyst extension toolbox provide methods for describing the physical components of a surface. The hydrologic tools allow you to identify sinks, determine flow direction, calculate flow accumulation, delineate watersheds, and create stream networks. The image below is of a resulting stream network derived from an elevation model.

First of all watershed boundary must be delineating by determining stream direction, calculating flow accumulation and also some other necessary steps for example area, slope, flow length and stream network density.

4.2.4.1. Hydrological processing by ArcHydro

Terrain Preprocessing uses DEM (digital elevation model) to identify the surface drainage pattern. Once preprocessed, the DEM and its derivatives can be used for efficient watershed delineation and stream network generation.

The steps in the Terrain Preprocessing menu should be performed in sequential order, from top to bottom. The processes to use depend on the type and quality of the initial DEM. Processing must be completed before Watershed Processing functions can be used.

It is important to fill the sinks before starting terrain processing steps, because it makes water depressions and the necessary water does not flow to the river, which gives errors while calculating flow accumulation and flow direction. Sinks are filled by clicking on Fill Sinks in the Terrain Pre-processing menu. The output of Hydro DEM is 'Fill' as shown in (Figure 4.4).

DEM: DEM

Hydro DEM: Filled

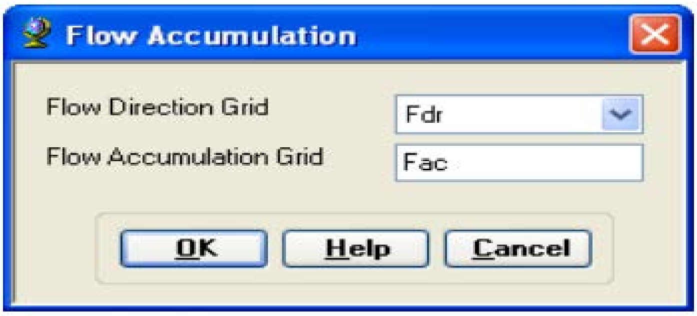
Figure 4.4 Filling sinks in ArcHydro

The flowing step is flow direction; this function computes the flow direction for a given grid. The values in the cells of the flow direction grid indicate the direction of the steepest descent from that cell. The function Flow Direction with Sinks may be used instead to process a DEM with known sinks. This step generated by selecting Flow Direction in the Terrain Pre-processing menu and then inputting sink-filled DEM as Hydro DEM for processing (Figure 4.5).

Hydro DEM: Fil
Outer Wall Polygon: Null
Flow Direction Grid: Fdr

Figure 4.5 Flow direction step in ArcHydro

The next step is Flow Accumulation. This function computes the flow accumulation grid that contains the accumulated number of cells upstream of a cell, for each cell in the input grid. For using the totally filled DEM to generate the flow accumulation as the area being processed in the tutorial is dendritic and does not have sinks. This step is generated by selecting Flow direction in Terrain Pre-processing (Figure 4.6).



Flow Direction Grid: Fdr
Flow Accumulation Grid: Fac

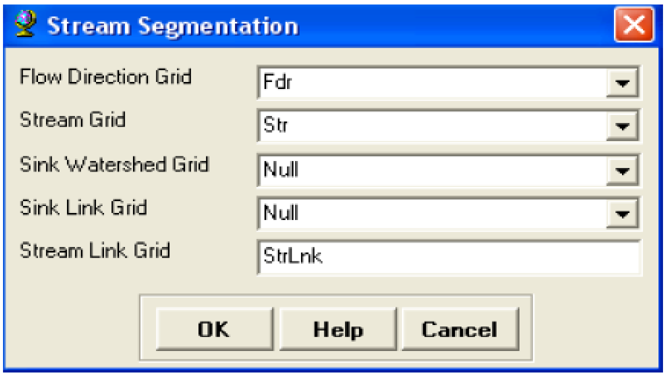
Figure 4.6 Flow accumulation step in ArcHydro

After determining the Flow Accumulation Grid, the next step is obtaining the stream definition. This function computes a stream grid based on a flow accumulation grid and a user specified threshold. The cells in the input flow accumulation grid that have a value greater than the threshold are assigned a value of 1 in the stream grid. All other cells are assigned no data (Figure 4.7). This is accomplished by selecting Terrain Pre-processing, then the Stream definition option. A default value is displayed for the river threshold. This value represents 1% of the maximum flow accumulation: it is the recommended threshold for stream determination. Note that these streams are used to prepare preprocessed data that will help speed up point delineation. These streams do not need to be meaningful or representative of existing streams. Any other value of threshold can be selected. Smaller threshold will result in denser stream network and usually in a greater number of delineated catchments, which may hinder delineation performance (ESRI, 2016).

Flow Accumulation Grid: Fac
Stream Grid: Str

Figure 4.7 Stream definition step in ArcHydro

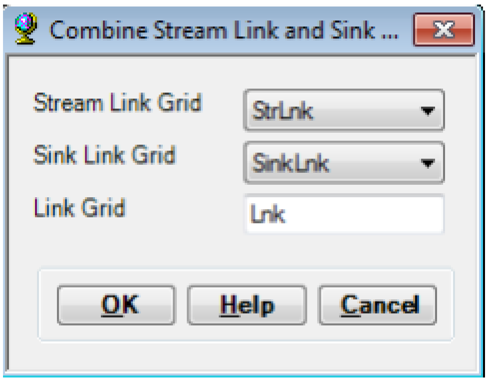
The next step is stream segmentation. This function creates a grid of stream segments that have a unique identification. A segment may either be a head segment, or it may be defined as a segment between two segment junctions. All the cells in a particular segment have the same grid code that is specific to that segment. The input Sink Watershed Grid and Sink Link Grid are optional and may be used to mask the input stream grid so that no stream links are created in those areas. This step created by selecting Stream segmentation in Terrain Pre-processing (Figure 4.8).



Flow Direction Grid: Fdr
Stream Grid: Str
Sink Watershed Grid: Null
Sink Link Grid: Null
Stream Link Grid: StrLnk

Figure 4.8 Stream segmentation step in ArcHydro

The next step is combine stream link. This function creates a link grid combining the stream link grid representing dendritic areas and the sink link grid representing deranged areas (i.e. areas with sinks). The Link grid is used to generate catchments – one catchment will be created for each link and will represent the area draining into that link. Applying this step it necessary to select terrain processing then combine stream link and Sink link (Figure 4.9).


Combine Stream Link and Sink ...

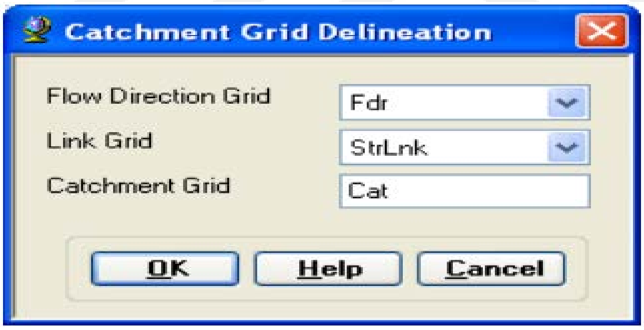
Stream Link Grid: StrLnk

Sink Link Grid: SinkLnk

Link Grid: Lnk

Figure 4.9 Combine stream link and sink link step in ArcHydro

The next step is catchment grid delineation. This function creates a grid in which each cell carries a value (grid code) indicating to which catchment the cell belongs. The value corresponds to the value carried by the stream segment or sink link that drains that area, defined in the input stream segment link grid (Stream Segmentation) or sink link grid (Sink Segmentation). It is important to use the Stream Link generated using the Stream Segmentation function. This step is generated by selecting Combine stream link in Terrain Pre-processing (Figure 4.10).


Catchment Grid Delineation

Flow Direction Grid: Fdr

Link Grid: StrLnk

Catchment Grid: Cat

Figure 4.10 Catchment grid delineation step in ArcHydro

Next step is Catchment Polygon Processing; this function converts a catchment grid it into a catchment polygon feature class (Figure 4.11). The Terrain Pre-processing tool in Arc Hydro delineates the catchment area into sub-basins, which further enhances the profound watershed analysis. Also it is possible to use Raster to polygon process in ArcGIS, Arc toolbox, conversion tool and Raster to polygon steps must be applied for using this function.

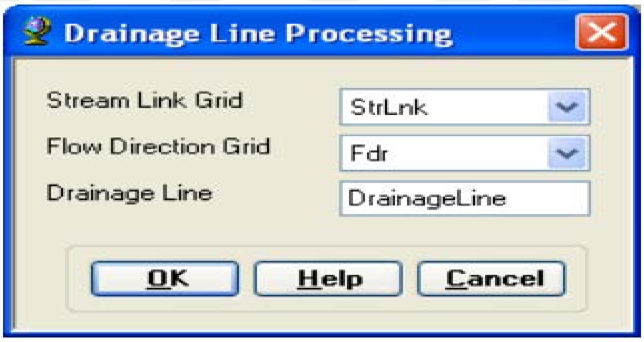

Catchment Polygon Proces...

Catchment Grid: Cat

Catchment: Catchment

Figure 4.11 Catchment polygon processing

The next step is Drainage Line Processing. This function converts the input Stream Link grid usually created with the Stream Segmentation function into a Drainage Line feature class. Each line in the feature class carries the identifier of the catchment in which it resides. Note that the function Flow Direction with Streams also generates the Drainage Line feature class based on the input Stream feature class. In order to use this function select terrain processing then applies Drainage Line processing (Figure 4.12).


Drainage Line Processing

Stream Link Grid: StrLnk

Flow Direction Grid: Fdr

Drainage Line: DrainageLine

Figure 4.12 Drainage line processing

The next step is Adjoint Catchment Processing. This function generates the aggregated upstream catchments from the "Catchment" feature class. For each catchment that is not a head catchment, a polygon representing the whole upstream area draining to its inlet point is constructed and stored in a feature class that has an "Adjoint Catchment" tag. This feature class is used to speed up the point delineation process (Figure 4.13).

Adjoint Catchment Processing

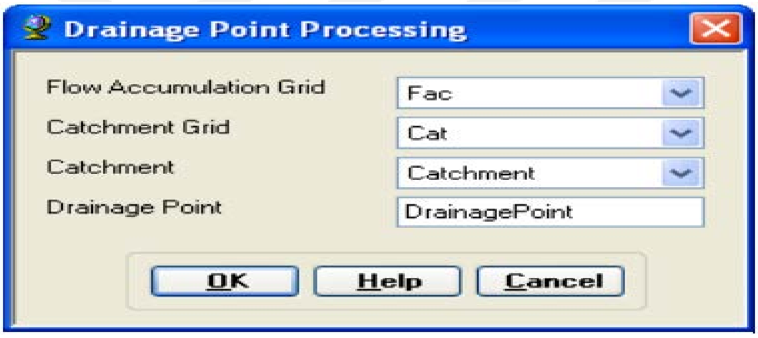
Drainage Line: DrainageLine

Catchment: Catchment

Adjoint Catchment: AdjointCatchment

Figure 4.13 Adjoint catchment processing

The next step is Drainage Point Processing. This function allows generating the drainage points associated to the catchments. Confirm that the input to Drainage Line is “Drainage_Line”, and the input to Catchment is “Catchment”. The output is Drainage Point, having the default name “Drainage_Point” that can be overwritten (Figure 4.14).



Drainage Point Processing

Flow Accumulation Grid: Fac

Catchment Grid: Cat

Catchment: Catchment

Drainage Point: DrainagePoint

Figure 4.14 Drainage point processing

The last steps are Longest Flow Path and Flow Path Adjoint Catchments. These functions allow generating the longest flow paths associated to the catchments. But these steps are time-consuming. If you do not plan to generate these types of features you may skip these steps as well as the next one. Other function is Slope function. This function allows generating a slope grid in percent or degree for a given DEM. Confirm that the input to Raw DEM is an unprocessed DEM and specify the type of slope grid to create (slope in percent or in degree).

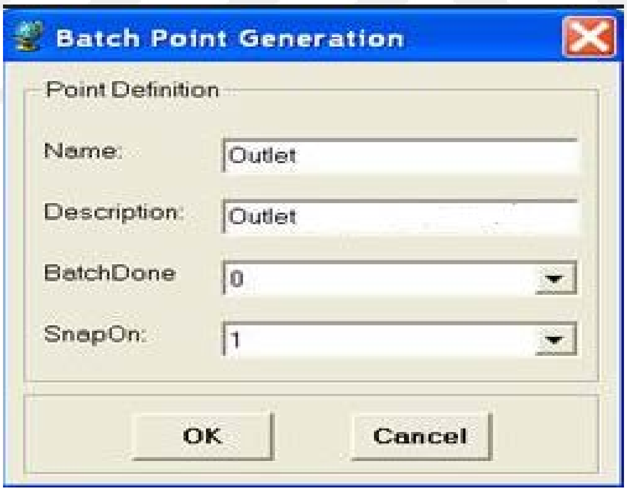
4.3. Hydrological Process (Watershed Processing)

The steps in Terrain Preprocessing need to be performed before the watershed delineation functions may be used. The preprocessing functions partition terrain into manageable units to allow fast delineation operations.

4.3.1. Batch Watershed Delineation

It specifies the water collection area located at the entrance of a given point (Batch point). Flow Accumulation, Catchment and Drainage Line data sets should be on the screen. Catchment a single cell is determined by enlarging the discharge segment of the field as shown below. The purpose here is to determine the point that runs the water in the water collection area.

When the discharge point is determined and the Batch Point Generation key is pressed, Feature table is created. It is confirmed that the file name is Batch Point in the point creation (Figure 4.15).



Name: Outlet
Description: Outlet
BatchDone 0
SnapOn: 1

Figure 4.15 Batch point generation

The next step is Batch watershed delineation. The data for the domains are entered using the outputs from the previous operations as shown below. Watershed and Watershed Point are output files (Figure 4.16).

Batch Point: BatchPoint
Flow Direction Grid: Fdr
Stream Grid: Str
Snap Stream Grid: Str
Catchment: Catchment
Adjoint Catchment: AdjointCatchment
Watershed: Watershed
Watershed Point: WatershedPoint

Figure 4.16 Batch watershed delineation

When Batch watershed delineation is applied the output watershed will be appeared on the screen. This output is compatible with DEM and other acquired data it will be.

4.3.2. Reservoir Estimation by GIS

In the places where the rainfall regime like our country is not proper time and space, the construction of the storage facilities is important in terms of management of water resources in terms of management of the water resources in the places where the rainfall regime like Turkey is not proper time and space. For this reason, it is necessary to transfer the water to the month, the season, the year, the year when the streams are abundant, the water is scarce, the month, the season and the years. This is done through the construction of storage facilities.

First of all, the current values of the river and the amount of water needed are evaluated together to determine the volume of water to be stored depending on the maximum water level and the water level by various methods so that the water needs can be met economically.

In this study, reservoir volume was calculated according to the determined water level (Güreşçi et. al., 2012).

From the Arc Toolbox menu; The Spatial Analyst Tools → Surface → Contour List command is selected. The "DEM" file obtained in the Input raster option is used as input. The folder in which the output file "Active Volume" is to be recorded is specified in the Output Polyline Feature field. Since the output file is in the vector property, create a personal geo database before doing this (dam.mdb). Contour values are entered as according to the maximum water depth of the dam is in meter. The maximum water level will be obtained as contour line. To draw the active volume area, a feature class with the polygon name "Active volume_a" is created. After the axle location is determined, the trace is commanded over the water feature of the line feature and the lines are closed at the axle location and the polygon showing the dam lake area is obtained (Güreşçi et al., 2012). From the Arc Toolbox menu; Spatial Analyst Tools → Extraction → Extract by Mask command is selected. In the input raster option "DEM" file is used as input. In order to cut off the lake area covered by the active volume from this raster, the feature mask data field "Active volume_a" is entered. In the output raster case, the output file will be "active_volume_r". The lake area is created with this step. To find the volume below the maximum water level From the Arc Toolbox menu; 3D Analyst Tools → Functional Surface → Surface Volume command is selected. In the input surface option, the "active_volume_r" file is used as input. In the output text file field, the output file will be "active volume.txt". "BELOW" is selected in the "Reference Plane" case, since we will calculate the maximum volume below the maximum height. In the case of "Plane Height", the maximum water depth. Finally the outputs are generated. Dataset, Plane_Height, Reference, Z_Factor, Area_2D, Area_3D, Volume.

4.3.3. Estimation of Rainfall Distribution by IDW and Kriging Interpolation Method

IDW and Kriging Interpolation Method were modeling in this study in order to estimate the long term rainfall of study area and its close region. The aim of this step is to compare IDW and Ordinary Kriging (OK) methods based on error estimation in rainfall distribution.

4.3.3.1. IDW

IDW is one of the most common techniques for interpolation of scatter points. IDW has a fundamental assumption that the interpolating surface should be influenced most by the nearby points and less by the more distant points. The interpolating surface is a weighted average of the scatter points, and the weight assigned to each scatter point diminishes as the distance from the interpolation point to the scatter point increases. The values to unknown points are calculated with a weighted average of the values available at the known points (Shahbeik et al., 2013).

4.3.3.2. Kriging interpolation method

The Kriging method has been used for Geostatistical interpolation and has been proved to be sufficiently huge for estimating values at unsampled locations based on the sampled data (Bijanzadeh et al., 2014). Kriging is a group of geostatistical methods for interpolation of the different regional variables' values at an unobserved location from observations of its value at nearby locations, which consist of OK, universal kriging, indicator kriging, co-kriging, and others (Bayraktar and Turalioğlu, 2005). The ordinary kriging method is one of the kriging methods, which plays an important role in interpolation and mapping precipitation data in any region. OK plays a special role because it is compatible with a stationary model, only involves the variogram, and is in fact the form of kriging that is most often used. The most popular and efficiency method types in Kriging is Ordinary Kriging. Ordinary Kriging was utilized in this study.

4.3.3.3. Determining of rainfall for drainage area using Thiessen Polygon method with GIS

Precipitation, which is the main source of water, is measured at precipitation stations and represents the measurement point rather than a specific area. However, it is necessary to know the spatial distribution of the rainfall during the studies. This study describes an application of Thiessen's method with ArcGIS 10, which was developed for the calculation of average areal precipitation in any drainage area. In the Thiessen Method there are influence zones of rainfall stations. These effect polygons are defined geometrically and the amount of precipitation in that polygon of the station is considered homogeneous. Triangles formed from stations close to each other are plotted in the middle sidewalls of the triangles, and the effect stations of the rain stations are found. The ratio of the effect polygon area to the total drainage area within a station's drainage area gives the impact weight of that station. The resulting impact weight is multiplied by the rainfall value of the station, indicating the total rainfall value per impacting polygon (Güreşçi et al., 2012).

CHAPTER 5

RESULTS & DISCUSSION

5.1. Population Forecasting

5.1.1. Population of Gaziantep Province According to Arithmetic Increase Method

When arithmetic growth coefficients are calculated in accordance with the population census results of 1960, the values are derived as shown in Table 5.1 and population forecasting in previous years, R^2 was calculated as 0.9710; value of RMSE was found as 75.566 people.

Table 5.1 Ka coefficients calculated in reference to 1960 and population forecasting of previous years according to arithmetic method

Year	Turkish Statiststical Institute Population census	In reference to 1960, (Ka) values	(Ka)max	Estimated populations in accordance with arithmetic method	R^2	RMSE (people)
1960	124097	-	-	-	0.9710	75.566
1965	160012	7183	7183	-		
1970	227652	10355.55	10355.55	195927		
1975	300882	11785.66	11785.66	279429		
1980	374290	12509.65	12509.65	359810		
1985	473635	13981.52	13981.52	436838		
1990	689848	18858.36	18858.36	543542		
1995	832703	20245.88	20245.88	784139		
2000	949559	20636.55	20636.55	933932		
2007	1190963	22699.27	22699.27	1094014		
2008	1256384	23589.31	23589.31	1213662		
2009	1299143	23980.53	23980.53	1279973		
2010	1370598	24930.02	24930.02	1323123		
2011	1397313	24965.02	24965.02	1395528		
2012	1442059	25345.42	25345.42	1422278		
2013	1501556	25989.79	25989.79	1467404		
2014	1556381	26523.77	26523.77	1527545		
2015	1626985	27325.23	27325.23	1582904		

5.1.2. Population of Gaziantep Province According to Geometric Increase Method

When geometric increase coefficients were calculated in reference to population census results of 1965, the values were derived from calculations as shown in Table 5.2 for population forecasting in previous years, R^2 was calculated as 0.9834; value of RMSE was found as 41.378 people.

Table 5.2 Kg coefficients calculated in reference to 1960 and population forecasting of previous years according to geometric method

Year	Turkish Statiststical Institute Population census	In reference to 1960, (Kg) values	(Kg)max	Estimated populations in accordance with geometric method	R^2	RMSE (people)
1960	124097	-	-	-	0.9834	41.378
1965	160012	0.0508	0.0508	-		
1970	227652	0.0606	0.0606	206901		
1975	300882	0.0590	0.0590	308337		
1980	374290	0.0552	0.0552	404210		
1985	473635	0.0535	0.0535	493253		
1990	689848	0.0571	0.0571	619127		
1995	832703	0.0543	0.0543	918160		
2000	949559	0.0508	0.0508	1092934		
2007	1190963	0.0481	0.0481	1355751		
2008	1256384	0.0482	0.0482	1249668		
2009	1299143	0.0479	0.0479	1318461		
2010	1370598	0.0480	0.0480	1362922		
2011	1397313	0.0474	0.0474	1438046		
2012	1442059	0.0471	0.0471	1465250		
2013	1501556	0.0470	0.0470	1511708		
2014	1556381	0.0468	0.0468	1573879		
2015	1626985	0.0467	0.0467	1631006		

5.1.3. Population of Gaziantep Province According to İlbank Method

When they were calculated in accordance with İlbank method, the values were derived from calculations as shown in Table 5.3 and population forecasting in previous years, R^2 was calculated as 0.9834; value of RMSE was found as 41.169 people.

Table 5.3 Multiplication factors of ilbank calculated in reference to 1960 and population forecasting of previous years according to ilbank method

Year	Turkish Statiststical Institute Population census	In reference to 1960, (Ç) values	(Ç)max	Population in accordance with İlbank method	R^2	RMSE (people)
1960	124097	-	-	-	0.9834	41.169
1965	160012	5.21	3	-		
1970	227652	6.25	3	206270		
1975	300882	6.08	3	308259		
1980	374290	5.67	3	404210		
1985	473635	5.50	3	493253		
1990	689848	5.88	3	619127		
1995	832703	5.59	3	917958		
2000	949559	5.21	3	1092959		
2007	1190963	4.93	3	1355751		
2008	1256384	4.94	3	1249668		
2009	1299143	4.90	3	1318461		
2010	1370598	4.92	3	1362922		
2011	1397313	4.86	3	1438046		
2012	1442059	4.83	3	1465250		
2013	1501556	4.81	3	1511708		
2014	1556381	4.79	3	1573879		
2015	1626985	4.79	3	1631006		

5.1.4. Population of Gaziantep Province According to Regression Analysis

In Figure 5.1, the population distribution of Gaziantep city center (1960-2015) is shown in graphic. When population distribution values are analyzed in accordance with regression analysis method, for many years; it has been seen that the most appropriate method is exponential regression analysis method which provides the best adaptation with trend line among linear, logarithmic, polynomial, moving average and exponential regression methods. The derived values in accordance with exponential regression method have shown in Table 5.4 and population forecasting in previous years, R^2 was calculated as 0.9958; value of RMSE was found as 26.504 people.

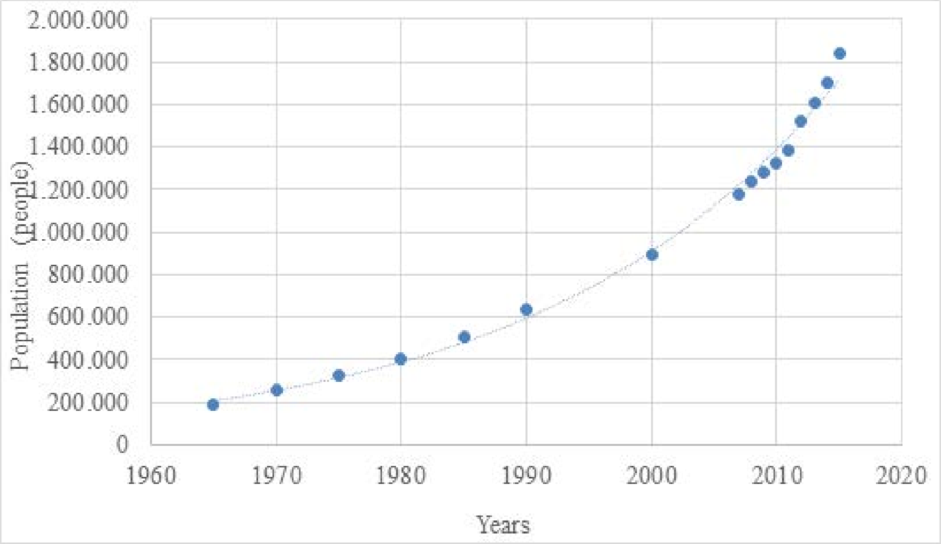


Figure 5.1 The population distribution of Gaziantep city center by years

Table 5.4 Population forecasting of the past years according to exponential regression analysis method

Year	Turkish Statiststical Institute Population census	The Results of Exponential Regression Analysis (people)	R^2	RMSE
1960	124097	-	0.9958	26.504
1965	160012	-		
1970	227652	152.643		
1975	300882	188.690		
1980	374290	233.249		
1985	473635	288.330		
1990	689848	356.418		
1995	832703	440.586		
2000	949559	673.243		
2007	1190963	905.879		
2008	1256384	945.115		
2009	1299143	986.049		
2010	1370598	1.028.757		
2011	1397313	1.073.314		
2012	1442059	1.119.801		
2013	1501556	1.168.302		
2014	1556381	1.218.903		
2015	1626985	1.271.696		

5.2. Population Projection and Water Need of Gaziantep City Center

For population forecasting in previous years, according to the derived values of R^2 and RMSE, it has seen that the most appropriate method for population forecasting is exponential regression analysis method and population forecasting for the future has been made by this method.

In calculations for Gaziantep province, it has seen that water consumption per person is 105 lt/capi/day (70.070.540 (total water consumption) /1.842.368 (population of city center) /365(days) =105 lt/capi/day). However, unpredictable Syrian migration to the city and rapidly developing industry makes it more appropriate to prefer a safer value for water consumption values. It has been utilized in calculations 225 liters water which is the daily water consumption value per person according to İlbank's estimation and population forecasting and water need until 2050 have shown in Table 5.5.

Table 5.5 Gaziantep city center, population projection and estimated water need according to population of Gaziantep city center

Year	According to exponential regression analysis, estimated population	Estimated water need (m^3/year)
2016	1.326.775	108.961.437
2017	1.384.240	113.680.744
2018	1.444.194	118.604.453
2019	1.506.744	123.741.416
2020	1.572.004	129.100.869
2021	1.640.090	134.692.450
2022	1.711.125	140.526.212
2023	1.785.237	146.612.644
2024	1.862.559	152.962.690
2025	1.943.230	159.587.767
2026	2.027.394	166.499.788
2027	2.115.204	173.711.180
2028	2.206.817	181.234.910
2029	2.302.398	189.084.505
2030	2.402.119	197.274.081
2031	2.506.159	205.818.360
2032	2.614.705	214.732.708
2033	2.727.953	224.033.150
2034	2.846.105	233.736.412
2035	2.969.375	243.859.938

2036	3.097.983	254.421.931
2037	3.232.162	265.441.382
2038	3.372.153	276.938.105
2039	3.518.207	288.932.771
2040	3.670.586	301.446.946
2041	3.829.566	314.503.132
2042	3.995.431	328.124.804
2043	4.168.480	342.336.453
2044	4.349.024	357.163.634
2045	4.537.388	372.633.005
2046	4.733.910	388.772.382
2047	4.938.944	405.610.782
2048	5.152.858	423.178.483
2049	5.376.037	441.507.071
2050	5.608.882	460.629.501

5.2.1. Düzbağ Dam Water Capacity

It has planned that the Düzbağ Dam, which is considered to meet drinking and utility water needs of the city center of Gaziantep for the long term, is located 4 km away from the Kahramanmaraş - Helete (Düzbağ) town, on the Göksu River which is the tributary of the Euphrates River by DSİ. Estimated water need according to population forecasting has been taken into account in order to determine the water quantity which will be taken from the dam. The data on water flow level for many years (from 1984 to 2013) has been taken from the D21A262- Düzbağ Flow Measurement Station (FMS) which is operated at water-well of the Göksu River, has been utilized to estimate the water capacity of the dam (Table 5.6). Due to missing observed values for 1988, observed value has been estimated via correlation with daily water flow level observations of D21A262 Ardıl Stream- D21A187 Ardıl Water Flow Measurement Station.

Table 5.6 Observed water flow measurements of D21A262 station

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	August	Sept	Av.
1984	6.00	9.10	13.7	11.5	17.6	26.5	23.2	15.1	10.1	7.98	6.45	5.32	12.71
1985	4.43	5.52	4.89	8.35	13.4	19.50	25.8	17.0	6.64	5.30	5.92	3.89	10.05
1986	5.46	5.51	6.44	13.7	13.3	19.50	11.5	7.90	6.11	4.26	3.23	2.93	8.32
1987	3.79	5.07	5.60	11.9	18.9	26.20	51.3	26.3	14.4	10.2	7.98	6.88	15.71
1988*	**3.49**	**4.88**	**11.3**	**4.11**	**8.92**	**17.0**	**32.9**	**22.28**	**8.97**	**6.65**	**4.79**	**4.01**	**10.78**
1989	3.65	4.40	7.00	4.87	4.67	12.80	9.64	7.14	5.75	4.37	3.68	3.33	5.94
1990	3.71	8.30	12.4	10.2	12.5	21.50	15.4	10.6	8.00	6.64	5.41	4.75	9.95
1991	4.31	4.33	5.43	4.49	6.07	15.50	14.5	7.71	6.23	5.21	4.31	3.99	6.84
1992	3.86	4.95	9.51	8.29	7.28	22.20	34.4	22.2	10.9	6.95	6.47	5.39	11.87
1993	5.41	6.65	12.5	7.08	9.1	26.00	48.3	36.5	17.0	11.5	9.61	7.57	16.43
1994	7.30	6.57	6.33	11.5	15.1	22.40	19.1	11.2	8.14	6.33	4.47	4.50	10.24
1995	4.80	5.28	6.57	13.6	14.3	27.90	35.9	18.6	11.8	8.87	7.13	6.00	13.40
1996	5.65	8.12	6.64	27.8	24.0	54.60	58.6	31.4	16.6	11.9	9.37	7.65	21.86
1997	8.81	9.44	18.6	18.0	11.9	11.30	30.0	20.1	11.70	7.97	6.26	4.59	13.22
1998	4.58	10.8	18.4	12.3	17.0	27.4	42.8	17.9	9.16	7.14	5.82	5.51	14.90
1999	4.56	4.67	16.5	13.4	23.7	22.5	22.4	11.6	8.04	5.92	4.72	4.51	11.88
2000	3.70	3.68	3.86	6.48	8.20	21.5	34.8	14.0	8.69	6.16	4.95	4.23	10.02
2001	3.93	3.54	3.89	5.56	5.33	10.4	9.10	7.79	5.81	4.17	3.53	2.89	5.49
2002	3.08	3.51	29.0	19.4	20.6	37.5	45.4	18.4	11.1	8.3	6.67	5.74	17.39
2003	5.20	4.54	4.40	5.30	7.57	23.0	53.8	17.9	11.3	8.03	6.5	5.80	12.78
2004	5.11	4.79	6.99	11.2	16.8	45.4	24.0	14.2	8.15	6.44	5.15	4.75	12.74
2005	3.65	4.47	3.95	3.76	7.23	24.0	16.4	11.0	6.78	5.15	4.13	3.48	7.83
2006	3.18	3.92	3.96	3.64	12.3	26.1	21.5	12.8	8.71	6.12	4.1	3.85	9.18
2007	3.99	10.3	4.46	3.23	5.08	15.6	12.0	9.46	6.18	4.72	4.14	3.18	6.86
2008	3.35	3.47	5.20	3.18	4.43	25.2	11.7	6.91	5.01	3.99	2.92	3.06	6.53
2009	2.68	2.62	2.53	2.96	11.0	23.0	23.7	12.6	7.33	5.53	4.18	3.33	8.45
2010	2.78	6.11	18.5	43.4	26.5	23.5	15.1	10.7	7.10	5.88	4.22	3.60	13.94
2011	3.58	3.06	6.01	4.43	14.1	30.0	29.5	20.1	11.0	7.33	6.36	5.83	11.77
2012	4.35	4.20	3.27	5.74	5.25	19.1	37.8	17.4	10.3	7.78	6.88	4.87	10.57
2013	3.89	3.55	18.1	16.0	25.0	25.5	19.4	15.1	10.1	6.61	5.35	5.24	12.82
Total Av.													11.34

When the flow rate values of many years are considered, the average flow rate is 11.34 m^3/s. Maximum average flow rate has been observed in 1996 water year and minimum average flow rate has been observed in 2001 water year. The dam has been planned to complete in 2023. Even if the current total water supply flow rate is 6 m^3/s, (189 million m^3/year) the actual water need of the city is 125 million m^3/year. Pumping efficiency and working times have been adjusted in accordance with this efficiency. The seepage loss is also another important parameter for water need projection. It has been accepted that seepage loss rate is approximately 55 % in the current situation, until 2050 it will be reduced to about 30 %, zoning in the system. The 30% as seepage loss rate will be a significant standard in international norms for Gaziantep province. Until Düzbağ Dam is activated, the flow rate of Düzbağ regulator and water distribute line is estimated 5 m^3/s.

When Kartalkaya Dam’s flow rate (4 m^3/s) is considered, the flow rate of water distribute is on the safe side. When the Düzbağ dam is activated, the flow rate of water distribute is 7.50 m^3/s and 245.520.00 m^3 water will be able to supply per year. The amount of water considered to be taken from the dam is given in Table 5.8 when Table 5.7 is examined, according to the current situation, it is necessary to operate the dam in 2020 and the dam will be sufficient until 2044. Also at Table 5.9 it has seen that according to %30 water loss in city network and subscriber counters, (598 million m^3) water is necessary for Gaziantep province at 2050.

Table 5.7 Water quantity from Düzbağ dam according to population forecasting

Year	Estimated Water Need (m^3)	Water quantity from current water resources (m^3)	Estimated water quantity from dam (m^3)
2016	108.961.437	125.000.000	-
2017	113.680.744	125.000.000	-
2018	118.604.453	125.000.000	-
2019	123.741.416	125.000.000	-
2020	129.100.869	125.000.000	4.100.869
2021	134.692.450	125.000.000	9.692.450
2022	140.526.212	125.000.000	15.526.212
2023	146.612.644	125.000.000	21.612.644
2024	152.962.690	125.000.000	27.962.690
2025	159.587.767	125.000.000	34.587.767
2026	166.499.788	125.000.000	41.499.788
2027	173.711.180	125.000.000	48.711.180
2028	181.234.910	125.000.000	56.234.910
2029	189.084.505	125.000.000	64.084.505
2030	197.274.081	125.000.000	72.274.081
2031	205.818.360	125.000.000	80.818.360
2032	214.732.708	125.000.000	89.732.708
2033	224.033.150	125.000.000	99.033.150
2034	233.736.412	125.000.000	108.736.412
2035	243.859.938	125.000.000	118.859.938
2036	254.421.931	125.000.000	129.421.931
2037	265.441.382	125.000.000	140.441.382
2038	276.938.105	125.000.000	151.938.105
2039	288.932.771	125.000.000	163.932.771
2040	301.446.946	125.000.000	176.446.946
2041	314.503.132	125.000.000	189.503.132

2042	328.124.804	125.000.000	203.124.804
2043	342.336.453	125.000.000	217.336.453
2044	357.163.634	125.000.000	232.163.634
2045	372.633.005	125.000.000	247.633.005
2046	388.772.382	125.000.000	263.772.382
2047	405.610.782	125.000.000	280.610.782
2048	423.178.483	125.000.000	298.178.483
2049	441.507.071	125.000.000	316.507.071
2050	460.629.501	125.000.000	335.629.501

Table 5.8 R^2 and RMSE values of the methods of population forecasting

Method of Population Forecasting	R^2	RMSE (people)
Arithmetic Method	0.9710	75.556
Geometric Method	0.9834	41.378
İlbank Method	0.9834	41.169
Exponential Regression Analysis Method	0.9958	26.504

Table 5.9 Water need in accordance with population forecasting and consumption

Year	Water need according to population forecasting (m^3)	Water need according to consumption-in order to %30 water loss (m^3)
2020	129.100.869	167.831.129
2030	197.274.081	256.456.305
2040	301.446.946	391.881.029
2050	460.629.501	598.818.351

5.3. GIS-linked Interface

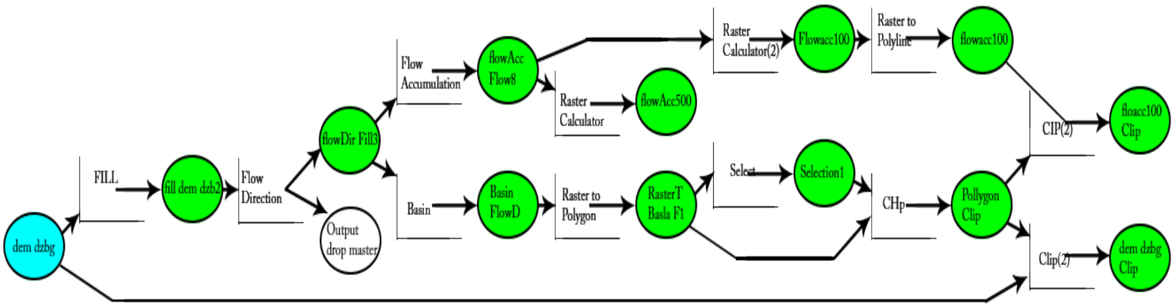


Figure 5.2 GIS-linked interface

Model Builder is an implementation that applied to create, edit, and manage models. Models are workflows that string together sequences of geoprocessing tools, feeding the output of one tool into another tool as input. ModelBuilder can also be thought of as a visual programming language for building workflows. Model can be also used to integrate other applications. With this applications user can create their own model with toolbox in ArcGIS. ModelBuilder is an easy application for creating and running workflows containing a sequence of tools. In this study SRTM-30m DEM was utilized in workflows. Firstly, Düzbağ DEM was clipped in Turkey DEM for delineating the boundaries of the watershed. Then other necessary steps were applied to clipped DEM consequently watershed was created. With this new model users can be delineate the watershed with one step. This model can be used in Python scripting and other models. Furthermore, this model is user friendly when considering the wasting of time. Model can be used for all watershed applications in order to delineating the watershed easily.

5.4. Terrain (DEM) Pre-processing

Digital elevation model (DEM) is the digital representation of the earth surface terrain. It is an essential component in the hydrological models. The DEM is significant to calculate both topographic parameters such as slopes, slope length and shape and aspects as well as hydrologic parameters such as flow direction, flow accumulation, watershed delineation, stream networks, and flow length (El-Magd et. al., 2010). Terrain Pre-processing uses digital elevation model (DEM) of the study area in order to identify the boundary of the Göksu River Basin as a necessity for the hydrological processing (Figure 5.3), shows the digital elevation model which covers an area larger than the Göksu River Basin. Other necessary steps were applied by using fill sink, Flow direction, flow accumulation, stream definition, pour point and delineated watershed commands in arc map 10.4 (Figures 5.3 – 5.7).

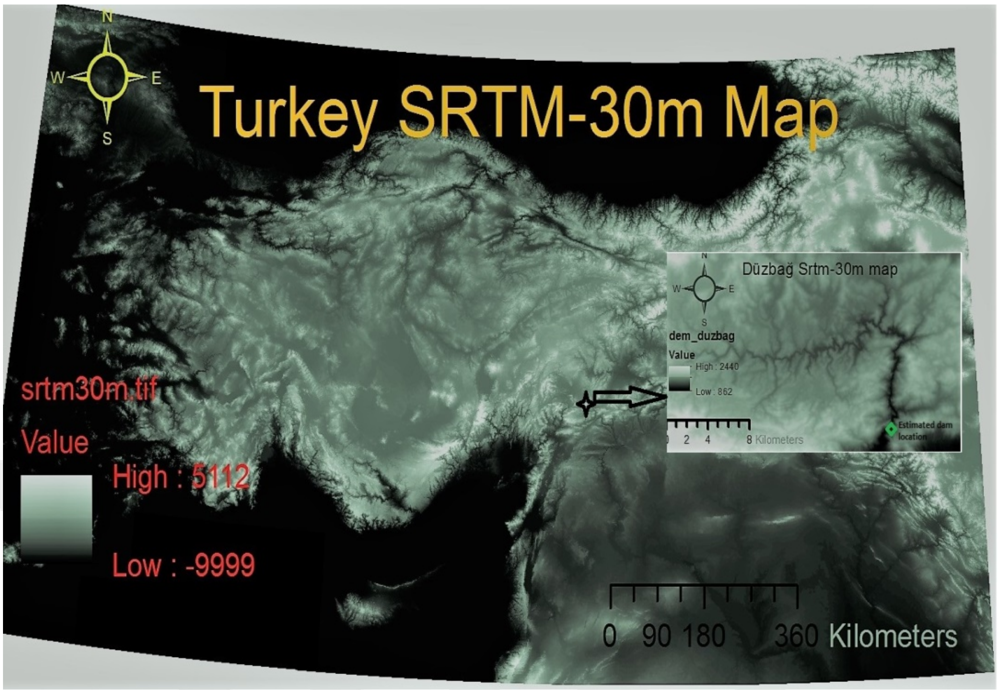


Figure 5.3 Terrain DEM location at Turkey map

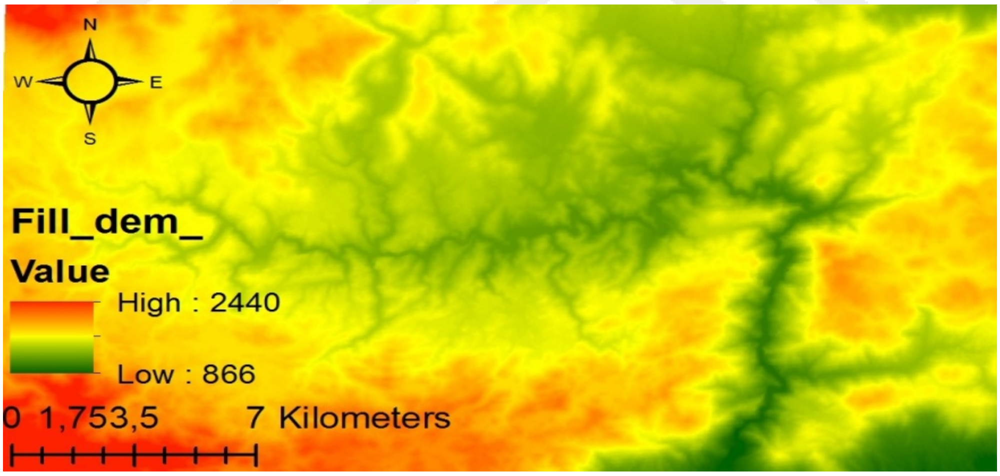


Figure 5.4 Filled sink

5.4.1. Flow Direction

Flow direction, hydrologically can be defined as water flows in the direction of the steepest downhill gradient. The direction that yields the steepest downhill slope is the inferred direction of water flow. Flow direction algorithms are divided in two main groups based on how they distribute flow from one grid cell to another cell (Erskine et al. 2006; Gruber and Peckham 2008; Wilson et al. 2008; Rampi et al. 2014). The first group consists of single flow direction (SFD) algorithms, which allow flow to pass to only one neighboring cell downslope. The following algorithms are examples of the SFD group: the Deterministic D8 algorithm proposed by (O'Callaghan and Mark, 1984) and the random single direction algorithm Rho8 described by (Fairfield and Leymarie, 1991). The second group consists of multiple flow direction algorithms, which allow flow to pass to more than one neighbor cell downslope (Rampi et al. 2014). Basic algorithm in ArcGIS is sometimes referred to as the D8 method as illustrated in (Figure 5.5). D8 flow algorithm computes the direction of the flow on a DEM from the source cell to one of its 8 neighbor cells with highest slope. Computing the flow directions using D8 approach is trivial if the elevation of each cell is greater than at least one of its neighbor cells (Survila et. al., 2016).

Determination of flow direction at every point throughout a landscape allows the modeler to infer drainage areas, flow lengths, and delineate watersheds. Flow directions based on Digital Elevation Models (DEMs) are needed in hydrology to determine the paths of water, sediment and contaminant movement (Tarboton, 1997). According to Kang (2008) a flow direction raster shows the direction of water which flows out of each cell of a filled elevation raster.

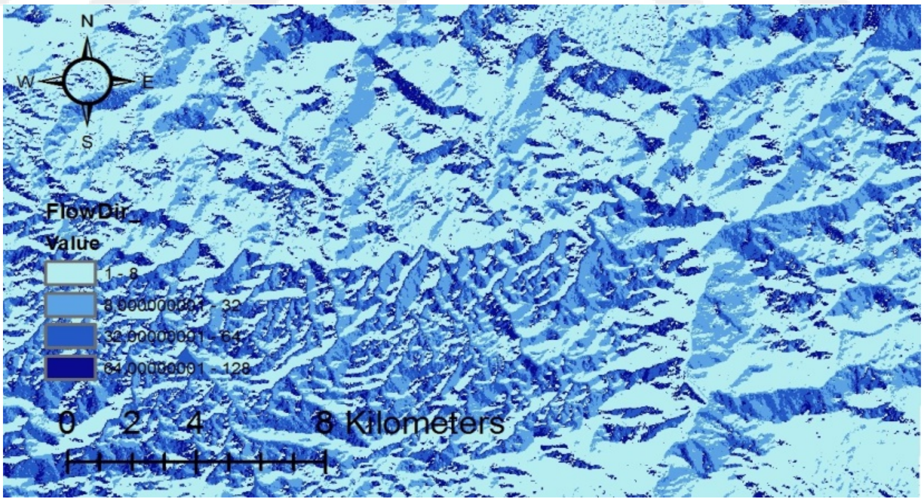


Figure 5.5 Flow direction

5.4.2. Flow Accumulation

Once you have a raster that indicates flow direction, a number of other interesting and useful calculations are possible. In particular, you can determine the locations of all the linear bodies of water, and you can determine, from slope and elevation, those areas where water may accumulate during times of intense precipitation. This is accomplished with the

Arc Toolbox Flow Accumulation tool (ESRI, 2009). The raster of accumulated flow to each cell which is defined by accumulating the weight for all cells that flow into each downslope cell is the result of Flow Accumulation. Cells with undefined flow direction will not contribute to any downstream flow they will only collect flow. The accumulated flow is based on the number of cells flowing into each cell in the resultant raster. The accumulated flow (or drainage area) is calculated by the summation of grid cells that drain to a receiving cell. This can be estimated both by algorithms that deal with partial flow from and to cells and by algorithms that only calculate with whole cells. Literally, one unit of water is poured on every cell (Schmidt, 2003). Flow accumulation was computed by using Flow Direction outputs. Stream Network was defined from flow accumulation values of each cell (Figure 5.6 – Figure 5.7). Also Figure 5.8 illustrated combine stream link that define the whole river basin water network.

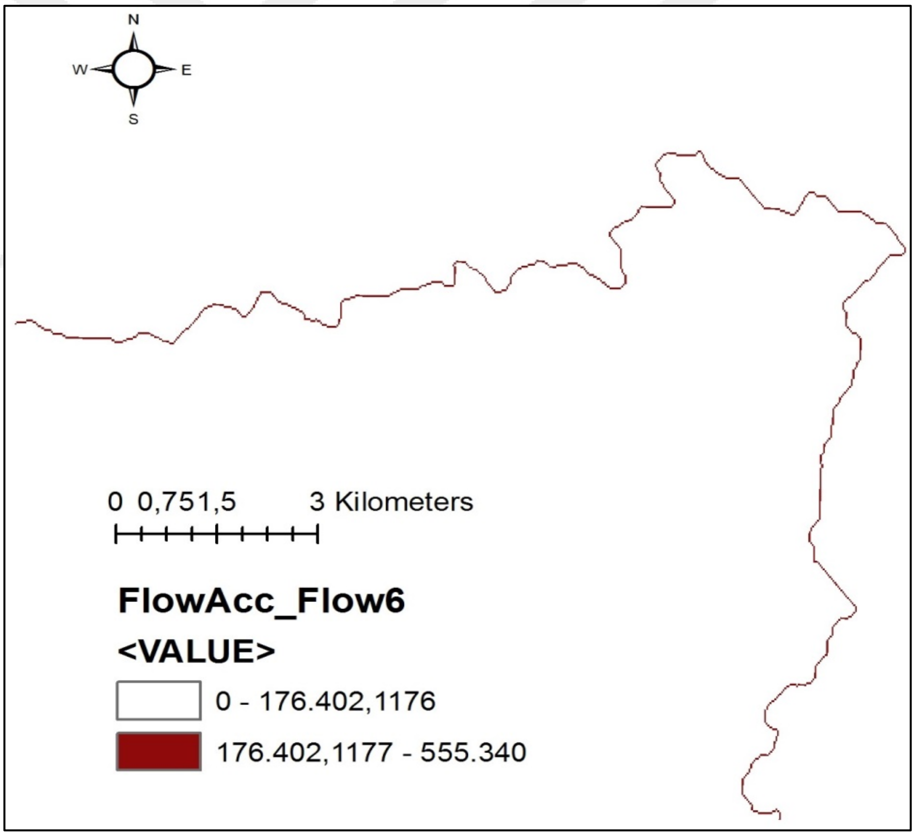


Figure 5.6 Flow accumulation

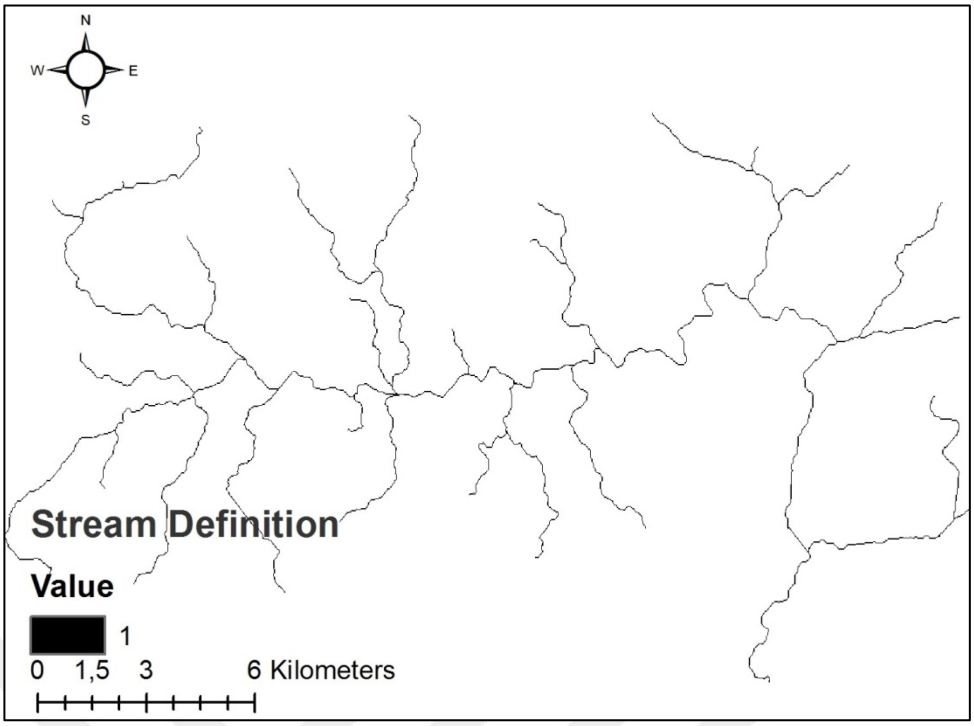


Figure 5.7 Stream definition

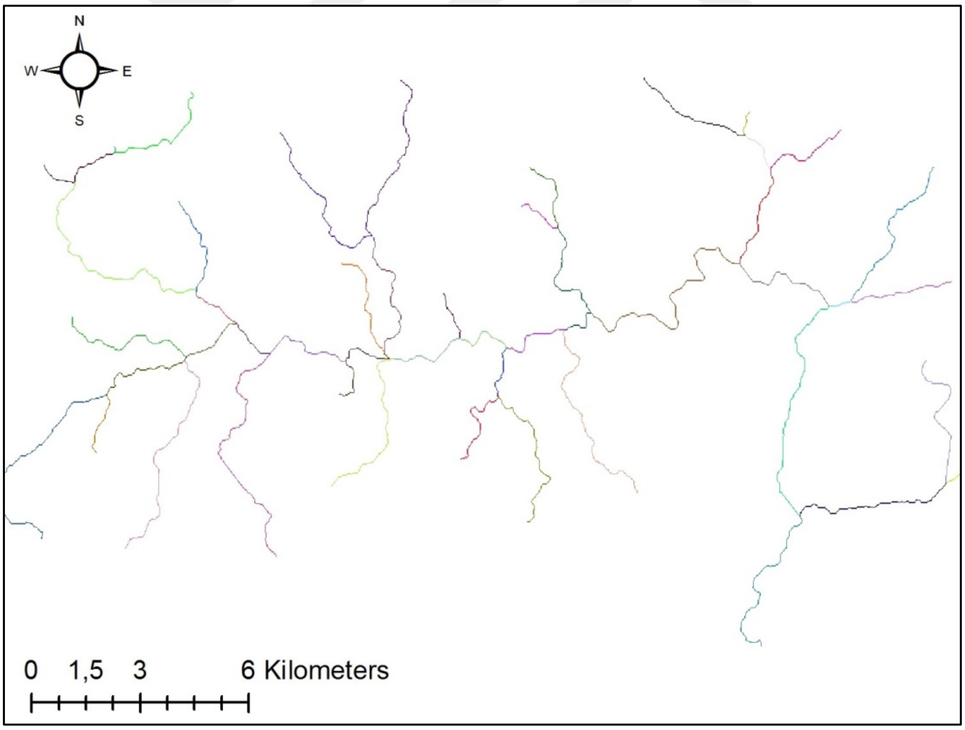


Figure 5.8 Combine stream link

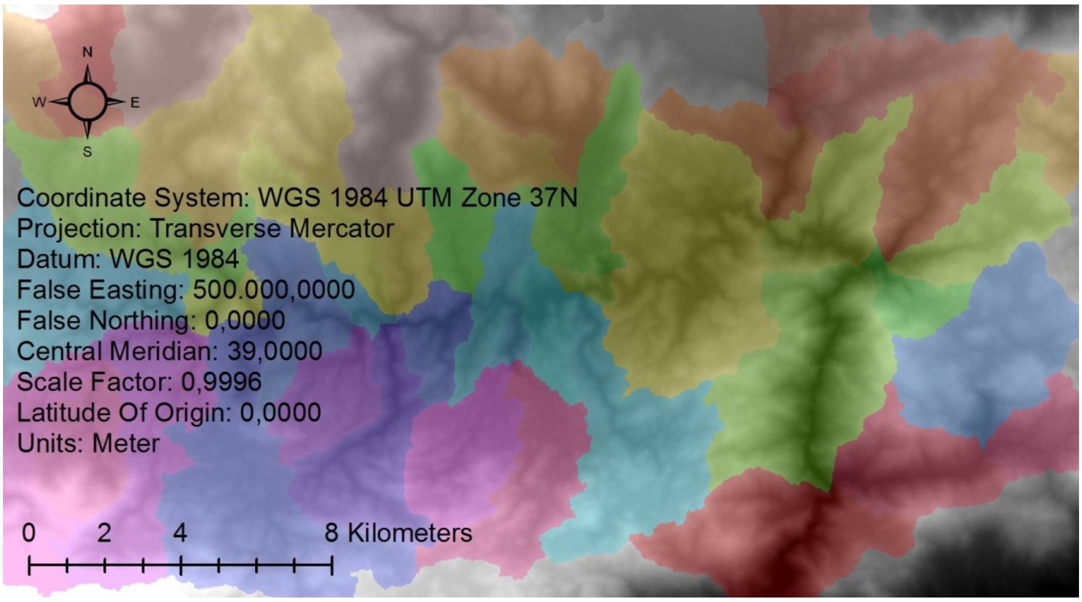


Figure 5.9 Catchment area of Göksu River basin

62 different catchment areas have showed at (Figure 5.9). Catchments are showed by their own color which is related to surface water area.

5.4.3. Defining Pour Point

Watersheds are physically delineated by the area upstream of a point of interest which is known as outlet point, pour point or discharge point. A pour point is the point at which water flows out of the contributing area surrounded by ridge line. Ridgelines are boundaries which separate watersheds from each other. The pour point may be a gauge station, a dam or any subjective point on the river network. In this work the pour point is a point in the dam location that crosses the Göksu River.

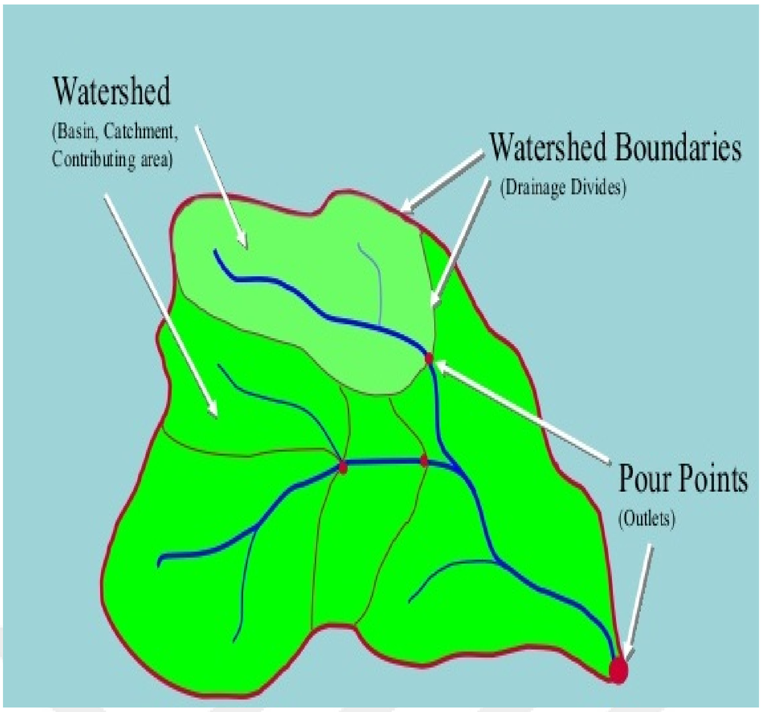


Figure 5.10 Defining pour point

5.5. Watershed Delineation

A Watershed is an upslope area of land where surface water from rain and melting snow or ice joins and flows to a particular cross-section of a stream which is named as the drainage point, the exit, the outlet or the pour point of the basin. At the pour point of a river the flow of water meets other water-bodies, like a river, lake, reservoir, estuary, wetland, sea, or ocean. A watershed, also called basin, catchment, drainage area or contributing area, simply could be a part of a larger watershed. The boundaries between watersheds are called drainage divides or ridge lines. Watersheds are physically delineated by the area upstream from the outlet point. Watersheds can be delineated both manually on paper maps and digitally in a GIS environment. In GIS applications the Watershed function uses a raster of flow direction to determine contributing area (Figure 5.10).

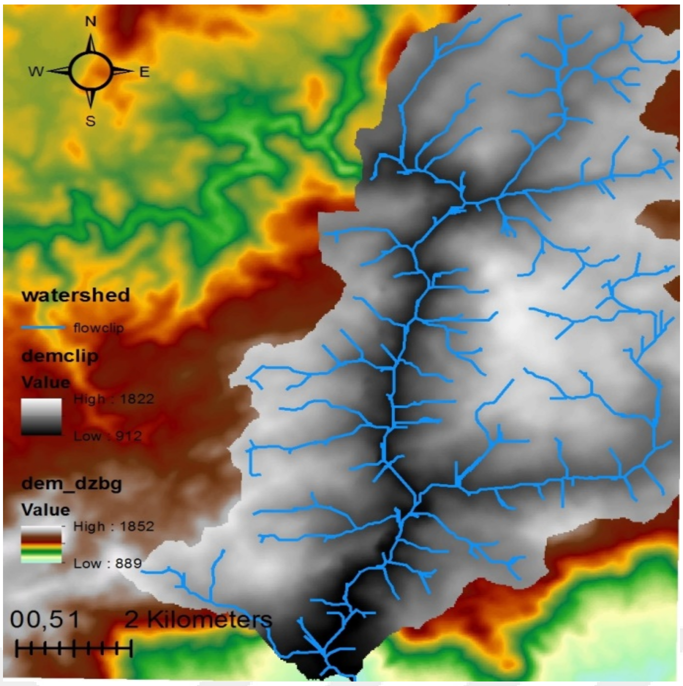


Figure 5.11 Delineating boundary of the Düzbağ dam by terrain area

When the threshold is used to define a watershed, the pour points for the watersheds will be the junctions of a stream network derived from flow accumulation. The features identify the pour points, when a feature dataset is used to define a watershed. The watershed map for the Göksu River Basin (Düzbağ Dam location) was delineated by employing the flow direction raster acquired previously and a defined pour point (Figure 5.11). The total area of river basin was estimated to be about 43,332 km^2 and the perimeter is about 917 km.

5.6. Hydrological Processing of the Basin

The hydrological processing of the Göksu River Basin starts with filling all of the sinks in the raster data if there are any, after delineating the boundaries of the basin (Figure 5.12). If a cell is surrounded by high elevated cells, the water is expected to be trapped in that cell and cannot flow further. Next, the flow direction and the flow accumulation grids are calculated based on the flow path of the steepest decent (Figures 5.13 and 5.14). The function stream definition (Figure 5.15) was used to extract the stream grid from flow accumulation grid for all the cells. Then, drainage points of all stream tributaries that are associated with the sub-catchments were defined. The location of the drainage points are the outlet of each stream tributary. One of the aims of the hydrological processing is to delineate the sub-catchments and acquire hydrological data for the sub-catchments in the Göksu River Basin (Figure 5.16). A total number of 59 sub-basins have been identified.

Area of sub-basins ranged from 2078 km^2 to 26 km^2 where total watershed area of the Göksu River Basin was found to be 26,325 km^2. The longest flow path of the sub-basins ranged from 89 km to 10 km. However the average slope of the sub-basins varied from 0.131 % to 8.84 %.

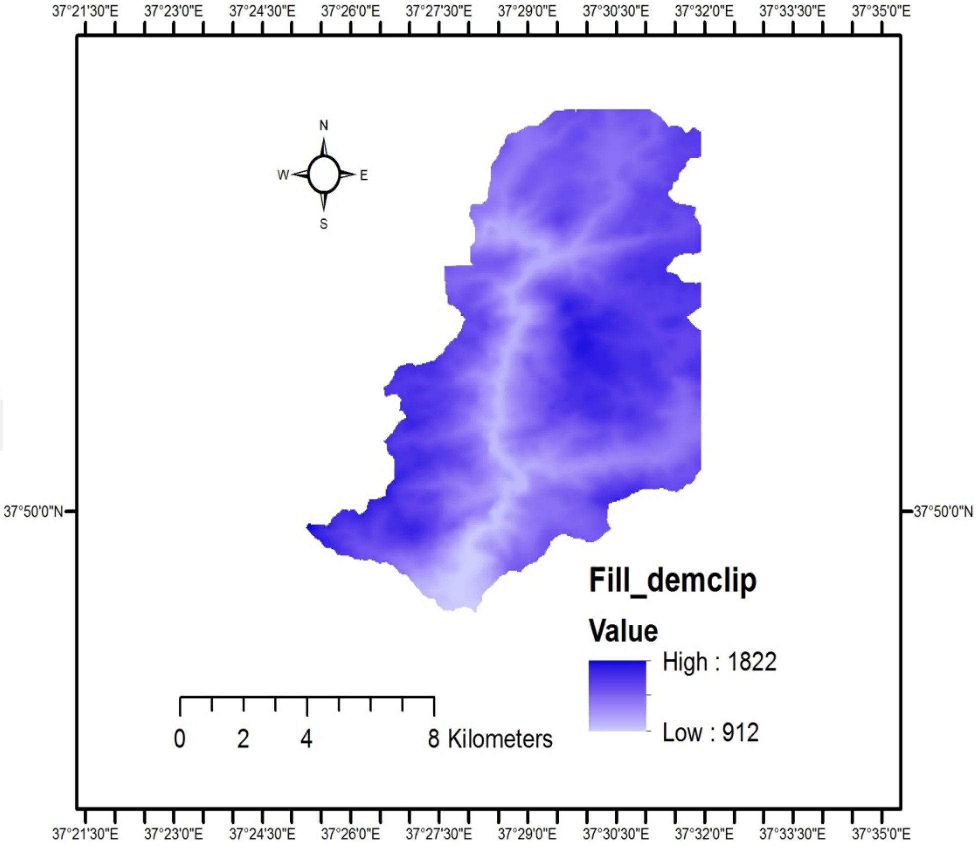


Figure 5.12 Fill sinks of the Göksu River basin

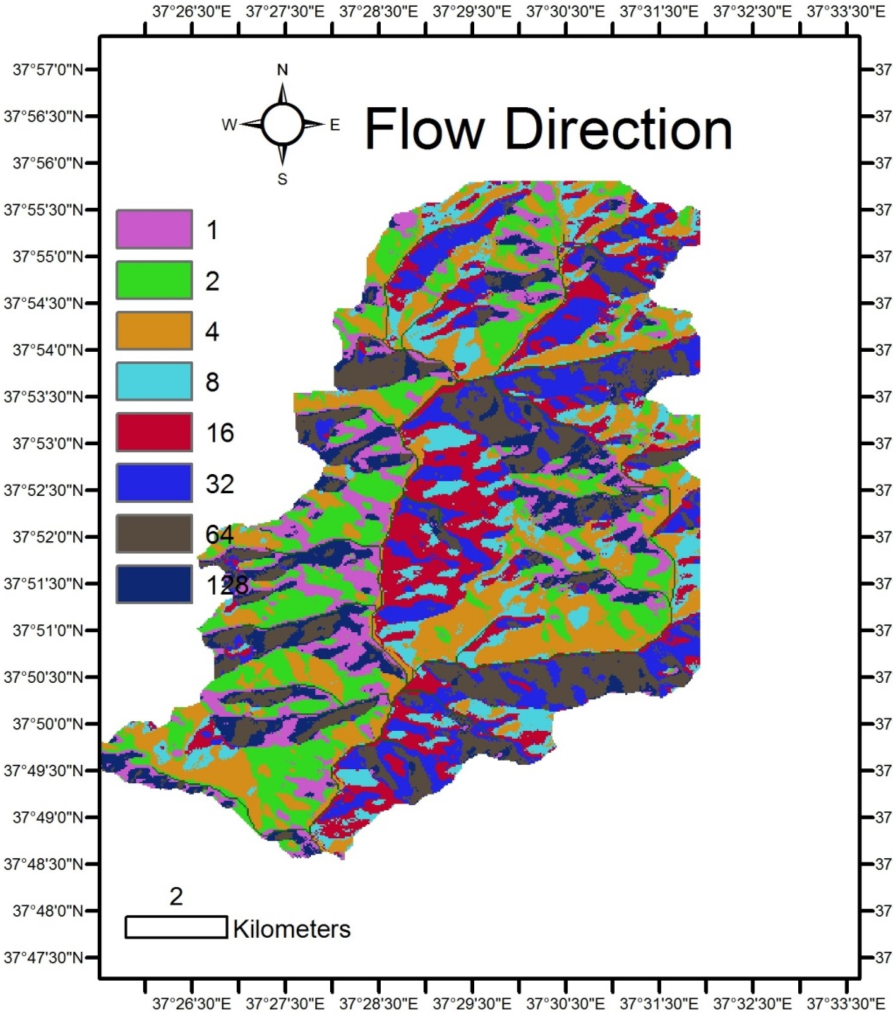


Figure 5.13 Flow direction of the Göksu River basin

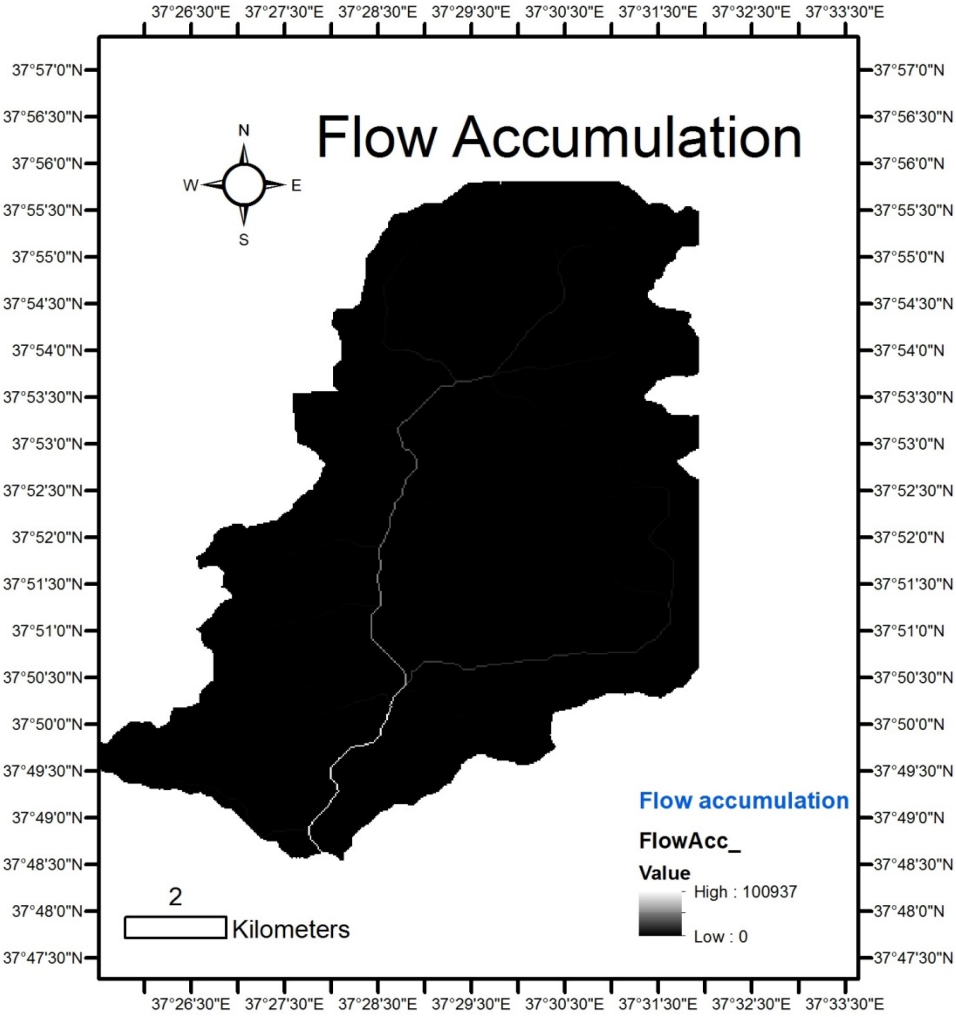


Figure 5.14 Flow accumulation of the Göksu River basin

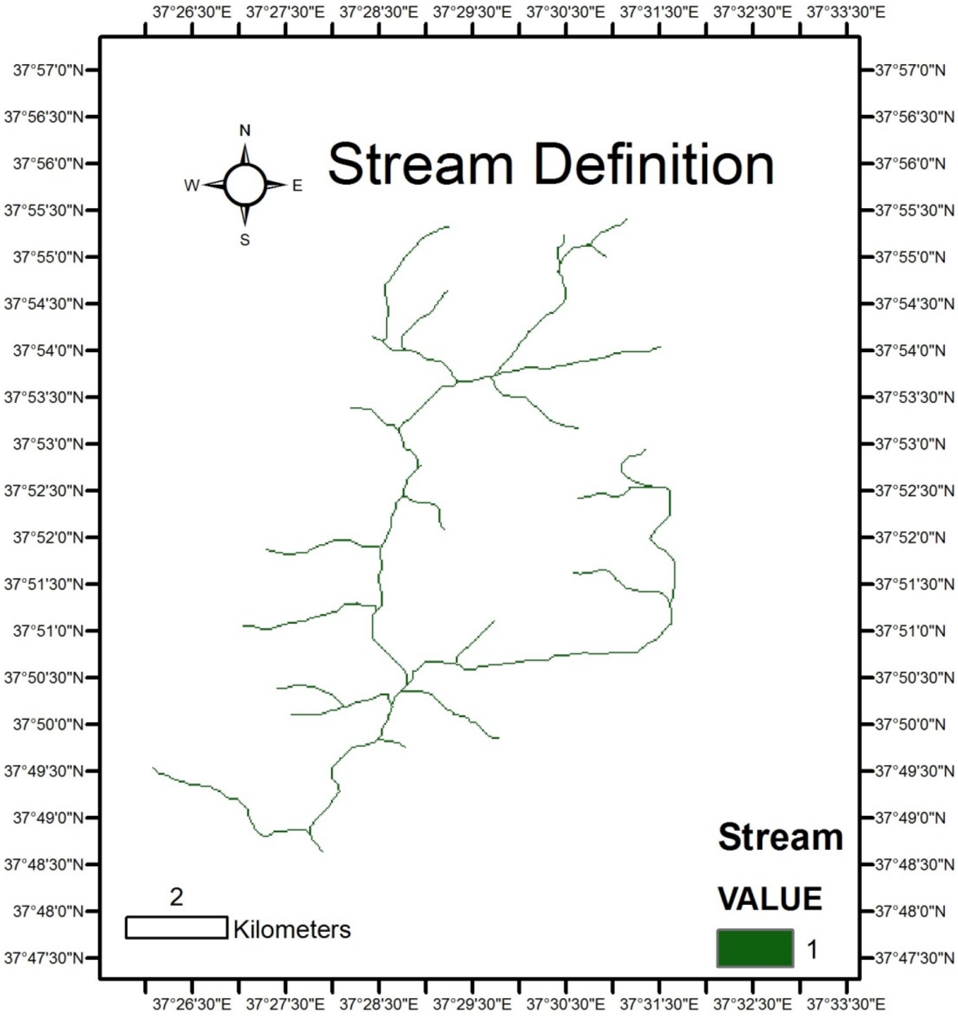


Figure 5.15 Stream definition

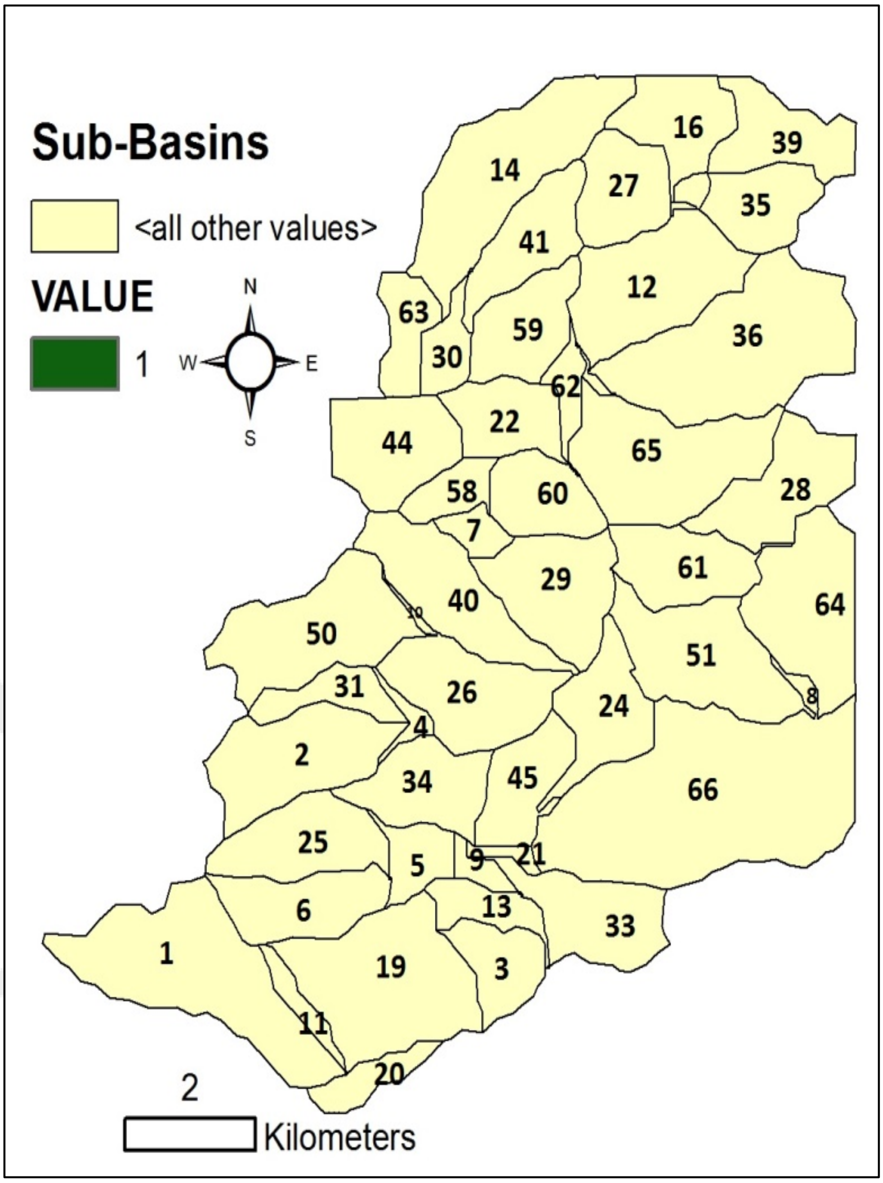
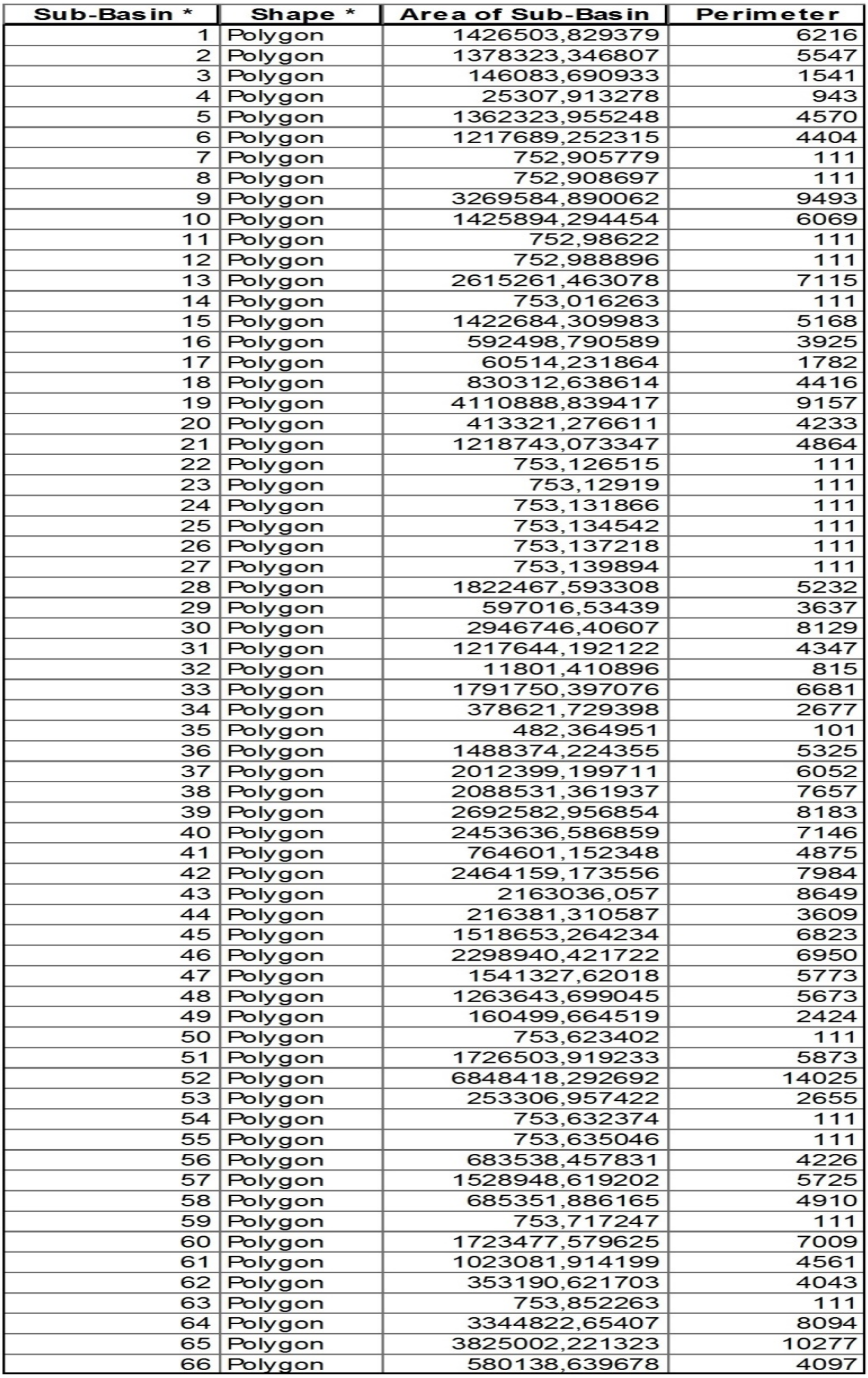


Figure 5.16 Delineating different sub-catchments boundary

Table 5.10 Hydrological features of the Göksu River sub-catchments



Sub-Basin *	Shape *	Area of Sub-Basin	Perimeter
1	Polygon	1426503,829379	6216
2	Polygon	1378323,346807	5547
3	Polygon	146083,690933	1541
4	Polygon	25307,913278	943
5	Polygon	1362323,955248	4570
6	Polygon	1217689,252315	4404
7	Polygon	752,905779	111
8	Polygon	752,908697	111
9	Polygon	3269584,890062	9493
10	Polygon	1425894,294454	6069
11	Polygon	752,98622	111
12	Polygon	752,988896	111
13	Polygon	2615261,463078	7115
14	Polygon	753,016263	111
15	Polygon	1422684,309983	5168
16	Polygon	592498,790589	3925
17	Polygon	60514,231864	1782
18	Polygon	830312,638614	4416
19	Polygon	4110888,839417	9157
20	Polygon	413321,276611	4233
21	Polygon	1218743,073347	4864
22	Polygon	753,126515	111
23	Polygon	753,12919	111
24	Polygon	753,131866	111
25	Polygon	753,134542	111
26	Polygon	753,137218	111
27	Polygon	753,139894	111
28	Polygon	1822467,593308	5232
29	Polygon	597016,53439	3637
30	Polygon	2946746,40607	8129
31	Polygon	1217644,192122	4347
32	Polygon	11801,410896	815
33	Polygon	1791750,397076	6681
34	Polygon	378621,729398	2677
35	Polygon	482,364951	101
36	Polygon	1488374,224355	5325
37	Polygon	2012399,199711	6052
38	Polygon	2088531,361937	7657
39	Polygon	2692582,956854	8183
40	Polygon	2453636,586859	7146
41	Polygon	764601,152348	4875
42	Polygon	2464159,173556	7984
43	Polygon	2163036,057	8649
44	Polygon	216381,310587	3609
45	Polygon	1518653,264234	6823
46	Polygon	2298940,421722	6950
47	Polygon	1541327,62018	5773
48	Polygon	1263643,699045	5673
49	Polygon	160499,664519	2424
50	Polygon	753,623402	111
51	Polygon	1726503,919233	5873
52	Polygon	6848418,292692	14025
53	Polygon	253306,957422	2655
54	Polygon	753,632374	111
55	Polygon	753,635046	111
56	Polygon	683538,457831	4226
57	Polygon	1528948,619202	5725
58	Polygon	685351,886165	4910
59	Polygon	753,717247	111
60	Polygon	1723477,579625	7009
61	Polygon	1023081,914199	4561
62	Polygon	353190,621703	4043
63	Polygon	753,852263	111
64	Polygon	3344822,65407	8094
65	Polygon	3825002,221323	10277
66	Polygon	580138,639678	4097

Table 5.10 illustrated Sub-basins of the Göksu River. Each sub-basin has its own area andperimeter. Also all units indicated as meter (perimeter) and square meter (area). Düzbağ surface area is approximately 3.78 m^2 *(10^6). According to real measurement taking information from General Command Mapping is 3.81 m^2* (10^6).

5.7. Hydrological Analysis of the Basin

The Göksu River Basin was hydrological analyzed in order to determine the slope map, Thiessen polygon map, Thiessen polygon areas for a proposed dam location in the study area.

5.7.1. Slope Model of the Basin

The Slope function in ArcGIS calculates the maximum rate of change between each cell and its eight neighbors. For each cell, the Slope tool calculates the maximum rate of change in value from that cell to its neighbors. Basically, the maximum change in elevation over the distance between the cell and its eight neighbors identifies the steepest downhill descent from the cell.

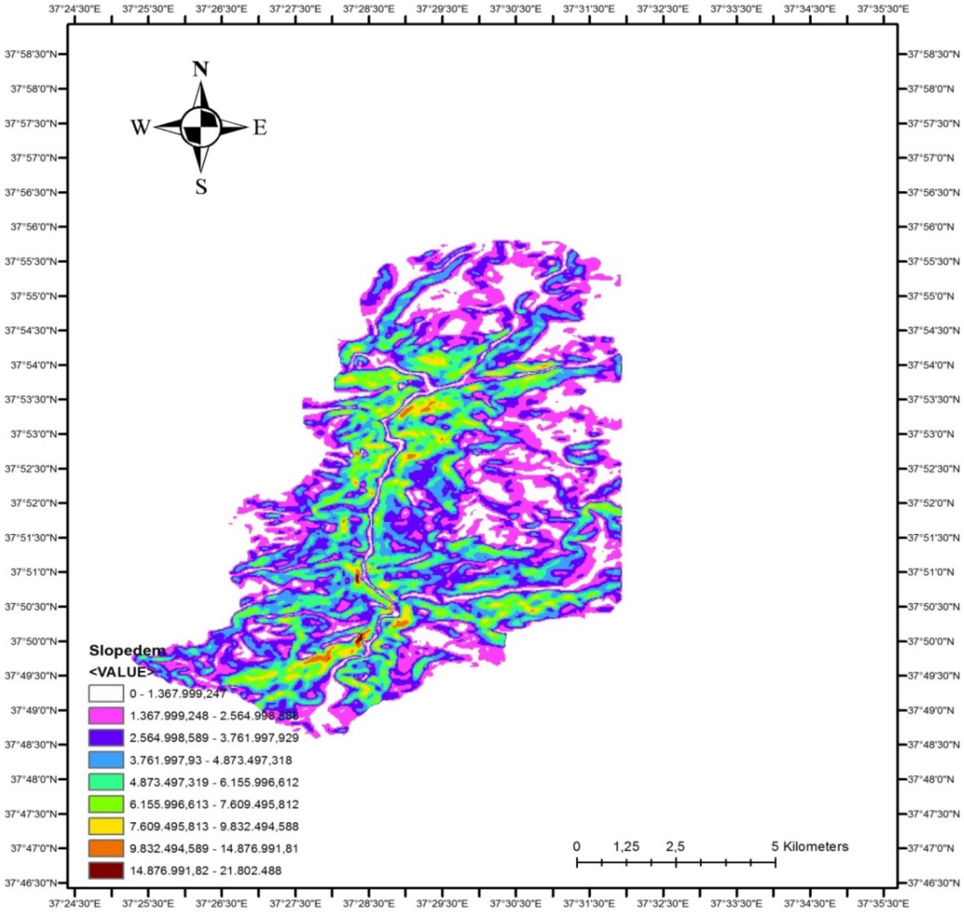


Figure 5.17 Slope map of the Göksu River basin

Conceptually, the tool fits a plane to the z-values of a 3 x 3 cell neighborhood around the processing or center cell. The slope value of this plane is calculated using the average maximum technique. The direction the plane faces is the aspect for the processing cell. The lower the slope value the flatter the terrain; the higher the slope value, the steeper the terrain (Figure 5.17).

5.8. IDW and Kriging Interpolation

The study area located between Elbistan and Doğanşehir meteorological stations. The rainfall regime in the Göksu River Basin is increasing as moving from North West to the South East part of the basin. The rainfall season in the Göksu River Basin region generally starts from October and lasts until end of May, about eight months. July has the lowest precipitation month (2 mm) and the January has the highest precipitation (93mm). Annual temperature in study area is 13.7°C and the annual rainfall is 537mm. Study area also affected Kahramanmaraş region climates. For this reason the mountainous areas with high slopes take more precipitation and provide more surface runoff than the rest of the basin.

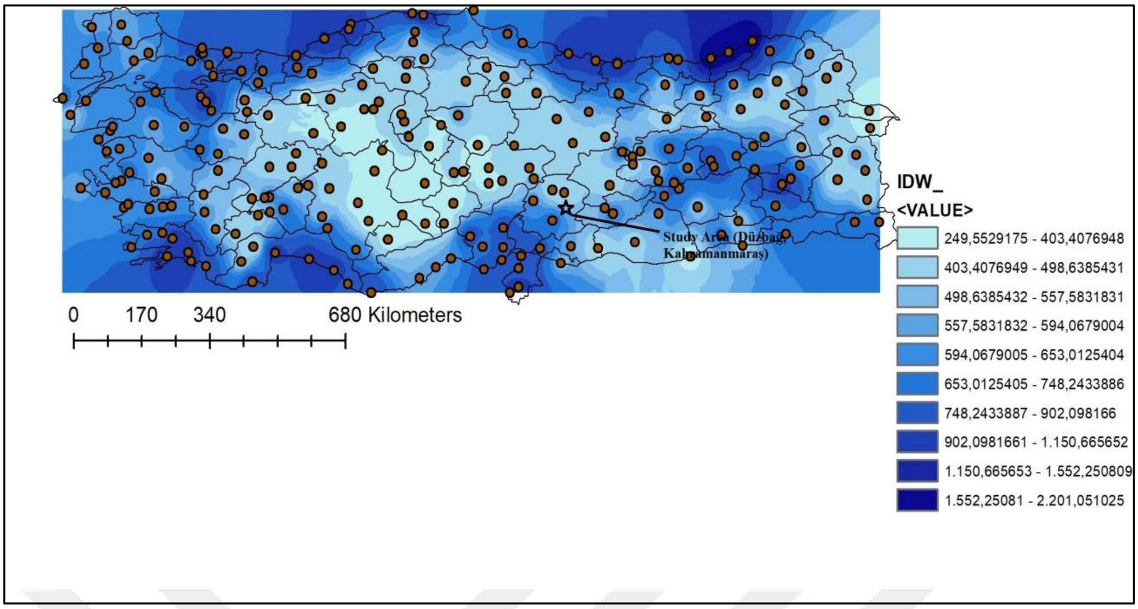


Figure 5.18 Annual precipitation map of Turkey according to IDW method

Figure 5.18 relates to the distribution of annual precipitation by (IDW). Figure 5.19 illustrates the distribution of annual precipitation by Ordinary Kriging Interpolation (OK). The map generated by ArcGIS program for whole meteorological stations located in Turkey. All stations data is for five years (2010-2015) annually. The pixel value counted from the map for study area region and according to IDW, estimated rainfall by ArcGIS is about 526 mm. On the other hand Ordinary Kriging showed that estimated rainfall is approximately 542 mm. The real parameter is 537 mm annually. Also standard deviation is 142,670 at Ordinary Kriging and 213,180 at IDW method. The results showed that the best model to generate rain properties map was Ordinary Kriging with spherical and models. The reason for this is the weight difference in the Kriging method. It is not only in the distance. Furthermore like real parameters, estimated values show the driest month as August and the wettest one is December. The Kriging method has been shown to make the best possible estimate in the field interpolation. It is emphasized that after the Kriging method, the second best estimate is obtained from the IDW method results. Mainly in this study; it is aimed to estimate the lack of data belonging to station points and to obtain the most correct data belonging to that station. By comparing two methods, it is tried to determine the method that gives more accurate result when missing data is encountered.

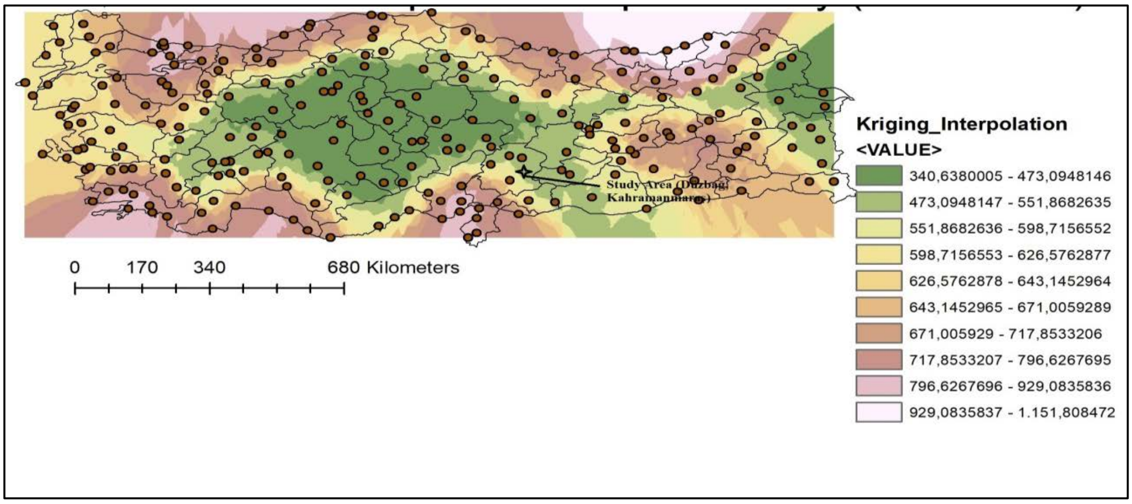


Figure 5.19 Annual distribution of precipitation by ordinary kriging

5.9. Thiessen Polygon of the Basin

In order to achieve exact estimation of the spatial distribution of rainfall, it is necessary to use interpolation methods, for this, the Thiessen polygon method is considered as the most important in engineering praxis. In order to estimate the distribution of the precipitation from 4 rainfall measurement station located surrounding the Göksu river basin, it is essential to utilize interpolation methods. Furthermore Thiessen polygon method is widely used in engineering praxis was. The basin included stations was divided into polygons showed as Thiessen polygons (Figure 5.20).

The advantages of the Thiessen polygon are; Ease of application, accuracy depends largely on sampling density, boundaries often odd shaped as transitions between polygons are often abrupt.

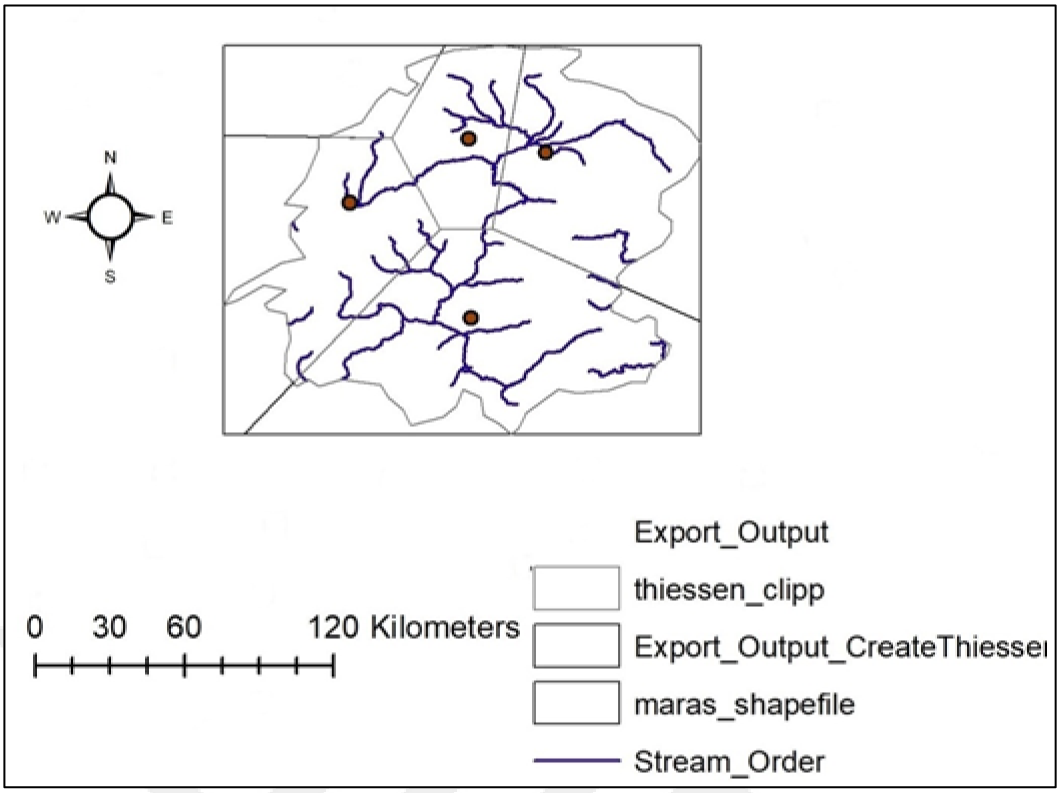


Figure 5.20 Thiessen polygon of the study area

5.9.1.Determination of Rainfall-runoff Coefficient of the Göksu River Sub-Basins

The annual average discharge and the annual total precipitations measured at 4 meteorological stations in and outside of the basin were utilized in calculations in order to estimate the rainfall-runoff coefficient of the sub-basins. Because of having a simple technique for estimating a design discharge from a small watershed, rational method was utilized in the calculations. On the other hand, Thiessen polygon method was applied on account of obtain the impact area of each meteorological station in the sub-basins. The annual total precipitations were obtained from monthly total precipitations and the annual average discharge flows were taken from monthly average discharge data. The rainfall-runoff coefficients of four sub-catchments were estimated. Results of the rainfall-runoff coefficients were found to be 0.458, 0.489, 0.621 and 0.504 for Kahramanmaraş, Elbistan, Göksun and Afşin sub-catchments relatively (Figures 5.20-5.24).

5.9.2. Calculation of Rainfall-runoff Coefficient of the Kahramanmaraş Sub-Basin

In order to determination of Kahramanmaraş sub-basin rainfall-runoff, rainfall meteorological station and flow measurement station was utilized that located around the Göksu river. The sub-basin has an area of 5673 km^2, with an annual average stream discharge flow of about 59 m^3/s for the period of 2010–2015 which was obtained from monthly average discharge values. Thiessen polygon method was used in order to evaluate the annual average precipitation of the region. The rainfall-runoff coefficient was found to be 0.458 for the sub-basin (Figure 5.21; Table 5.11).

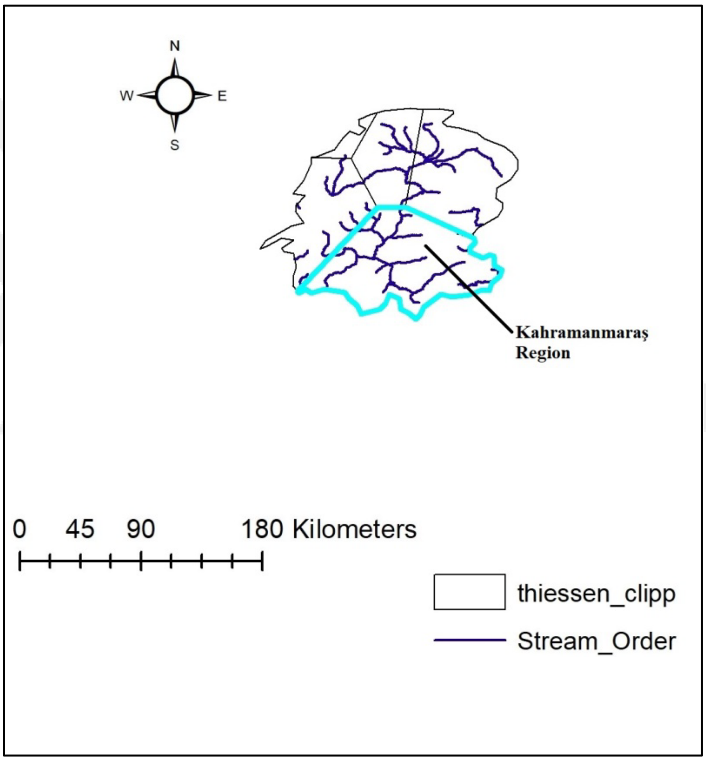


Figure 5.21 Kahramanmaraş sub-basin

Table 5.11 Rainfall-runoff coefficient of Kahramanmaraş sub-basin

Sub-Basin	Average Annual Precipitation (mm)	Area(km^2)	Discharge(m^3/s)	C= Q/(A*İ*10^3)
Kahramanmaraş	716	5673	59	0.458

5.9.3. Calculation of Rainfall-runoff Coefficient of the Göksun Sub-Basin

In order to determination of Göksun sub-basin rainfall-runoff, rainfall meteorological station and flow measurement station was utilized that located around the study area. The sub-basin has an area of 3073 km^2, with an annual average stream discharge flow of about 37 m^3/s for the period of 2010–2015 which was obtained from monthly average discharge values. Thiessen polygon method was used in order to evaluate the annual average precipitation of the region. The rainfall-runoff coefficient was found to be 0.621 for the sub-basin (Figure 5.22; Table 5.12).

Table 5.12 Rainfall-runoff coefficient of Göksun sub-basin

Sub-Basin	Average Annual Precipitation (mm)	Area(km^2)	Discharge(m^3/s)	$C= Q/(A*\dot{I}*10^3)$
Göksun	611	3073	37	0.621

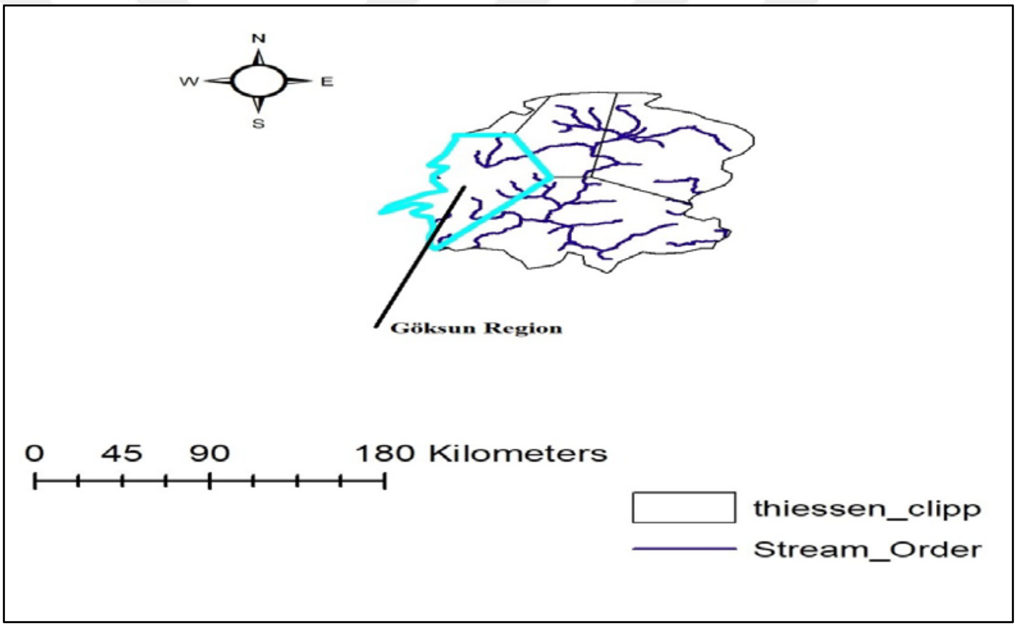


Figure 5.22 Göksun region

5.9.4. Calculation of Rainfall-runoff Coefficient of the Afşin Sub-Basin

In order to determination of Afşin sub-basin rainfall-runoff, rainfall meteorological station and flow measurement station was utilized that located around the study area. The sub-basin has an area of 2172 km^2, with an annual average stream discharge flow of about 15 m^3/s for the period of 2010–2015 which was obtained from monthly average discharge values. Thiessen polygon method was used in order to evaluate the annual average precipitation of the region. The rainfall-runoff coefficient was found to be 0.504 for the sub-basin (Figure 5.23; Table 5.13).

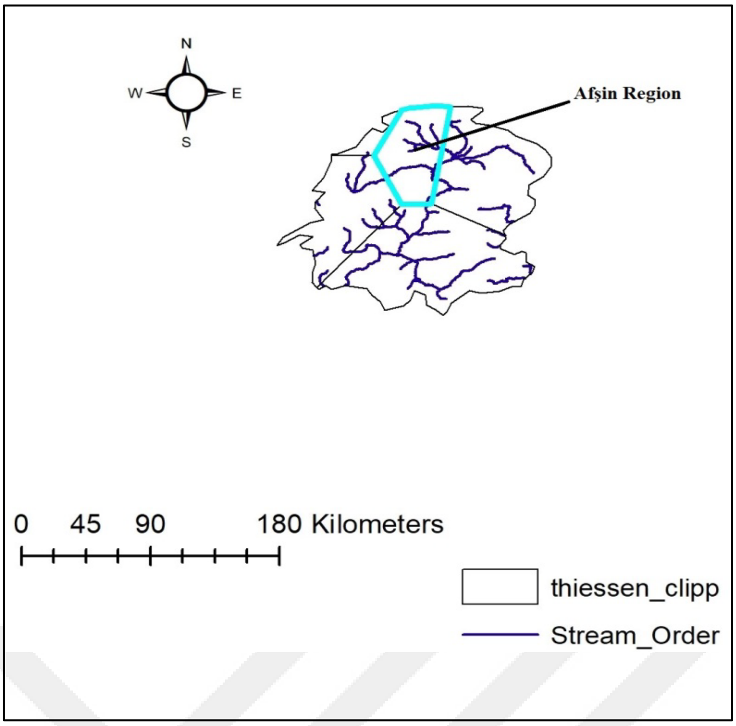


Figure 5.23 Afşin region

Table 5.13 Rainfall-runoff coefficient of Afşin sub-basin

Sub-Basin	Average Annual Precipitation (mm)	Area(km^2)	Discharge(m^3/s)	$C= Q/(A*İ*10^3)$
Afşin	432	2172	15	0.504

5.9.5. Calculation of Rainfall-runoff Coefficient of the Elbistan Sub-Basin

In order to determination of Elbistan sub-basin rainfall-runoff, rainfall meteorological station and flow measurement station was utilized that located around the study area. The sub-basin has an area of 4038 km^2, with an annual average stream discharge flow of about 25 m^3/s for the period of 2010–2015 which was obtained from monthly average discharge values. Thiessen polygon method was used in order to evaluate the annual average precipitation of the region. The rainfall-runoff coefficient was found to be 0.489 for the sub-basin (Figure 5.24; Table 5.14).

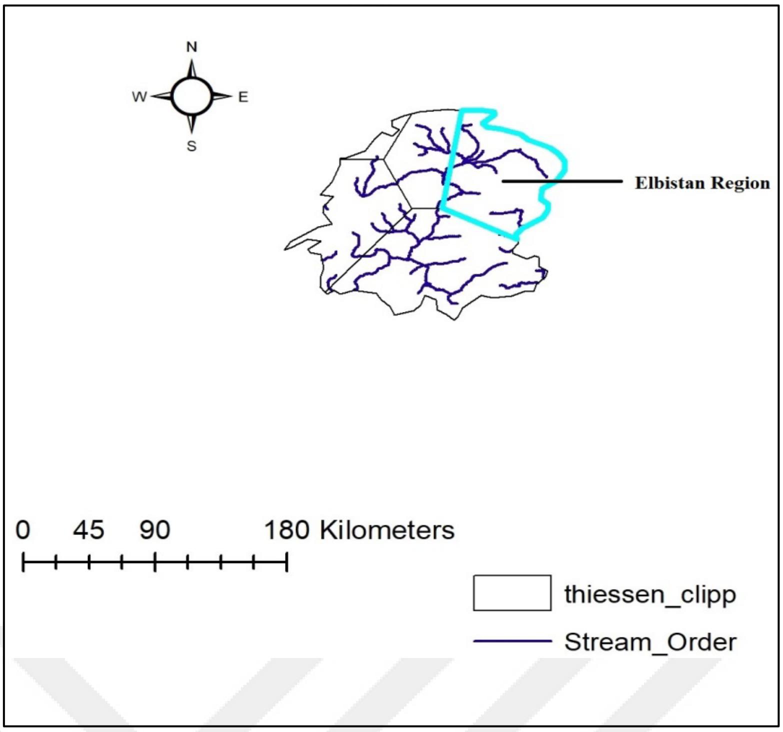


Figure 5.24 Elbistan region

Table 5.14 Rainfall-runoff coefficient of Elbistan sub-basin

Sub-Basin	Average Annual Precipitation (mm)	Area(km^2)	Discharge(m^3/s)	C= Q/(A*İ*10^3)
Elbistan	399	4038	25	0.489

5.10. Estimation the Rainfall-runoff Coefficient for a Considered Dam

Estimating the annual average discharge as well as discharge variation within certain periods of time is crucially important in planning phase of a water resources project. Most of the time, these kinds of projects are carried out at the sections of rivers where flow measurements do not exist or they may not be observed for a long enough period. The discharge observations of the closed flow measurement station are carried to that particular cross-section by a number of different statistical methods.

When the project is a dam these discharge data will be used in determining the design flow of the spillway, the volume of the reservoir, the height of the dam, the amount of the energy can be generated, etc. The dam location is the point at which water flows out of a particular sub-basin. The contributing area or the sub-catchment which supply water to the project location is delineated from a raster data of flow direction by using watershed function in ArcGIS. The selected project location is the cross- section which has been proposed for a dam project named Düzbağ Dam (Figure 5.25).

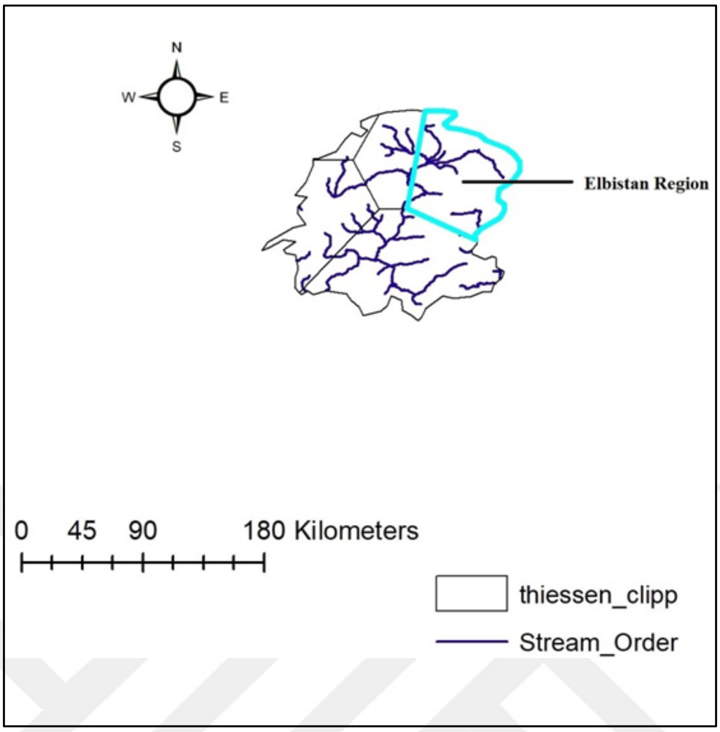


Figure 5.25 Rainfall-runoff coefficient related to contributed area

A rainfall-runoff coefficient for the contributing area to Düzbağ Dam was determined to be 0.489 by employing the coefficients determined earlier for Afşin, Elbistan, Kahramanmaraş and Göksu sub-basins, their areas and a weighted average method (Table 5.14). Among these sub-catchments Elbistan was partially included in the dam site contributing area while the other three sub-catchments were totally included. The discharge values of the stream at project site were evaluated by employing the meteorological stations within and nearby the sub-basin and the rainfall-runoff coefficient. The discharge was found to be 25 m^3/s by using rational method Table (5.14).

Table 5.15 Estimation long-term annual average discharge for a considered dam

Propose Dam project name dam project	Average Areal Rainfall (mm)	Contributed Area km^2	Averge Annual Discharge calculation (m^3/s)	Runoff coefficient
Düzbağ	399	4038	25	0.489

5.11. Estimation of Düzbağ Dam Reservoir Capacity by GIS

Water resources planning and management is the major challenge to most rural communities especially in arid areas, for they struggle securing water to cover for various uses like drinking water, domestic use, livestock watering and irrigation (Sawunyama et al., 2006). According to the Climate A (2007), river basins are the geographic area contained within the watershed limits of a system of streams and rivers converging toward the sameterminus, generally the sea or sometimes an inland water body. Streams and rivers are important for taking water, in order to transmist to necessary population. Due to taking water, dams and reservoirs have been constructed to collect, store and manage the supply of water to sustain civilization.

5.11.1. Case Study for Düzbağ Dam

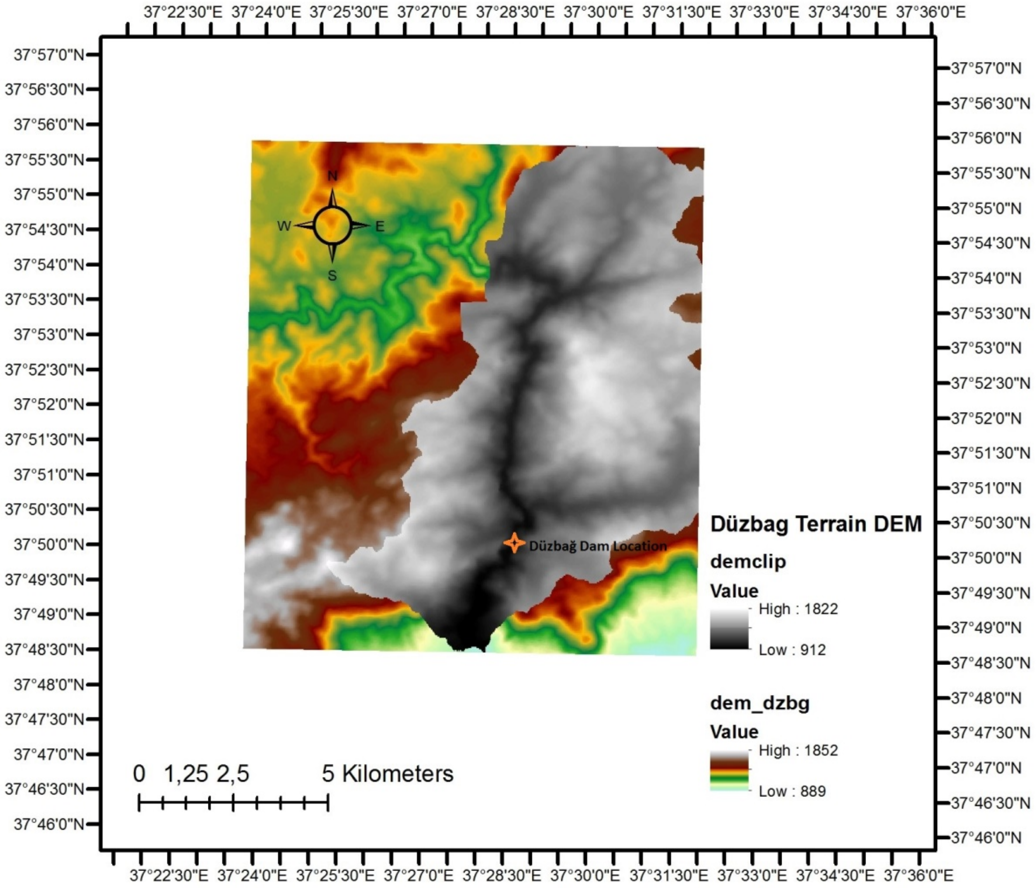


Figure 5.26 Düzbağ dam location

According to Becue et al. (2002) the main parameters to be taken account in choosing a dam site and type are; Topography and inflow in the catchment area, morphology in the river valley, geological conditions, climate and flood regime. The objective is in fact to have a volume of water available for increasing dry weather river flow, irrigation or drinking-water supply, or free storage capacity to attenuate flooding. In many cases, the considerations set out above will be sufficient to select several types of dam as potential alternatives. Arai et al. 2003 were explained ‘dam type is classified according to the main material of dam-body, to design feature, and to execution of work’. For example, if the foundation is rock, loose materials are available near the site and flood flows are high, the choice will be between an RCC dam and an Earth fill dam with a costly spillway. In dam site Pebbles and sandstones were examined. Geological conditions of Düzbağ terrain makes it possible for construction of Earth fill dam. Under these circumstances dam location and dam type were estimated (Figure 5.26). Other dams types must be take consider in to select most suitable dam.

5.11.2. Contour List of Dam Area

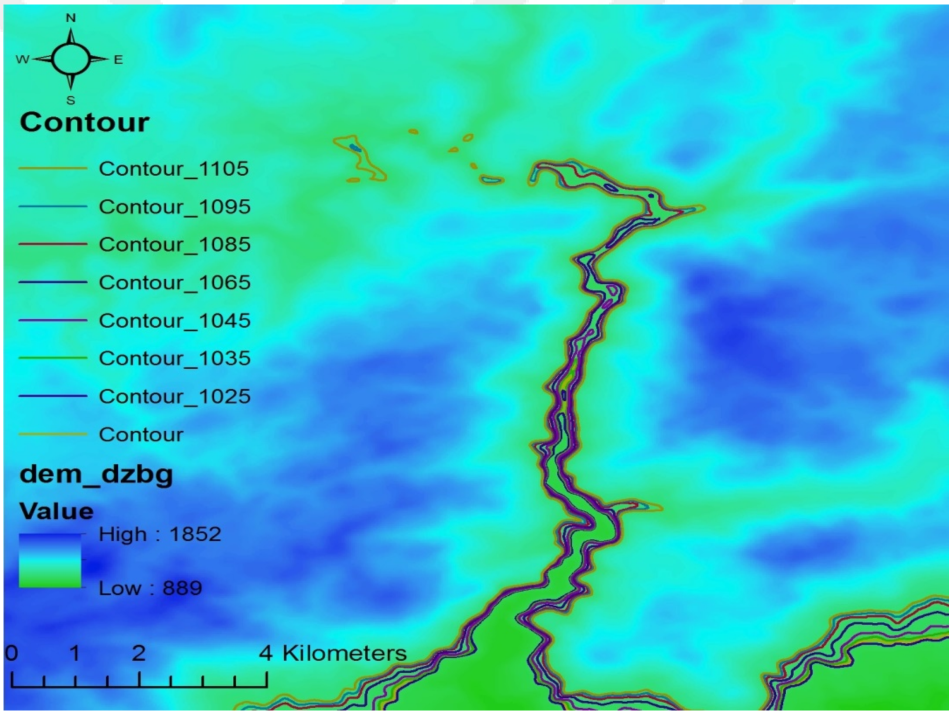


Figure 5.27 Contour list of dam area

Minimum and maximum water codes of the Düzbağ dam were estimated between 1025-1105m. 7 contour lines were utilized in calculation. Contour lines were defined 1025 to 1105 for (Contour_1025, Contour_1035, Contour_1045, Contour_1065, Contour_1085, Contour_1095, Contour_1105). Dem values are also range between 889m-1852m. In order estimate dam reservoir capacity, dam reservoir must be created. According to state reservoir area, necessary contours were utilized in ArcGIS toolbox (Figure 5.27).

5.11.3. Reservoir Area of Düzbağ Dam

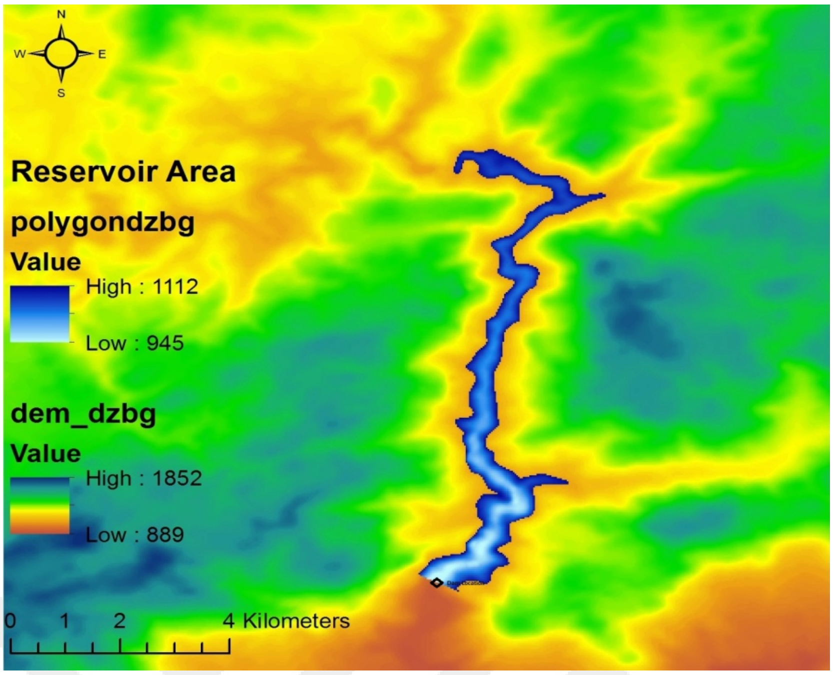


Figure 5.28 Reservoir area of düzbağ dam

After defining dam location, Polygon of reservoir area was created. Reservoir area was created for each contour line (1025-1105). Maximum water code (1105m) polygon was illustrated in (Figure 5.28).

5.11.4. Reservoir Capacity of Düzbağ Dam

Table 5.16 Area-Volume table due to different elevations

Elevation (m)	Area (m^2)	Volume (m^3)
1025	1,009,476	30,350,000
1045	1,500,334	55,280,000
1065	2,198,477	92,010,000
1085	3,366,824	149,590,000
1105	4,420,307	226,400,000

According to different elevations of dam reservoir, minimum reservoir capacity estimated about 30 million m^3 and maximum reservoir capacity estimated as roundly 226 million m^3 (Table 5.16).

5.11.5. Volume-Elevation-Area Graph by ArcGIS

The elevation-area-volume graph reveals data on changes in reservoir area and volume, depending on the water level. These graphs are important for the preparation of annual operating programs for reservoirs.

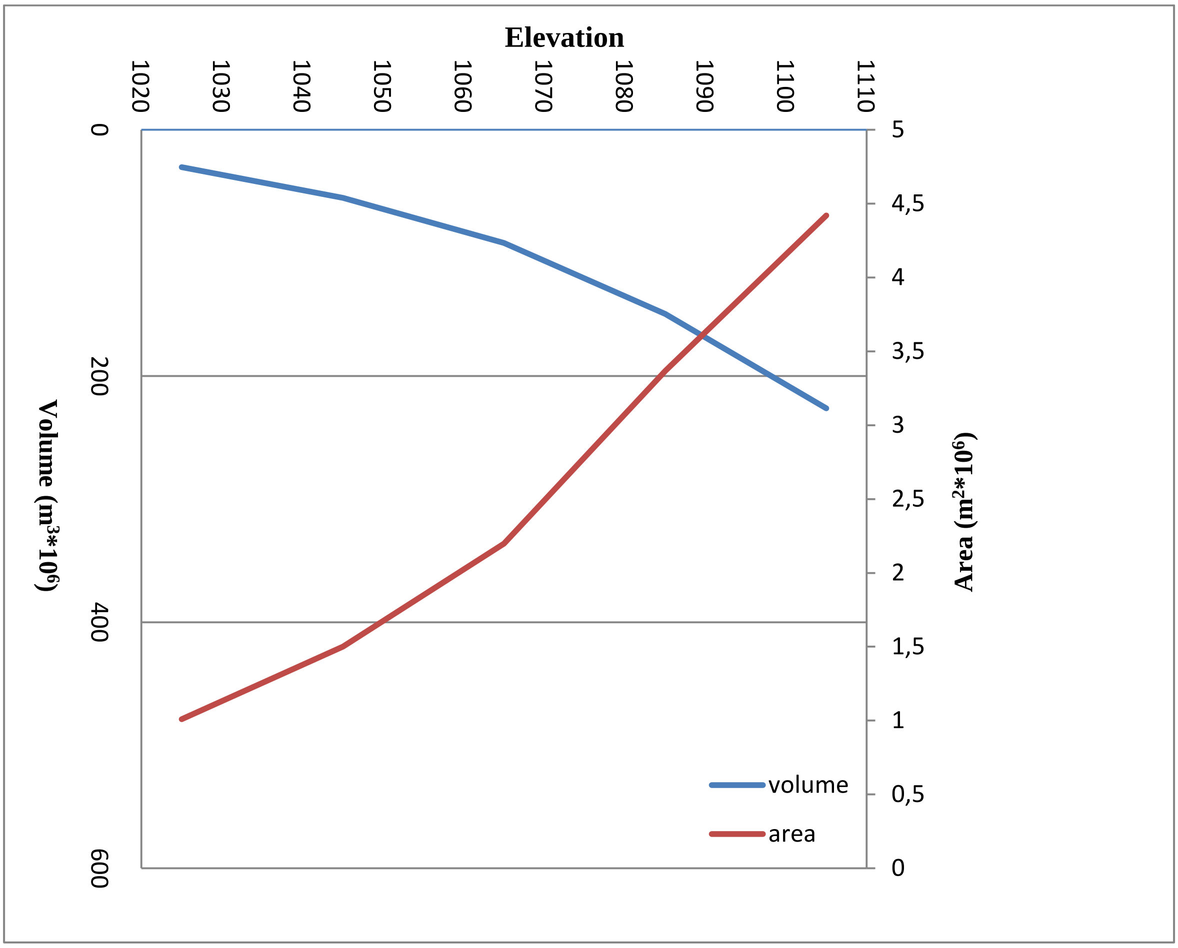


Figure 5.29 Variation of elevation with volume and area for dam reservoir volume

According to maximum elevation (1105m) reservoir area determined about 4 million m^2 that illustrated in (Figure 5.29).

CHAPTER 6

CONCLUSIONS

In Gaziantep, need for drinking and household water increases day by day in parallel with the increasing population, civic improvement and development in the area of industry. In addition to the available household and drinking water resources, more water reserves are needed. Local water usage is a multiplex element of social and physical characteristics, urban planning strategies, ground works and public water policies. Drinking and household water is a growing problem especially in Gaziantep. Population projection is necessary to estimate the future population by the trend (increase) line. Projections make prospective estimates on population with mathematical formulas. However, because these estimates are made under normal circumstances, changes in the political, social and economic structures of countries will also cause changes in population projections. For Gaziantep province, the method in which the trend of population is best observed was investigated and regression analysis has been applied. The values of R^2 and RMSE which were derived in accordance with exponential regression analysis method and the best trend line (least observed error) has seen from the exponential regression analysis method among these methods, and this analysis method has been used in the population estimation. According to exponential regression analysis, it has been estimated that the population of Gaziantep city center will reach 1.572.004 in 2020, 2.402.119 people in 2030, 3.670.586 people in 2040, and 5.608.812 people in 2050 which is the target projection. Estimated water demand in the target year of projection has been calculated as 460.629.501 m^3 according to the population of 2050 and the water consumption per capita of Ilbank (225lt / person). The seepage loss rate 30% was added to water consumption which has been calculated for the upcoming years and the consumption-based water need has been calculated. The estimated values of water need in accordance with population and consumption have been given in (Table 5.5) and (Table 5.7). The water need of Gaziantep has been met from Kartalkaya Dam, Mizmilli water-wells and water-wells in inner city and approximately 125.000.000 m^3 water has been supplied to city from these resources per year.

It can be said that the current resources and Düzbağ Dam will be insufficient in long term, when the effect of migrant population from Syria to urban population and increase of Gaziantep province population are considered. According to data from Provincial Disaster and Emergency Directorate, when the current situation is evaluated, as of 2016, about 300 thousand Syrians live in the city additional to Gaziantep's own population.

Syrian population must be added to the population of the city for future population projection of Gaziantep. The Düzbağ dam, which will be built in Helete town of Çağlayancerit district in Kahramanmaras province, makes it possible to supply water with gravity flow and zero energy cost makes this project positive. But, this water supply will no longer meet the growing population need in the future. It will be inevitable that as a safe recourse Euphrates River will be considered to meet water need and similar needs of increasing population, extreme migration (Syrian population). This situation should be examined by notably GASKİ, DSİ and Metropolitan Municipality of Gaziantep and the other public institutions, in addition required precautions should be taken immediately. In this study also, Göksu river basin hydrological analysis was examined.

The main objective of this study is to determine the hydrologic characteristics of Göksu river basin and estimate the reservoir capacity of the Düzbağ dam, considered to supply water to Gaziantep province, located in Göksu river basin. On the other hand, new hydrological interface was generated. With this new model users can be delineate the watershed with applying one step. This model can be used in Python scripting and other models. Furthermore, this model is user friendly when considering the wasting of time. Model can be used for all watershed applications in order to delineating the watershed easily.

ArcGIS V.10.4 and ArcHydro 10.4 were developed and sold by Environmental Systems Research Institute, Inc. (ESRI) were used in this study for finding the hydrologic parameters of the Göksu basin. Data layers for all of the Göksu River Basin were acquired. These layers include basin boundaries, the length of the main river, digital elevation models (DEMs), digital raster graphic maps, basin slope map, stream network, flow measurements stations, meteorological stations and Thiessen polygon area map around the basin.

The main characteristics of the basin, like the area, shape, elevation, slope, orientation, soil type, channel networks, water reservoir capacity and land cover of the region was derived by using ArcGIS. For determining the parameters, it is necessary to utilize DEM data in calculations for the corresponding basin. In Turkey, suitability of the data to determine the hydrologic characteristic of a basin and other necessary steps is not easy to find, therefore DEMs are taken from USGS (United States Geological Survey). DEMs are taken in format of ASTER and STRM of 30m x 30m resolutions.

Göksu river water quality was analyzed with the samples taken from the river in order to examine the chemical analysis of the water of the Göksu River. According to the results of this analysis, the water pH value was measured as 7.63, the color value was 9, and the turbidity was measured as 4.7. According to the TS 266 water standards, these values are in the acceptable range. When the other analysis parameters are examined, it seems that they are in accordance with the regulation on water for human consumption purposes. The results of the analysis show that the water is at a drinkable level.

The rainfall map was generated by ArcGIS program for whole meteorological stations located in Turkey. The results showed that the best model to generate rain properties map was Ordinary Kriging with spherical and models. The reason for this is the weight difference in the Kriging method. It is not only in the distance. Furthermore like real parameters, estimated values show the driest month as August and the wettest one is December.

According to different elevations of dam reservoir, minimum reservoir capacity estimated about 30 million m^3 and maximum reservoir capacity estimated as roundly 226 million m^3 by estimation by ArcGIS reservoir capacity calculation. On the other hand, by the 1/1000 map taken from the general command of mapping and General Directorate of State Hydraulic Works reservoir capacity calculated as 189 million m^3. Difference between ArcGIS and real parameter is about topographic variable of study region.

The shuttle radar system can not be scanning related topography of the study region exactly. As a result, sliding can be occurred at image used in ArcGIS. Also ArcGIS explained this situation by standart deviation. In this study srtm-30m DEM was utilized for study area and standart deviation occurred as 37.16. Also in order to use SRTM-3m or SRTM-1m DEM, the difference can be decreased. But both DEMs make it not possible for utilize in calculations because of high cost and not easy to find.

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